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CLEO Management thanks the following corporate sponsors for their generous support:

[List of sponsors logos]

Conference on Lasers and Electro-Optics®
## Schedule-at-a-Glance

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<th>Sunday 13 May</th>
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<td>Speaker Ready Room</td>
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<td>Coffee Breaks</td>
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<td><strong>CLEO TECHNICAL PROGRAMMING</strong></td>
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<td>Short Courses</td>
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<td>Technical Sessions</td>
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<tr>
<td>Special Symposium and A&amp;T Topical Reviews</td>
<td>08:00–12:30</td>
<td>13:00–19:00</td>
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<td>Plenary Sessions</td>
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<td>Dynamic e-Posters</td>
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<td><strong>CLEO:EXPO AND SHOW FLOOR ACTIVITIES</strong></td>
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<tr>
<td>Poster Sessions and Free Lunches in Exhibit Hall</td>
<td>11:30–13:00 Free Lunch</td>
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<tr>
<td>OIDA VIP Industry Leaders Speed Meetings Lunch</td>
<td>12:00–13:30</td>
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<td>CLEO Theaters I &amp; II</td>
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<td>Meet the OSA Editors’ Reception</td>
<td>15:30–17:00</td>
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<td>KMLabs Lunch and Learn Event</td>
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<td>Technology Transfer Program</td>
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<td><strong>SPECIAL EVENTS</strong></td>
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<td>OSAF Data Science &amp; Career Opportunities</td>
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<td>OSAF Cheeky Scientist Workshop</td>
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<td>OIDA Executive Forum on the Exploding Role of Optics in Sensing</td>
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<td>OSA Technical Group Events</td>
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<td>Social Media 102</td>
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<td>Workshop: Understanding Unconscious Bias</td>
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<td>Diversity &amp; Inclusion in Optics and Photonics Reception</td>
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<td>Conference Reception</td>
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Welcome to CLEO!

It is our pleasure to welcome you to CLEO 2018 in San Jose, CA. CLEO continues to be the world’s premier international forum for scientific and technical optics, uniting the fields of lasers and optoelectronics by bringing together all aspects of laser technology, from basic research to industry applications. Within the scope of a single conference, CLEO provides a forum where attendees can explore new scientific ideas, engineering concepts, and emerging applications in fields such as biophotonics, optical communications, and novel light sources. While the quality of work presented remains assured by CLEO’s world-renowned technical program, the conference continues to evolve with new features to enhance your experience.

CLEO offers high quality content in five core event elements:

- **Fundamental Science**: The premier venue for discussion of basic research in optical and laser physics and related fields. Topics include modern spectroscopy, ultrafast and nonlinear light-matter interactions, quantum optics, low-dimensional optical materials, quantum information science, nanophotonics, plasmonics, and metamaterials.

- **Science & Innovations**: World-leading scientific research and innovation in lasers, optical materials, and photonic devices. Topics include laser processing of materials, terahertz science and technologies, ultrafast optics, biophotonics, nanophotonics, fiber photonics, nonlinear optical and laser technologies, metrology, sensing, and energy-efficient “green” photonics.

- **Applications & Technology**: Exploration of the transition of fundamental research into emerging applications and products. The scope spans innovative laser and EO components and systems and applications. This topic includes biomedical devices for diagnostics and therapeutics, high power laser systems for industry and defense, photonics instrumentation and technologies for metrology, industrial processes, environmental sensing, and energy conservation.

- **CLEO:EXPO**: The exhibition will showcase more than 200 participating companies featuring a wide range of photonics innovations, products and services. It is expected to attract more than 4,000 attendees including researchers, engineers, and leaders from top research institutions and major businesses who represent the fastest growing markets in optics and photonics.

- **CLEO Theaters**: This program focuses on the latest trends in the photonics marketplace and provides a forum to discuss new products and emerging technologies. All presentations and discussions are focused on the latest in photonics products and services that have been playing an important role in the industry and those that potentially hold a future business opportunity.

This year’s CLEO features 5 extraordinary plenary speakers. On Tuesday morning, Nader Engheta and Vasilis Ntziachristos are our featured speakers. Engheta will describe exciting features and novel opportunities arising from light-matter interaction in metastructures, while Ntziachristos will discuss exciting recent progress in optoacoustic microscopy and its potential clinical impact. On Wednesday morning, featured speakers are Jian-Wei Pan and Sara Seager. Pan will highlight new developments that could lead to a satellite-based global quantum communication network, and Seager will discuss the dramatic advances in the discovery and characterization of exoplanets.

The International Day of Light is celebrated across the world on 16 May as the anniversary of the first successful operation of the laser in 1960 by physicist and engineer Theodore Maiman. CLEO is the perfect home to recognize this day. This conference epitomizes “how a scientific discovery can yield revolutionary benefits to society in communications, healthcare and many other fields,” as quoted on the IDL site. In recognition of the International Day of Light, CLEO is excited have a third Wednesday plenary speaker, John C. Mather, Nobel Laureate, who will talk about our exploration of the universe through light waves.

The CLEO Technical Program committee maintains a rigorous peer review system that emphasizes and maintains high technical quality in all presentations. This rigorous process is made possible by the combined efforts of over 300 volunteers in 25 technical committees. In 2018, the conference features an outstanding collection of contributed paper presentations, invited speakers and tutorials. We are excited to offer more than 1300 oral presentations, 230 invited talks by some of the most respected researchers in our international community, and 23 tutorials. This year’s poster sessions include an outstanding list of more than 500 posters, including a specially selected subset of posters that are dynamic E-posters. Furthermore, selected topics are highlighted in special symposia and topical reviews comprising tutorials and invited talks. Participation from industry is particularly encouraged through these topical reviews. Finally, we are pleased to offer a comprehensive short course program featuring 17 courses.
We extend our sincere thanks to the Technical Program Co-Chairs; Michael M. Mielke and Jin Ung Kang in Applications & Technology; and Stewart Aitchison and Todd Pittman in Fundamental Science, Amr S. Helmy and Shinji Yamashita in Science & Innovations for coordinating the work of our subcommittees to compile this outstanding CLEO program. We also thank Robert Fisher and Ben Eggleton, Short Course Co-Chairs, and all of the program committee members whose leadership, dedication, and hard work has been critical to maintaining the high quality of the meeting. Additionally, we would like to thank the APS Division of Laser Science, the IEEE Photonics Society, The Optical Society (OSA), and the exhibitors for their support and contributions to the meeting. Finally, we thank the OSA staff for their professional assistance and dedication in organizing this event.

We welcome you to the conference and thank you for your participation.
Conference Services

Registration
Concourse Level

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CLEO:EXPO
Exhibit Hall
The CLEO:EXPO is open to all registered attendees. Visit a diverse group of companies representing every facet of the lasers and electro-optics industries. Exhibition information can be found on page 32.

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Speaker and Presider Ready Room
Room 211A
All technical presentation speakers and session presiders are required to check in to the Speaker Ready Room located on the Concourse Level in Room 211A. Speakers are required to check in 24 hours before their session begins.

Session presiders should check in one to two hours prior to their session for instructions on how to use in-room equipment and check for speaker cancellations and changes. Computers will be available to review uploaded slides.

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Coat and Baggage Check
Lower Lobby, Street Level
Coat and baggage check is available to conference attendees for a nominal fee.

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<td>Thursday, 17 May</td>
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<td>Friday, 18 May</td>
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Customer Service & Information Center
Concourse Level
For questions about the program, locating sessions or general conference information, visit the Conference Information Center. Lost and Found items will be left at the Conference Information Center for 24 hours. Please put your name on all conference materials (Program Book and Short Course Notes).

There is a replacement fee for Program Books and badges.

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E-Center Kiosks
Concourse Level
The E-Center provides multiple viewing stations allowing attendees to check email. The E-Center Kiosks will be open during registration hours. Please limit your time on a station between 10 to 15 minutes so others may have time to check their emails. Kiosk hours will mirror Registration hours.

First Aid and Emergency Information
The First Aid room, staffed with emergency medical personnel, is located on the Exhibit Level. This room will be open during all conference hours. In the event of an emergency, please contact a security guard or a CLEO staff member. All accidents, injuries or illnesses in the San Jose Convention Center should be reported to the Public Safety Office immediately; call the office at extension 3500 from any white courtesy phone.

Wireless Access
San Jose Convention Center offers free Wi-Fi experience. To access the network just connect to the SSID, “Wickedlyfastwifi”, a return, SSID is easily readable.

No personal information or password needed with unlimited Wi-Fi access provided in the Convention Center.

All conference locations are in the San Jose Convention Center unless otherwise noted.
CLEO Announces CLEO KIDS - Child Care Options

This will be the first time CLEO has offered subsidized on-site childcare to attendees who want to bring their kids. We have contracted with KiddieCorp, an established childcare provider service that other conferences have used for childcare with great success.

Childcare reservations must be made 24 hours prior to date of service. Childcare services is based on space availability. Please contact Debbie Leffall at +1 916-595-7033 for reservation options.

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The IEEE Photonics Society, in partnership with the IEEE Foundation, is proud to announce the establishment of the IEEE Photonics Fund. This fund will be used to enhance the humanitarian and educational initiatives of the Society by providing members and the photonics community with the ability to contribute directly to mission-driven imperatives, such as Humanitarian Projects, Student Resources, STEM Outreach and Diversity Initiatives.

The IEEE Photonics Fund

The IEEE Photonics Society has contributed USD $100K to The IEEE Photonics Fund. Will you match us with your donation? With the establishment of this fund, you too can play a direct role in this vital work. Visit the IEEE Photonics Society booth or www.PhotonicsSociety.org for more information.

The Optical Society Booth

Exhibit Hall, #1927
Email: info@osa.org
Website: www.osa.org

Founded in 1916, The Optical Society (OSA) is the leading professional association in optics and photonics, home to accomplished science, engineering, and business leaders from all over the world.

Through world-renowned publications, meetings, and membership programs, OSA provides quality information and inspiring interactions that power achievements in the science of light. More than 21,000 OSA members, residing in over 100 countries and spanning academia, government and industry, call OSA their professional home.

Stop by to meet OSA staff, and learn more about our publications, conferences and meetings, and membership for individuals and companies.

The Optical Society Member Lounge

Concourse Level

OSA members are invited to take a brief respite from the conference at the Member Lounge. Whether it’s to plan your schedule, meet up with other members or print your boarding pass, the lounge offers comfortable seating, light refreshments, coffee service and a computer/printer. In addition, take advantage of renewing your membership at 50% discount for one-year! You can renew at the OSA Member Lounge or the OSA Booth on the Exhibit Floor. This special rate is available whether you’re rejoining for the first time or renewing for another year.

OSA Member Lounge Schedule:

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OSA CAM Lounge

Room 213

The Celebrating All Members (CAM) videos are an opportunity for OSA members to share their stories in 3 minutes or less about what/who inspired them to get into their field, what excites them about their current work and what OSA means to them. These short vignettes are shown on our website (osa.org/100), on social media and at some of our conferences. Stop by on Monday or Tuesday between 09:00–16:00 for a quick interview.

All conference locations are in the San Jose Convention Center unless otherwise noted.
Conference Materials

Access to Technical Digest and Postdeadline Papers

Technical attendees have early and continuous access to the CLEO:2018 Technical Digest, including the Postdeadline Papers. The Technical Digest is comprised of the two-page summaries of tutorial, invited and accepted contributed/postdeadline papers. They can be downloaded individually or by downloading daily .zip files. (.zip files are available for 60 days after the conference).

2. Select the Access Digest Papers link on the right side of the web page.
3. Log in using the same email address and password you used to register for the meeting. You will be directed to the conference page where you will see the .zip file links at the top of the page. Please note: if you are logged in successfully, you will see your name in the upper right-hand corner.

Access is limited to Full Conference attendees only, not Exhibits Pass Plus or One-Day attendees. If you need assistance with your login information, please use the “forgot password” utility or “Contact Help” link.

The available paper summaries will be submitted to the IEEE Xplore Digital Library (www.ieeeexplore.ieee.org), provided that the paper is presented by a co-author during CLEO 2018.

Poster PDFs

Authors presenting posters have the option to submit the PDF of their poster, which will be attached to their papers in OSA Publishing’s Digital Library. If submitted, poster PDFs will be available three weeks after the conference. Submit your poster PDF no later than 31 May to cstech@osa.org. Your PDF should be named using your presentation number with “-1” added at the end (JTh2A.24-1.pdf).

Short Course Notes

Notes typically include a copy of the presentation and any additional materials provided by the instructor. Each course has a unique set of notes, which are distributed on-site to registered course attendees only. Notes are not available for purchase separately from the course.

CLEO App

Manage your conference experience by downloading the CLEO App to your Smartphone or tablet.

Download the app one of three ways

1. Search for ‘CLEO Conference’ in the app store.
2. Go to cleoconference.org/app
3. Scan the QR code

Schedule

Search for conference presentations by day, topic, speaker or program type. Plan your schedule by setting bookmarks on programs of interest. Technical attendees can access technical papers within session descriptions.

Exhibit Hall

Search for exhibitors in alphabetical order and set a bookmark reminder to stop by their booth. Tap on the map icon within a description, and you’ll find their location on the EXPO floor map. View a daily schedule of all activities occurring on the show floor.

Access Technical Digest Papers

Full technical registrants can navigate directly to the technical papers right from the CLEO mobile app. Locate the session or talk in “Event Schedule” and click on the “Download PDF” link that appears in the description.

IMPORTANT: You will need to log in with your registration email and password to access the technical papers. Access is limited to Full Conference attendees only.

Posters

Authors presenting posters have the option to submit the PDF of their poster, which will be attached to their papers in OSA Publishing’s Digital Library. If submitted, poster PDFs will be available three weeks after the conference. Submit your poster PDF no later than 31 May to cstech@osa.org. Your PDF should be named using your presentation number with “-1” added at the end (JTh2A.24-1.pdf).

Short Course Notes

Notes typically include a copy of the presentation and any additional materials provided by the instructor. Each course has a unique set of notes, which are distributed on-site to registered course attendees only. Notes are not available for purchase separately from the course.

Need assistance?

Contact our support team, available 24 hours a day Monday through Friday, and from 09:00 to 21:00 EDT on weekends, at +1.888.889.3069 option 1.

Android users who downloaded the app for CLEO 2017 or earlier years may need to download a new version of the app. Scan the QR code or search for ‘CLEO Conference’ in the Google Play Store.

All conference locations are in the San Jose Convention Center unless otherwise noted.
Plenary Sessions and Awards Ceremony

Plenary Session I
Tuesday, 15 May, 08:00–10:00
Grand Ballroom

Metaphotonics
Nader Engheta, University of Pennsylvania, USA

Materials are often used to control and manipulate photons. Metamaterials and metasurfaces are two representative classes of judiciously designed structures that provide unprecedented platforms for sculpting waves and fields. Their extreme properties lead to novel opportunities in photonics. Light-matter interaction in metastructures exhibits unusual functionalities with numerous exciting features and potential applications.

Nader Engheta is the H. Nedwill Ramsey Professor at the University of Pennsylvania. He received his PhD from Caltech. His current research activities span various areas of nanophotonics, metamaterials, nano-optics, electrodynamics, graphene optics, optical circuits, imaging and sensing inspired by eyes of animal species, and physics and engineering of light-matter interaction. His most recent awards include William Streifer Scientific Achievement Award, SPIE Gold Medal, Fellow of US National Academy of Inventors, Vannevar Bush Faculty Fellow Award, IEEE Electromagnetics Award, and URSI Balthasar van der Pol Gold Medal. He is a Fellow of OSA, APS, MRS, SPIE, IEEE, URSI, and AAAS.

Listening to Light: Advances in Opto-acoustic Imaging
Vasilis Ntziachristos, Technical University of Munich, Germany

Optical imaging is unequivocally the most versatile and widely used visualization modality in the life sciences. Yet it has been significantly limited by photon scattering, which complicates imaging beyond a few hundred microns. Progress with fast tunable lasers, spectral techniques and advanced instrumentation have allowed the development of multi-spectral opto-acoustic tomography (MSOT) for clinical use, offering unprecedented optical imaging performance and assessment of disease pathophysiology. The talk illuminates progress with opto-acoustic macroscopy and mesoscopy and its implication toward clinical impact.

Vasilis Ntziachristos is Professor of Medicine, Professor of Electrical Engineering and Director of the Chair for Biological Imaging (CBI) at the Technical University of Munich, Director of the Institute for Biological and Medical Imaging (IBMI) at the Helmholtz Zentrum Muenchen and Director of Bioengineering at the Helmholtz Pioneering Campus. He has received the Diploma in Electrical Engineering and Computer Science from the Aristotle University of Thessaloniki, Greece and the MSc and PhD degrees in Bioengineering from the University of Pennsylvania in Philadelphia. Prior to his current appointment he served as faculty at Harvard University and the Massachusetts General Hospital.

Plenary Session II & International Day of Light
Wednesday, 16 May, 08:00–10:00
Grand Ballroom

Quantum Communication Network and Future Aspects
Jian-Wei Pan, University of Science and Technology of China, China

Based on state of the art fiber technologies, the prevailing quantum communication technology allows practical communication in the metropolitan area. However, the distance of fiber-based quantum communications is limited due to intrinsic fiber loss. To overcome these problems, we are taking two paths in parallel: quantum repeaters and through satellite, to establish a global quantum communication network.

Jian-Wei Pan obtained his PhD degree of Experimental Physics from the University of Vienna in 1999. In 2001, he was appointed as full professor of physics by the University of Science and Technology of China (USTC). In 2011, he was elected as the academician of Chinese Academy of Sciences (CAS). In 2012, he was elected as the World Academy of Science (TWAS) Fellow. His research focuses on quantum optics, quantum information and quantum foundations. He has accomplished a series of profound achievements in experimental quantum information science. Due to his numerous progresses on quantum communication and multi-photon entanglement manipulation, quantum information science has become one of the most rapidly developing fields of physical science in China in recent years.

Mapping the Nearest Stars for Habitable Worlds
Sara Seager, Massachusetts Institute of Technology, USA

For thousands of years people have wondered, “Are there planets like Earth?”; “Are such planets common?”; and “Do any have signs of life?” Today, astronomers are poised to answer these ancient questions, having recently found thousands of planets that orbit nearby Sun-like stars, called exoplanets.” The presentation will share the latest advances in this revolutionary field and work to answer the question, “Are we alone?” Or put another way, where are the neighbors, and how far away are they? In a few decades of research in optoelectronics and spectroscopy, we could know an answer.

Sara Seager is a planetary scientist and astrophysicist at the Massachusetts Institute of Technology. She has pioneered many research areas in the characterization of exoplanets. Her present research focus is on the search for life by way of exoplanet atmospheric “biosignature” gases. She works on space missions for exoplanets including as: the PI of the CubeSat ASTERIA; the Deputy Science Director of the MIT-led NASA Explorer-class mission TESS; and as a lead of the Starshade Rendezvous Mission (a space-based direct imaging exoplanet discovery concept under technology development).

All conference locations are in the San Jose Convention Center unless otherwise noted.

CLEO • 13–18 May 2018
to find a true Earth analog orbiting a Sun-like star. Among other accolades, she was elected to the US National Academy of Sciences in 2015 and is a 2013 MacArthur Fellow.

Astronomers travel the universe with imagination and observation, and most of the information arrives as light waves, showing the distant universe as it was when the light was sent out. We can now see at wavelengths ranging from over 10 meters to less than a picometer, limited only by our ingenuity and the opacity of our environment. We are beginning to learn the story of our own origins, from the expanding early universe, to the formation of galaxies, stars, and black holes, to the stellar nuclear processes producing the heavy elements of life, to the formation of planets. That history is full of catastrophic events, apparently necessary for our own existence. I will show some of the future discoveries we hope to see through NASA’s James Webb Space Telescope (JWST), discuss the expanding views of the universe, and outline the technology that will lead us to deeper understanding.

John C. Mather is a Senior Astrophysicist in the Observational Cosmology Laboratory at NASA’s Goddard Space Flight Center (GSFC). His research centers on infrared astronomy and cosmology. As an NRC postdoctoral fellow at the Goddard Institute for Space Studies, he led the proposal efforts for the Cosmic Background Explorer (74-76), and came to GSFC to be the Study Scientist (76-88), Project Scientist (88-98) and also the Principal Investigator for the Far IR Absolute Spectrophotometer (FIRAS) on COBE. He showed that the cosmic microwave background radiation has a blackbody spectrum within 50 ppm. As Senior Project Scientist (95-present) for the James Webb Space Telescope, he leads the science team, and represents scientific interests within the project management. He has received many awards including the Nobel Prize in Physics, 2006, for his precise measurements of the cosmic microwave background radiation using the COBE satellite. He was elected as an OSA Honorary Member in 2016.

**Awards Ceremony**

**Tuesday, 15 May**

**Grand Ballroom**

**OSA Charles Hard Townes Medal**

The Optical Society (OSA) established this medal in 1980 to honor Charles Hard Townes, whose pioneering contributions to masers and lasers led to the development of the field of quantum electronics. It is given to an individual or a group for outstanding experimental or theoretical work, discovery or invention in the field of quantum electronics.

The 2018 recipient is Peter Fritschel, Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, USA, recognized for advances in quantum-limited precision measurement in the Advanced LIGO detectors, leading to the first direct detection of gravitational waves.

**The Optical Society 2018 Fellows**

These Fellows are being recognized at CLEO. Visit osa.org/fellows for a complete list of 2018 Fellows.

- **Andrea Armani**, University of Southern California, USA
  For contributions to integrated photonics with applications in telecommunication and chemical and biological detection

- **Hou-Tong Chen**, Los Alamos National Laboratory, USA
  For seminal contributions to the field of metamaterials, including active metamaterials and the realization of novel electromagnetic structures at terahertz frequencies

- **Yu-Ao Chen**, University of Science and Technology of China, China
  For outstanding contributions on photonic quantum information and quantum simulation

- **Stavros Demos**, Laboratory for Laser Energetics, University of Rochester, USA
  For pioneering and sustained contributions to understanding dynamic behaviors and improved performance in optical materials for high power lasers and developing multimodal imaging and characterization methods for medical and other applications

- **Heike Ebendorff-Heidpriem**, University of Adelaide, Australia
  For ground breaking science contributions to the field of optical glasses and fibers

- **Sasan Fathpour**, CREOL, The College of Optics and Photonics, University of Central Florida, USA
  For pioneering contributions to the field of integrated photonics, particularly heterogeneous integration in silicon photonics for second- and third-order nonlinear optics and mid-infrared wavelengths applications

- **Almantas Galvanauskas**, Center for Ultrafast Optical Science (CUOS), EECS Department, University of Michigan, USA
  For pioneering contributions to the science and technology of ultrashort pulse and high power fiber lasers, novel fiber structures, nonlinear interactions in fibers and fiber lasers, and fiber laser beam and pulse combining

All conference locations are in the San Jose Convention Center unless otherwise noted.
Goëry Genty, Tampere University of Technology, Finland
For pioneering research in the study of supercontinuum generation and nonlinear instabilities in optical fibers

Dr. Constantin Haefner, Lawrence Livermore National Laboratory, USA
For pioneering next generation, high average power Petawatt laser systems enabling a new arena of applications and sustained advancement of state-of-the art technologies in large-scale, high intensity, peak-power laser systems

Sivanandan S. Harilal, Pacific Northwest National Laboratory, USA
For pioneering contributions to the fundamentals of laser ablation, optical spectroscopy of laser ablation plumes and laser-plasma light sources

John E. Heebner, Lawrence Livermore National Laboratory, USA
For numerous innovations, achievements, and technical leadership in high energy laser systems and integrated optics including nonlinear optical microresonators and ultrafast light deflectors

Nicusor Iftimia, Physical Sciences Inc., USA
For original contributions in biomedical optics, especially pioneering the use of optical coherence tomography for interstitial tissue imaging and biopsy guidance, as well as for outstanding service to the biomedical optics community

Mona Jarrahi, University of California, Los Angeles, USA
For pioneering contributions to terahertz optoelectronics and microwave photonics through development of novel engineered materials, plasmonic nanostructures, and quantum well devices

Jungsad Kim, Duke University, USA
For research on scalable modular quantum computers and networks using trapped ions, large-scale optical switches, quantum optics with single-photon sources and detectors, and gigapixel-scale cameras

Tobias Kippenberg, Ecole Polytechnique Federale de Lausanne, Switzerland
For pioneering fundamental and applied research on microresonator frequency combs and cavity optomechanics

Tien-Chang Lu, National Chiao Tung University, Taiwan
For pioneering and outstanding contributions to wide bandgap semiconductor vertical-cavity surface-emitting lasers, light-emitting diodes, microcavity polariton lasers and surface plasmon polariton lasers

Zhenqiang Ma, University of Wisconsin-Madison, USA
For pioneering contributions to flexible optoelectronics and semiconductor nanomembrane based photonics

Arash Mafi, University of New Mexico, USA
For pioneering contributions to fundamental understanding of quantum and nonlinear behavior of optical waveguides, light propagation in disordered media, and development of Anderson localizing optical fibers

Mo Mojahedi, Department of Electrical and Computer Engineering, University of Toronto, Canada
For seminal contributions to the field of plasmonics and hybrid plasmonics with important applications to nano-photonics and sensing

John Nees, University of Michigan, USA
For contributions to the development of short pulse high rep-rate laser technology as well as to the science of high intensity short pulse laser interactions with matter

Valdas Pasiskevicius, Royal Institute of Technology (KTH), Sweden
For substantial contributions to the development of novel applications of structured nonlinear optical materials and service to the optics community, particularly OSA

Alan B. Petersen, Spectra-Physics, MKS Instruments, Inc., USA
For significant and innovative contributions to the design of commercial scientific and industrial UV laser systems and for long term service to the optics community

Pepijn Pinkse, Universiteit Twente, Netherlands
For original and pioneering contributions in the fields of nanophotonics, quantum optics, and quantum secure authentication

Innocenzo Pinto, University of Sannio, INFN, LVC, and KAGRA, Italy
For fundamental contributions to thermal noise reduction in the mirror coatings of the LIGO interferometric gravitational wave detectors, and for original contributions to the science of Electromagnetics

Derryck T. Reid, Heriot-Watt University, United Kingdom
For the invention of two-photon autocorrelation using photodiodes and the development of frequency combs based on ultrafast optical parametric oscillators

Pascale Senellart, Center for Nanoscience and Nanotechnology, France
For inventing in-situ optical lithography that couples quantum dots and optical cavities with nanometric precision, realising solid-state single and entangled photon sources of unsurpassed performance that are moving quantum optics towards a scalable future

Glenn Solomon, Joint Quantum Institute, USA
For pioneering the development of semiconductor quantum dot optical materials and device structures for solid-state quantum optics

Kartik Srinivasan, National Institute of Standards & Technology, USA
For outstanding contributions to nanophotonics and quantum optics, including cavity-QED, frequency conversion, and integrated optics such as photonic crystals

Thomas Südmeyer, Université de Neuchâtel, Switzerland
For seminal contributions to ultrafast photonics, in particular in the area of ultrafast thin disk lasers, nonlinear frequency conversion, and optical frequency combs

Hong-Bo Sun, Tsinghua University, China
For pioneering contributions to the field of laser nanofabrication in both fundamental research and industrial applications, as well as ultrafast spectroscopy and their applications on deep insight into nanophotonic materials and devices

Sergei Tochitsky, University of California, Los Angeles, USA
For outstanding contributions to the development of high-power picosecond CO2 lasers and their applications in nonlinear optics and laser-driven particle acceleration

All conference locations are in the San Jose Convention Center unless otherwise noted.
M. Selim Ünlü, Boston University, USA
For pioneering contributions in utilization of optical interference in enhanced photodetectors and biological sensing and imaging

Mu Wang, Nanjing University and American Physical Society, China
For original contributions in designing of metallic subwavelength microstructures to control the polarization, propagation and intensity of light, optimizing physical properties and striving for their applications in optics and opto-electronic exchange

IEEE Photonics Society 2018 Fellows
Michael Krames, Pacific Bell, USA
For leadership in GaN-based light-emitting device physics and its commercialization
Hong-Bo Sun, Tsinghua University, China
For contributions to laser nanofabrication and ultrafast spectroscopy

James P. Gordon Memorial Speakership
Established in 2014 with the support of the Gordon family, The James P. Gordon Memorial Endowment funds a speakership on Quantum Information and Quantum Optics to a CLEO invited speaker. This speakership pays tribute to Dr. Gordon for his numerous high-impact contributions to quantum electronics and photonics, including the demonstration of the maser.

The recipient receives a $1,500 honorarium and their presentation will be recorded and archived in OSA's media library. The contents will serve as an educational resource for the next generation of optics and photonics leaders.

Congratulations to
Mikhail Lukin, Harvard University, USA

Tingye Li Innovation Prize
The Tingye Li Innovation Prize, established in 2013, honors the global impact Dr. Li made to the field of Optics and Photonics. This prize is presented to a young professional with an accepted paper that has demonstrated innovative and significant ideas and/or contributions to the field of optics. The recipient of this prize receives a $3,000 stipend, an invitation to the Chairs' Reception, and special recognition at the conference.

Congratulations to
Logan G. Wright, Cornell University, USA

Maiman Student Paper Competition
The Maiman Student Paper Competition honors American physicist Theodore Maiman for his demonstration of the first working laser and his other outstanding contributions to optics and photonics. It recognizes student innovation and research excellence in the areas of laser technology and electro-optics. The competition results will be announced during the meeting. The prize is endowed by a grant from HRL Laboratories LLC, the IEEE Photonics Society and the APS Division of Laser Science and is administered by the OSA Foundation.

Congratulations to our finalists:
Sheldon Kwok, Massachusetts Institute of Technology, USA
Nils Otterstrom, Yale University, USA
Dominik Peller, University of Regensburg, Germany
Brian Stern, Cornell University, USA

Incubic/Milton Chang Travel Grant
The OSA Foundation is pleased to award 10 recipients this year's Incubic/Milton Chang Student Travel Grant, endowed by Milton and Rosalind Chang. The list of recipients can viewed at www.osa.org/foundation.

Plenary Speaker Meet-n-Greet
Tuesday, 15 May, 10:15–10:45
Theater I, Exhibit Hall, #2433
Meet Nader Engheta, Vasilis Ntziachristos and Jian-Wei Pan, ask questions and network with your colleagues.

Plenary Speaker Meet-n-Greet
Wednesday, 16 May, 10:15–10:45
Theater I, Exhibit Hall, #2433
Meet John Mather and Sara Seager, ask questions and network with your colleagues.
Special Symposia

Future Directions in Terahertz Nanoscopy
Monday, 14 May, Session I: 08:00–10:00,
Session II: 10:30–12:30
Executive Ballroom 210A

Organizers
Tyler Cocker, Universitäten Regensburg, Germany
Daniel Mittleman, Brown University, USA

Terahertz and multi-terahertz microscopy with subwavelength spatial resolution has recently progressed from proof-of-principle demonstrations to scientific studies capable of revealing unique information. For example, the ability of terahertz nanoscopy to combine spatial resolution on the nanometer (or even sub-nanometer) scale with ultrafast temporal resolution may ultimately make it a ‘killer application’ for terahertz technology—one that can address scientific questions that are inaccessible via any other experimental approach. It may even be possible to obtain a comprehensive picture of nanoscale dynamics by combining cutting-edge terahertz-based techniques like near-field scanning optical microscopy and lightwave-driven scanning tunneling microscopy. Still, technical challenges remain that must be solved before the full potential of these techniques can be realized, either individually or together. In this symposium, we will discuss the latest results and future prospects of terahertz nanoscopy, as well as scientific goals for the field.

Invited Speakers
Joanna Atkin, Univ. of North Carolina at Chapel Hill, USA, Towards Quantitative Conductivity Measurements with Infrared Near-Field Optical Microscopy
Dmitri Basov, Columbia University, USA, Nano-THz Imaging of Quantum Materials
Frank Hegmann, University of Alberta, Canada, Future Directions in Terahertz Scanning Tunneling Microscopy
Pernille Klarskov Pedersen, Brown University, USA, Pushing Terahertz Emission Microscopy to the Nanoscale
Jun Takeda, Yokohama National University, Japan, Nanoscale Electron Manipulation Using Phase-controlled THz Near-fields

Multimodal and Molecular Contrast Optical Imaging
Tuesday, 15 May, Session I: 13:00–15:00,
Session II: 17:00–19:00
Salon I & II, San Jose Marriott

Organizer
Wolfgang Drexler, Medizinische Universität Wien, Austria

Momentary clinical medical imaging technologies are expensive and complex with limited sensitivity and specificity. Multimodal and molecular contrast optical imaging offers low-cost, non-invasive, accurate, rapid alternatives and the potential to address global medical needs. This symposium focuses on the combination of state-of-the-art optical imaging modalities to enable enhanced clinical diagnosis in a variety of medical fields. A special emphasis will be on approaches enabling molecular contrast as well as endoscopic imaging.

Tutorial Speaker
Irene Georgakoudi, Tufts University, USA, Bringing Functional High Resolution Diagnostics to the Bedside Using Multimodal, Label-free, Two-photon Imaging

Invited Speakers
Thomas Bocklitz, IPHT Jena, Germany, Nonlinear Optical Endoscopy
Audrey Bowden, Stanford University, USA, Multimodal Endoscopic Bladder Imaging
Zhongping Chen, University of California Irvine, USA, Intra-vascular Multimodal Imaging
Johannes de Boer, Vrije Univ Amsterdam, Netherlands, Combined Optical Coherence Tomography and Near Infrared Fluorescence of Cancer-specific Antibodies
Adam de la Zerda, Stanford University, USA, Molecular Imaging with Optical Coherence Tomography

Kristen Maitland, Texas A&M University, USA, Reflectance Confocal Microscopy and Fluorescence Lifetime Imaging in the Oral Cavity

New Advances in Adaptive Optics Retinal Imaging
Wednesday, 16 May, Session I: 13:00–15:00,
Session II: 17:00–19:00
Salon VI, San Jose Marriott

Organizer
Mircea Mjutan, Physical Sciences Inc., USA

Adaptive optics (AO) has recently achieved success in a range of high resolution retinal imaging applications in ophthalmology using instruments from flood illumination full-field retinal cameras and confocal scanning laser ophthalmoscopes (SLO) to optical coherence tomography (OCT). AO is being used as a tool to understand structural and functional aspects of vision, the elegant but complex retinal circuitry, and the dissolution of that structure, wiring and processes during the progression of disease. It has been used in direct measurements of the foveal avascular zone, retinal capillary erythrocyte and leukocyte velocity, pulsatility, and other functional dynamics. The RPE cell mosaic is being mapped in monkeys and humans and correlated to the cone mosaic. Diseases such as rod-cone dystrophy and genetic defects are confirmed and explored directly in the live eye. High-resolution retinal imaging is being applied to advanced molecular and gene therapies, both in their development and as the primary method to determine treatment efficacy at the cellular level. Systems are slowly migrating from the research lab into the clinic for use on patients with a variety of diseases and conditions. New developments such as dark-field imaging methods and OCT Angiography are clearly making their mark on ophthalmology research and practice.

Invited Speakers
Jacque Duncan, University of California San Francisco, USA, Adaptive Optics Scanning Laser Ophthalmoscopy in Retinal Degenerations: New Insights in Structure and Function
Alfredo Dubra, Stanford University, USA, Adaptive Optics Scanning Light Ophthalmoscopy: Beyond Structural Imaging

Ethan Rossi, University of Pittsburgh, USA, Imaging Single Cells in the Living Eye from the Retinal Pigment Epithelium to the Ganglion Cell Layer

Robert Zawadzki, University of California Davis, USA, Progress on Functional Retinal Imaging with OCT: Recent Advancements in Measurements and Modeling of Photoreceptor Optophysiology

Advances in Integrated Microwave Photonics
Thursday, 17 May, Session I: 14:00–16:00,
Session II: 16:30–18:30
Executive Ballroom 210D

Organizers
David Marpaung, University of Twente, Netherlands
Maurizio Burla, ETH Zurich, Switzerland
Jose Capmany, Universidad Politecnica de Valencia, Spain

The field of integrated microwave photonics explores the incorporation of photonic integration technology for the generation, processing and measurement of radio-frequency and microwave signals and is one of the fastest growing fields in signal processing. At present, the field of integrated microwave photonics has adopted significantly distinct approaches, technological tools, and focused applications compared to the recent past. A new research paradigm is to explore general purpose and programmable signal processor capable of synthesizing a multitude of on-demand signal processing tasks. On the other hand, incorporation of new technological tools such as on-chip frequency combs, opto-acoustic interactions, and plasmonics open new ways of manipulating RF signals. From the applications side, emerging concepts such as 5G communications and the Internet of Things (IoT) are expected to shape development of new systems focusing on high operating frequencies in the millimeter-waves, low power consumption, and high level of integration with electronics. This symposium emphasizes on these recent advances in integrated microwave photonics and their application to emerging massive takeover applications. It seeks for transformative ideas about the future developments field and, at the same time, attempts to bridge dialogues between device-focused and application-driven approaches.

Invited Speakers
Richard DeSalvo, Harris Corporation, USA, Advanced Microwave Photonics Applications and Routes to Hybrid Integration
Jonathan Klamkin, Univ. of California Santa Barbara, USA, Integrated Microwave Photonic Component Technologies
Juerg Leuthold, ETH Zurich, Switzerland, Plasmonics for RF Photonics
Chris Roeloffzen, LionIX International, Netherlands, Integrated Microwave Photonics for 5G
Xiaoxiao Xue, Tsinghua University, China, Microcomb Engine for Microwave Photonics
Jianping Yao, University of Ottawa, Canada, Photonic Integrated Circuits for Microwave Signal Generation and Processing

Integrated Sources of Non-Classical Light: Perspectives and Challenges
Thursday, 17 May, Session I: 14:00–16:00,
Session II: 16:30–18:30
Executive Ballroom 210C

Organizers
Marco Liscidini, Universita degli Studi di Pavia, Italy
Alireza Marandi, Stanford University, USA
John Sipe, University of Toronto, Canada

Parametric fluorescence in bulk crystals for generating non-classical light, such as a single photon, photon pairs, and squeezed states, has been an essential part of quantum optics for more than three decades. Recently, the use of integrated photonic structures has attracted attention as a promising strategy for generation and manipulation of non-classical states of light. This is particularly interesting because light confinement at the micro- and nano-scale can enhance the nonlinear light-matter interaction by several orders of magnitude, and the optical properties of these structures can be engineered beyond what can be achieved in bulk materials, for instance in terms of dispersion. Moreover, using integrated structures offers the promise of better stability, scalability, and lower cost, which are typical of integrated devices. Hence, “Great Expectations” have been raised for using integrated photonics toward development of scalable quantum technologies as well as extending the frontiers of light-matter interactions. Despite recent advances, the generation and control of non-classical light on a chip for the realization of practical and scalable quantum devices is still a major challenge. The goal of this symposium is to provide a forum for discussing the state-of-the-art developments in integrated photonics for generation and manipulation of non-classical light as well as major challenges and potential directions in using them toward practical quantum technologies.

Invited Speakers
Andrea Fiore, Technische Universiteit Eindhoven, Netherlands, Tailoring Radiative Emission in Integrated Quantum Light Sources
Matteo Galli, Universita degli Studi di Pavia, Italy, Nonclassical Light Sources for Silicon Photonics
Roberto Morandotti, INRS-Energie Mat & Tele Site Varennes, Canada, Scalable On-chip Generation and Coherent Control of Complex Optical Quantum States
Sven Ramelow, Humboldt Universität zu Berlin, Germany, Nonlinear Quantum Optics in Si3N4 micro-ring Resonators
Andrey Sukhorukov, The Australian National Univ., Australia, Photon-pair Generation and Quantum-classical Correspondence in Nonlinear Nanostructures

All conference locations are in the San Jose Convention Center unless otherwise noted.
Emerging Quantum Sensing Techniques and Applications
Friday, 18 May, Session I: 10:30–12:30,
Session II: 14:00–16:00
Executive Ballroom 210B
Organizers
Peter Humphreys, Delft University of Technology, Netherlands
Marina Radulaski, Stanford University, USA

There has been substantial recent progress in developing novel quantum sensing techniques by building on the latest developments in a diverse range of quantum optics platforms. These new sensors will enable unprecedented scientific inquiries through a combination of enhancing temporal and spatial resolutions, enabling robust and compact sensing devices and through extending the range of conditions over which signals can be detected. For instance, NV-center magnetometers can provide sub-nanometer and sub-milli-hertz precision, enabling sensing of individual electron spins, and have even been embedded in nanodiamonds for in-situ detection of temperatures at the sub-cellular level. Drawing on research on atomic vapors, entangled atom metrology can reduce noise 100 times below the standard quantum limit. New optomechanical devices will enable compact sensors able to detect minute variations in the gravitational field. The challenges facing this nascent field are: harnessing quantum phenomena to move sensing beyond classical boundaries, and refining these techniques to move beyond laboratory. This symposium will focus on emerging quantum sensing concepts and experiments, aiming to bring together researchers from across this new field along with potential future beneficiaries of these techniques.

Invited Speakers
Ania Bleszynski Jayich, UCSB, USA, Quantum Sensing and Imaging with Diamond Spins
Alexey Gorshkov, Univ. of Maryland, USA, Optimal and Secure Measurement Protocols for Quantum Sensor Networks
Sebastien Gleyzes, College de France – CNRS, France, Quantum Metrology with Rydberg Atoms
Lee McCuller, MIT Kavli Institute for Astrophysics and Space Research, USA, The LIGO Squeezed Light Upgrade
Morgan Mitchell, ICFO -The Institute of Photonic Sciences, Spain, Quantum Sensing with Extreme-coherence Spin Ensembles

Lasers in Accelerator Science and Technology
Friday, 18 May, Session I: 08:00–10:00,
Session II: 10:30–12:30
Executive Ballroom 210C
Organizer
Sergio Carbajo, Stanford University and SLAC National Accelerator Laboratory, USA

Unifying laser and accelerator physics is essential for the development of future accelerators, light sources, and other scientific instruments due to increasingly synergistic advances at the cross-section between these two fields. Laser fields are ideal agents to tailor the 6-D phase-space distribution of charged particle beams because they can imprint correlations with extremely high spatio-temporal precision. In addition to long-standing uses in photo-injectors and compact acceleration, recent laser applications to free electron laser seeding, accelerators on a chip, hybrid x-ray light sources, and more have highlighted the need for further research into laser-particle interactions. The goal of this symposium is to fill this breach and to bring experts in various aspects of this interdisciplinary field to expose present and future opportunities in laser research and development to serve accelerator technology and applications, from instrumentation requirements to science cases.

Invited Speakers
Félicie Albert, Lawrence Livermore National Laboratory, USA, Light Sources from Laser Wakefield Acceleration: Development and Applications
Jerome Faure, LOA-ENSTA, France, Recent Progress on High-Repetition Rate Laser-Plasma Acceleration
William Graves, Arizona State University, USA, X-ray Laser Based on Inverse Compton Scattering
Peter Hommelhoff, Friedrich-Alexander-Universität Erlangen, Germany, Hotonics-based Laser-driven Particle Acceleration: from Proof-of-concept Structures to the Accelerator on a Chip
Agostino Marinelli, SLAC National Accelerator Laboratory, USA, Laser-shaping of Electron Beams for X-ray Free-electron Laser Applications
Liang Jie Wong, SIMTech, Singapore, Linear-Field Particle Acceleration in Free Space by Spatiotemporally Structured Laser Pulses
Applications & Technology Topical Reviews

Photonics-enabled Quantum Technologies in Transition
Monday, 14 May, Session I: 08:00–10:00,
Session II: 10:30–12:30
Salon VI, San Jose Marriott

Organizers
Dana Anderson, University of Colorado at Boulder, USA
Wilhelm Kaenders, Toptica Photonics AG & Inc., Germany

With applications ranging from computing to navigation, quantum technology starts to make its way into the mainstream economy through both startups and well-established corporations. The evolution reflects a maturation of science and technology from novel laboratory demonstrations and prototypes to sophisticated and highly-engineered instruments. The challenges facing deployment of quantum-enabled systems are often more of a classical rather than quantum nature: Questions regarding how best to imbue quantum performance in classical systems such as for navigation and communication define a new regime for systems engineering while questions addressing size, weight, power and cost present new challenges for systems integration and manufacturing. In so many cases quantum and photonics technologies are intimately intertwined. Advances in optics and photonics technology will thus go hand-in-hand with the evolution and deployment of quantum technology. This symposium will focus on maturing quantum-enabled instruments and systems and their application in quantum information, metrology, and sensing domains. We aim to bring together researchers in both quantum-enabled classical applications such as navigation and timekeeping, and quantum applications such as quantum computing and secure communications.

Invited Speakers
David Andersen, Rydberg Technologies, USA, Quantum RF electric-field Sensing with Rydberg-atom Vapors
John Burke, DARPA, USA, The Challenge of Complexity, Control, and Low Reliability in Quantum Sensors
Tatjana Curcic, Quantum Valley Innovations, Canada, From Basic Research to Quantum Technologies: Challenges and Opportunities
Bruno Desrueille, MUQUANS, France, Innovative Laser Solutions for Operational Quantum sensors
Karl Nelson, Honeywell, USA, Photonics-enabled Quantum Timing and Navigation at Honeywell
Max Perez, ColdQuanta, USA, Engineering Challenges in Commercial Photonics-enabled Quantum Technologies
Rik van Gorsel, id Quantique, USA, 10 Years of Commercial Quantum Key Distribution: Engineering Achievements and Market Challenges
Brent Young, AOsense, USA, Photonics for Quantum Sensing

Advanced Applications of Laser Radar and Remote Sensing
Tuesday, 15 May, Session I: 13:00–15:00
Wednesday, 16 May, Session II: 13:00–15:00
Theater I

Organizer
Fabio Di Teodoro, The Aerospace Corporation, USA

This topical review will address cutting-edge research and development of laser-based standoff sensors from a system standpoint to include new laser transmitters, detectors, and advanced sensing concepts. Examples include sensors deployed in ground, airborne and space-based platforms for reconnaissance and imaging, environmental/meteorological studies, chemical/biological detection as well as autonomous navigation. Such systems must address many technological challenges including the design, performance improvement, maturation, and qualification of suitable laser transmitters and detectors; minimization of size, weight, power consumption, and cost; increase in ruggedness and support for operation in thermo-mechanically harsh environments; and improvement of long-term reliability.

Invited Speakers
Gerald Buller, Heriot-Watt University, UK, Three-Dimensional Imaging Under Extreme Conditions Using Single-Photon Counting
Lute Maleki, OEwaves Inc, USA, LiDAR for Autonomous Vehicles: Challenges and Opportunities for Photonics
Paul McManamon, Exciting Technology LLC, USA
Marcos Sirota, Sigma Space Corp, USA, Recent Advances in Single Photon Sensitive Mapping Lidars
Mariano Troccoli, Evolution Photonics Inc, USA, High Performance Mid-IR Devices and Applications to Gas Sensing

Advances in Supercontinuum Technologies
Tuesday, 15 May, Session I: 13:00–15:00
Wednesday, 16 May, Session II: 13:00–15:00
Theater II

Organizer
Adam Devine, Fianium Ltd., UK

Advances in Supercontinuum Technologies I: Supercontinuum Generation

Almost two decades after the pivotal experiments of supercontinuum generation in photonic crystal fibers, significant advances continue to be made in the area of broadband light generation within waveguides. This topical review session will focus on recent advances and cutting edge research in supercontinuum generation technology.
**Topical Review on Neurophotonics**

Thursday, 17 May, Session I: 08:00–10:00, Session II: 14:00–16:00
Willow Glen, San Jose Marriott

Organizers
Kishan Dholakia, Univ. of St Andrews, UK
Chris Xu, Cornell Univ., USA

Advanced neurophotonics enable recording and stimulation of a population of neurons at high spatial and temporal resolution, deep within a living, intact animal brain. Research in neurophotonics is a major part of the multibillion-dollar BRAIN Initiative, and will likely play an essential role in understanding how the brain works at the level of neural circuits, which will provide a bridge between microscopic interactions at the neuronal level and the complex computations performed at larger scales. This topical review session will focus on the development of optical tools for neuroscience and brain research.

**Tutorial Speaker**
Jerome Mertz, Boston Univ., USA, The Challenge of Large-scale Neuronal Imaging

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**Scientific and Commercial Progress in Semiconductor Laser Technology**

Thursday, 17 May, Session I: 16:30–18:30
Friday, 18 May, Session II: 08:00–10:00
Willow Glen, San Jose Marriott

**Organizer**
Bojan Resan, Univ. of Applied Sciences Northwestern Switzerland, Switzerland

Semiconductor lasers continue to pave the way towards practical use in numerous applications. Many scientific ideas are on the horizon, but many challenges remain to be solved. Semiconductor lasers are a large and fruitful field and capture the largest share of the commercial laser market. We will review the recent developments in optically pumped VECSELs (semiconductor disc lasers), edge emitters, and their applications. Particular focus will be devoted to devices operating in challenging wavelength regions, efficient wavelength conversion architectures, boundaries for power scaling and ultrashort pulse generation.

**Invited Speakers**
Mircea Guina, Optoelectronics Research Centre, Finland, Progress in VECSELs: from Gain Mirror Technology to New Applications
Nils Hempler, M Squared Lasers, UK, Commercial Semiconductor Disk Lasers

**Time-Stretch Technology: Principles and Applications**

Friday, 18 May, Session I: 10:30–12:30, Session II: 14:00–16:00
Willow Glen, San Jose Marriott

**Organizers**
Hongwei Chen, Tsinghua Univ., China
Keisuke Goda, Univ. of Tokyo, Japan

Optical time stretch is a method based on the exploitation of temporal dispersion for temporally stretching information-encoded ultrashort optical pulses such that the information is detected and digitized by a slow photodetector and a slow digitizer, respectively. With pulse repetition, such a measurement can be performed at a rate of MHz to GHz, allowing for fast, continuous, real-time measurements. Since it was conceived, optical time stretch has been mainly used in data acquisition for femtosecond digitization, data compression, and spectroscopy. In recent years, the method has been further studied and advanced, enabling the observation of non-repetitive and statistically rare events on ultrashort time scales such as soliton explosions, soliton molecules, optical rogue waves, and the birth of mode-locking. Furthermore, it has led to the development of ultrafast imaging, high-throughput imaging flow cytometry, ultrafast optical coherence tomography, and ultrafast surface vibrometry. This special symposium provides a forum for introducing the fundamental principles, emerging applications, and recent advances of optical time stretch as well as for discussing its technical challenges and future perspectives.
Invited Speakers

Dale Capewell, Roguescope Technologies, USA, Coherent RogueScope

Goëry Genty, Tampere Univ. of Technology, Finland, Real-time Measurements of Nonlinear Instabilities in Optical Fibers

Cheng Lei, Univ. of Tokyo, Japan, Optofluidic Time-stretch Microscopy for Precision Medicine

Ray Man, Amonics Limited, Hong Kong, Studying Nonlinear Pulse Interactions using Time Stretch

Adam C. Scofield, Aerospace Corporation, USA, Demonstration of GHz-band RF Receiver and Spectrometer Using Random Speckle Patterns

Kevin Tsia, Univ. of Hong Kong, Hong Kong, Large-scale, Deep Single-cell Analysis by All-optical Laser-scanning Imaging Cytometry
Short Courses

Short Course Chairs
Robert Fisher, R. A. Fisher Associates, USA
Ben Eggleton, Univ. of Sydney, Australia

The CLEO Short Course Program includes a range of topics at a variety of educational levels. Widely recognized experts in industry and academia lead attendees in building skills and/or achieving new insight, and the small-classroom setting provides a tremendous, interactive learning opportunity. Short Courses are an excellent opportunity to learn about new products, cutting edge technology and vital information at the forefront of the laser science and electro-optics fields.

Certificates of Attendance are available for those who register and attend a course. You may request a certificate upon completion of the online course evaluation. If you have any questions about receiving a Certificate of Attendance or completing the course evaluation, please email shortcourses@cleoconference.org with your name and course name(s).

Monday, 14 May 2018
12:30–15:30
Instructor: Tobias Kippenberg, Ecole Polytechnique Federale de Lausanne, Switzerland

12:30–16:30
SC455: Integrated Photonics for Quantum Information Science and Technology
Instructor: Dirk Englund; MIT, USA
SC378: Introduction to Ultrafast Optics
Instructor: Rick Trebino, Georgia Institute of Technology, USA

Tuesday, 15 May 2018
12:00–15:00
SC410: Finite Element Modeling Methods for Photonics and Optics
Instructor: Arti Agrawal, City Univ., UK
SC352: Introduction to Ultrafast Pulse Shaping–Principles and Applications
Instructor: Marcos Dantus, Michigan State Univ., USA
SC448: Plasmonics
Instructor: Mark Brongersma, Stanford Univ., USA

12:00–16:00
SC270: High Power Fiber Lasers and Amplifiers
Instructor: W. Andrew Clarkson, Optoelectronics Res. Ctr., Univ. of Southampton, UK
SC438: Photonic Metamaterials
Instructor: Nader Engheta, Univ. of Pennsylvania, USA

Sunday, 13 May 2018
08:30–12:30
SC361: Coherent MidInfrared Sources and Applications
Instructor: Konstantin Vodopyanov; CREOL, The College of Optics & Photonics, Univ. Central Florida, USA
SC149: Foundations of Nonlinear Optics
Instructor: Robert Fisher, R. A. Fisher Associates, USA
SC466: Silicon Integrated Nanophotonics NEW
Instructor: Yurii A. Vlasov, Univ. of Illinois at Urbana-Champaign, USA

08:30–15:00
SC456: How to Start A Company
Instructor: Jes Broeng, DTU, Denmark, and Milton Chang, Incubic, USA

13:30–16:30
SC439: Attosecond Optics
Instructor: Zenghu Chang, Univ. of Central Florida, USA
SC403: NanoCavity Quantum Electrodynamics and Applications
Instructor: Jelena Vuckovic, Stanford Univ., USA

13:30–17:30
SC396: Frontiers of Guided Wave Nonlinear Optics
Instructor: Ben Eggleton, Univ. of Sydney, Australia
SC157: Laser Beam Analysis, Propagation, and Shaping Techniques
Instructor: James Leger, Univ. of Minnesota, USA
SC301: Quantum Cascade Lasers: Science, Technology, Applications and Markets
Instructor: Federico Capasso, Harvard Univ., USA
Short Course Descriptions
Courses are listed by date and time. Complete course descriptions are available at: www.cleoconference.org/shortcourses.

SC361 - Coherent MidInfrared Sources and Applications
Konstantin Vodopyanov, CREOL, The College of Optics & Photonics, Univ. Central Florida, USA
Sunday, 13 May, 08:30–12:30

This course will make a comprehensive review of different techniques for producing coherent light in this important yet challenging spectral region. It will examine different state-of-the-art approaches from diverse areas of photonics that include: solid-state lasers based on rare-earth and transition metals, fiber lasers, semiconductor lasers (including intra- and intersubband cascade lasers), laser sources based on nonlinear optical frequency downconversion (including difference frequency generators, optical parametric oscillators, generators and amplifiers), Raman sources and others. Since the course is focused mostly on modern-day techniques, such traditional areas as carbon dioxide lasers and free electron lasers will be not be covered. Explaining fundamental principles behind a given technique will precede discussions on each topic. The course will review several emerging technologies such as supercontinuum generation in fibers and waveguides, as well as frequency combs generation. Several important mid-IR applications will be also reviewed and include molecular sensing, spectroscopy with frequency combs, and medical and military applications.

Short Course Benefits:
This course will enable you to:
- Get a clear idea of existing laser sources in the mid-IR spectral region (2-20 µm) and understand their operational principles, as well as advantages and disadvantages
- Distinguish between different operational regimes, from continuous-wave to few optical cycle pulsed operation
- Distinguish between broadband and narrow-band sources, as well as between the supercontinuum and the frequency comb regimes
- Learn about new applications of mid-IR coherent sources, from trace molecular detection and remote sensing to ultrastan spectroscopy and attosecond physics
- Identify what kind of laser source you need for your particular application

Short Course Level: Intermediate

Short Course Audience: Students, academics, researchers and engineers in various disciplines who require a broad introduction to the subject and would like to learn more about the state-of-the-art and upcoming trends in mid-infrared coherent source development and applications. Undergraduate training in either engineering or science is assumed.

SC149 - Foundations of Nonlinear Optics
Robert Fisher, R. A. Fisher Associates, USA
Sunday, 13 May, 08:30–12:30

This introductory and intermediate level course provides the basic concepts of nonlinear optics. Although some mathematical formulas are provided, the emphasis is on simple explanations. It is recognized that the beginning practitioner in nonlinear optics is overwhelmed by a constellation of complicated nonlinear optical effects, including second-harmonic generation, optical Kerr effect, self-focusing, self-phase modulation, self-steepening, fiber optic solitons, chirping, stimulated Raman and Brillouin scattering, and photorefractive phenomena. It is our job in this course to demystify this daunting collection of seemingly unrelated effects by developing simple and clear explanations for how each works, and learning how each effect can be used for the modification, manipulation or conversion of light pulses. Examples will address the nonlinear optical effects that occur inside optical fibers and those that occur in liquids, bulk solids, and gases. This course will incorporate the creation of cartoons to lock in the basic concepts.

Short Course Benefits:
This course will enable you to:
- Explain and manipulate the Slowly-Varying Envelope Approximation (SVEA)
- Recognize what nonlinear events come into play in different effects
- Appreciate the intimate relationship between nonlinear events which at first appear quite different
- Discuss how a variety of different nonlinear events arise, and how they affect the propagation of light
- Describe how wavematching, phase-matching, and index matching are related
- Summarize how self-phase modulation impresses “chirping” on pulses
- Explain basic two-beam interactions in photorefractive materials
- Develop an appreciation for the extremely broad variety of ways in which materials exhibit nonlinear behavior

Short Course Level: Beginner and Intermediate

Short Course Audience: Although we start at the very beginning of each topic, we move quite rapidly in order to grasp a deep understanding of each topic. Therefore, both beginners and intermediates will benefit greatly from this course. The material will be of interest to graduate students, to researchers, to members of the legal profession, to experts who are just transferring to this field, to managers, and to anyone else who just wants to learn how nonlinear optics works. This course, offered on Sunday Morning, will also give an excellent nonlinear optics foundation for those feeling the need so they can also take any of the following more specialized nonlinear optics courses at this CLEO conference: SC396: Frontiers of Guided Wave Nonlinear Optics; SC378: Introduction to Ultrafast Optics; SC270: High Power Fiber Lasers and Amplifiers; SC410: Finite Element Modeling Methods for Photonics and Optics; and SC352: Introduction to ultrafast pulse shaping—principles and applications.
The discovery of high-order harmonic generation in high intensity laser-atom interaction at the end of 1980s paved the way. In 2001, attosecond light pulses, a train of attosecond bursts or single isolated attosecond pulses, were measured for the first time. It was accomplished by first converting the attosecond photons to photoelectrons in a combination of weak extreme ultraviolet and strong infrared fields, and then retrieve the spectral phase of the attosecond pulse by reconstituting the photoelectron spectrum. Since then, various sub-optical-cycle gating schemes such as polarization gating and Double Optical Gating have been demonstrated.
to generation isolated attosecond pulses. By properly compensating the intrinsic chirp, 53 as pulses were characterized in 2017, which is so far the shorted light pulses. The new frontier in attosecond optics research is to significantly increase the photon flux and to extend the spectrum to the “water window.” This course covers: (1) High harmonic generation. (2) Carrier-envelope phase of femtosecond driving lasers. (3) Semi-classical model and Strong Field Approximation. (4) Phase-matching in partially ionized media. (5) Sub-cycle gating and attosecond pulse characterization. (6) Attosecond streaking and transient absorption spectroscopy.

**Short Course Benefits:**

This course will enable you to:

- Specify parameters of femtosecond driving lasers that are critical to the generation of attosecond pulse trains and single isolated attosecond pulses
- Compare pros and cons of driving lasers based on Ti:Sapphire Chirped Pulse Amplification and Optical Parametric Amplifiers
- Explain the principle and techniques of locking the carrier-envelope offset frequency of femtosecond oscillators and carrier-envelope phase of amplified pulses
- Define short and long trajectories in the attosecond generation process using the Strong Field Approximation in the Lewenstein model
- Estimate the cutoff photon energy and attosecond chirp using the semi-classical model
- Calculate ionization probability of atoms in an intense laser field with the Ammosov-Delone-Krainov (ADK) tunneling rate
- Describe the principle of attosecond streak camera for characterizing attosecond pulses, as well as identify the major factors that affects the phase matching of high harmonic generation in partially ionized media

**Short Course Level:** Beginner (No background or minimal training is necessary to understand course material)

**Short Course Audience:** This short course targets senior undergraduate students, graduate students, postdoc fellows, scientists and engineers seeking to enter attosecond optics. The audience should have studied electromagnetism, optics, lasers, quantum mechanics and atomic physics at undergraduate or graduate levels. Prior knowledge of femtosecond lasers is required. Although basic theory is covered, it emphasizes on experimental aspects of attosecond optics, such as locking the carrier-envelope phase of the driving lasers and designing time-of-flight spectrometers for attosecond streak cameras.

**SC403 - NanoCavity Quantum Electrodynamics and Applications**

Jelena Vuckovic, Stanford Univ., USA

Sunday, 13 May, 13:30–16:30

Strong localization of light in nanophotonic structures leads to enhanced light-matter interaction, which can be employed in a variety of applications, ranging from improved (higher speed, lower threshold) optoelectronic devices, to biophotonics, quantum information and low threshold nonlinear optics. In particular, quantum dots in optical nanocavities are interesting as a test-bed for fundamental studies of such light-matter interaction (cavity quantum electrodynamics - QED), as well as an integrated platform for information processing. As a result of the strong field localization inside of sub-cubic wavelength volumes, they enable very large emitter-field interaction strengths (vacuum Rabi frequencies in the range of 10’s of GHz – a few orders of magnitude larger than in atomic cavity QED). In addition to the study of new regimes of cavity QED, this can also be employed to build devices for quantum information processing, such as ultrafast quantum gates, nonclassical light sources, and spin-photon interfaces. Beside quantum information systems, many classical information processing devices greatly benefit from the enhanced light-matter interaction in such structures; examples include all-optical switches operating at the single photon level, electro-optic modulators controlled with sub-fJ energy and operating at GHz speed, and lasers with threshold currents of 100nA.

This course will introduce cavity QED (e.g., strong and weak coupling regimes, Purcell effect, etc.), with particular emphasis on semiconductor nanocavities. We will also describe state of the art in solid state cavity QED experiments and applications.

**Short Course Benefits:**

This course will enable you to:

- Explain light matter interaction in optical nanostructures
- Discuss state of the art in solid state cavity QED
- Identify benefits of employing nano-cavity QED for certain applications

**Short Course Level:** Beginner

**Short Course Audience:** Scientists and engineers interested in cavity QED and nanophotonic devices in general. Some background in electromagnetics, quantum mechanics, and optoelectronics is helpful, but not required

**SC396 - Frontiers of Guided Wave Nonlinear Optics**

Ben Eggleton, Univ. of Sydney, Australia

Sunday, 13 May, 13:30–17:30

This course will review recent research and applications in the field of nonlinear guided wave optics with emphasis on both fundamentals and emerging applications. Starting from a strong foundation in the principles of nonlinear optics, we will review recent progress in emerging nonlinear optical platforms with an emphasis on the different materials, including silicon, chalcogenide, III-V semiconductors, lithium niobate, photonic crystal fibres, nanophotonic circuits and others. We will establish key figures of merit for these different material systems and a general framework for nonlinear guided wave optics with emphasis on the applications in emerging areas of science and technology. We will then review recent progress and breakthroughs in the following areas: All-optical processing, Ultra-fast optical communications, Slow light, highly nonlinear and emerging waveguides, Ultrafast measurement and pulse characterization, Frequency combs and optical clock, Optical parametric amplifiers and oscillators, Generation and applications of optical super-continuum, Nonlinear localization effects and solitons, Nonlinear optics for quantum information.

All conference locations are in the San Jose Convention Center unless otherwise noted.
Short Course Benefits:
This course should enable the participants to:

- Get state of the art knowledge of nonlinear optics in emerging waveguides and materials
- Understand the applications of nonlinear optics in key applications
- Have a foundation of nonlinear waveguide physics for emerging applications and science

Short Course Level: Advanced Beginner

Short Course Audience: This course assumes some basic knowledge/familiarity of nonlinear optics. Individuals lacking such knowledge should consider taking SC149: Foundations of Nonlinear Optics first.

SC157 - Laser Beam Analysis, Propagation, and Shaping Techniques
James Leger, Univ. of Minnesota, USA
Sunday, 13 May, 13:30–17:30

The propagation and focusing properties of real laser beams are greatly influenced by beam shape, phase distortions, degree of coherence, polarization, and aperture truncation effects. The ability to understand, predict, and correct these real-world effects is essential to modern optical engineering. Attendees of this course will learn a variety of techniques for measuring and quantifying the important characteristics of real laser beams, be able to calculate the effects of these characteristics on optical system performance, and explore a variety of beam shaping techniques to optimize specific optical systems.

The course starts with a basic and intuitive description of Gaussian beam characteristics from an ideal laser. These concepts are extended to non-Gaussian beams (e.g., high-order Hermite Gaussian beams, top-hat shapes, laser arrays, and non-diffracting beams) and the relative merits of various beam shapes are discussed. The properties of optical vortex beams, cylindrical vector beams, and orbital angular momentum are then explored. Beam characterization methods such as \( M^2 \), Strehl ratio, and TDL are reviewed. Simple expressions for estimating the effects of laser aberrations and coherence on beam focusing and propagation are developed. Coupling of light into single and multi-mode fibers, as well as far-field light concentration limits are explored as real-world examples. The constant radiance theorem and étendue are employed as engineering tools to optimize optical design, and simple analytical tools are presented to estimate the effects of spatial beam shape, phase aberrations, and coherence on beam concentration. The course ends with a description of internal and external cavity beam shaping techniques using phase and polarization modulation.

Short Course Benefits:
This course will enable you to:

- Measure the quality of a laser beam using several methods
- Interpret the meaning of various laser specifications
- Understand Gaussian laser beam properties from an intuitive standpoint
- Predict the propagation and focusing properties of non-ideal and aberrated laser beams
- Determine the concentration limits of a light field
- Design optimal beam concentration optics
- Compare different beam profiles for specific applications and calculate ideal performance
- Design beam shaping optics using polarization and phase manipulation

Short Course Level: Advanced Beginner

Short Course Audience: This course is designed to provide laser engineers, optical system designers, and technical management professionals with a working knowledge of laser beam characterization, analysis, and modification. Physical and intuitive explanations of most topics are designed to make the concepts accessible to a wide range of participants.

SC301 - Quantum Cascade Lasers: Science, Technology, Applications and Markets
Federico Capasso, Harvard Univ., USA
Sunday, 13 May, 13:30–17:30

Quantum Cascade Lasers (QCLs) are fundamentally different from diode lasers due to their physical operating principle, which makes it possible to design and tune their wavelength over a wide range by simple tailoring of active region layer thicknesses, and due to their unipolar nature. Yet they use the same technology platform as conventional semiconductor lasers. These features have revolutionized applications (spectroscopy, sensing, etc.) in the mid-infrared region of the spectrum, where molecules have their absorption fingerprints, and in the far-infrared or so-called Terahertz spectrum. In these regions until the advent of QCLs there were no semiconductor lasers capable of room temperature operation in pulsed or cw, as well high output power and stable/wide single mode tunability. The unipolar nature of QCL, combined with the capabilities of quantum engineering, leads to unprecedented design flexibility and functionality compared to other lasers. The physics of QCLs, design principles, supported by modeling, will be discussed along with the electronic, optical and thermal properties. State-of-the-art performance in the mid-ir and Terahertz will be reviewed. In particular high power cw room temperature QCLs, broadly tunable QCL, short wavelength MWIR QCLs and recent breakthroughs in THz room temperature operation will be presented. A broad range of applications (IR countermeasures, stand-off detection, chemo-bio sensing, trace gas analysis, industrial process control, medical and combustion diagnostics, imaging, etc.) and their ongoing commercial development will be discussed.

Short Course Benefits:
This course will enable you to:

- Describe underlying QC Laser physics, operating principles and fundamental differences between standard semiconductor lasers and QC lasers
- Explain quantum design of the key types of QC lasers, which have entered real world applications, and how their electrical and optical properties can be tailored to optimize performance in the mid-infrared and THz regions.

All conference locations are in the San Jose Convention Center unless otherwise noted.
• Discuss experimental device performance, including physical limits, design constraints and comparison with theory and determine device characteristics (current-voltage and light-current curves; differential and power efficiency, threshold, gain and losses; spectral behavior, single mode operation; high speed operation)

• Explain the basics of QC laser device technology: fabrication process, materials growth options

• Illustrate the basics of a chemical sensing system; discuss applications of state-of-the-art mid-infrared QC lasers to sensing and present several examples of QC laser commercialization

• Discuss current and future markets of QC lasers

Short Course Level: Beginner

Short Course Audience: Graduate students; qualified undergraduates (mostly senior level) majoring in EE or physics/ applied physics; researchers in industry, academia and government labs; engineers, sales reps and technical managers.

Education: Undergraduate degree or a Ph.D or pursuing a Ph.D in EE, Physics or Applied Physics, with knowledge of introductory level semiconductor devices.


Tobias Kippenberg, Ecole Polytechnique Federale de Lausanne, Switzerland

Monday, 14 May, 12:30–15:30

Radiation pressure denotes the force that optical fields exert and which have wide ranging applications in both fundamental science and applications such as Laser cooling or optical tweezers. Radiation pressure can, however, also have a profound influence on micro- and nanophotonic devices, due to the fact that radiation pressure can couple optical and mechanical modes. This optomechanical coupling gives rise to a host of new phenomena and applications in force, displacement and mass sensing. This course is intended to give an introduction of the Physics and Applications of cavity optomechanics and highlight the rapid developments in this emerging field. Optomechanical coupling can be used to both cool and amplify mechanical motion and thereby allow new light driven photon clocks. Optomechanical refrigeration of mechanical modes gives insights into the quantum limits of mechanical motion. In addition, radiation pressure coupling enables new way of processing light all optically enabling optical mixers, delay lines or storage elements. Moreover, the basic limitations of optomechanical displacement measurements, due to quantum noise and practical laser phase noise limitations, will be reviewed, relevant across a wide range of sensing experiments.

The course will make contact to practical applications of optomechanics in Metrology (force sensors, mass sensors and light driven optical clocks) and review fundamental design principles of optomechanical coupling and the design of high Q mechanical oscillators. The use of finite element simulations will be covered.

Short Course Benefits:

This course will enable you to:

• Explain gradient and scattering light forces in microcavities and micromechanical systems

• Design high –Q nano-and micro- mechanical oscillators (finite element modeling, FEM)

• Discuss the fundamental limits of mechanical Q in NEMS/MEMS

• Describe of the fundamental and practical limits of displacement sensors

• Summarize Applications of optomechanics in mass and force sensing

• Explain the basic optomechanical phenomena (amplification, cooling)

• Discuss the standard quantum limit (SQL)

• Characterize radiation pressure driven oscillations in terms of fundamental oscillator metrics

• Define Phase and frequency noise of oscillators

• Know the influence of phase and amplitude noise of a wide variety of laser systems (fiber lasers, Ti:Sa, diode lasers) in optomechanical systems

Short Course Level: Advanced Beginner

Short Course Audience: This course is intended for physicists and optical and electrical engineers desiring both focused fundamental knowledge of cavity optomechanical coupling (i.e., radiation pressure coupling of light and NEMS/MEMS) but also a view of emerging applications of this new technology. The instruction will be at a level appropriate for graduate students and will assume some basic knowledge of laser.

SC455 - Integrated Photonics for Quantum Information Science and Technology

Dirk Englund, MIT, USA

Monday, 14 May, 12:30–16:30

The rules of quantum mechanics enable applications that are inherently more powerful than their classical counterparts. Quantum key distribution now makes it possible to transmit information with unconditional security; quantum simulation is beginning to address problems that are intractable on classical computers; and quantum metrology techniques push the boundaries of precision measurements.

Many of these quantum technologies rely fundamentally on advanced photonics that place extremely demanding requirements on precision, efficiency, and mode complexity. Over the past decade, new generations of photonic integrated circuits have been developed to begin to address these requirements.

This course will cover basic concepts and recent progress in photonic integrated circuits technology for quantum information processing, with a focus on two primary application areas: quantum communications -- from quantum cryptography to entanglement distribution over quantum networks -- and quantum computing, including analog and digital approaches. Motivated by these applications, the course will discuss nonclassical light sources, photonic interfaces with atomic memories, high-fidelity mode transformation circuits,
nonlinear photonic quantum gates, and waveguide-integrated single photon resolving detectors.

**Short Course Benefits:**

This course will enable you to:

- Describe a practical quantum key distribution system, estimate performance, and identify central limitations
- Propose methods to extend the reach of quantum secure communications
- Describe the main classes of quantum communications
- Categorize the major areas of quantum computing
- Diagram quantum networks
- Design photonic integrated circuits for quantum key distribution and quantum repeaters

**Short Course Level: Advanced Beginner**

**Short Course Audience:** The course is designed for an audience interested in the key ideas and technology of photonic quantum communication and computation. It will probably be most valuable to participants who have some background in quantum information science or integrated optics and who want to better understand where the intersections of these fields and where the challenges and opportunities lie. The course should be useful for graduate students and industrial and academic researchers with an interest in applied photonic quantum technologies.

**SC378 - Introduction to Ultrafast Optics**

Rick Trebino, Georgia Institute of Technology, USA
Monday, 14 May, 12:30–16:30

Ultrafast Optics—the science and technology of ultrashort laser pulses—is one of the most exciting and dynamic fields of science. While ultrashort laser pulses seem quite exotic (they’re the shortest events ever created!), their applications are many, ranging from the study of ultrafast fundamental events to telecommunications to micro-machining to biomedical imaging - to name a few. Interestingly, these lasers are readily available, and they are easy to understand. But their use requires some sophistication. This course is a basic introduction to the nature of these lasers and the pulses they generate. It will discuss the principles of their generation and amplification and describe their most common distortions in space and time and how to avoid them—or take advantage of them. In addition, it will cover the nonlinear optics of ultrashort pulses for converting pulses to almost any color, as well as the additional interesting and potentially deleterious effects nonlinear optical processes can cause. Finally, it will cover techniques for ultrashort-pulse measurement.

**Short Course Benefits:**

This course will enable you to:

- Explain how ultrashort-pulse lasers and amplifiers work
- Describe ultrashort pulses and their many distortions
- Use nonlinear optics to an convert ultrashort laser pulse to virtually any wavelength
- Take advantage of—or avoid—nonlinear-optical high-intensity effects
- Meaningfully measure ultrashort pulses

**SC410 - Finite Element Modeling Methods for Photonics and Optics**

Arti Agrawal, City Univ., UK
Tuesday, 15 May, 12:00–15:00

Numerical modelling and simulation of optical devices and components is a key tool in improving performance by reducing time and monetary costs, design optimization and characterization as well as innovating new ideas. Both passive and active devices are modelled and optimized numerically. In some cases simulation is the only way to explore phenomena where technology is not advanced enough for fabrication. The interaction of the optical beam with physical effects such as non-linearity, stress, strain, change in refractive index due to temperature, application of electric fields etc. are now extremely important. Modelling complements experimental work perfectly and almost no research is conducted without it.

The Finite Element (FE) method is one of the most popular and powerful methods for modelling in Photonics. This short course starts with Maxwell’s equations and explains the basic principles of numerical modelling and the key assumptions involved. This foundation is used to develop the FE method, including a brief tour of the mathematics. How the method can be applied to various optical devices is discussed in detail. How can physical effects be included with the FE method for modelling is considered. The course ends with an explanation of FE based beam propagation methods and how these can be used to find the evolution of the optical fields.

Some salient features of the short course include:

- Emphasis on practical application of FEM for modelling of devices
- Discussion on developing code
- Perfectly Matched Layer and Periodic boundary condition
- Generating mesh for structures, post-processing of results
- Discussion on popular commercial software such as COMSOL and how to best utilize them

Methods covered include:

- Full vector Finite Element method for modal solution
- Introduction to inclusion of physical effects with the optical model

Practical illustrations include:

- Optical fibers including photonic crystal fibers
- Si slot waveguides, nanowires and high index contrast structures
- Bent waveguides and loss
- Plasmonic waveguides

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All conference locations are in the San Jose Convention Center unless otherwise noted.
Short Course Benefits:
This course will enable you to:

- Identify and explain basic principles of numerical modelling in Photonics
- Discuss and explain Full vector Finite Element Method (FEM) for modal solutions
- Introduction to FEM with physical effects (non-linearity, stress/strain, acousto-optic, electro-optic effect etc.)
- Discuss and explain how to incorporate Perfectly Matched Layer and Periodic boundary condition
- Summarize how to generate mesh for structures and post-processing of results
- Tips on how to best utilise commercial software
- Discuss the application of the method to practical devices: nano wires, optical fibers, sensors etc.
- Identify the appropriate modeling method for their problem
- How to incorporate PML boundary conditions and write your own code

Short Course Audience: This course is intended for researchers, engineers and students who use simulation in their work in both fundamental and applied aspects of Optics and Photonics, especially for components and devices. The course is useful for members of both academic and industrial institutions. Basic background and familiarity in Optics will be sufficient.

SC352 - Introduction to Ultrafast Pulse Shaping--Principles and Applications
Marcos Dantus, Michigan State Univ., USA
Tuesday, 15 May, 12:00–15:00

Pulse shaping is an integral part of every femtosecond laser, and learning about pulse shaping can help us better understand dispersion, pulse characterization and pulse compression. This course begins by describing how the spectral phase affects the temporal characteristics of a femtosecond pulse with a hands-on computer simulation. The essential physics and a brief background of the development of shapers are provided. The course goes over the experimental implementation requirements and then covers some of the most salient applications of pulse shapers, among them: (a) pulse compression, (b) pulse characterization, (c) creation of two or more pulse replicas, and (d) control of nonlinear optical processes such as selective two-photon excitation and selective vibrational mode excitation (e) material processing, (f) microscopy and others. The course provides a good foundation for those wanting to explore the more fundamental aspects of light-matter interactions, and it also provides multiple examples of practical applications that are made possible by pulse shaping.

Short Course Benefits:
This course will enable you to:

- Gain a better understanding of femtosecond laser pulses and their applications
- Learn pulse shaper design principles
- Compare among different pulse shaper designs and to determine which one is best suited for a particular application
- Simulate the output pulse from a pulse shaper given a particular phase and amplitude modulation
- Predict the effect caused by introducing a simple phase such as a linear, quadratic or cubic function on a transform-limited pulse
- Learn two different approaches to creating pulse replica that can be independently controlled with attosecond precision in the time domain using the pulse shaper
- Measure the spectral phase of laser pulses using the pulse shaper itself as the measurement tool, and eliminating phase distortions to compress the output pulses
- Summarize the advantages of having an adaptive pulse shaper for controlling the output of ultrafast lasers

Short Course Level: Advanced Beginner (basic understanding of topic is necessary to follow course material)

Short Course Audience:
This course, updated yearly, is intended for everyone that uses or intends to use femtosecond laser pulses in academic research or industry. Attendees will learn how pulse shaping can greatly enhance femtosecond laser applications. No prior knowledge about pulse shaping is required.

SC376 - Plasmonics
Mark Brongersma, Stanford Univ., USA
Tuesday, 15 May, 12:00–15:00

Plasmonics is an exciting new field of science and technology that aims to exploit the unique optical properties of metallic nanostructures to enable routing and active manipulation of light at the nanoscale. Nanometallic objects derive these properties from their ability to support collective electron excitations, known as surface plasmons (SPs). Presently we are witnessing an explosive growth in both the number and range of plasmonics applications; it is becoming eminently clear that both new fundamental science and device technologies are being enabled by the current plasmonics revolution. The intention of this tutorial is to give the participants a fundamental background and working knowledge of the main physical ideas used in plasmonics, as well as an overview of modern trends in research and applications.

The Short Course will begin with a general overview of the field of plasmonics. This will be followed by an introduction to the basic concepts that enable one to understand and design a range of plasmonic functionalities. This part will be followed by an in-depth discussion of a range of active and passive plasmonic devices that have recently emerged. Particular attention will be given to nanometallic structures in which surface plasmons can be generated, routed, switched, amplified, and detected. It will be shown that the intrinsically small size of plasmonic devices directly results in higher operating speeds and facilitates an improved synergy between optical and electronic components. The field of plasmonics is rapidly growing and has started to provide a whole range of exciting new research and development opportunities that go well beyond chipscale components. A number of such developments will be investigated, including new types of optical sensors, solar cells, quantum plasmonic components, non-linear, and ultrafast devices. At the end of the tutorial, a critical assessment of the entire field is given and some of the

All conference locations are in the San Jose Convention Center unless otherwise noted.
truly exciting new opportunities for plasmonics are identified. A comparison of metallic and high-index semiconductor antennas and metamaterials will be made as well.

**Short Course Benefits:**

This course will enable you to:

- Obtain a working knowledge of the key physical concepts used in Plasmonics that enable light manipulation at ultra small length- and time-scales
- Understand choices of different metal types, shapes, and sizes to accomplish different plasmonic functionalities
- Find out about common electromagnetic computational tools to design plasmonic structures and devices
- Get a feel for the current state of the field in terms of fundamental understanding as well as device applications
- Learn about the most recent trends and developments in research and applications

**Short Course Level:** Beginner

**Short Course Audience:** Optical engineers and scientists who are interested in learning about the rapidly emerging field of plasmonics and its potential impact.

**SC270 - High Power Fiber Lasers and Amplifiers**

W. Andrew Clarkson, Optoelectronics Res. Ctr., Univ. of Southampton, UK

Tuesday, 15 May, 12:00–16:00

**Short Course Description:**

Recent advances in cladding-pumped fiber lasers and amplifiers have been dramatic, leading to unprecedented levels of performance in terms of output power, efficiency, beam quality and wavelength coverage. These achievements have attracted growing interest within the community and have fueled thoughts that fiber-based sources may one day replace conventional “bulk” solid-state lasers in many application areas. The main attractions of cladding-pumped fiber sources are derived directly from their geometry, which simultaneously allows very efficient generation of coherent light and almost complete immunity from the effects of heat generation, which are so detrimental to the performance of other types of lasers.

This course aims to provide an introduction to high power fiber lasers and amplifiers, starting from the basic principles of operation and ending with examples of current state-of-the-art devices and some thoughts on future prospects. The course will cover a range of topics, including basic fiber laser and amplifier theory, spectroscopy of the relevant rare earth ions for high power devices, a discussion of the factors influencing laser and amplifier performance, fiber design and fabrication, pump sources and pump launching schemes, fiber resonator design, master-oscillator and power-amplifier configurations, linewidth control and wavelength selection, transverse mode selection, nonlinear loss processes (SBS and SRS) and their impact on performance, and heat generation and its impact on power scalability. The course will also give an overview of techniques (e.g. coherent and spectral beam combining) for further scaling of output power and provide an introduction to hybrid fiber-bulk laser schemes for scaling pulse energy.

**Short Course Benefits:**

This course will enable you to:

- Calculate threshold pump power and slope efficiency, and estimate the maximum output power that can be obtained from a given fiber laser oscillator or amplifier configuration
- Select the optimum pump source for a given rare earth ion transition and fiber design
- Design the pump light collection and coupling scheme and estimate the pump launch efficiency
- Specify the fiber parameters (e.g. cladding design, core size, rare earth ion concentration) required for a particular laser or amplifier configuration
- Design the fiber laser resonator and amplifier and select the operating wavelength
- Estimate thermally induced damage limit
- Estimate the power scaling limit
- Measure fiber laser performance characteristics and relate these to fiber design and resonator parameters

**Short Course Level:** Advanced Beginner

**Short Course Audience:** This course is intended for individuals with a basic knowledge of lasers and optics who wish to learn about the basic principles and capabilities of fiber lasers and amplifiers when operating at high power levels. The course will also cover some of the practical issues of operating these devices and provide an update for those wishing to learn about some of the latest developments in this rapidly advancing field.

**SC438 - Photonic Metamaterials**

Nader Engheta, Univ. of Pennsylvania, USA

Tuesday, 15 May, 12:00–16:00

Controlling electromagnetic and optical fields and waves can be achieved via materials. The wave-matter interaction can be engineered using structures made of materials with required parameters and structures with selected shapes, dimensions and sizes. Recent advances in materials science and engineering, condensed matter physics, optical materials, nanoscience and nanotechnology have made it possible to tailor materials with unusual parameters and characteristics. The field of metamaterials, along with its two-dimensional version known as metasurfaces, has seen growing interest and extensive development in recent years. Metamaterials are engineered composite structures made of subwavelength inclusions with suitable materials and proper arrangements. The compositions, arrangements, alignments, densities and distributions of these building blocks in host media provide a variety of degrees of freedom in the design of light-matter interaction with such structures. Manipulation of light at the nano-, micro-, meso- and macroscales using metamaterials and metasurfaces provides rich platforms for tailoring electromagnetic waves with desired functionalities.

In this tutorial, we will begin with the basics of electromagnetic wave interaction with material media and structures. Then the course will get into some of the specifics of the characteristics of metamaterials and metasurfaces including the dispersion properties, scattering mechanisms, effective-medium phenomena, and unconventional features of waves in...
such environments. We will then discuss some of the specific topics in photonic metamaterials such as extreme-parameter metamaterials (i.e., epsilon-near-zero (ENZ), mu-near-zero (MNZ), and epsilon-and-mu-near-zero (EMNZ) structures) and their specialized wave-matter interactions, graphene metamaterials as a platform for ideas for one-atom-thick optical device concepts, optical metatronics (“lumped” nanocircuitry) and informatic metastuctures for photonic information processing and computing at the nanoscale, scattering engineering using metamaterials (such as cloaking), guided waves in metamaterials, and nonreciprocal metastructures. Various features and potential applications of these topics will also be presented and discussed. During the course, we will have interactive discussions and question-answer sessions.

**Short Course Benefits:**

This course will enable you to:

- Describe the basics of electromagnetic field and wave interaction with metamaterials and metasurfaces
- Explain some of the important properties of photonic metamaterials
- Discuss some of the scenarios in light-matter interaction with “extreme-parameter” metamaterials
- Describe the fundamentals of optical nanocircuits (“optical metatronics”), with potentials for information processing in nanophotonics
- Explain some of the salient features of scattering and guidance of lights in metamaterials and metasurfaces

**Short Course Level:** Beginner

**Short Course Audience:** Graduate students and senior undergraduates with EE, Physics, and Applied Physics interests; Engineers, researchers and technical managers from industry, government labs, and universities; Introductory knowledge of electromagnetics and optics is required.
Special Events

OSAF Data Science Career Opportunities
Sunday, 13 May, 08:30–17:00
Market 1, Hilton San Jose
Instructor: Roberto Reif, Metis, USA

Sponsored by the OSA Foundation and Milton and Rosalind Chang, this course provides an introduction to careers in data science. It incorporates interactive lectures and group exercises. By attending this course, attendees will learn how their technical skills can transition into the data science field and what a career in data science is like, understand what the field of data science is and the roles, necessary skills, and types of problems data scientists work on, and gain insight into the data science project lifecycle and outputs.

Roberto Reif is a senior data scientists at Metis. Prior to Metis, he led the signal processing team at Sensoria Inc. and was a program manager at Microsoft. He has worked on applications in the healthcare, internet of things, biomedical optics, and business intelligence. He has a PhD in Biomedical Engineering from Boston University’s Biomedical Optics Laboratory and completed a senior postdoctoral research fellowship at the University of Washington’s Biophotonics and Imaging Laboratory. He has co-authored several scientific publications, book chapters, and patents.

Attendance is limited to 50 people. The required registration fee of $25 includes lunch.

Hosted by: OSA Foundation

OSAF Cheeky Scientist Career Development Workshops
Sunday, 13 May, Session I: 13:00–14:00,
Session II: 16:00–17:00
Winchester 1&2, Hilton San Jose
Instructor: Isaiah Hankel, Cheeky Scientist, USA

Isaiah Hankel works with hundreds of graduate students and postdocs daily assisting them to transition to industry by first showing them how to present themselves as business professionals. These programs will provide you with a strong understanding of what it takes to have a tailored industry resume and how to showcase your transferrable skills.

Session Schedule

Session I: The Modern Job Search:
Using online profiles to maximize the effectiveness of the job seeking/transition process. Hiring managers use LinkedIn to determine whether they will bring in a candidate for an interview, this topic will cover all the key elements of the LinkedIn profile and how each section should be used to strategically maximize its impact. In addition, we will show candidates how to use LinkedIn algorithms to support their job search, and sell themselves to perspective employers.

Session II: Networking: An Art & Science:
This section is created based on the networking strategies of some of the most strategic networkers in the world and also goes into the science of building rapport and why this is important for the job seeking professional. While this topic tends to be popular, it seems people are still not using it effectively and thus we have detailed specific action steps job seekers can take, and specific scripts to use while networking.

Workshops are complimentary for OSA Members. There is limited space at each. RSVP online through CLEO Special Events site.

Hosted by: OSA Foundation

OIDA Executive Forum on the Exploding Role of Optics in Sensing
Monday, 14 May, 08:30–18:00
Almaden Ballroom, Hilton San Jose

This event aims to match applications leaders needing new solutions with early-stage technologies in a range of sectors, spanning consumer to industrial markets. While the ultimate activity is “matchmaking” the emphasis will be on the end-product vendors’ needs and investor perspectives. The workshop will focus on segments within the field that have particular promise today, such as mobility and automation, Big Data and AI, and manufacturing issues related to these products. Some key questions for discussion will be:

- What is needed from the photonics industry? Which are the problems that optics and photonics can have the greatest impact on?
- What are the enabling technologies that have the most promise?
- What are the bottlenecks or “showstoppers” among photonics technologies today, and potential solutions?

OSA Optical Material Studies Technical Group Special Talk
Monday, 14 May, 12:00–13:00
Room 230A

Students and recent graduates are invited to join the OSA Optical Material Studies Technical Group for a special talk on potential career paths during lunch on Monday. Attendees will have the opportunity to hear from two recent graduates, one who has pursued a career in industry and one who has pursued a career in academia, who will provide insight into their current research and their career paths. An RSVP is required for this technical group event; please contact TGactivities@osa.org to register, pending availability.

Hosted by: OSA Optical Material Studies Technical Group

All conference locations are in the San Jose Convention Center unless otherwise noted.
Workshop: Understanding Unconscious Bias  
Monday, 14 May, 14:00–15:30, 16:00–17:30  
Winchester 1&2, Hilton San Jose  
Speaker: Sara Bendoraitis, American Univ., USA  
Research demonstrates that we all have unconscious biases. These biases can result in best and brightest talent made to feel unwelcome, invisible, and not important to the success of the organization. This training will explore concepts and engage participants to better understand implicit bias, increase awareness and understanding the impact on organizational culture and identify ways to promote greater engagement with diversity and inclusion.  
Programs are open to OSA Members. There is limited space. RSVP required through CLEO Special Events Page.  

OSA Technical Group Poster Session  
Tuesday, 15 May, 19:00 – 20:30  
Room 230A/B  
Join the OSA Technical Groups for a series of focused poster sessions, bringing together students and colleagues for an opportunity to share their latest research findings and exchange ideas. After listening to the poster presentations and connecting with fellow attendees over refreshments, you’ll have a chance to cast your vote for the best poster from each of the four participating technical groups. Among the technical groups participating this year will be the Optical Material Studies Technical Group, the Ultrafast Optical Phenomena Technical Group, the Systems and Instrumentation Technical Group and the Environmental Sensing Technical Group.  

Diversity & Inclusion in Optics and Photonics Reception  
Monday, 14 May, 17:30–18:30  
Market 1&2, Hilton San Jose  
Join us for a reception to connect with the optics and photonics community to discuss diversity in the field. Come to learn, share and engage with colleagues around this important topic. Please RSVP by going to CLEO Special Events site to let us know you are attending.  

OSA Nanophotonics Technical Group 20x20 Talks  
Monday, 14 May, 19:00–20:30  
Room 230A  
This special session hosted by OSA Nanophotonics Technical Group offers a unique platform for individuals to present their research in a creative and concise fashion that differs from the usual oral or poster session. Selected participants will showcase their research in a presentation of 20 images, in which each image is displayed for 20 seconds. Presenters will talk along to the images as the slides advance automatically. Immediately following presentations, attendees are invited to join the technical group for small reception where they can telework with colleagues over refreshments.  

Meet OSA Publishing Journal Editors Reception  
Tuesday, 15 May, 15:30–17:00  
Exhibit Hall #2425  
Join OSA Publishing’s Journal Editors for conversation and ice cream. The Editors welcome your questions, concerns, and ideas for any of OSA’s Journals. Topics for discussion can include best practices when submitting a manuscript; elements of a useful manuscript review; criteria editors look for in submitted manuscripts; or the process to propose a Feature Issue topic for publication in an OSA Journal. All are welcome.  

OSA Photonic Metamaterials Technical Group Tutorial on Metasurface Design and Simulation  
Wednesday, 16 May, 12:00–13:00  
Room 230A  
Join the OSA Photonic Metamaterials Technical Group for a tutorial on metasurface design and simulation during lunch on Wednesday. This tutorial, aimed at students and new researchers, will focus on hands-on skills. Dr. Wei Ting Chen from Harvard University, with assistance from Alexander Zhu and Yao-Wei Huang, will provide an overview of metasurfaces followed by a tutorial on how to perform the simulation. An RSVP is required for this technical group event; please contact TGactivities@osa.org to register, pending availability.  

All conference locations are in the San Jose Convention Center unless otherwise noted.
Conference Reception
Wednesday, 15 May, 19:30–20:30
Grand Ballroom

Enjoy a festive evening with your colleagues, while intermingling with the exhibitors and viewing the first poster session. The reception is open to all attendees and badges must be worn to enter the reception.

Sponsored by: THORLABS

Lunch at the CLEO:EXPO
Tuesday and Wednesday, 16 & 17 May, 11:30–13:00
Thursday, 18 May, 12:30–14:00
Exhibit Hall

Grab some lunch and network with exhibitors to check out their innovative products and services that can help your organization.

Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018
Thursday, 17 May, 18:30 – 20:00
Room 230A

OSA Members are invited to join the OSA Nonlinear Optics Technical Group for a special panel discussion presenting the exciting and hot topics in nonlinear optics that were presented during CLEO: 2018. Short presentations from our panelists highlighting important themes from the conference will be followed by moderated question and answer sessions. Following the conclusion of the panel discussion, members are invited to join the technical group for a small reception where they can network with colleagues over refreshments. This technical group event is open to OSA Members; please contact TGactivities@osa.org to register, pending availability.

Hosted by: OSA Nonlinear Optics Technical Group

Postdeadline Paper Sessions
Thursday, 17 May, 20:00–22:00
Locations announced on the Conference Update Sheet

The Technical Program Committee has accepted a limited number of postdeadline papers for oral presentation. The purpose of postdeadline papers is to give participants the opportunity to hear new and significant materials in rapidly advancing areas.
Exhibit Hall

Make sure to visit the show floor which features a diverse group of companies, representing every facet of the lasers and electro-optics industries. Learn about new products, find technical and business solutions, and gain the most up-to-date perspective of the laser-related business environment. Review the list of exhibitors on the following pages to see the companies you’ll meet at CLEO.

CLEO:EXPO is free of charge for all conference registrants.

| Tuesday, 15 May | 10:00–17:00 |
|                | 10:00–13:00; 15:00–17:00 |
| Wednesday, 16 May | 10:00–17:00 |
|                | 10:00–13:00; 15:00–17:00 |
| Thursday, 17 May | 10:00–15:00 |
| Exhibit-only time | 10:00–14:00 |

Exhibit Hall Rules

Children 12 and under must be accompanied by an adult at all times. Strollers are not allowed on the show floor at any time.

Neither photography nor videotaping is permitted in the Exhibit Hall. Exhibitors need to get permission from Show Management to photograph their own booths. Non-compliance may result in the surrendering of film and removal from the hall.

For further questions, visit Registration on the Concourse Level.

Exhibitors (as of 9 April 2018)

3DOptix
AdValue Photonics, Inc.
Advanced Research Systems
AdvR
AIP Publishing
Allied Laser Solutions
ALPAO
Alpes Lasers SA
Alpine Research Optics
Altos Photonics, Inc.
American Elements
American Institute of Physics
American Physical Society (APS)
AMPHOS, Inc.
Amplitude Laser Group
APE - Applied Physics & Electronics, Inc.
Aspen Systems - Laser Cooling
Attocube Systems, Inc.
AUREA Technology
Azur Light Systems
Boston Electronics Corporation
Bristol Instruments, Inc.
Calmar Laser, Inc.
CASTECH, Inc.
Changchun New Industries Optoelectronics Tech. Co.
Chinese Laser Press
Chromacity
Class 5 Photonics GmbH
Cobolt AB
Coherent Solutions
Coherent, Inc.
Cornell NanoScale Facility
CREOL, University of Central Florida
Crestec Corporation
Cristal Laser SA
Crystalline Mirror Solutions, GmbH
CST of America, Inc.
Cybel, LLC
Cycle GmbH
DataRay, Inc.
Daylight Solutions, Inc.
DCM Tech
Double Helix LLC
Edmund Optics, Inc.
EEOptics Corp.
EKSM Optics
EKSPLA
Elas
Electro-Optics Technology, Inc.
Energetiq Technology, Inc.
EOSPACE, Inc.
EXFO
FASTLITE
Femtochrome Research, Inc.
few-cycle Inc.

All conference locations are in the San Jose Convention Center unless otherwise noted.
All conference locations are in the San Jose Convention Center unless otherwise noted.
CLEO:EXPO Technology Playground

Using the game card placed in your attendee bag (obtained at Registration), stop by participating exhibitor booths to hear about their products and services. They’ll stamp your card; and when you’ve met with all of them, you’ll be entered into a daily drawing to win a $100 gift card.

Exhibitors Participating:
Calmar Laser
Edmund Optics
Gentec-EO USA, Inc.
KMLabs
MKS Newport Corporation
Optmax
Optosigma
OZ Optics
Sacher Lasertechnik GmbH
Thorlabs

Exhibit Hall Coffee Breaks

The exhibit floor is the perfect place to build and maintain professional contacts, and these breaks provide ideal networking opportunities. Complimentary coffee will be served at these times:

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Sponsored by

MKS Student Lounge
#1340

All student attendees are invited to the MKS Student Lounge, co-sponsored by OSA. The lounge provides an opportunity to relax and spend time networking with other students, while enjoying complimentary, wireless internet and refreshments.

Sponsored by

Plenary Speaker Meet-n-Greets
Theater I, #2433

Meet CLEO Plenary speakers, ask questions and network with your colleagues.

Tuesday, 15 May 10:15–10:45
Nader Engheta and Vasilis Ntziachristos

Wednesday, 16 May 10:15–10:45
John Mather, Jian-Wei Pan and Sara Seager

Free Lunch at the CLEO:EXPO
Tuesday and Wednesday, 16 & 17 May, 11:30–13:00
Thursday, 18 May, 12:30–14:00
Exhibit Hall

Grab some lunch and network with exhibitors to check out their innovative products and services that can help your organization.

POSTER SESSIONS

OIDA VIP Industry Leaders Speed Meetings Lunch
Tuesday, 15 May, 12:00–13:30
#2605

This session brings together Industry Executives to share their business experience with Young Professionals, Recent Graduates and Students – how they started their careers, lessons learned and using their degree in an executive position. Informal networking during lunch is followed by a transition to “speed meetings” – brief, small-group visits with each executive to discuss industry trends or career topics.

If you have any questions about this event or are a Student or Recent Graduate and interested in attending, please email vipevents@osa.org

Sponsored by

All conference locations are in the San Jose Convention Center unless otherwise noted.
KMLabs Lunch & Learn Event
Wednesday, 15 May, 12:00–13:30
VIP Industry Networking, #2605

Tabletop Laser Sources at Short Wavelengths Beyond the Ultraviolet—Implementation and Application

Speaker: Henry C. Kapteyn, Kapteyn-Murnane Laboratories Inc. and Department of Physics, Univ. of Colorado Boulder

The recent availability of commercial tabletop-scale lasers at wavelengths in the vacuum-UV to EUV to soft x-ray spectral regions (i.e. $h\nu \approx 5-500$ eV) presents new opportunities for next-generation optical nanometrology as well as studies of fundamental processes in materials science, chemistry, and biology. In this talk, we will discuss the enabling high-harmonic generation technology, the characteristics of the light, its applications, and what it takes to put these sources to use in your lab.

Sponsored by

Technology Transfer Program
Thursday, 17 May
Theater I, #2433

The Technology Transfer Program includes a Keynote presentation, a Technology Transfer Tutorial and a Pitch Panel. The Technology Transfer Tutorial provides attendees an opportunity to learn more about the licensing process: funding, entrepreneurship, technology transfer, and intellectual property. The Pitch Panel provides entrepreneurs an opportunity to showcase their technology, explain why it’s valuable and discuss the next steps to commercialization.

10:15 – 10:45 Keynote Speaker:
Ruth Houbertz, Multiphoton Optics GmbH, Germany

10:45 – 11:30 Tech Transfer Tutorial
Presenters:
Hossin Abdeldayem, NASA-Goddard Space Flight Center, USA
Newton Frateschi, INOVA - UNICAMP, Brazil
Yuzuru Takashima, Univ. of Arizona, USA

11:30 – 13:00 Pitch Panel w/ Feedback from Panelists
Pitch Panelist:
Leslie Kimerling, Double Helix, USA
Presenters:
Kristan Corwin, Kansas State Univ., Department of Physics, College of Arts and Sciences, USA
Aykutlu Dana, Nanoeye, Inc., USA
Pouya Dianat, Drexel University and Nanograss Solar LLC, USA
Lu Lan, Boston Univ., USA

Visit www.cleoconference.org/techtransfer for complete information.

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CLEO Committees

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CLEO A&T 1: Biomedical Applications
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Manyalibo Matthews, LLNL, USA
Dirk Mueller, Coherent, USA
Jie Qiao, RIT, USA

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Kara Peters, North Carolina State Univ., USA
Greg Rieker, Univ. of Colorado, USA
Brian Simonds, NIST, USA
Mike Thorpe, Bridger Photonics Inc., USA

CLEO A&T 4: Applications in Energy & Environment
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Mark Zondlo, Princeton Univ., USA, Subcommittee Chair
David Bomse, Mesa Photonics, Inc. USA
Bernhard Buchholz, PTB, Germany
David Canteli, Universidad Politecnica de Madrid, Spain
Amir Khan, Delaware State Univ., USA
Jan Nekarda, Fraunhofer ISE, Germany
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Jeff Shapiro, Massachusetts Institute of Technology, USA, General Chair
Stewart Aitchison, Univ. of Toronto, Canada, Program Chair
Todd Pittman, Univ. of Maryland Baltimore County, USA, Program Chair

FS 1: Quantum Optics of Atoms, Molecules and Solids
Tracy Northup, Universität Innsbruck, Austria, Subcommittee Chair
Takao Aoki, Waseda Univ., Japan
Daniel Felinto Pires Barbosa, Universidade Federal de Pernambuco, Brazil
Adam Black, US Naval Research Laboratory, USA
Natalie de Leon, Princeton Univ., USA
Hugues de Riedmatten, ICFO - The Institute of Photonic Sciences, Spain
Edward Flagg, West Virginia Univ., USA
Elizabeth Goldschmidt, US Army Research Laboratory, USA
Peter Humphreys, Technische Universität Delft, Netherlands
Virginia Lorenz, Univ. of Illinois at Chicago, USA
Andreas Muller, Univ. of South Florida, USA
Marina Radulaski, Stanford Univ., USA

FS 2: Quantum Science, Engineering and Technology
Joshua Bienfang, National Institute of Standards and Technology, USA, Subcommittee Chair
Konrad Banaszek, Univeristyt Warszawski, Poland
Michael Brodsky, Max-Planck-Institut für die Physik des Lichts, Germany
John Howell, Univ. of Rochester, USA
Yoon-Ho Kim, Pohang Univ. of Science & Technology, South Korea
Olivier Pfister, Univ. of Virginia, USA
Raphael Pooser, Oak Ridge National Laboratory, USA
Kevin Resch, Univ. of Waterloo, Canada
John Sipe, Univ. of Toronto, Canada
Martin Stevens, National Institute of Standards & Technology, USA
Shigeki Takeuchi, Kyotou Univ., Japan
Philip Walther, Universität Wien, Austria

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FS 3: Metamaterials and Complex Media
Alexey Yamilov, Missouri Univ. of Science and Technology, USA, Subcommittee Chair
Viktoria Babicheva, Georgia State Univ., USA
Igal Brener, Sandia National Labs, USA
Yaron Bromberg, The Hebrew Univ., Israel
Yidong Chong, Nanyang Technological Univ., Singapore
Xu Fang, Univ. of Southampton, UK
Liang Feng, Univ. of Pennsylvania, USA
Sylvain Gigan, Laboratoire Kastler Brossel, France
Zubin Jacob, Purdue Univ., USA
Boubacar Kante, Univ. of California San Diego, USA
Andrei Lavrenenko, Danmarks Tekniske Universitet, Denmark
Junsuk Rho, POSTECH, South Korea
Ekatarina Shamonina, Univ. of Oxford, UK

FS 4: Optical Excitations and Ultrafast Phenomena in Condensed Matter
Keshav Dani, Okinawa Institute of Science and Technology, Japan, Subcommittee Chair
Elbert Chia, Nanyang Technological Univ., Singapore
Hui Deng, Univ. of Michigan, USA
Mackillo Kira, Univ. of Michigan, USA
Chih-Wei Lai, US Army Research Laboratory, USA
Xiaoqin Li, Univ. of Texas at Austin, USA
Kaikui Liu, Peking Univ., China
Noa Marom, Carnegie Mellon Univ., USA
Ilias Perakis, Univ. of Alabama at Birmingham, USA
Denis Seletskiy, Univ. of Konstanz, Germany
Mark Sherwin, Univ. of California Santa Barbara, USA
Diyar Talbayev, Tulane Univ., USA
Jerome Tignon, CNRS - Laboratoire Pierre Aigrain, France
Lyubov Titova, Univ. of Alberta, USA
Ulrike Wogg, Technische Universitat Berlin, Germany

FS 5: Nonlinear Optics and Novel Phenomena
Mercedeh Khajavikhan, CREOL, Univ. of Central Florida, USA, Subcommittee Chair
Tal Carmon, Technion Israel Institute of Technology, Israel
Demetrios Christodoulides, Univ. of Central Florida, USA
Scott Diddams, National Institute of Standards & Technology, USA
Sara Ducci, Université Paris Diderot, France
Arash Mafi, Univ. of New Mexico, USA
Konstantinos Makris, Univ. of Crete, Greece
David Moss, Swinburne Univ. of Technology, Australia
Peter Rakich, Yale Univ., USA
Mikael Rechtsman, Pennsylvania State Univ., USA

FS 6: Nano-Optics and Plasmonics
Amit Agrawal, National Institute of Standards and Technology, USA, Subcommittee Chair
Andrea Baldi, Dutch Institute for Fundamental Energy Research, Netherlands
Palash Bharadwaj, Rice Univ., USA
Peter Catrysse, Stanford Univ., USA
Andrea Di Falco, SUPA, Univ. of St Andrews, UK
Monika Fleischer, Universität Tübingen, Germany
Hayk Harutyunyan, Emory Univ., USA
Ido Kaminer, Technion Israel Institute of Technology, Israel
Mo Mojahedi, Univ. of Toronto, Canada
Esther Wertz, Rensselaer Polytechnic Institute, USA
Wei Zhou, Virginia Tech, USA
Rashid Zia, Brown Univ., USA

FS 7: High-Field Physics and Attoscience
Michael Chini, Univ. of Central Florida, USA, Subcommittee Chair
Luca Argenti, Univ. of Central Florida, USA
Jens Biegert, ICFO - The Institute of Photonic Sciences, Spain
Francesca Calegari, DESY, Hamburg, Italy
Oren Cohen, Technion Israel Institute of Technology, Israel
Matthias Fuchs, Univ. of Nebraska Lincoln, USA
Shambhu Ghimire, SLAC/Stanford Univ., USA
Nobuhisa Ishii, Institute for Solid State Physics, Japan
Julia Mikhailova, Princeton Univ., USA
Arvinder Sandhu, The Univ. of Arizona, USA
Olga Smirnova, Max Born Institute, Germany
Xiaoming Wang, Washington State Univ., USA
Amelle Zaïr, Kings College London, UK

Science & Innovations
Nathan Newbury, National Institute of Standards & Technology, USA, General Chair
Jessie Rosenberg, International Business Machines Corp., USA, General Chair
Amr S. Helmy, Univ. of Toronto, Canada, Program Chair
Shinji Yamashita, Univ. of Tokyo, Japan, Program Chair

CLEO S&I 1: Light-Matter Interactions and Materials Processing
Tsing-Hua Her, Univ. of North Carolina at Charlotte, USA, Subcommittee Chair
Feng Chen, Shandong Univ., China
Ya Cheng, Shanghai Institute of Optics and Fine Mechanics, China
James Fitz-Gerald, Univ. of Virginia, USA
Carl Liebig, Air Force Research Laboratory, USA
Chih Wei Luo, National Chiao Tung Univ., Taiwan
Renee Sher, Wesleyan Univ., USA
Javier Solis, Instituto de Óptica “Daza de Valdés,” Spain
Zijie Yan, Clarkson Univ., USA

CLEO S&I 2: Advanced Science and Technology for Laser Systems and Facilities
Jake Bromage, Univ. of Rochester, USA, Subcommittee Chair
M J Daniel Esser Heriot-Watt Univ., UK
Erhard Gaul, Univ. of Texas at Austin, USA
Max Lederer, European XFEL, Germany
Seong Ku Lee, CoREeLS IBS-GIST, South Korea
Xiaoyan Liang, Shanghai Institute of Optics & Fine Mechanics, China
Thomas Metzger, TRUMPF Scientific Lasers GmbH + Co. KG, Germany
Dimitrios Papadopoulos, LULI, France
Brendan Reagan, Colorado State Univ., USA
Clara Saraceno, Ruhr Universität Bochum, Germany
David Spence, Macquarie Univ., Australia
Thomas Spinka, Lawrence Livermore National Laboratory, USA

All conference locations are in the San Jose Convention Center unless otherwise noted.
CLEO S&I 3: Semiconductor Lasers
Mikhail Belkin, Univ. of Texas at Austin, USA, Subcommittee Chair
Chadwick Canedy, NRL, USA
Connie Chang, UC Berkeley, USA
Lan Fu, Australian Nat’l Univ., Australia
Nicolas Grandjean, EPFL, Switzerland
Qing Gu, UT Dallas USA
Peter Heim, Thorlabs Quantum Electronics, USA
Ted Masselink, Humboldt Univ. of Berlin, Germany
Nobuhiko Nishiyama, Tokyo Institute of Technology, Japan
Boon Siew Ooi, KAUST, Saudi Arabia
Leon Shtengel, SUNY - Stony Brook, USA
Yoshitomo Okawachi, Columbia Univ., USA
Qijie Wang, Case Western Reserve Univ., Singapore

CLEO S&I 4: Nonlinear Optical Technologies
Michelle Y. Sander, Boston University, USA, Subcommittee Chair
Amol Choudhary, Univ. of Sydney, Australia
Katia Gallo, KTH Royal Institute of Technology, Sweden
Shu-Wei Huang, UCLA Engineering IV, USA
Kartik Srinivasan, National Inst of Standards & Technology, USA
Markku Vainio, Univ. of Helsinki, Finland
Sergey Vasilyev, IPG Photonics Corp., USA

CLEO S&I 5: Terahertz Science and Technologies
Matthias Hoffmann, SLAC National Accelerator Laboratory, USA, Subcommittee Chair
Tyler Cocker, Universität Regensburg, Germany
Martin Koch, Philipps-Universität Marburg, Germany
Juliette Mangeney, École normale supérieure, France
Daniel Mittleman, Brown Univ., USA
Tadao Nagatsuma, Osaka Univ., Japan
Rohit Prasankumar, Los Alamos National Laboratory, USA
Miriam Vitiello, Scuola Normale Superiore di Pisa, Italy
Stephan Winnerl, Forschungszentrum Dresden-Rossendorf, Germany

CLEO S&I 6: Optical Materials, Fabrication and Characterization
Thomas Murphy, Univ. of Maryland at College Park, USA, Subcommittee Chair
Guang-Hua Duan, Alcatel-Thales III-V Laboratory, France
Matthew Escarra, Tulane Univ., USA
Frederic Gardes, Univ. of Southampton, UK
Juejun Hu, Massachusetts Institute of Technology, USA
Eiichi Kuramochi, NTT Corporation, Japan
Robert Norwood, The Univ. of Arizona, USA
Roberto Paiella, Boston Univ., USA
Zhipei Sun, Aalto Yliopisto, Finland
Frank (Fengqiu) Wang, Nanjing Univ., China

CLEO S&I 7: Micro- and Nano-Photonic Devices
Takasumi Tanabe, Keio Univ., Japan, Subcommittee Chair
Ali Adibi, Georgia Institute of Technology, USA
Vladimir Aktsyu, National Institute of Standards & Technology, USA
Paul Barclay, Univ. of Calgary, Canada
Daryl Beggs, Cardiff Univ., UK
Alfredo De Rossi, Thales Research & Technology, France
Dirk Englund, Massachusetts Institute of Technology, USA
Karen Grutter, Univ. Technical Services, Inc., USA
Zhihong Huang, Hewlett Packard Laboratories, USA
Weijiang Jiang, Rutgers Univ., USA
Jin Liu, Sun Yat-Sen Univ., China
Nobuyuki Matsuda, NTT Basic Research Laboratories, Japan
Jeremy Munday, Univ. of Maryland at College Park, USA
Sharon Weiss, Vanderbilt Univ., USA
Lan Yang, Washington Univ. in St Louis, USA

CLEO S&I 8: Ultrafast Optics, Optoelectronics & Applications
Christophe Dorrer, Univ. of Rochester, USA, Subcommittee Chair
Jose Azana, INRS-Énergie, Matériaux et Télécommunications, Canada
Alan Fry, SLAC National Accelerator Laboratory, USA
Fumihiko Kannari, Keio Univ., Japan
Thomas Planchon, Delaware State Univ., USA
Liejia Qian, Shanghai Jiao Tong Univ., China
Bojan Resan, Univ. of Applied Sciences, Switzerland
Lawrence Shah, Luminar Technologies, USA
Catherine Teisset, TRUMPF Scientific Lasers, Germany
Laszlo Veisz, Umea Univ., Sweden
Tobias Witting, Max-Born-Institut, Germany

CLEO S&I 9: Components, Integration, Interconnects and Signal Processing
Weidong Zhou, Univ. of Texas at Arlington, USA, Subcommittee Chair
Sasan Fathpour, CREOL, Univ. of Central Florida, USA
Qiaoqiang Gan, State Univ. of New York at Buffalo, USA
Zetian Mi, Univ. of Michigan, Ann Arbor, USA
Richard Penty, Univ. of Cambridge, UK
Haisheng Rong, Intel Corporation, USA
Jian Wang, Huazhong Univ. of Science and Technology, China
Winnie Ye, Carleton Univ., Canada

All conference locations are in the San Jose Convention Center unless otherwise noted.
CLEO S&I 10: Biophotonics and Optofluidics
Andreu Llobera, Carl Zeiss Vision GmbH, Germany, Subcommittee Chair
Hatice Altug, Ecole Polytechnique Federale de Lausanne, Switzerland
Michelle Digman, Univ. of California, Irvine, USA
Emily Gibson, Univ. of Colorado Boulder, USA
Ewa Goldys, Macquarie Univ., Australia
Aaron Hawkins, Brigham Young Univ., USA
Jessica Houston, New Mexico State Univ., USA
Rainer Andreas Leitgeb, Medical Univ. Vienna, Austria
Ute Neugebauer, Center for Sepsis Control and Care Jena, Germany
Maria Ramos-Payan, Instituto de Microelectronica de Barcelo, Spain
Katarina Svanberg, Lund Laser Centre, Sweden

CLEO S&I 11: Fiber Photonics
Sze Yun Set, Univ. of Tokyo, Japan, Subcommittee Chair
Kazi Abedin, OFS Laboratories, USA
Shaif-UL Alam, Univ. of Southampton, UK
Camille-Sophie Bres, École polytechnique fédérale de Lausanne, Switzerland
Neil Broderick, Univ. of Auckland, New Zealand
Gregory Cowle, Lumentum, USA
Liang Dong, Clemson Univ., USA
Julien Fatome, Université de Bourgogne, France
Stuart Jackson, Macquarie Univ., Australia
Khue Kieu, The Univ. of Arizona, USA
William Renninger, Yale Univ., USA
Masaki Tokurakawa, Univ. of Electro-communications, ILS, Japan
Kenneth Kin-Yip Wong, Univ. of Hong Kong, Hong Kong
Meng Zhang, Beihang Univ., China

CLEO S&I 12: Lightwave Communications and Optical Networks
David Geisler, Massachusetts Institute of Technology Lincoln Lab, USA, Subcommittee Chair
Anjali Agarwal, Vencore Labs, USA
Xi Chen, Nokia Bell Labs, USA
Francesco Da Ros, Technical Univ. Of Denmark, Denmark
Marija Furdek, KTH Royal Institute of Technology, Sweden
Vladimir Grigoryan, Ciena Corporation, USA
Yue-Kai Huang, NEC Laboratories America Inc, USA
Masayuki Matsumoto, Tokyo Electric Power Co., Japan
Ryan Scott, Keysight Technologies, Inc, USA
Yikai Su, Shanghai Jiao Tong Univ., China
Stylianos Sygletos, Aston Univ., UK

CLEO S&I 13: Active Optical Sensing
Todd Stievater, US Naval Research Laboratory, USA, Subcommittee Chair
Brian Brumfield, Pacific Northwest National Laboratory, USA
Adam Fleisher, National Institute of Standards & Technology, USA
Jason Guicheteau, US RDECOM ECBC, USA
R. Jason Jones, The Univ. of Arizona, USA
Gamani Karunasiri, Naval Postgraduate School, USA
Waruna Kulatilaka, Texas A&M Univ., USA
Bernhard Lendl, Technische Universität Wien, Austria
Michal Nikodem, Wrocław Research Centre EIT+, Poland
Ian White, Univ. of Maryland at College Park, USA
Michael Wojcik, Space Dynamics Laboratory, USA

CLEO S&I 14: Optical Metrology
Ian Coddington, National Institute of Standards & Technology, USA, Subcommittee Chair
E. Anne Curtis, National Physical Laboratory, UK
Tara Fortier, National Institute of Standards & Technology, USA
Jungwon Kim, Korea Advanced Institute of Science & Technology, South Korea
Nathan Lemke, Air Force Research Laboratory, USA
Marco Marangoni, Politecnico di Milano, Italy
Mark Notcutt, Stable Laser Systems, USA
Laura Sinclair, National Institute of Standards & Technology, USA
Guanhao Wu, Tsinghua Univ., China

IEEE/Photonics Society
Ann Catrina Coleman, Univ. of Texas at Dallas, USA, Chair
Seth Bank, Univ. of Texas at Austin, USA
Kent Choquette, Univ. of Illinois at Urbana-Champaign, USA
Peter Smowton, Cardiff Univ., UK
Weidong Zhou, Univ. of Texas at Arlington, USA

The Optical Society
Craig Arnold, Princeton Univ., USA
Ingmar Hartl, DESY, Germany
Jessie Rosenberg, IBM TJ Watson Research Center, USA
Yuuri Vlasov, Univ. of Illinois at Urbana-Champaign, USA
Jonathan Zuegel, Laboratory for Laser Energetics, Univ. of Rochester, USA

APS/Division of Laser Science
Nicholas Bigelow, Univ. of Rochester, USA
Rohit Prasankumar, Los Alamos National Laboratory, USA

Exhibitor Representative
Anjul Loiacono, Thorlabs Inc, USA

Ex-Officio
Peter Andersen, Danmarks Tekniske Universitet, Denmark
Stewart Aichison, Univ. of Toronto, Canada
Sterling J. Backus, Kaptiyen-Murnane Labs., USA
Zhigang Chen, San Francisco State Univ., USA
Christophe Dorrer, Univ. of Rochester, USA
Ben Eggleton, Univ. of Sydney, Australia
Robert A. Fisher, RA Fisher Associates, LLC, USA
Amr Helmy, Univ. of Toronto, Canada
Nicusor Iftimia, Physical Sciences Inc., USA
Jin Kang, Johns Hopkins Univ., USA
Michal Lipson, Columbia Univ., USA
Natalia Litchinitser, State Univ. of New York at Buffalo, USA
Michael M. Mataloni, Physical Sciences Inc., USA
Eric Mottay, Amplitude Systemes, France, Chair
Nathan Newbury, National Institute of Standards & Technology, USA
Irina Novikova, College of William & Mary, USA
Todd Pittman, Univ. of Maryland Baltimore County, USA
Sergey V. Polyakov, NIST, USA
Jeff Shapiro, MIT, USA
Christine Silberhorn, Universität Paderborn, Germany
Stephanie Tomasulo, Naval Research Laboratory, USA
Shinji Yamashita, Univ. of Tokyo, Japan

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CLEO • 13–18 May 2018
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Joe Haus, Univ. of Dayton, USA
Kent Choquette, Univ. of Illinois at Urbana-Champaign, USA
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Anne Kelley, Univ. of California Merced, USA
Kate Kirby, American Physical Society, USA
Elizabeth A. Rogan, The Optical Society, USA

Joint Council on Applications
Eric Mottay, Amplitude Systemes, France, Chair
Wilhelm G. Kaenders, Toptica Photonics Inc, Germany
Amy Eskilson, Inrad Optics, USA
Peter Fendel, Thorlabs Inc., USA
Klauss Klein, Coherent, Inc., US
Tyler Morgus, Thorlabs Inc., USA
Rick Plympton, Optimax Systems, USA
Carsten Thomsen, NKT Photonics, Denmark
Mark Tolbert, Toptica Photonics, USA
Chris Wood, Insight Photonic Solutions, USA

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Explanation of Session/Presentation Codes

The first letter of the code designates the meeting (For instance, A=Applications & Technology, F=Fundamental Science, S=Science and Innovations, J=Joint). The second element denotes the day of the week (Monday=M, Tuesday=Tu, Wednesday=W, Thursday=Th, Friday=F). The third element indicates the session series in that day (for instance, 2 would denote the second parallel sessions in that day). Each series of sessions begins with the letter A in the fourth element and continues alphabetically through a series of parallel sessions. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.). For example, a presentation coded SM2A.4 indicates that this paper is part of Science and Innovations (S) and is being presented on Monday (M) in the second series of sessions (2), and is the first parallel session (A) in that series and the fourth paper (4) presented in that session.

Agenda of Sessions — Sunday, 13 May

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<td>Registration, Concourse Level</td>
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<tr>
<td>08:30–17:00</td>
<td>OSAF Data Science Career Opportunities Course, Market 1, Hilton San Jose</td>
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<tr>
<td>08:30–12:30</td>
<td>SC149: Foundations of Nonlinear Optics</td>
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<td>SC361: Coherent MidInfrared Sources and Applications</td>
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<td>SC466: Silicon Integrated Nanophotonics</td>
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<tr>
<td>08:30–15:00</td>
<td>SC456: How to Start A Company</td>
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<tr>
<td>13:00–14:00</td>
<td>OSAF Cheeky Scientist Career Development Workshop (Session I), Winchester 1&amp;2, Hilton San Jose</td>
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<tr>
<td>13:30–16:30</td>
<td>SC439: Attosecond Optics</td>
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<td>SC403: NanoCavity Quantum Electrodynamics and Applications</td>
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<td>SC301: Quantum Cascade Lasers: Science, Technology, Applications and Markets</td>
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<td></td>
<td>SC396: Frontiers of Guided Wave Nonlinear Optics</td>
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<tr>
<td>16:00–17:00</td>
<td>OSAF Cheeky Scientist Workshop (Session II), Winchester 1&amp;2, Hilton San Jose</td>
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## Agenda of Sessions — Monday, 14 May

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<th>Time</th>
<th>Room/Location</th>
<th>Session</th>
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<td>07:00–18:00</td>
<td>Registration, Concourse Level</td>
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<tr>
<td>08:00–10:00</td>
<td>JM1A • Symposium on Future Directions</td>
<td>ODA Executive Forum on the Exploding Role of Optics in Sensing, Almaden</td>
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<tr>
<td></td>
<td>in Terahertz Nanoscopy I</td>
<td>Ballroom, Hilton San Jose</td>
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<td>SM1B • Nonlinear and Microwave</td>
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<td>Integrated Photonics</td>
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<td>SM1C • RF Photonic &amp; Radio-over-</td>
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<td>SM1D • Nonlinear Resonators</td>
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<td>FM1E • Topological Optics</td>
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<td>FM1F • Highly Correlated and</td>
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<td>Topological States of</td>
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<td>FM1G • Quantum Photonic Devices</td>
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<td>FM1H • Solid State Spin-Photon</td>
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<td>Interfaces</td>
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<td>SM11 • Modulator on Integrated Platform</td>
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<tr>
<td>08:30–10:00</td>
<td>OIDA Executive Forum on the Exploding</td>
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<td>Role of Optics in Sensing, Almaden</td>
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<td></td>
<td>Ballroom, Hilton San Jose</td>
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<td>10:00–10:30</td>
<td>Coffee Break, Concourse Level</td>
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<tr>
<td>10:30–12:30</td>
<td>JM2A • Symposium on Future Directions</td>
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<tr>
<td></td>
<td>in Terahertz Nanoscopy II</td>
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<td></td>
<td>SM2B • Novel Nanophotonic Structures</td>
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<td>and Devices</td>
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<td>SM2C • ShortReach Communication</td>
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<td>SM2D • Nonlinear Optical Phenomena</td>
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<td>FM2E • Topological Photonics and Lasers</td>
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<td>FM2F • Exciton-polaritons and Other</td>
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<td>Excitation in Semiconductors</td>
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<td>FM2G • Novel Nonophotonic Light Sources</td>
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<td>FM2H • Quantum Optics with Single</td>
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<td>Atoms</td>
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<td>SM2I • Integrated Detectors</td>
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<td>12:00–13:00</td>
<td>OSA Optical Material Studies Technical</td>
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<td></td>
<td>Group Special Talk, Room 230A</td>
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<td>12:30–13:00</td>
<td>Lunch Break (on your own)</td>
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<td>Information Science and Technology</td>
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<td>13:00–14:00</td>
<td>Social Media 102, Market Room 1, Hilton</td>
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<td>13:30–15:30</td>
<td>SM3A • Terahertz Nonlinear Spectroscopy</td>
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<td>SM3B • Optical Modulators</td>
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<td>SM3C • SDM Communications I</td>
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<td>SM3D • Nonlinear Optics in Fibers and</td>
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<td>Waveguides</td>
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<td>FM3E • Symmetries in Optics</td>
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<td>FM3F • High Harmonic Generation in Solids</td>
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<td>FM3G • Quantum Sources I</td>
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<td>FM3H • Chiral and Topological Quantum</td>
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<td>SM3I • Optical Phase Arrays</td>
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<td>14:00–15:30</td>
<td>Workshop: Understanding Unconscious</td>
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<td>15:30–16:00</td>
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<td>SM4A • THz High-field Generation and</td>
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<td>SM4B • Microrings and Novel Modulation</td>
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<td>SM4D • Optical Meteorology</td>
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<td>Nonlinear Optical Technologies</td>
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<td>FM4E • PT-Symmetry and Non-Hermitian</td>
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<td>FM4F • Probing Materials with</td>
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<td>Ultrafast Electricity and Extreme Light</td>
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<td>FM4G • Quantum Sources II</td>
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<td>FM4H • Quantum Optics with Atomic and Molecular Ensembles</td>
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<td>SM4I • Novel Emitters</td>
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<td>16:00–17:30</td>
<td>Workshop: Understanding Unconscious</td>
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<td>Bias, Winchester 1&amp;2, Hilton San Jose</td>
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<tr>
<td>17:30–18:30</td>
<td>Diversity &amp; Inclusion in Optics and</td>
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<td>Photonics Reception, Market 1&amp;2, Hilton</td>
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<td>San Jose</td>
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<td>19:00–20:30</td>
<td>OSA Nonophotonics Technical Group 20x20</td>
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<td>Talks, Room 230A</td>
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<td>Meeting Room 212 A/C</td>
<td>Meeting Room 212 B/D</td>
<td>Marriott, Salon I &amp; II</td>
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<tr>
<td>Registration, Concourse Level</td>
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<tr>
<td>AM1J • Advanced Microscopy and Imaging Techniques</td>
<td>SM1K • Raman Scattering and Applications</td>
<td>SM1L • Precision Clocks and Time Transfer</td>
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<tr>
<td>OIDA Executive Forum on the Exploding Role of Optics in Sensing, Almaden Ballroom, Hilton San Jose</td>
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<td>Coffee Break, Concourse Level</td>
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<tr>
<td>AM2J • Biomedical Imaging</td>
<td>SM2K • Fiber Sensing and Measurement</td>
<td>SM2L • Optical Microwave Generation</td>
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<td>OSA Optical Material Studies Technical Group Special Talk, Room 230A</td>
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<td>Lunch Break (on your own)</td>
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<td>SC455: Integrated Photonics for Quantum Information Science and Technology</td>
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<td>SC378: Introduction to Ultrafast Optics</td>
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<td>Social Media 102, Market Room 1, Hilton San Jose</td>
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<td>Workshop: Understanding Unconscious Bias, Winchester 1&amp;2, Hilton San Jose</td>
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<td>Coffee Break, Concourse Level</td>
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<tr>
<td>FM3J • Imaging and Cloaking in Metamaterials</td>
<td>SM3K • Billouim Scattering and Applications</td>
<td>SM3L • Photonic Frequency References and Sources</td>
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<td>Workshop: Understanding Unconscious Bias, Winchester 1&amp;2, Hilton San Jose</td>
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<td>Diversity &amp; Inclusion in Optics and Photonics Reception, Market 1&amp;2, Hilton San Jose</td>
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<tr>
<td>OSA Nonophotonics Technical Group 20x20 Talks, Room 230A</td>
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# Agenda of Sessions — Tuesday, 15 May

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<th>Time</th>
<th>Executive Ballroom 210A</th>
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<th>Executive Ballroom 210H</th>
<th>Meeting Room 211 B/D</th>
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<td>08:00–10:00</td>
<td>JTu1A • Plenary Session I &amp; Awards Ceremony, Grand Ballroom</td>
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<td>OIDA VIP Industry Leaders Speed Meetings Lunch, Exhibit Hall, #2605</td>
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<td>12:00–16:00</td>
<td>SC270: High Power Fiber Lasers and Amplifiers</td>
<td>SC376: Plasmonics</td>
<td>SC438: Photonic Metamaterials</td>
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<td>13:00–15:00</td>
<td>STu3A • Quantum Photonic Technology</td>
<td>STu3B • OAM and Photodetective</td>
<td>STu3C • Advanced Short Reach and Free Space Communications</td>
<td>STu3D • Terahertz Communications</td>
<td>FTu3E • Thermal and Quantum Applications of Metasurfaces</td>
<td>STu3F • Nonlinear Integrated Photonic Platforms</td>
<td>FTu3G • Quantum Key Distribution</td>
<td>FTu3H • Quantum Optics with Solid-state Single Emitters</td>
<td>ATu3I • OCT and LIDAR</td>
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<td>17:00–19:00</td>
<td>FTu4A • Quantum Information Processing</td>
<td>STu4B • Wavelength and Phase-sensitive Integrated Devices</td>
<td>STu4C • Nonlinearity Compensation</td>
<td>STu4D • Terahertz QCLs</td>
<td>FTu4E • Quantum and Non-local Plasmonics</td>
<td>STu4F • Nonlinear Optical Phononics &amp; Optomechanics</td>
<td>FTu4G • Continuous Variable Quantum Computing</td>
<td>FTu4H • Novel Solid State Systems for Quantum Optics</td>
<td>ATu3R • Advanced Review on A&amp;T Topical Technologies I</td>
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<td>OSA Technical Group Poster Session, 230A/B</td>
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<td>Marriott, Salon V</td>
<td>Marriott, Salon VI</td>
<td>Marriott, Willow Glen</td>
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<td>JTu3O • Laser Modification of Materials</td>
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CLEO • 13–18 May 2018
## Agenda of Sessions — Wednesday, 16 May

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<td>Exhibit Hall Free Lunch</td>
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<td>12:00–13:00</td>
<td>OSA Photonic Metamaterials Technical Group Tutorial on Metasurface Design and Simulation, Room 230A</td>
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<td>13:00–15:00</td>
<td>SW3A • Microresonator Combs, SW3B • Hybrid Lasers on Silicon, SW3C • High Capacity Transmission, SW3D • Terahertz Nano-imaging and Spectroscopy, FW3E • Frequency Combs &amp; Precision Metrology, FW3F • Single-Photon Detectors, FW3G • Nonlinear Nano-optics, FW3H • Active and Tunable Metasurfaces, SW3I • Low-dimensional and Phase-change Materials</td>
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<td>17:00–19:00</td>
<td>SW4A • High-Q Microcavities, SW4B • Nitride-based Integrated Photonics, SW4C • Optical Switching, SW4D • Novel THz Techniques, FW4E • Quantum and Nonlinear Phenomena, FW4F • Beyond Qubits, FW4G • Plasmon-mediated Control of Light Emission, FW4H • Shaping Emission Using Metasurfaces, SW4I • Silicon Hybrid Integration</td>
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<td>SW3J • Biosensors &amp; Photonic Devices</td>
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<td>AW3O • Optical Enhancement of Photovoltaics</td>
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<td>JW3P • Symposium on New Advances in Adaptive Optics Retinal Imaging I</td>
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<td>JW4P • Symposium on New Advances in Adaptive Optics Retinal Imaging II</td>
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**Agenda**

**CLEO** • 13–18 May 2018
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<td>07:30–18:00</td>
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<td>08:00–10:00</td>
<td>STh1A • Novel Structures and Devices</td>
<td>STh1B • Integrated Photonic Sensors</td>
<td>STh1C • Machine Learning for Communication</td>
<td>FTh1D • Nonlinear Metamaterials and Metasurfaces</td>
<td>FTh1E • Nonlinear Phenomena in van der Waals Heterostructure</td>
<td>FTh1F • Novel Integrated Quantum Sources</td>
<td>FTh1G • Quantum Interference, Imaging and Spectroscopy</td>
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<td>10:00–15:00</td>
<td>Exhibition Open, Exhibit Hall</td>
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<td>10:15–13:00</td>
<td>Technology Transfer Program, Exhibit Hall Theater</td>
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<td>10:00–11:30</td>
<td>Coffee Break &amp; Exhibit Only Time, Exhibit Hall</td>
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<td>11:30–13:00</td>
<td>JTh2A • Poster Session III, Exhibit Hall</td>
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<td>14:00–16:00</td>
<td>STh3A • Photonic Crystals</td>
<td>STh3B • Networks on a Chip</td>
<td>JTh3C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges I</td>
<td>JTh3D • Symposium on Advances in Integrated Microwave Photonics I</td>
<td>FTh3E • Non-diffracting and Vortex Beams</td>
<td>STh3F • Mid-IR Nonlinear Devices</td>
<td>STh3G • Quantum Information Processing on Photonic Nanostructures</td>
<td>ATh3H • Control of Quantum Optical and Opto-mechanical Systems</td>
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<td>16:00–16:30</td>
<td>Coffee Break, Concourse Lobby</td>
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<td>16:30–18:30</td>
<td>STh4A • Waveguide Structures</td>
<td>STh4B • On-chip and Offchip Coupling Schemes</td>
<td>JTh4C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges II</td>
<td>JTh4D • Symposium on Advances in Integrated Microwave Photonics II</td>
<td>FTh4E • Multimode Nonlinear Fiber Optics</td>
<td>STh4F • Optical Parametric Oscillators</td>
<td>FTh4G • Cats and Kets</td>
<td>FTh4H • Nanophotonic Emitters, Detectors and Modulators</td>
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<td>18:30–20:00</td>
<td>Dinner Break (on your own)</td>
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<td>18:30–20:00</td>
<td>Emerging Trends in Nonlinear Optics — A Review of CLEO: 2018</td>
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<td>20:00–22:00</td>
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<td>Coffee Break &amp; Exhibit Only Time, Exhibit Hall</td>
<td>JTh2A • Poster Session III, Exhibit Hall</td>
<td>Exhibit Hall Free Lunch</td>
<td>Coffee Break, Concourse Lobby</td>
<td>Dinner Break (on your own)</td>
<td>Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018</td>
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### Agenda of Sessions — Friday, 18 May

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<th>Time</th>
<th>Executive Ballroom 210A</th>
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<tr>
<td>07:30–15:30</td>
<td>Registration, Concourse Level</td>
<td>SF1A • Si Photonics</td>
<td>FF1B • Quantum Enhanced Measurements</td>
<td>JF1C • Symposium on Lasers in Accelerator Science and Technology I</td>
<td>FF1D • Ultrafast Spectroscopy of 2D Materials</td>
<td>FF1E • THz Generation and Novel Phenomena</td>
<td>FF1F • Spatial and Temporal Control of Light Using Metasurfaces</td>
<td>SF1G • Surface Emitting Lasers</td>
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<td>10:00–10:30</td>
<td>Coffee Break, Concourse Level</td>
<td>SF2A • Nonlinear Photonics in Integrated Structures</td>
<td>JF2B • Symposium on Emerging Quantum Sensing Techniques and Applications I</td>
<td>JF2C • Symposium on Lasers in Accelerator Science and Technology II</td>
<td>FF2D • THz Electrodynamics and control of Electronic Degrees of Freedom</td>
<td>FF2E • Novel Nonlinear Optical Materials</td>
<td>FF2F • Fundamental Nanophotonics: Sensing and Infrared Applications</td>
<td>SF2G • Mid-infrared Semiconductor Lasers</td>
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<td>12:30–14:00</td>
<td>Lunch Break (on your own)</td>
<td>SF3A • Integrated Photonics (III-V Heterogeneous)</td>
<td>JF3B • Symposium on Emerging Quantum Sensing Techniques and Applications II</td>
<td>FF3C • Optimization and Design of Metasurfaces</td>
<td>FF3D • Spectroscopy of Low Dimensional Systems</td>
<td>FF3E • Photon-Phonon Interactions and Cooling</td>
<td>FF3F • Optomechanical Interactions and Single Particle Tracking</td>
<td>SF3G • Quantum Cascade Lasers</td>
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<td>SF1I • Perovskites and Organics</td>
<td>SF1J • Metasurfaces</td>
<td>SF1K • Hollow Core Fibers</td>
<td>AF1M • Fiber-Optic Based Sensing</td>
<td>SF1N • Ultrafast Mid-IR Sources</td>
<td>FF1P • Attosecond and X-Ray Spectroscopy</td>
<td>AF1Q • A&amp;T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology II</td>
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<td>SF2I • Electrooptic and Nanophotonic Materials</td>
<td>SF2J • Cavity Optomechanics</td>
<td>SF2K • Novel Fiber Technology</td>
<td>FF2L • Polaritons in 2D Materials</td>
<td>AF2M • Imaging &amp; Microscopy</td>
<td>SF2N • Ultrafast Oscillators</td>
<td>FF2P • High-order Harmonic Generation in Solids</td>
<td>AF2Q • A&amp;T Topical Review on Time-Stretch Technology: Principles and Applications I</td>
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<td>SF3I • Materials for Fiber and Solid State Lasers</td>
<td>SF3J • Mid IR Sensing and Optical Forces</td>
<td>SF3K • Mode-Locked Fiber Lasers</td>
<td>AF3M • Instruments and Components for Spectroscopy</td>
<td>SF3N • Ultrafast Pulse Manipulation</td>
<td>FF3P • Strong-field Physics in Solids</td>
<td>AF3Q • A&amp;T Topical Review on Time-Stretch Technology: Principles and Applications II</td>
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Infrared Near-Field Optical Microscopy, Towards Quantitative Conductivity Measurements with Nanoscale Spatial Resolution

Joanna M. Atkin1, Infrared Near-Field Optical Microscopy, Towards Quantitative Conductivity Measurements with Nanoscale Spatial Resolution

Pernille Klarck Pedersen1,2, Angela C. Pizzuto1, Brown Univ., USA; 2DTU Fotonik, Technical Univ. of Denmark, Denmark. Using a scattering-type optical nearfield microscope the spatial resolution of Laser Terahertz Emission Microscopy (LTEM) can be improved dramatically. With this material properties can be studied optically with a resolution of only 20 nm.

Heterogeneously Integrated InP Widely Tunable Laser and SiN Microring Resonator for Integrated Comb Generation

Keith A. McKinzie1, Cong Wang1, Abdullah Al Noman1,2, Pernille Klarck Pedersen1,2, Angela C. Pizzuto1, Brown Univ., USA; 2DTU Fotonik, Technical Univ. of Denmark, Denmark. We propose heterogeneously integrated InP laser and SiN microring resonator with fixed frequency comb generation.

Invited Talk: Towards Quantitative Conductivity Measurements with Infrared Near-Field Optical Microscopy

Joanna M. Atkin1, Infrared Near-Field Optical Microscopy, Towards Quantitative Conductivity Measurements with Nanoscale Spatial Resolution

Chemistry, Univ. of North Carolina at Chapel Hill, USA. Mid-infrared scattering-type scanning near-field optical microscopy (s-SNOM) is a non-destructive optical method to extract nanoscale conductivity maps in semiconductors. Combined with spectroscopic analysis, we can extract quantitative local dielectric properties.

Demonstration of Stimulated Raman Scattering on a Silicon Nitride Photonic Integrated Waveguide

Haolan Zhao1,2,3, Stephan Clemmen4, Ali Razia1, Roel Baets2,3,4, Photonics Research Group, IntEC, Ghent Univ., Belgium; 2Center for Nano- and Biophotonics, Ghent Univ., Belgium. We report the first demonstration of stimulated Raman scattering (SRS) enabled by an integrated nanophotonic waveguide with CW excitations. It constitutes an important step towards all-on-a-chip Raman sensor suitable for both gas and liquid detection.

Optically Powered Radio-Over-Fiber Systems

Motoharu Motoharu Matsuura1, Infinera Corporation, USA. This paper introduces recent works on optically powered radio-over-fiber systems, which drive remote antenna units by power-over-fiber without any other external power supplies. This paper also discusses the perspective on future mobile communications.
SM1D.2 • 08:15
Tunable Insertion of Uniform-Amplitude Multiple Coherent Lines into a Kerr Frequency Comb Using Nyquist Pulse Generation
Fatemeh Alishahi, Peicheng Liao, Amirhossein Mahjari Anaei, Ahmad Falahpour, Ahmad Alimani, Yinwen Cao, Arne Kordts, Martin Pfeiffer, Tobias J. Kippenberg, Alan E. Willner

FM1E.1 • 08:15
Observation of Aharonov-Bohm Suppression of Optical Tunneling in Twisted Multicore Fibers
Midyia Parto, Jose Enrique Antonio-Lopez, Juan Carlos Alvarado Zacarias, Rodrigo Armandoa Correa, Demetrios N. Christodoulides

FM1F.2 • 08:15
Controlling electron-phonon interaction in the Bi$_2$Se$_3$ topological insulator by Dirac-plasmon engineering
Chihun Lin, Sangwan Sim, Soohyun Park, Seongwan Choi, Soojoon Lee, Hyunyong Choi, Minwoo Kim, Ji-Soo Moon, Manym Salehi, Seung Young Seo, Aloysius Soon, Moon-Ho Ham, Hyunyong Choi, Yonsei Univ., South Korea; Soongsil Univ., South Korea; Gwangju Inst. of Science and Technology, South Korea; Rutgers Univ., USA; Pohang Univ. of Science and Technology, South Korea; Seoul National Univ., South Korea.

SM1D.3 • 08:30
Spatial-mode-based coupling dispersion engineering for integrated optical waveguide
Yi Li, Akihiro Okumura, Shun'ya Yoshida, Yorikazu Tsukada, Hiroshi Horikoshi

FM1E.2 • 08:30
Topological Lossless Optical Digitizer
Yonatan Plotnik, Yonatan Nemirovski, Mordechai Segev, Technion, Israel

FM1F.3 • 08:30
Ultrafast Photocurrent Measurements of Bulk-Conduction Induced Spin Hall Effect in the Topological Insulator Bi$_2$Se$_3$
Hojin Lee, Seonghik Oh, Dahun Kim, Hyeon Kim, Hyunyong Choi, Yonsei Univ., South Korea; Soongsil Univ., South Korea; Sungkyunkwan Univ., South Korea; 4Physics, Pohang Univ. of Science and Technology, South Korea; 5Physics & Astronomy, Seoul National Univ., South Korea.

SM1D.4 • 08:45
Switching Dynamics of Counter-propagating Light States in Microresonators
Leonardo Del Bino, Scott Papp, Michael T. Woodley, Momchil Minkov, Shanhui Fan, Stanford Univ., USA

FM1E.3 • 08:30
Topological Mass Conversion
Yonatan Plotnik, Yonatan Nemirovski, Mordechai Segev, Technion, Israel

FM1F • Highly Correlated and Topological States of Matter
Presider: Robert Kaindl; Lawrence Berkeley National Lab, USA

SM1D.1 • 08:00
Searching for New Regimes in Microresonator Frequency Combs Using a Pulsed Pump Laser
Jordan Stone, Daniel C. Cole, Scott Papp

FM1E.1 • 08:00
Experimental Observation of the Coupling of a Nonlinear Wave to a Topological Edge State
Anistan Bisanov, Mark Kremer, Martin Wimmer, Alexander Szameit, Ulf Peschel

FM1F.1 • 08:00
Ultrafast Photocurrent Measurements of Bulk-Conduction Induced Spin Hall Effect in the Topological Insulator Bi$_2$Se$_3$
Yoshitomo Okawachi, Columbia Univ., USA
FM1G.1 • 08:00
A Universal Two-Qubit Quantum Processing System, Xiaogang Qiang1, Xiaoqi Zhou1, Jianwei Wang1, Calum Wilkes1, Thomas Loke1, Sean O’Gara1, Laurent Kling2, Graham Marshall3, Raffaele Santagata4, Jingbo Wang4, Jeremy L. O’Brien5, Mark G. Thompson6, Jonathan Mathewson7, 1Quantum Engineering Technology Labs, Univ. of Bristol, UK; 2State Key Lab of High Performance Computing, NUDT, China; 3State Key Lab of Optoelectronic Materials and Technologies and School of Physics, Sun Yat-sen Univ., China; 4School of Physics, The Univ. of Western Australia, Australia. We report a universal two-qubit silicon photonic quantum processor, able to initialise, operate and analyze arbitrary two-qubit states and processes applications in quantum information processing.

FM1G.2 • 08:15
A Large-Number and Multilayer Quantum Walk using Silicon Nano-photonic Chip, Lingxiao Wan1, Libin Yan1, Gong Zhang1, Jiangto Huang1, Leong Chuan Kwek1, Joseph F. Fitzsimons1, Yudong Chang2, Jiangbo Hong3, Alexander Szameit4, Xiaoqi Zhou5, Man-Hong Yung6, Xiaolong Su7, Wee Ser1, Weibo Gao1, Aiqun Liu8, 1National University of Singapore, Singapore; 2Singapore Univ. of Technology and Design, Singapore; 3Singapore Univ. of Technology and Design, Singapore; 4Univ. of Rostock, Germany; 5Sun Yat-sen Univ., China; 6Southern Univ. of Science and Technology, China; 7Shanghai Jiaotong Univ., China; 8Shanxi Univ., China. We demonstrated 2D quantum walks in a Si3N4 chip and study how different parameters affect light distribution. Such scalable quantum device will have a promising application in the field of quantum communication and simulation.

FM1G.3 • 08:30
Monolithically Integrated Hong-Ou-Mandel Experiment in LiNbO3, Kai-Hong Luo1, Sebastian Brauner1, Christoph Eigner1, Rainmund Ricken1, Polina Sharapova1, Torsten Meier1, Harald Herrmann1, Christine Silberhorn2, 1Dept. of Physics, Univ. of Paderborn, Germany. We implemented a fully integrated Hong-Ou-Mandel (HOM) interference circuit which comprises a qubit generation, passive routing, fast active polarization manipulation, electro-optic balanced switching, and a variable time delay based on Ti:LiNbO3 waveguides.

FM1H.1 • 08:00
Invited Spin-photon Quantum Interfaces in Solids, Mete Atature1, 2Cambridge Univ., UK. TBD

FM1H.2 • 08:30
Frequency Control of Single Quantum Emitters in Integrated Photonic Circuits, Emma Schmidgall1, Srivatsa Chakravarthi1, Michael Gould1, Ian Christen1, Karine Herrstrom1, Fariba Hatami1, Kai-Mei Fu1, 1Univ. of Washington, USA; 2Univ. of California, Irvine, USA. We present a high-performance cavity filter and a high-temperature nitrogen-vacancy (NV) qubit. This NV device is integrated on the surface of a silicon photonic platform.

FM1H.3 • 08:45
Noncavity Design for Reduced Spectral Diffusion of Solid-State Defects, Sara L. Mouradian1, Noel Wan1, Michael Walsh1, Eric A. Berson1, Matthew Trustheim1, Tim Schröder2, Dirk Englund3, 1MIT, USA; 2Niels Bohr Inst., Denmark. We report on the reduced spectral diffusion of nitrogen vacancy (NV) centers in waveguides and cavities. We also design a novel cavity that provides both high quality factor and isolation from diamond surfaces.

FM1H.4 • 08:45
Investigation of Deep Learning Attacks on Nonlinear Silicon Photonic PUFs, Iskandar Atakhashi1, Bryan Bosworth1, Brian Grubel1, Michael Kossey1, Jesus Villaalba1, A.B. Cooper1, Najim Dehaki1, Amy Foster1, Mark A. Foster1, 1Johns Hopkins Univ., USA. We demonstrate that nonlinear silicon photonic Physical Unclonable Functions (PUFs) are resistant to adversarial deep learning attacks. We find that this resistance is rooted in the optical nonlinearity of the silicon photonic PUF token.

SM1I.1 • 08:00
Enhanced Polling and Inflation of Highly-Linear Mach-Zehnder Modulators on Si/Insulator Organic Hybrid Platform, Hamed Daliri1, Arash Dehghannasiri2, Tianren Fan3, Tarek Hassan4, Valerio Morandi5, Hossein Toghinejad6, Amir H. Hosseinia7, Ali Asghar Eftekhari8, Ali Adibi9, 1Georgia Inst. of Technology, USA. Effective inflation and polling of electro-optic polymer (EOP) inside world-record vertical slot of 40 nm is demonstrated for a Mach-Zehnder modulator on a hybrid Si/SiN/EOP platform with highly-linear and high-power handling performance capabilities.

SM1I.2 • 08:15
High-speed silicon-organic hybrid modulator enabled by sub-wavelength grating waveguide ring resonator, Zeyu Pan1, Xiaochuan Xu2, Chi-Jui Chung3, Hai-Yan4, Ke Chen5, Yuguang Wang3, Xiaohua Jia3, Ray Chen4, 1Univ. of Texas at Austin, USA; 2Omega Optics, Inc., USA; 3Swindon University of Technology, Australia. We present a high-speed modulator based on electro-optic polymer infiltrated sub-wavelength grating waveguide ring resonator. A 3-dB small signal modulation bandwidth of 41.36 GHz has been demonstrated.

SM1I.3 • 08:30
Silicon-conductive oxide nano-cavity modulator with extremely small active volume, Erwen Li1, Qian Gao1, Ray Chen1, Larry R. Dalton2, Juerg Leuthold3, 1University of Bristol, UK; 2ETH Zurich, Switzerland; 3University of Science and Technology, China. We design and experimentally demonstrated an ultra-compact modulator using transparent conductive oxide as the gate on 1-D silicon photonic crystal cavity. The device offers an ultra-small active volume (<0.06 μm3) and 45 dBm energy efficiency.

SM1I.4 • 08:45
100 Gbd Plasmonic IQ Modulator, Wolfgang Heri1, Benedikt Baueufle1, Yuriy Fedoryshyn1, Ame Josten1, Christian Haffner1, Tatsumiko Watanabe2, David Hilkeruss1, Delwin Elder2, Larry R. Dalton2, Juerg Leuthold3, 1ETH Zurich, Switzerland; 2Huawei Technologies, Germany; 3Univ. of Washington, USA. Demonstration of a plasmonic IQ modulator operating at 100 Gbd QPSK and at 32 Gbd 16QAM. The device is orders of magnitude smaller than any photonic counterpart.
Brillouin microscopy in clinical trials; at cell level, Brillouin microscopy enables characterization of intracellular elasticity.

We will describe recent progress of Brillouin microscopy, an all-optical imaging modality to map mechanical properties of material based on Brillouin scattering. In ophthalmology, Brillouin microscopy is in clinical trials; at cell level, Brillouin microscopy provides better resolution and micro-Raman microscopy enables characterization of intracellular elasticity.

All-optical imaging modality to map mechanical properties of material based on Brillouin scattering. In ophthalmology, Brillouin microscopy is in clinical trials; at cell level, Brillouin microscopy provides better resolution and micro-Raman microscopy enables characterization of intracellular elasticity.

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All-optical imaging modality to map mechanical properties of material based on Brillouin scattering. In ophthalmology, Brillouin microscopy is in clinical trials; at cell level, Brillouin microscopy provides better resolution and micro-Raman microscopy enables characterization of intracellular elasticity.
AM1M.1 • 08:00
**Invited**
Ultrafast Laser Microwelding of Optical Materials, Duncan P. Hand, Richard Carter, Robert R. Thomson, M. J Daniel Esler, Michael Traughton, Ian Elder, Robert Lamb, Hercotte-Watt Univ., UK; Leonardo Aeronautic and Space Systems, UK. Construction of precision optical systems (e.g. lasers) involves bonding optical materials (glasses and crystals - mirrors, beamsplitters, laser crystals) to structural materials (typically metals). I will describe an ultrafast laser welding process for such applications.

AM1M.2 • 08:30
Controlling Femtosecond Laser Ablation of Germanium for Laser Polishing Applications, Lauren L. Taylor, Jing Xu, Thomas Smith, Michael Pomerantz, John Lambropoulos, Jie Qiao, Rochester Inst. of Technology, USA. Sensitivity of femtosecond laser ablation to laser parameters was investigated to evaluate controllability of germanium material removal. A processing metric was determined, enabling a method to control laser polishing with flexible combinations of laser parameters.

AM1M.3 • 08:45
Process Optimization by Bursts of Ultrafast Laser Pulses and Considerations of Absorptance and Residual Heat, Beat Neuenschwander, Daniel J. Faerster, Beat Jaeggli, Bern Univ. of Applied Sciences, Switzerland; Institut für Stahlwerkzeuge fsw, University of Stuttgart, Germany; LASER.AG, Switzerland. It will be shown that an increased absorptance of a copper surface machined with an ultrafast 3 pulse burst may be responsible for the detected increase of the specific removal rate in this case.

SM1N.1 • 08:00
Ultrashort Pulse Laser Irradiation Tests on Silica Glass with Random Antireflective Surface Structures, Lynda E. Busse, Steven R. Flom, Jesse Frantz, Brandon Shaw, Christopher Wilson, Ishwar D. Aggarwal, Jas Sanghera, US Naval Research Lab, USA; Univ. of North Carolina at Charlotte, USA; Sotera Defense Solutions, USA. We show similar laser induced damage results for silica glass with and without random antireflective surface structures under high intensity fs/laser irradiation.

SM1N.2 • 08:15
High Stability Time-Lens-Based Picosecond Seed Source, Christophe Dorrer, Richard Brown, Univ. of Rochester, USA. The design of an optical source based on an electro-optic time lens is described. Excellent pulse-duration stability, short-term jitter, and long-term drift performance are demonstrated, making it suitable as a seed for high-energy laser systems.

SM1N.3 • 08:30
Large-Mode Optical Cavity for UV Laser Power Recycling, Yun Liu, Abdurahim Rakhman, Oak Ridge National Lab, USA. A large-mode Fabry-Perot cavity has been developed for power enhancement of UV laser. Megawatt peak power has been realized inside the cavity through power recycling of 50ps/402 MHz UV pulses operating in a 10ms/10Hz burst mode.

SM1N.4 • 08:45
Passive compensation of beam misalignment caused by air convection in thin-disk lasers, Tom Dietrich, Stefan Pichler, Christoph Röcker, Martin Rumpf, Marwan Abdou Ahmed, Thomas Graf, Universität Stuttgart, Germany; Martin Photonics, Germany. We present a new approach to passively compensate for the misalignment instabilities caused by convection of heated ambient air in front of a thin-disk laser crystal by means of exploiting the spectral dispersion of a diffractive grating-waveguide mirror.
08:00–10:00
AM1P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition I
Presider: Wilhelm Kaenders; Toptica Photonics AG & Inc., Germany

AM1P.1 • 08:00
Invited
From Basic Research to Quantum Technologies: Challenges and Opportunities, Tatjana Curcic, 1 US Air Force Office of Scientific Res, USA. Quantum Science research has laid foundations for many new technologies, with applications ranging from brain imaging to information security. In this talk, I will discuss challenges and opportunities accompanying the development of quantum technologies.

AM1P.2 • 08:30
Invited
Innovative Laser Solutions for Operational Quantum Sensors, Bruno Desruelle, MUQUANS, France. We present the innovative laser technologies developed for our Absolute Quantum Gravimeter. We describe the work we have done to develop a solution capable of meeting the demanding requirements associated to quantum manipulation of laser cooled atoms, in a compact fibered architecture.

FM1Q • Optical Filamentation and X-rays
Presider: Alexander Gaeta; Columbia University, USA

FM1Q.1 • 08:00
Precise Holographic Measurements Reveal High Electron Densities in Mid-Infrared Laser Filaments in Air, Dimitris Papazoglou1,2, Valentina Shumakova1, Skirmantas Ališauskas1, Vladimir Fedorov1,2, Audrius Pugžlys1,3, Andrius Baltuska1,4, Stylianos Tzortzakis1,2; 1Vienna Univ. of Technology, Austria; 2Foundation for Research and Technology-Hellas, Greece; 3Univ. of Crete, Greece; 4Center for Physical Sciences & Technology, Lithuania; 5Texas A&M Univ. at Qatar, Qatar. We report on precise experimental measurements of the electron plasma density in plasma strings generated in air by 3.9μm laser filaments using holography. We discuss the origin and impact of the high electron densities observed.

FM1Q.2 • 08:15
Impact of Polarization on Mid-IR Air Filaments, Valentina Shumakova1, Claudia Gollner1, Andrius Baltuska1,2, Vladimir Fedorov1,2, Stylianos Tzortzakis1,2, Alexander Voronin3,4, Alexander Mitrofanov6,7, Alexander Voronin4,5,8, Daniil Kartashov9, Audrius Pugžlys1,2; 1Vienna Univ. of Technology, Austria; 2Center for Physical Sciences & Technology, Lithuania; 3Texas A&M Univ. at Qatar, Qatar; 4Lebedev Physical Inst. of the Russian Academy of Sciences, Russia; 5Foundation for Research and Technology-Hellas, Greece; 6Lomonosov Moscow State Univ., Russia; 7Russian Quantum Center, Russia; 8Texas A&M Univ., USA; 9Friedrich-Schiller Univ. Jena, Germany. We report results of experimental investigation on polarization evolution and losses in linearly and circularly polarized mid-IR filaments in air under different focusing conditions.

FM1Q.3 • 08:30
Shaping Long-lived Electron Wavepackets to Create Customizable Optical Spectra, Rumen R. Dangovski1, Nicholas Rivera1, Marim Soldo1, Ido Kaminer2; 1MIT, USA; 2Electrical Engineering, Technion Israel Inst. of Technology, Israel. We introduce new shape-invariant electron wavepackets constructed via superpositions of states in the ionization continuum, enabling customizable optical emission spectra in the eV-keV range. Their shape-invariance is prolonged indefinitely in exchange for larger spatial spreads.

FM1Q.4 • 08:45
Near-infrared Filament Conductivity in Multi-Filament Regime, Milos Burger1, Patrick J. Skrodzki1, Igor Jovanović1; 1Univ. of Michigan, USA. Scaling of the electrical conductive properties of femtosecond laser filaments with energy is of significant interest. We observe that the formation of multiple filaments does not impede the increase of air conductivity with laser power.
Bias Dependence of Laser Terahertz Emission Nanoscopy, Angela C. Pizzuto1, Permile Klarskov Pedersen1,2, Daniel M. Mittleman1,2, Brown Univ., USA; 3Photonic Engineering, Technical Univ. of Denmark, Denmark. We demonstrate depletion of terahertz emission from semiconductors by applying a DC bias between a substrate and an AFM probe operating in tapping mode. The depletion is strongly dependent on the probe tapping amplitude.

All-electronic THz Nanoscopy, Clemens Liewald1,2, Fritz Keilmann1, Faculty of Physics and Center for NanoScience (CeNS), LMU Munich, Germany; 3Nanosystems Initiative Munich, Germany. We demonstrate 50-nm resolved near-field imaging at λ=500 μm for the first time, using a high-harmonic microwave circuit for emitting/detecting via free space to a standard s-SNOM, and map conductivity contrasts at near single-charge sensitivity.

Nano-THz Imaging of Quantum Materials, Dmitri Basov1,2, Columbia Univ., USA. We developed THz nano-spectroscopy and nano-imaging operational at liquid helium temperatures. I will discuss first low-temperature nano-imaging data for ballistic plasmonic transport in graphene, correlated oxides and cuprate high temperature superconductors.

A highly versatile microwave photonic filter based on an integrated optical frequency comb source, Jiayang Wu1, Xiaoyang Xu1, Thach Nguyen1, Sai T. Chu1, Brett Little1, Robert to Morandotti1, Arman Mitchell1, David J. Moss1, Swinburne Univ. of Technology, Australia; 2RMIT Univ., Australia; 3City Univ. of Hong Kong, China; 4Chinese Academy of Science, China; 5INRS-Énergie, Matériaux et Télécommunications, Canada. We experimentally demonstrate a highly versatile microwave photonic filter (MPF) based on Kerr optical comb generated by an integrated microring resonator (MR). The MPF features improved Q factors, wideband tunability, and highly reconfigurable filtering shapes.
Widely Tunable Sidebands and Optical Frequency Combs in Passive Nonlinear Resonators, Miro J. Erkintalo

We demonstrate ultra-low power wavelength conversion via four-wave mixing in a hydrogenated amorphous silicon microring resonator. For electrical powers as low as 130 mW, we report the first chip-based microresonator comb source consisting of unclosed vortex lines forming some axis, and closed ones, engirlding the axis.

Fully Integrated Chip Platform for Electrically Pumped Frequency Comb Generation, Brian Stern

We demonstrate the first chip-based microresonator comb source consisting of a semiconductor laser integrated with a silicon nitride microresonator. For electrical powers as low as 130 mW, we generate a single-soliton comb spanning 90 nm.

Ultra-low Power Wavelength Conversion in a Hydrogenated Amorphous Silicon Microring Resonator, Kangmei Li, Michael Kossseg, Amy Foster

We demonstrate ultra-low power wavelength conversion via four-wave mixing in a hydrogenated amorphous silicon microring resonator with 10-μm radius. The results show 22.8-dB conversion efficiency enhancement in the ring compared to a 3.8-mm long waveguide.

Observation of Unconventionally Extended Flat-band States in Photonic Lieb Lattices, Shiqi Xia, Ajith Ramachandran, Qiujian Xue, Dinhui Li, Xiuying Liu, Lijun Tang, Daohong Song, Sergey Flach, Zhigang Chen

We use Manifold Learning to classify topological phases of photonic systems, from an arbitrary set of measurements without any prior knowledge or assumptions.

Experimental Realization of Photonic Topological Insulators in Synthetic Dimensions, Eran Lustig, Steffen Weimann, Yonatan Plotnik, Miguel Bandres, Alexander Szameit, Mordechai Segev

We report the first experimental realization of photonic topological insulators in synthetic dimensions.

Optically Induced Correlated Phase in CaKFe4As2 Superconductor, Richard H. Kim, William R. Meier, Chrig Vainsani, Xi Zhang, Martin Mootz, Zongxin Yao, Mingxu Xu, Italo F. Perakis, Cai-Zhuang Wang

Ultrafast correlation phenomena is studied on a newly discovered, 1144-type superconductor CaKFe4As2 for the first time. Broadband spectral-temporal visualization follows distinct pair-breaking processes and reveal the build-up of a hidden quasiparticle phase with an estimated gap of ~10 meV.
We study the steady state entanglement of this source of bright and broadband, squeezed-light, using active plasmonic approaches and ultra-high quality factor cavity as funneling regime.

We present measurements showing near-life-time limited quantum dot single photon sources for quantum dots embedded in nanoguides, demonstrating the robust suppression of environmental transitions, for quantum dots in solid and nanophotonic waveguides.

We report non-reciprocal microwave-to-optical conversion based on intermodal Brillouin scattering in silicon waveguides. We experimentally demonstrate an efficient classical microwave-to-optical converter using coupled optical microresonators on lithium niobate with $Q = 2.7 \times 10^6$. We measure full-depth optical modulation with a 7 GHz microwave driving voltage of $V_{	ext{pp}} = 70$ mV.

We demonstrate a plasmonic Graphene-based electro-absorption modulator heterogeneously integrated in Silicon photonics consuming 110 aJ/bit and being 15 μm compact. We show how the plasmonic metal enables steep switching via improved contact resistance.
AM1J.4 • 09:00 Plasmonics Improves the Sensitivity of Smartphone Fluorescence Microscopy, Qingshan Wei, Guillermo Acuna, Seungkyeum Kim, Carolin Vietz, Derek Tseng, Jongjae Chae, Daniel Shi, Wei Luo, Philip Pinnefeld, Aydogan Ozcan, North Carolina State Univ., USA; 2Braunschweig Univ. of Technology, Germany; 3Univ. of California, Los Angeles, USA. We developed a handheld and cost-effective film as a plasmonic substrate, enabling the detection of ~80 fluorophores per diffraction-limited spot.

AM1J.5 • 09:15 Deep Learning Microscopy: Enhancing Resolution, Field-of-View and Depth-of-Field of Optical Microscopy Images Using Neural Networks, Yair Rivenson, Zoltán Göröcs, Harun Gunaydin, Yibo Zhang, Hongda Wang, Aydogan Ozcan, Univ. of California Los Angeles, USA; 2School of Engineering and Applied Science, University of Pennsylvania, USA; 3North Carolina State Univ., USA; 4Physics, Harvard Shool, USA. Different complex-valued optical transmission functions is experimentally validated by imaging various samples with independent fiber lasers is used to pump the supercontinuum.

AM1J.6 • 09:30 High-resolution optical coherence tomography in vivo using a nano-optic endoscope, Hamid Pahlevaninezhad, Mohammadreza Khorasaninejad, Tao Wei Huang, Zhujun Qiu, Federico Capasso, Melissa Suter, David Adams, Arun S. Shenoi, Menlo Systems GmbH, Germany; 2Max Planck Inst. of Quantum Optics, Germany. We present agreement in the measurement of optical atomic clock transition frequencies using two independent optical frequency combs to sub-millihertz levels and discuss experiments to improve the measurement instability via coherent atomic clock spectroscopy.

AM1J.7 • 09:45 Robust Holographic Autofocusing Based on Edge Sparsity, Yibo Zhang, Hongda Wang, Yichen Wu, Miu Tamamitsu, Aydogan Ozcan, Univ. of California Los Angeles, USA. A robust holographic autofocusing criterion based on the edge sparsity of refocused images is presented. Its performance is experimentally validated by imaging various samples with different complex-valued optical transmission functions.

AM1K.4 • 09:00 Power Combined, Octave-spanning, CW Supercontinuum using Standard Telecom Fiber with Output Power of 70W, Arun S, Vishal Choudhry, V Balasawmy, V R Supradeepa, Centre for Nano Science and Engineering, Indian Inst. of Science (IISc), India. We demonstrate a high power 70W continuous-wave supercontinuum laser using standard telecom fiber, spanning over an octave (850-1900nm).

AM1K.5 • 09:15 Multi-Wavelength Diode-Pumping of Fiber Raman Laser, Soonki Hong, Yutong Feng, Johan Nilsson, Optoelectronic Research Centre, UK. A fiber Raman laser pumped by two wavelength-combined multimode diode lasers at 950 nm and 976 nm generates up to 25 W of output power at a single wavelength (1020 nm) with 51% slope efficiency.

AM1K.6 • 09:30 Enhancing the Detection Sensitivity of Temporal Imaging by Distributed Raman Amplification, Lingxiao Yang, Sheng Wang, Chi Zhang, Bowen Li, National Univ. of Singapore, Singapore; 2Physics, Harvard Univ., USA. An enhanced temporal imaging system for the first time to enhance the detection sensitivity. 6.7-dB sensitivity improvement has been experimentally demonstrated for a 20-nm-bandwidth signal by a 170-mW Raman pump.

AM1K.7 • 09:45 Absolute Frequency Comb Comparisons and the Measurement of Optical Atomic Clock Transitions, Christine Lisdat, Christian Grott, Silvio Keller, Sofia Herbers, Sebastian Hähner, Uwe Sterr, Stefano Origlia, Mysoor Pramod, Stephan Schiller, Physical-Technische Bundesanstalt, Germany; 2Heinrich-Heine-Universität Düsseldorf, Germany. We report on two transportable lattice clocks with strontium. The first was built by PTB and is installed in a car trailer. It was used to demonstrate "chronometric levelling", i.e. height measurements with clocks by frequency comparisons against a reference clock via optical fibre links. The second apparatus originates from the Space Optical Clock consortium, which has the goal to prepare a space mission with an optical lattice clock. The work is supported by CRC 1128 geo-Q and iSOC.

SM1L.4 • 09:00 Sub-mHz Spectral Purity Transfer for Next Generation Strontium Optical Atomic Clocks, Michela Giunta, Wolfgang Hänsel, Matthias Lezux, Marc Fischer, Ronald Holzwarth, Menlo Systems GmbH, Germany; Max Planck Inst. of Quantum Optics, Germany. We report on a fiber-based optical frequency comb transferring the stability of ultra-stable lasers from 194THz to 429THz. Sub-mHz level transfer to a fiber-delivered 698.4nm output port for future Strontium QPM-limited lattice clocks is demonstrated.

SM1L.5 • 09:15 Portable Optical Lattice Clocks, Christian Lisdat, Jacopo Grott, Silvio Keller, Sofia Herbers, Sebastian Hähner, Uwe Sterr, Stefano Origlia, Mysoor Pramod, Stephan Schiller, Physikalisch-Technische Bundesanstalt, Germany; Heinrich-Heine-Universität Düsseldorf, Germany. I will report on two transportable lattice clocks with strontium. The first was built by PTB and is installed in a car trailer. It was used to demonstrate "chronometric levelling", i.e. height measurements with clocks by frequency comparisons against a reference clock via optical fibre links. The second apparatus originates from the Space Optical Clock consortium, which has the goal to prepare a space mission with an optical lattice clock. The work is supported by CRC 1128 geo-Q and iSOC.
AM1M.5 • 09:15
Laser-based Fabrication of Microfluidic Devices for Porous Media Applications, Kristyan L. Wlodarczyk1, Amir Jahanbakhsh1, Richard Carter2, Robert R. Maier3, Duncan P. Hand4, Mercedes Maroto-Valer5, Henzo Watt6, UK. A picosecond laser is used for rapid prototyping of enclosed microfluidic devices from borosilicate glass substrates. The fabrication method and applications of these devices for the investigation of subsurface flow processes in porous media are presented.

AM1M.6 • 09:30
Ultrafast Laser Texturing on Si with Burst-mode Picosecond Laser Pulses, Iaroslav Gnilitskyi1, Leonardo Orazi1, Tommi White2, Vitaly Grudiev3,1, UNIMORE, Italy, 1Dept. of Mechanical & Aerospace Engineering, Univ. of Missouri, USA; 2NoviNano Inc., Ukraine. Picosecond laser-induced periodic surface structures (PLIPSS) have been fabricated on surface of Si in uniform and burst-mode regimes at a high speed. The effects of burst-mode respect to uniform one are examined in term of chemical, mechanical and morphological properties.

AM1M.7 • 09:45
Influence of Laser Power and Scanning Velocity in One- and Two-Step Laser Cladding on Ultra-Thin Substrates, Tobias Gabriel1, Florian Scherm2, Marek Gorywoda3, Uwe Glatzel4,1, IMTEK, Germany; 2Center for Laser Materials, Univ. of Technology Sydney, Australia. The shock wave created by a high energy ablation plume enabling higher resolution in laser induced cladding on 200 µm thin substrates is a challenge due to poor heat dissipation. Successful coatings were produced using Yb fiber laser with closed-loop controlled laser power. Samples were investigated by SEM and EDS.

SM1N.5 • 09:00
In situ 3-D temperature mapping of high average power cryogenic laser amplifiers, Han Chi1, Kristian Dehne2, Cory Baungarten3, Hanchen Wang4, Liang Yin5, Brendan Reagan6, Jorge Roca7,8, Depart. of Electrical and Computer Engineering, Colorado State Univ., USA; 2Dept. of Physics, Colorado State Univ., USA; 3Dept of Physics, Florida State Univ., USA. We demonstrate an accurate, in situ, noninvasive optical technique to generate 2-D and 3-D maps of the temperature profile within cryogenic amplifiers operating at high average power.
AM1P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition I—Continued

AM1P.3 • 09:00
Engineering Challenges in Commercial Photonics-enabled Quantum Technologies, Max Perez
ColdQuanta, Inc., USA. As quantum technologies mature, their physical potential clarify but the practical engineering challenges remain. We describe the challenges and trade-offs made when transitioning quantum devices from the Lab to the commercial domain.

AM1P.4 • 09:30
10 years of commercial quantum key distribution: engineering achievements and market challenges, Rik van Gorsel, id Quantique, USA. Quantum communication needs good and reliable instrumentation. id Quantique (IDQ) started in 2002. In order to launch our QKD system in 2007 for elections in the Swiss canton of Genève, we needed to develop the necessary instrumentation as very little existed. For example, a good NIR-SPAD (near infrared single photon avalanche photodiode detector). We have continuously been improving the detectors, so that now we have a NIR-SPAD with single digit dark count rates per second. With such a low dark count rate instrument, we have been able to show quantum key distribution through more than 300 km of high quality optical communication fiber. Our developments in electronics have paralleled the developments in single photon instrumentation. Good hardware is not enough for good technology. Quantum physics-based hardware, firmware, and QKD software needs to be integrated. It also requires the ability and flexibility to integrate new technological developments in any area of quantum communication. For example, originally systems were all-fiber. Current developments in free space communication are rapid and it is not unlikely that a reliable, robust infrastructure will mean a distributed hybrid system with a combination of free space (large distances) and wired communication (in hubs, and free space complement). Good technology is not enough for a good quantum communication network. Trust probably is the most precious element. Trust takes years to build and is very valuable to us. Trust cannot be abstract, but has to be practical and verifiable. For example, our quantum random number generator (QRNG) has been time-proven, and certified by independent organizations in different countries. Current progress in quantum communication is rapid and accelerating and makes the development of solutions to technology and implementation bottlenecks more urgent. I look forward to detail both the technological achievements and discuss the constraints, including limitations by the current infrastructure, solutions to national security concerns of global quantum communication network(s), and the feasibility of cross-border partnerships, e.g. IDQ and US partners.

AM1P.5 • 09:45
Parametric-Down Conversion of X-rays into the Optical Regime, Aviad Schori
1Bar-Ilan Univ., Israel; 2European XFEL, Germany; 3Diamond Light Source, UK; 4European Synchrotron Radiation Facility, France. We observe parametrically down converted x-ray signal photons that correspond to idler photons at optical wavelengths. The results represent a new method for probing valence-electron charges and microscopic optical responses of crystals with atomic-scale resolution.

AM1P.6 • 09:00
Few-Cycle-Culse-Driven Metasurface-Based Multi-Color X-ray Source, Gilles D. Rosolen, Liang Jie Wong, Nicholas Rivera
1Bjorn Maes, 2Marin Soljacic, 3Ido Kaminer
1Univ. of Mons, Belgium; 2Singapore Inst. of Manufacturing Technology, Singapore; 3MIT, USA. We present a multi-harmonic metasurface-based hard X-ray source in which velocity-matched few-cycle laser pulses lead to output brightness enhancements of over 1000 times compared with the non-optimized case.

AM1P.7 • 10:00
Picosecond backward-propagating lasing of atomic hydrogen via femtosecond 2-photon-excitation in a flame, PengJi Ding
1ColdQuanta, Inc., USA. We report on the observation of backward-propagating 656-nm lasing of atomic hydrogen in flame using 205-nm femtosecond laser pulses. It shows a donut-shaped spatial mode and smooth temporal profile, suggesting spatially-resolved measurements in few-millimeters resolution.

FM1Q.5 • 09:00
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FM1Q.8 • 09:45
Resonance-Enhanced Harmonics From Air Plasma In The Perturbative Regime, Rostyslav Danylo
1, Ying Liu 2, Mingwei Lei 3, An Zhang 3, Qiang Liang 3, Zhengquan Fan 1, Xiang Zhang 3, Hongbing Jiang 4, Chengyi Wu 4, Aurelien Houard 2, Vladimir Tikhonchuk 3, Qihuang Gong 4, Andrei Mysyrowicz 2
1Shanghai Key Lab of Modern Optical System, Univ. of Shanghai for Science and Technology, China; 2Laboratoire d’Optique Appliquée, ENSTA ParisTech, CNRS, Ecole Polytechnique, Université Paris-Saclay, France; 3Centre Lasers Intenses et Applications, Université de Bordeaux, CEA, CNRS UMR, France; 4State Key Lab for Mesoscopic Physics, Inst. of Modern Optics, Dept. of Physics, Peking Univ., China. Air pumped by mid-infrared femtosecond pulses gives rise to coherent emission at 391 nm. Based on ellipticity dependence measurement and time-resolved characterization, we attribute this emission to resonance-enhanced harmonics in perturbative regime.
Monday, 10:30–12:30

**JM2A.1 • 10:30**

**Nanoscale Electron Manipulation Using Phase-controlled THz Near-fields**

Jun Takeda 1, Katsumasa Yoshioka 2, Yusuke Arashida 1, Ikufumi Katayama 3

1Yokohama National Univ., Japan; 2Yokohama National Univ., Japan. By utilizing terahertz scanning tunneling microscopy (THz-STM) with phase-controlled THz near-fields, we could successfully implement the phase-resolved sub-cycle electron dynamics in a tunnel junction.

**JM2A.2 • 11:00**

**Sampling the Terahertz Near-Field in Ultrafast Terahertz Scanning Tunneling Microscopy**

Vedran Jelic 1, Peter H. Nguyen 1, Yang Luo 2, Daniel Mildenberger 3, Jesus A. Calzada 4

1Univ. of Alberta, Canada; 2Center for Advancing Electronics Dresden, Dresden, Germany; 3cfaed - Center for Advancing Electronics Dresden, Dresden, Germany; 4Dept. of Physics and Applied Optics Beijing Area Major Lab, 4 Dept. of Physics and Applied Optics Beijing Area Major Lab, Beijing University of Technology, China. We demonstrate that 800 nm femtosecond pulses focused onto the tip of an ultrafast terahertz scanning tunneling microscope (THz-STM) can be used to sample the terahertz electric near-field at the tip apex.

**JM2A.3 • 11:15**

**Nonlinear Plasmonic Response of Doped GaAs Nanowires Observed in s-nNIM**

Denny Lang 1, Leila Balaghi 1,2, Emmanouil Dimakis 1, Rene Hubner 1, Susanne Kehr 3, Lukas Engl 1, Oleksy Pashkin 1, Stephan Winnerl 1, Harald Schneider 1, Manfred Helm 1,3

1Inst. of Applied Physics, Technische Universität Dresden, Dresden, Germany; 2cfaed - Center for Advancing Electronics Dresden, Dresden, Germany; 3Insitut für Nachrichtentechnik, Technische Universität Berlin, Berlin, Germany. We present nanoscopic infrared-optical investigations on highly n-type doped GaAs-based nanowires, revealing interesting nonlinear phenomena such as a pronounced redshift of the plasma resonance by the strong THz fields of a free-electron laser.

**JM2A.4 • 11:30**

**Watching a Single Molecular Orbital Move**

Dominik Peller 1, Tyler Cocker 1, Ping Yu 1, Jascha Repp 1, Rupert Huber 1

1Univ. of Regensburg, Germany. We explore a new arena of ultrafast microscopy capturing the femtosecond motion of an individual molecule. Entering a novel, single-electron tunneling regime with lightwave-driven scanning tunneling microscopy, we resolve femtosecond vibrations of a single molecule with sub-angstrom precision.

**SM2B.1 • 10:30**

**Subwavelength Engineered Metamaterial Devices for Integrated Photonics**

Michael Galili 1, Toshihiro Moroita 2, Krieten Yind 1, Leif K. Oxenløве 1

1DTU Fotonik, Denmark; 2Queen’s National Inst. , Ireland. We will present an overview and recent advances of this surging field.

**SM2B.2 • 11:00**

**Separating Valley Excitons in a MoS2 Monolayer at Room Temperature with a Metasurface**

Liyang Sun 1, Chun-Yuan Wang 2, Alexandre Krasnoki 3, Junho Choi 1

1Dept. of Physics, The Univ. of Texas at Austin, USA; 2Dept. of Physics, National Tsing-Hua Univ., Taiwan; 3Dept. of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA. We demonstrate directly contacted graphene-silicon (THz-STM) with phase-controlled THz near-fields, we could successfully implement the phase-resolved sub-cycle electron dynamics in a tunnel junction.

**SM2B.3 • 11:15**

**Broadband Waveguide Integrated Black Phosphorus Modulator for Mid Infrared Application**

Roaming Peng 1, Hao Huang 1, Enis Akbaba 1, Kejia Li 1, Hatem Akel 1, Tedros Tsegaye 1, Sunil Khatana 1

1Univ. of Delaware, USA; 2Nokia Bell Labs, USA. We report an all-fiber orbital angular momentum (OAM) multiplexing transmission link over 2.6-km conventional OM-3 fiber for data center networks. OAM modes are excited, multiplexed and demultiplexed by commercial SFP+ transceivers and mode selective couplers.

**SM2B.4 • 11:30**

**Small-signal model for heterogeneous integrated graphene-silicon photonics, Dun Mao 1, Thomas M. Kananen 1, Po Hao Huang 1, Enis Akbaba 1, Kejia Li 1, Hatem Akel 1, Tedros Tsegaye 1, Suril Khatske 1, Lumentum Operations LLC, USA. We demonstrate sensitivity improvement for 100 G single wavelength PMD link using an APD receiver. 2.7 dB OMA sensitivity advantage is observed as compared to a PIN receiver using the same TIA.**

**SM2C.1 • 10:30**

**2.6-km All-Fiber Orbital Angular Momentum (OAM) Multiplexing Link for Data Center Networks (DCNs) using Mode Select Coupler and Commercial SFP+ Transceivers**

Yize Liang 1, Xinzhau Su 2, Yifan Zhao 1, Jie Hu 1, Wei Zhou 1, Yan Luo 1, Zongyuan Huang 1, ShuHu Li 1, Jian Wang 1

1WuhanNational- Lab for Optoelectron, China. We report an all-fiber orbital angular momentum (OAM) multiplexing transmission link over 2.6-km conventional OM-3 fiber for data center networks. OAM modes are excited, multiplexed and demultiplexed by commercial SFP+ transceivers and mode selective couplers.

**SM2C.2 • 10:45**

**Intensity-Modulation Direct-Detection OCDM System Based on Digital Up-Conversion**

Rongping Guan 1, Francesco Da Ros 1, Minhao Pu 1, Mads Lilienthal 1, Yi Zheng 1, Elizaveta Semenova 1, Pierre-Yves Bony 1, Michael Galili 1, Toshihiro Moroita 2, Krieten Yind 1, Leif K. Oxenløve 1

1DTU Fotonik, Denmark. We demonstrate a WDM-PON transmitter based on optical Fourier transformation of a single-source TDM-PON using a single AlGaAs-on-insulator waveguide, 128 WDM-PON signals at 2 Gb/s are generated and transmitted over a 100-km unamplified link.

**SM2C.3 • 11:00**

**128 × 2 Gb/s WDM PON System with a Single TDM Time Lens Source using an AlGaAs-On-Insulator Waveguide**

Pengyu Guan 1, Francesco Da Ros 1, Minhao Pu 1, Mads Lilienthal 1, Yi Zheng 1, Elizaveta Semenova 1, Pierre-Yves Bony 1, Michael Galili 1, Toshihiro Moroita 2, Krieten Yind 1, Leif K. Oxenløve 1

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We will review a compact and highly tunable source of optical frequency combs using cascaded four-wave mixing in a loop augmented by tailored optical feedback. We achieve ~98 lines in a 25GHz C-band frequency comb spanning 20nm.

SM2D.3 • 11:00

Invited

Generation of Quantum States in Nonlinear Whispering-Gallery Resonators, Christoph Marquardt1,2, Max-Planck-Institut für Physik des Lichts, Germany; 1Universität Erlangen-Nürnberg, Germany. We will review a compact and highly tunable source of photon-pairs and squeezed light based on efficient parametric down conversion in a triply resonant whispering-gallery resonator (WGR) made out of lithium niobate.

SM2D.4 • 11:30

Two-Beam Coupling in Dual-Seeded Four-Wave Mixing, Nicholas Brewer1, Meng-Chang Wu1, Bonnie L. Schmitt1, Paul D. Lett1,2, Univ. of Maryland, USA; 1National Inst. of Standards and Technology, USA. We observe the two-beam coupling effect in dual-seeded four-wave mixing. The effect adds excess noise to the probe seeds at frequencies below 5 MHz when both probe seed powers are over 10 µW.

Monday, 10:30–12:30

Executive Ballroom 210D

CLEO: Science & Innovations

10:30–12:30

SM2D • Nonlinear Optical Phenomena

Presider: Amol Choudhary, Univ. of Sydney, Australia

10:30

Power and Bandwidth Scaling of Electro-Optic Frequency Comb using Cascaded Four-Wave Mixing in a loop augmented by Tailored Optical Feedback, Roope Prakash1, B S Vikram2, Nagarjun KP2, Shankar Kumar Selvaraja1, V R Supradeepa1, Centre for Nano Science and Engineering, Indian Inst. of Science, Bangalore, India. We demonstrate power and bandwidth scaling of electro-optic frequency combs using cascaded four-wave mixing in a loop augmented by tailored optical feedback. We achieve ~98 lines in a 25GHz C-band frequency comb spanning 20nm.

SM2D.2 • 10:45

Widely-Tunable Optical Parametric Oscillation in MgF2, Microresonators, Noel Lito B. Sayson1, Hoan Pham1, Karen E. Webb1, Luke S. Trainor2, Harald G. Schweefel1, Stephanie Coen1, Miro J. Erkintalo1, Stuart G. Murdoch1, University of Auckland, New Zealand, New Zealand; 1The Univ. of Otago, New Zealand. We present a widely-tunable microresonator optical parametric oscillator based on a high-finesse MgF2 microdisk. The oscillator operates at low-power with output parametric sidebands discretely tunable from 1166 nm to 2226 nm.

SM2D.3 • 11:20

Generation of Quantum States in Nonlinear Whispering-Gallery Resonators, Christoph Marquardt1,2, Max-Planck-Institut für Physik des Lichts, Germany; 1Universität Erlangen-Nürnberg, Germany. We will review a compact and highly tunable source of photon-pairs and squeezed light based on efficient parametric down conversion in a triply resonant whispering-gallery resonator (WGR) made out of lithium niobate.

SM2D.4 • 11:30

Two-Beam Coupling in Dual-Seeded Four-Wave Mixing, Nicholas Brewer1, Meng-Chang Wu1, Bonnie L. Schmitt1, Paul D. Lett1,2, Univ. of Maryland, USA; 1National Inst. of Standards and Technology, USA. We observe the two-beam coupling effect in dual-seeded four-wave mixing. The effect adds excess noise to the probe seeds at frequencies below 5 MHz when both probe seed powers are over 10 µW.

FM2E • Topological Photonics and Lasers

Presider: Mikael Rechtsmans; Pennsylvania State Univ., USA

10:30–12:30

FM2E.1 • 10:30

Topological Photonics, Montsechi Segov1,2, Technion, Israel. The fundamentals of the new field of Topological Photonics will be described, along with recent discoveries such as photonic topological insulators in synthetic dimensions, topological protection of quantum states, and topological insulator lasers.

Moti Segov is the Robert J. Shillman Distinguished Professor of Physics, at the Technion, Israel. He received his BSc and PhD from the Technion in 1985 and 1990. After postdoc at Caltech, he joined Princeton as Assistant Professor (1994), becoming Associate Professor in 1997, and Professor in 1999. Subsequently, Moti went back to Israel, and in 2009 was appointed as Distinguished Professor. Moti’s interests are mainly in nonlinear optics, photonics, solitons, subwavelength imaging, lasers, quantum simulators and quantum electronics, although he finds entertainment in more demanding fields such as basketball and hiking. He has won numerous international and national awards, among them the 2007 Quantum Electronics Prize of the EPS, the 2008 Landau Prize (Israel), the 2009 Max Born Award of the OSA, and the 2014 Arthur Schawlow Prize of the APS. In 2011, he was elected to the Israel Academy of Sciences and Humanities, and in 2015 he was elected to the National Academy of Science of the USA. In 2014 Moti Segov won the Israeli Prize in Physics (highest honor in Israel). However, above all his personal achievements, he takes pride in the success of his graduate students and postdocs, among them are currently 19 professors in the USA, Germany, Taiwan, Croatia, Italy, India and Israel, and many holding senior R&D positions in the industry.

FM2E.2 • 11:30

Nonlinear Nanophotonics and Bound States in the Continuum, Luca Carletti1, Kirill Koshelev1,3, Costantino De Angelis2,1, University of Erlangen-Nuremberg, Germany. We reveal that nonlinear effects at the nanoscale can be enhanced by bound states in the continuum. We demonstrate SHG from subwavelength AlGaAs nanantennas with record-high conversion efficiency when resonator parameters match the proper conditions.

FM2E.3 • 11:45

Control of coherently coupled exciton-polaritons in atomic crystals, Xiaoyue Li1, Wei Bao1, Quanwei Li1, Chad Ropp1, Yuan Wang1,2, Xiang Zhang1,2, University of California Berkeley, USA; 1Materials Sciences Division, Lawrence Berkeley National Lab, USA. We demonstrate, for the first time, controlled polariton emission with hybrid composition in monolayer tungsten disulfide due to robust coherent exciton-photon coupling over a broad temperature range of 110-230 K in a single cavity.
10:30–12:30
FM2G • Novel Nonphotonic Light Sources
Presider: Mo Mojahedi; Univ. of Toronto, Canada

FM2G.1 • 10:30
Reconstructing the Scattering Matrix of Photonic Systems from Their Quasinormal Modes, Filippo Alpeggiani,1,2 Nishi Paraparuth1, Ewold Verhagen1, Laurens K. Kuipers1,2,3 Dept. of Quantum Nanoscience, TU Delft, Netherlands; 2Center for Nanophotonics, AMOLF, Netherlands. We demonstrate that the scattering matrix of nanophotonic systems is completely determined by their quasinormal modes and present a first-principle expansion technique which is directly applicable to an arbitrary number of modes and input-output channels.

FM2G.2 • 10:45
High harmonic plasmon generation by dressed electrons, Nicholas Rivera1, Liang Jie Wong2, Marin Salajpic3, Ido Kaminer1,3, MIT, USA; 2SimTECH, Singapore; 3Technion Israel Inst. of Technology, Israel. We show that high harmonics of highly spatially confined plasmons can be generated via free electrons using light intensities 103-104 times smaller than is required for an equivalent multiphoton effect in free space.

FM2G.3 • 11:00
A New Class of Light Sources Based on Electrically-Driven Optical Antennas, Claire Deeb1,2,3, Claire Deeb1,2,3, C2N - CNRS, France. A new class of nanoscopic light sources that are not limited by quantum states, but rather depend on the antenna architecture and the applied bias is proposed. These compact light sources, based on electrically-driven optical nanogap antennas, feature a tunable emission wavelength, a high quantum efficiency, and operate at room temperature.

FM2G.4 • 11:30
Generation of Vortex Beams using a Plasmonic-Quadrumer Nanocluster, Apurva Chaitanya Netlikka1, Pawel Wozniak1, Peter Banzer2,3, Israel De Leon4,5,6, School of Engineering and Sciences, Tecnológico de Monterrey, Mexico; 2Max Planck Inst. for the Science of Light, Germany; 3Inst. of Optics, Information and Photonics, Germany; 4Max Planck - Univ. of Ottawa Centre for Extreme and Quantum Photonics, Canada. We show that the interaction of tightly-focused circularly-polarized Gaussian beams with a nanophotonic quadrumer can generate orbital angular momentum beams in the farfield. These quadrumer can act like a nano-aplate, generating desired vortex order.

10:30–12:30
FM2H • Quantum Optics with Single Atoms
Presider: Virginia Lorenz; U. Illinois at Urbana-Champaign, USA

FM2H.1 • 10:30
Atom-mediated Spontaneous Parametric Down-conversion Using Evanescent Modes in Nonlinear Periodic Waveguides, Sina Saravi1,4, Alexander N. Poddubny1,2, Thomas Pertsch1, Frank Setzpfandt1, Andrey A. Sukhorukov1,2, Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany; 2FOM Univ., Russia; 4Technion Israel Inst., Russia; 3Nonlinear Physics Centre, Australian Natl. Univ., Australia. Relying on the bandgap modes of a nonlinear periodic waveguide, we propose the concept of atom-mediated spontaneous parametric down-conversion, where photon-pairs are only generated with a single 2-level emitter present, creating a heralded excitation mechanism.

FM2H.2 • 10:45
Towards Quantum-Enabled Flow Cytometry, Ivan A. Burenkov1,2, Yu-Hsiang Cheng3, Sergey Polyakov2,4, Joint Quantum Inst., NIST and UMD, USA; 3PML, National Inst. of Standards and Technology, USA. We enhance an optical flow cytometer with a photon-number statistics measurement. Our technique allows for an absolute measurement of biomarker concentration and proves sensitivity to a single biomarker (a colloidal quantum dot).

FM2H.3 • 11:00
Purcell-enhanced single-photon emission from an atom in a fiber-based cavity, Deepak Pandey1,2, Jose Gallego1, Tobias Mache1, Miguel Martinez-Dorantes1,3, Wolfgang Alt4, Dieter Meschede1,3, Inst. for Applied Physics, Univ. of Bonn, Germany. We report a sixfold Purcell broadening of a resonance line of a $^{197}$Eu$^{3+}$ atom, by strongly coupling it to a single-sided fiber-based Fabry-Perot cavity which collects 90% of the enhanced single photon emission.

FM2H.4 • 11:15
A Hybrid Nanophotonic-Magnetic Chip-Based Atom Trap, Adam T. Black1, Marcel W. Pruessner1,2, Doewon Park1, Charles T. Fancher1, Dmitry Kazakov1, Rita Mahon1, Mark Bashkansky1, Frederik K. Fatemi2, Todd Stievater1, US Naval Research Lab, USA; 1U.S. Army Research Lab, USA. We report progress toward the development of a chip-based cold atom trap based on nanoscale waveguides, which incorporates a fabricated two-wire magnetic trap to assist in transferring laser-cooled atoms to the waveguides.

FM2H.5 • 11:30
Coherent Superradiance by Single Atoms, Kyungwon An1, Jung Kim2, Daeoh Yang3, Seunghoon Oh1, Seoul National Univ., South Korea. We report cavity-mediated coherent single-atom superradiance, where single atoms with predefined correlation traverse a cavity one by one, emitting photons cooperatively with the atoms already gone through the cavity during the cavity field decay time.

Meeting Room
211 B/D

SM2I • Integrated Detectors
Presider: Zhihong Huang; Hewlett Packard Labs, USA

SM2I.1 • 10:30
High-performance InGaAs/In photodiodes on silicon using low-temperature wafer-bonding, Qianhuan Yu1, Ye Wang2, Lini Xie3, Souheil Nadi3, Kenye Sun4, jiahao zang5, Qinglong Li6, Robert M. Weikle7, Andreas Beling7, Univ. of Virginia, USA. We demonstrate back-illuminated III-V modified uni-traveling carrier photodiodes on silicon using SU-8 as the bonding layer. Responsivity at 1620nm, bandwidth, output RF power and OIP3 are 0.8A/W, 18GHz, 4dBm and 22.5dBm at 9GHz, respectively.

SM2I.2 • 10:45
Germanium Photodetector with Carrier Acceleration, De Zhou1, Yu Yu1, Yan Zu2, Xinliang Zhang1, Wuhan National Lab for Optoelectronics, China. We propose and demonstrate a carrier acceleration technique, which alleviates the transit-time delay by introducing a pair of on-chip accelerating electrodes. Equivalent circuit simulation and experimental results validate the improved performance.

SM2I.3 • 11:00
100 GHz Photocurrents and Photodiodes for Extreme and Quantum Photonics, Canada. We show that high harmonics of highly spatially confined plasmons can be generated via free electrons using light intensities 103-104 times smaller than is required for an equivalent multiphoton effect in free space.

SM2I.4 • 11:15
Nanostructured Fishnet Silicon Photodetector Pixels as a Fully-Contained Microspectrometer Chip, Jasper Cadusch1, Jinjun Meng1, Kenneth B. Crozier1,2,3, Dept. of Electrical and Electronic Engineering, Univ. of Melbourne, Australia; 2School of Physics, Univ. of Melbourne, Australia. We experimentally demonstrate a microspectrometer comprising twenty silicon photodetector pixels, whose responsivities are engineered via nanostructured fishnet patterns. We computationally reconstruct the spectrum of light that illuminates the chip from the measured pixel documents.

SM2I.5 • 11:30
High-speed Si plasmonic photodetector based on internal photomission and two-photon absorption, Hidetaka Nishi1, Hidetaka Nishi1,2,3,4,5,6, Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany; 2Graz University of Technology, Austria; 3Max Planck - Univ. of Ottawa Centre for Extreme and Quantum Photonics, Canada. We show that high harmonics of highly spatially confined plasmons can be generated via free electrons using light intensities 103-104 times smaller than is required for an equivalent multiphoton effect in free space.

SM2I.6 • 11:45
High-speed Si plasmonic photodetector based on internal photomission and two-photon absorption, Hidetaka Nishi1, Hidetaka Nishi1,2,3,4,5,6, Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany; 2Graz University of Technology, Austria; 3Max Planck - Univ. of Ottawa Centre for Extreme and Quantum Photonics, Canada. We show that high harmonics of highly spatially confined plasmons can be generated via free electrons using light intensities 103-104 times smaller than is required for an equivalent multiphoton effect in free space.
Interrogating Biological Dynamics in Five Dimensions with Multispectral Optoacoustic Tomography, Daniel Razansky1, 1Inst. for Biological and Medical Imaging, Helmholtz Center Munich, Germany; 2Faculty of Medicine, Technical Univ. of Munich, Germany. The talk focuses on the recent advances in multi-spectral optoacoustic tomography and microscopy, an emerging new technology that attains versatile endogenous and exogenous optical absorption contrast from deep tissues with excellent spatial and temporal resolution not achievable with other bio-imaging modalities.

Speckle-Free Non-Invasive Imaging with Speckle-Modulating Optical Coherence Tomography, Orly Liba1, Matthew D. Lew1, Elliott SoRelle1, Rebecca Dutta1, Debasish Sen1, Darius Moshfeghi1, Steven Chu1, Adam de la Zerda1; 1Stanford Univ., USA. Tissue polarimetry offers valuable insight into the microstructure and composition of biological samples. Recent developments enable accurate reconstruction of depth-resolved polarization properties, including vectorial birefringence, with fiber and catheter-based polarization sensitive optical coherence tomography.

Efficient Electro-Optic Modulation, Huiyong Guo1,2, Zhou Zheng2, Yi Liu1,2, Zeng Xiong2, Yiwen Ou2, Yiwen Ou2, Yiwen Ou2; 1Univ. of Toronto, Canada; 2Wuhan Univ. of Technology, China. We experimentally demonstrate a novel method for electro-optic modulation over 2–8 GHz using CO2-laser. The polarization and sensing characteristics of the gratings were investigated experimentally.

Broadband Multi-Species CARS in Gas-Filled Hollow-Core Photonic Crystal Fiber, Rinat Tyumenev1, Barbara M. Trabold1, Yi Liu1,2, Zeng Xiong2, Yiwen Ou2, Yiwen Ou2, Yiwen Ou2; 1Inst. for Light, Germany. We report CARS in hollow-core gas-filled PCF. The results pave the way to single-shot broadband (>4000 cm−1) CARS under ambient conditions. A detection limit of 300 ppm was reached with 200 mW overall laser power.

Reduction of Amplitude-to-Phase Conversion in Charge-Compensated Modified Uni-travelling Carrier Photodiodes, Jihao Zang1, Xiaojun Xue1, Qianhuan Yu1, Keye Sun1, Andreas Beling1, Joe C. Campbell1; 1Univ. of Virginia, USA. We report optimization of charge-compensated modified unistral travelling carrier photodiodes to reduce amplitude-to-phase conversion. Phase variation with photocurrent is decreased by up to 5 times.

Synthesizing Ultrastable Radio Waves from Light, William Loh1,2, Massachusetts Inst of Tech Lincoln Lab, USA. The continual development of advanced laser sources with ever-increasing spectral purity gives rise to the possibility of using light as the underlying means for the generation of ultrastable radio waves. In this tutorial, we review the techniques by which laser light can be used to synthesize some of the purest forms of RF oscillation known today.

William Loh is technical staff of the Quantum Information and Integrated Nanosystems group at MIT Lincoln Laboratory. He was previously at NIST Boulder and obtained his Ph.D. from MIT. His research focuses on the interplay between photonics and electronics for the generation of precision oscillators in both the optical and RF domains.
Industrial Applications Enabled by Energetic Next-gen Lasers, Craig W. Siders; Lawrence Livermore National Lab, USA. We will review the needs for next-generation applications of high-power lasers, compare with state-of-the-art technical performances, and discuss DPSSL architectures, evolved from Inertial Confinement Fusion and Inertial Fusion Energy lasers, to deliver multi-100-kW, PW-class performances.

Single-frequency Mod-hop Free Tunable 3um Laser Pumped by a 2W Diode for Isotopic Gas Sensing, Jue-Yu Lan; Hsien-Tse Guan, Yu-Chen Chen, Cheng-Wei Hsu; Dong-Yi Wu, Ming-Hsien Chou, Shang-Da Yang; Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan; HC Photonics Corp., Taiwan. A diode-pumped intracavity optical parametric oscillator is built to demonstrate single-frequency and mod-hop-free tuning operation over 20 GHz range around 3um. Performance is verified by measuring absorption spectrum of isotopic methane.

Industrial GHz femtosecond amplified laser source for high efficiency laser ablation, Gaëlle Bonamis; Konstantin Mihalchik, Inka Maneck-Hoening, Clemens Hoening, Eric Mottay; Amplitude Systemes, France; Université Bordeaux, France. We present a new high power industrial GHz femtosecond laser. The laser source provides GHz-bursts with up to 100W average power. First ablation tests show a three times increase in ablation efficiency.

Self-seeded high-power Mamashev oscillator, Pavel Sidorenko; Walter P. Fu, Logan Wright, Frank W. Wise; School of Applied and Engineering Physics, Cornell, USA. We demonstrate an environmentally stable, self-seeded fiber oscillator based on spectral reshaping and reamplification. The oscillator delivers 140 nJ, linearly chirped pulses with 110 nm spectral bandwidth that can be compressed externally to 63 fs.

Mechanically exfoliated Rhenium disulfide onto D-shaped optical fiber for sub-300 fs EDFL mode-locking, David Steinberg, Juan Zapata, Eunézio Thoroh de Souza, Lúcia Saito; Universidade Presbiteriana Mackenzie, Brazil. For the first time, we present the ultrashort pulse generation of sub 300-fs mode-locked Erhom doped fiber laser using mechanically exfoliated ReS2 deposited onto the polished surface of a D-shaped optical fiber.

All Fiber Laser with the Gain Medium of Tm3+ Doped Optical Fiber, Frédéric Delahaye, Fouad Amrani, Benoit Debord; GPPMM, XLIM, UMR 7252 Univ. de Limoges, France; Glo-Photonics, France; Instituto de Plasmas e Fusao Nuclear, Portugal. We report on the first tunable plasma-core fiber laser based UV-UV radiation source. The emission spans over 236-450 nm range. The source is made with microwave-driven plasma-core photonic-crystal-fiber and with a fixed beam output-coupling configuration.

Using Planar Hyperbolic Metamaterials to Enhance Spontaneous Emission in Two-dimensional Transition Metal Dichalcogenides, Cheng-An Lin; Cheng-Li Yu; Hsiang-Ting Lin; Chao-Yun Chang; Hao-Chung Kuo; Min-Hsiung Shih; Dept. of Photonics & Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan; Research Center for Applied Sciences (RCAS), Academia Sinica, Taiwan. We designed a one-dimensional planar hyperbolic metamaterials (P-HMMs) which supported high k modes and had better coupling compared to multilayers HMMs. Therefore, spontaneous emission enhancement and the strong coupling between P-HMMs and 2D materials were achieved.
AM2P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition II
Presider: TBD

AM2P1 • 10:30
The Challenge of Complexity, Control, and Low Reliability in Quantum Sensors, John H. Burke1; 1US Air Force Research Lab, USA. TBD

AM2P2 • 10:30
Invited
Photons for Quantum Sensing, Brenton C. Young1; 1AOSense, Inc., USA. Critical defense and civilian assets currently rely on the exquisite accuracy of atomic clocks. The rapidly expanding capabilities of quantum sensors will soon revolutionize high-accuracy navigation. AOSense is developing robust quantum technology components and systems.

AM2P3 • 11:00
Invited
Quantum RF Electric-field Sensing with Rydberg-atom Vapors, David Andersen; Rydberg Technologies LLC, USA. The emergence of quantum sensor technologies is driving a paradigm shift in modern sensing and measurement instrumentation by enabling fundamentally new detection capabilities and performance metrics that are unmatched by those of traditional sensor technology. Quantum sensing of radio-frequency (RF) electric fields using Rydberg electromagnetically-induced transparency (EIT) in atomic vapors has recently been established as a viable new quantum technology, and rapid progress is being made towards practical measurement devices. In this talk I will provide an overview of the technology, from the underlying measurement method to notable recent advances, including the realization of compact sensing elements capable of broadband RF measurement for MHz to >100 GHz electric fields, and measurement ranges spanning sub-10 mV/m to >10 kV/m (120 dB dynamic range in intensity). Existing challenges in extending RF field sensitivity limits, as well as new measurement capabilities and future directions will be discussed.

FM2Q • Non-Hermitian and PT Photonics
Presider: Yuan Wang; Univ. of Berkeley, USA

FM2Q1 • 10:30
Non-Hermiticity-induced flat bands, Hamidreza Ramezani1; 1Univ. of Texas, Rio Grande Valley, USA. We show increasing the non-Hermiticity in PT-symmetric Lieb lattices results in generating a robust entire flat band at the exceptional point. The obtained flat band is embedded in between dispersive bands and can be considered as BIC [1].</div>

FM2Q2 • 10:45
Photonic Parity-Time Symmetric Topological Edge States in a Two-Dimensional Lattice., Jiho Noh1, Wladimir A. Bernalcazar2, Taylor L. Hughes1, Michael C. Rechtsman1; 1Dept. of Physics, Pennsylvania State Univ., USA; 2Dept. of Physics, Univ. of Illinois at Urbana-Champaign, USA. We propose the realization of topological edge states in two-dimensional non-Hermitian parity-time symmetric structure with C6 symmetry. Also, we study the bulk topological invariants that explain the topological phase of the non-Hermitian Hamiltonian.

FM2Q3 • 11:00
Non-Hermitian Topological Photonics, Bo Zhen1, Hengyun Zhou1, Chao Peng1, Yoseob Yoon2, Chia Wei Hsu1, Keith Nelson1, Huitao Shen1, Liang Fu2, John Joannopoulos1; 1Stanford Univ., USA; 2MIT, USA; 3Yale Univ., USA. We present recent results in developing topological band theory for non-Hermitian systems as well as our experimental discovery of two phenomena: bulk Fermi arcs and fractional topological charges in polarization, both arising from paired exceptional points.

FM2Q4 • 11:30
Effects of non-Hermitian perturbations on Weyl Hamiltonians with arbitrary topological charges, Alexander Cerjan1, Meng Xiao1, Luqi Yuan1, Shanhui Fan1; 1Stanford Univ., USA. We provide a systematic study of non-Hermitian topologically charged systems, demonstrating that adding an arbitrary non-Hermitian perturbation transforms the Weyl points to one-dimensional exceptional contours, and can yield a topological phase transition.
Future Directions in Terahertz Scanning Tunneling Microscopy, Frank A. Hegmann; Physics, Univ. of Alberta, Canada. Terahertz scanning tunneling microscopy (THz-STM) has recently enabled new approaches for exploring ultrafast dynamics in materials with sub-nanometer spatial resolution. The basic physics of THz-STM, recent developments and future directions will be discussed.

Transfer printing of photonic nanostructures to silicon integrated circuits, Charalampos Klitis; Benoit Guilhabert; John McPhilimy; Stuart May; Ning Zhang; Michael J. Strain; Marc Sorel; Univ. of Glasgow, UK; Univ. of Strathclyde, UK. Optical systems require the integration of technologies fabricated on different materials. We use a transfer printing technique to integrate pre-processed III-V, polymer and silicon membrane devices onto passive optical circuits with nano-meter positional accuracy.

Impact of Phase-Filtering on Optical Spectral Reshaping with Microring Resonators for Directly-Modulated 4-PAM Signals, Oskars Ozolins; Francesco Da Ros; Valentina Cristofori; Xiaodan Pang; Aleksiej Usalcovs; Richard Schatz; Leif K. Oxenlowe; Sergei Popov; Gunnar Jacobsen; Christophe Peucheret; RISE-ACREROAB, Sweden; GTU Photonics, Technical Univ. of Denmark, Denmark; KTH Royal Inst. of Technology, Sweden; Univ. Rennes, CNRS, FOTON – UMR 6082, France. We investigate microring resonator (MRR)-based optical spectral reshaping for directly-modulated 4-PAM signals. The phase-filtering of MRR, and consequent dispersion added to the signal, yields 120% reach increase compared to the 95% of amplitude-only filtering.

A carrier-recovery-free 224Gb/s dual-polarization doubly differential 16-point constellation (2ASK-8PSK) is experimentally demonstrated for the first time. Utilizing 10-symbol decision feedback in the 2nd differential stage, the penalty with respect to conventional 16QAM is only 4.8dB.

Optical systems require the integration of technologies fabricated on different materials. We use a transfer printing technique to integrate pre-processed III-V, polymer and silicon membrane devices onto passive optical circuits with nano-meter positional accuracy.

OSA Optical Material Studies Technical Group Special Talk, Room 230A
12:00–13:00
Lunch Break (on your own)
12:30–13:30
12:30–15:30
SC455: Integrated Photonics for Quantum Information Science and Technology
12:30–16:30
SC378: Introduction to Ultrafast Optics
12:30–16:30
Social Media 102, Market 1, Hilton San Jose
13:00–14:00
rates that agrees well with theory. We show reduction in dark count of noise in quantum frequency conversion is spontaneous Conversion, Using Temperature to Reduce Noise in Quantum Frequency SM2D.5 • 11:45

A main source of noise in quantum frequency conversion is spontaneous Raman scattering, which can be reduced by lowering the operating temperature. We show reduction in dark count rates that agrees well with theory.

SM2D • Nonlinear Optical Phenomena—Continued

SM2D.5 • 11:45

Using Temperature to Reduce Noise in Quantum Frequency Conversion, Paulina S. Kuo, Jason Pelc, Carsten Langrock, M. M. Fejer,1,2 NIST, USA; 3Stanford Univ., USA. A main source of noise in quantum frequency conversion is spontaneous Raman scattering, which can be reduced by lowering the operating temperature. We show reduction in dark count rates that agrees well with theory.
submicron particles containing CsPbBr

We synthesized micro- and

Harvard Medical School, USA.

for Photomedicine, Massachusetts General Hospital and

Seva 1;

Wang1, Krishnakali Chaudhuri 1, Mohamed Alhabeb 2, Xian -

MXenes for Plasmonic and Metamaterial Devices,

FM2G.7 • 12:15
Plasmonic-assisted perovskite submicron lasers, Sangeeon

Cho1, Andreas C. Liapis1, Seok-Hyun Yun1; 1Harvard-MIT

Health Sciences and Technology, MIT, USA; 2Wellman Center

for Photomedicine, Massachusetts General Hospital and

Harvard Medical School, USA. We synthesized micro- and

submicron particles containing CsPbBr nanocrystals and silver

nanoparticles. Optically-pumped metal-perovskite particles

showed lasing, owing to high gain from perovskite and light

confinement by plasmonic scattering.

FM2G.6 • 12:00
Quantum State Teleportation from a Single Ion to a Single

Photon by Heralded Absorption, Jan Arenskötter1, Stephan

Kucera1, Matthias Kreis1, Pascal Eich1, Philipp Müller1, Jürgen

Eschner1; 1Universität des Saarlandes, Germany. Using a

high-brightness narrowband source of 40 Ca+-ion-resonant

tangled photon pairs at 854 nm, we teleport a qubit from

the D5/2 Zeeman sub-levels of the ion onto the polarization

cube of a single photon by heralded absorption.

FM2G.5 • 11:45
Direct Generation of Structured Light in Metallic Nanolaser

Arrays, William Hayenga1, Mitha Paro1, Enrique Sanchez

Cristobal1, Demetrios N. Christodoulides1, Mercedes Khaja-
vikhan1; 1Univ. of Central Florida, CREOL, USA. The interplay

between array geometry and the whispering galley-like modes

of individual nanolasers can lead to the direct generation of

structured light in nanoscale. Such nanolaser lattices emitting

OAM beams are experimentally demonstrated.

FM2G.4 • 11:30
Plasmonic-assisted perovskite submicron lasers, Sangeeon

Cho1, Andreas C. Liapis1, Seok-Hyun Yun1; 1Harvard-MIT

Health Sciences and Technology, MIT, USA; 2Wellman Center

for Photomedicine, Massachusetts General Hospital and

Harvard Medical School, USA. We synthesized micro- and

submicron particles containing CsPbBr nanocrystals and silver

nanoparticles. Optically-pumped metal-perovskite particles

showed lasing, owing to high gain from perovskite and light

confinement by plasmonic scattering.

FM2G.3 • 11:15
Optical power controlled quantum dot microlasers,

Jonghyun Park1, Jinwon Park1, Hyoungki Kim2,1, Young L.

Kim1, Vladimir M. Shalaev1, Yury Gogotsi2, Mohammad Aziz,

Chemical Vapour Deposition graphene and Black Phosphorus

as Thin-film Photodetectors, Sangyoon Cho1, Andreas C.

Liapis1, Seok-Hyun Yun1; 1Harvard-MIT Health Sciences and

Technology, MIT, USA. Recently, two-dimensional materials

have been widely investigated as thin-film photodetectors

due to their high performance. In this talk, we discuss

the performance of chemical vapor deposition graphene

and black phosphorus photodetectors, and demonstrate

their use in gas detection and optoelectronic devices.

SM2I.7 • 12:15
Mid-infrared waveguide integrated chalcogenide glass on

black phosphorus photodetector, Hongtao Lin1, Skylar

Deckoff-Jones2, Derek Kita1, Hanyu Zheng1, Duanhui Li1,

Hongtao Lin1, Yue Rong2, Yuanyuan Zhang3,4,7, Bin Li1,

Wei Zhang2, Juejun Hu1; 1UCSB, USA; 2HPE, USA. We

demonstrate the first mid-infrared waveguide integrated

chalcogenide glass on black phosphorus photodetector.

1Chinese Univ. of Hong Kong, Hong Kong. We observed

30 GHz dynamic response and 12 mA/W photosensitivity in a

graphene-on-Si$_3$N$_4$ photodetector. Our chemical vapor deposited graphene-
based photodetector is found to have an operating bandwidth comparable to the best

pristine graphene photodetector.
AM2J.4 • Biomedical Imaging—Continued

AM2J.4 • 11:45
In vivo Images of Rat Peripheral Cornea and Limbus With Full-Field Optical Coherence Tomography. Yu Ting Chen1, Ting Way Hu1, Wei Li Chen1, Sheng Lung Huang1, National Taiwan Univ., Taiwan; 2National Taiwan Univ. Hospital, Taiwan.

The anatomical structure of rat's peripheral cornea and limbus were delineated in vivo with cellular resolution. The loop-like limbal palisades of Vogt, the blood vessel, and peripheral nerve bundles in the peripheral cornea were identified.

AM2J.5 • 12:00
First Demonstration of in vivo Mueller Polarimetric Imaging on Human Uterine Cervix. Jérémy Vizet1, Jean Rehbinder1, Stanislas Deby2, Stéphane Roussel3, André Nacaz1, Ranya Saufi4, Catherine Geneste1, Christine Haie-Meder4, Hervé Fernandez1, François Moreau1, Angela Pernagallo4, UPICM, CNRS, Ecole Polytechnique, France; 2Dept. of Obstetrics and Gynecology, Univ. Hospital Brugmann, Université Libre de Bruxelles, Belgium; 3Service d'anatomie pathologique gynécologique, Institut Gustave Roussy, France; 4Service de Cunéothérapie, Institut Gustave Roussy, France.

We report on a packaged interferometer built with strongly-coupled multi-core optical fiber (MCF) for vibration sensing. An ultra-miniature test mass induces cyclic bending to the MCF which results in periodic shifts of the interference pattern.

AM2J.6 • 12:15
Mirau Based Ti:Al2O3 Spectroscopic Full-Field Optical Coherence Tomographic in vivo Skin Imaging. Rajendran Soundararajan1, Ting Wei Hu1, Manuel C. Delgado1, Yanding Qin2, Sheng Lung Huang1, National Taiwan Univ., Taiwan; 2Inst. of Robotics and Automatic Information System, Nankai Univ., China.

Hysteresis compensated piezoelectric transducer enables precise depth-dependent spectral information extracted from the optical coherence tomography raw interferometric data. Preliminary spectral analysis shows melanin absorptions at ~285.5 THz and ~325 THz.

AM2J.6 • 11:45
Packaged Multi-core Fiber Interferometric Vibration Sensor. Éloy Villatoro1, J.A. Flores-Braza1, E. Arroyo1, O. Arrizabalaga1, Jose Enrique Antonio-Lopez1, J. Zubia1, A. Schulzgen2, Rodrigo Amezcua Correa3, Univ. of the Basque Country, Spain; 4IKERBASQUE, Spain; 5Centro de Investigación e Innovación Tecnológica, IPN, Mexico; 6CREO, The College of Optics & Photonics, Univ. of Central Florida, USA.

We report on a packaged interferometer built with strongly-coupled multi-core optical fiber (MCF) for vibration sensing. An ultra-miniature test mass induces cyclic bending to the MCF which results in periodic shifts of the interference pattern.
A triple quantum cascade laser based sulfur species sensor for H2S, CH3SH and COS in petrochemical process streams, Harald Moser1, Johannes P. Wacławek1, Andreas Genner1, Christoph Gasser1, Bernhard Lendl1; 1Vienna Univ. of Technology, Austria Hydrogen sulfide (H2S), methyl mercaptan (CH3SH) and carbonyl sulfide (COS) gas detection based on second harmonic wavelength modulation spectroscopy (2F-WMS) using three modulation frequency multiplexed continuous wave quantum cascade lasers (cw QCLs) tunable is presented.

Compact bi-direction pumped hybrid double-cladding EYDF amplifier, Xiaolei Bai1,2, Quan Sheng1,2, Shijie Fu1,2, Zhaoxiu Xie1,2, Shi Wei1,2, Jianquan Yao1,2; 1Inst. of Laser and Plasma Physics, Chinese Academy of Sciences, China; 2Key Lab of Optoelectronics, School of Precision Instrument and Opto-electronic Information Science and Technology (Ministry of Education), Tianjin Univ., China. The double-cladding EYDF with different core diameter is connected by an asymmetric cladding light stripper (CLS) to realize bi-direction pumping and increase the loss of counter-propagating light. The experimental results shows that this amplifier has benefit to enhance the SBS threshold.

The 5.4 kW output power of the ytterbium-doped tandem-pumping fiber amplifier, Xuejiao Wang1, Ping Yan1, Zehui Wang1, Yusheng Huang1, Jading Tian1, Dan Li1, Qirong Xiao1, Mai Gong1; 1Tsinghua Univ., China. We present our results of a high-power tandem pumping fiber laser amplifier via optimizing the parameters. A 75 W 1080 nm seed was amplified to 5448 W successfully, along with the efficiency of 91.3%.

Strong coupling of 2D excitons to surface lattice modes of plasmonic crystals, Srimat Guddala1, Robert Collisson1, Mandeep Khatoniar1,3, Hussai Bhokari1, Jacob Trevino3,4, Vinod M. Menon1,3; 1Dept. of Physics, City College, City Univ. of New York (CUNY), USA; 2Dept. of Chemistry, City College, City Univ. of New York (CUNY), USA; 3PhD program in Physics, Graduate Center, City Univ. of New York (CUNY), USA; 4PhD program in Chemistry, Graduate Center, City Univ. of New York (CUNY), USA. We demonstrate strong coupling of 2D excitons in monolayer WSe2 to surface lattice modes of a plasmonic crystal resulting in large Rabi splitting of 95 meV at room temperature.
AM2P • A&T Topical Review on Photonics-enabled Quantum Technologies in Transition II—Continued

AM2P.4 • 12:00  *invited*

Photonics-enabled Quantum Timing and Navigation at Honeywell, Karl D. Nelson; Honeywell Aerospace, USA. Quantum technologies such as atom interferometry and atomic clocks are a promising pathway to more precise navigation. We show several ways in which Honeywell uses photonics as enabling technology for quantum control as we work toward putting devices in the field.

FM2Q.6 • 12:00

Exceptional Point Engineered Glass Slide for Microscopic Thermography, Han Zhao1, Zhaowei Chen2, Ruogang Zhao3; 1Dept. of Electrical and Systems Engineering, Univ. of Pennsylvania, USA; 2Dept. of Biomedical Engineering, The State Univ. of New York at Buffalo, USA; 3Dept. of Materials Science and Engineering, Univ. of Pennsylvania, USA. We demonstrate a thermosensitive glass slide with enhanced sensitivity by exploiting an optical exceptional point. The non-Hermitian exceptional point of the glass slide creates novel functionality for highly-sensitive thermal mapping compatible with conventional microscope systems.

FM2Q.7 • 12:15

Controllable Photonic Topological Insulating Chain Based on Non-Hermiticity, Kenta Takata1,2, Masaya Notomi1,3; 1NTT Nanophotonics Center, Japan; 2NTT Basic Research Labs, Japan; 3Tokyo Inst. of Technology, Japan. We determine theoretically a one-dimensional photonic insulating lattice whose bulk topology is controllable simply by tuning gain and loss. The system with four-cavity periods realizes a non-Hermiticity-induced topological transition and reconfigurable midgap topological interface states.
SM3A • Terahertz Nonlinear Spectroscopy
Presider: Andrea Markelz; Univ. at Buffalo, SUNY, USA

SM3A.1 • 13:30
Development of a THz Pump MeV Ultrafast Electron Diffraction Probe Apparatus, Ben Öhri-Olax1, Matthias C. Hoffmann1, Alexander H. Reid1, Renka Li1, Xiaohhe Shen1, Jie Yang1, Su Ji Park1, Ehren Mannenbach1, R. Keith Jobe1, Stephen Weatherby1, Steve Edstrom1, Wayne Polian1, Aaron Lindenberg1, Siegfried Giesen1, Xije Wang1; SLAC National Accelerator Lab, USA. We demonstrate a terahertz-ultrafast electron diffraction probe apparatus. Using the instrument, we show that intense focused THz pulses can characterize ultrafast electron bunches.

SM3A.2 • 13:45
Scalable setup for efficient terahertz generation using a segmented tilted-pulse-front excitation, László Pálffalvi1, György Tóth1, Levente Tokodai, Zuzaaana Matro1, József A. Fülöp1, Gábor Almási1,3, János Hebling1,2; Pecsi Tudományegyetem, Hungary; 1MTA-PTE High-Field Terahertz Research Group, Hungary; 2Szentgáthó Research Centre, Hungary. A nonlinear echelon slab structure is proposed for high-energy THz pulse generation. The most important advantage of the setup is the possibility of using plane parallel nonlinear optical crystal for producing good-quality, symmetric THz beam.

SM3B • Optical Modulators
Presider: Jian Wang; Huazhong Univ of Science and Technology, China

SM3B.1 • 13:30
Electrically Packaged Silicon-Organic Hybrid Modulator for Communication and Microwave Photonic Applications, Heiner Zwickel1, Juned N. Kemal2, Clemens Kieninger1, Yasar Kutuvantavida1, Matthias Lauermann1, Jonas Rittsherhofer1, Rastko Pajkovski1, Daniel Lindl1, Sebastian Randel1, Wolfgang Freude1, Christian Koos1; Karlsruher Institut für Technologie, Germany; 1Vanguard Photonics GmbH, Germany. We demonstrate electrical packaging of a silicon-organic hybrid (SOH) modulator. Gold traces on an Al2O3 substrate define the electrical connections to an IQ-modulator having a Pi-voltage of 1.5V. Signal generation up to 128Gb/s is demonstrated.

SM3B.2 • 14:00
Demonstration of Long-Term Thermal Stability of a Silicon-Organic Hybrid (SOH) Modulator at 105°C, Clemens Kieninger1,2, Yasar Kutuvantavida1,2, Juned N. Kemal1, Heiner Zwickel1, Hiroki Miura1, Feng Qiu1, Andrew Spring1, Kyushu Univ., Japan; 1Tokai Univ., Japan. The thermal stability of electro-optic polymer modulators is improved using a common ridge and hybrid silicon-to-polymer waveguide-structure. It reveals excellent thermal resistance at 105°C for 2,000 hours and generates 56Gb/s OOK and 96Gb/s PM-4 successfully.

SM3B.3 • 14:15
100-GHz Low Voltage Integrated Lithium Niobate Modulators, Cheng Wang1, Mian Zhang1, Xi Chen1, Maxime Bertrand1,2, Amirhassan Shams-Ansari1,4, Sethumadhavan Chandrasekhar1, Peter Winzer1, Marko Loncar1; 1Harvard Univ., USA; 4Nokia Bell Labs, USA; 2Univ. of Bordeaux, France; 3Dept. of Electrical Engineering and Computer Science, Howard Univ., USA. We demonstrate monolithically integrated lithium niobate modulators consisting of sub-wavelength waveguides and velocity-matched RF transmission lines. We measure an RF Vπ as low as 2.3V and an electro-optic bandwidth up to 100 GHz.

SM3B.4 • 14:30
Ultrafast Photocarrier Dynamics in Single-Layer Graphene Driven by Strong Terahertz Pulses, Ali Mousavian1, ByoungHwa Lee1, Andrew D. Sticikel1, Yun-Shik Lee1; 1Physics, Oregon State Univ., USA; 2Physics & Chemistry, Korea Military Academy, South Korea. Strong THz field enhances the THz transmission of photoexcitated graphene, increasing carrier scattering rates. High-field also reduces the relaxation time of the photocarriers by opening up the unoccupied states, while photoexcitation retards the relaxation process.

SM3C • SDM Communications I
Presider: Yikai Su; Shanghai Jiao Tong Univ., China

SM3C.1 • 13:30
Multimode and multicore fiber amplifiers for space-division multiplexed communication systems, Nicolas K. Fontaine1, Haoxiong Chen1, Roland Ryf1, Juan Carlos Alvarez-Zacarias1, Zeinab Sanjabi Eznaveh1, Jose Enrique Antonio-Lopez2, Rodrigo Amenezuela Correa2,3, Nokia Bell Labs, USA; 1CENIT, Univ. of Central Florida, USA. Multimode and multicore fiber amplifiers must amplify all modes with uniform gain in each mode while simultaneously producing large output powers per mode (20-dBm) with low noise figures. Leveraging the dense packing of modes, they can be built with less components than an array of single-mode fiber amplifiers. We will discuss several amplifier designs to improve these metrics.

SM3C.2 • 14:00
System Benefits of Coupled-Core Multicore Fibers with Different Coupling Lengths, Rene-Jean Essiambre1, Roland Ryf1, Georg F. Radermacher1, Nokia Corporation, USA; 2Pho
tonic Network System Lab, National Inst. of Information and Communications Technology, Japan. We study the impact of the linear coupling length and the number of cores on the nonlinear benefit of the coupled-core multicore fiber having up to 19 cores. Coupling lengths as short as a few meters improves transmission.

SM3C.3 • 14:15
Accurate modal dispersion measurements using maximally-orthogonal Stokes vectors, Ioannis G. Roudas1, Jaroslav Kwapisz1,2, Montana State Univ.-Bozeman, USA. We propose optimal launch modes minimizing the noise error in the estimation of the fiber modal dispersion vector. For a 20-mode fiber, the SNR is improved by 4 dB compared to conventional mode combinations.

SM3C.4 • 14:30
Experimental Demonstration of 400-Gbit/s Free-Space Mode-Division-Multiplexing by Varying Both Indices when Using Four Laguerre-Gaussian Modes or Four Hermite-Gaussian Modes, Kai Fang1, Haoqian Song1, Zhe Zhao1, Runzhou Zhang1, Hao Song1, Guodong Xie1, Long Li1, Jung Liu1, Jing Du1, Andreas F. Molisch2, Moshe Tur1, Alan E. Willner1; 1University of Southern California, USA. We experimentally demonstrate a 400-Gbit/s mode-division-multiplexed free-space-optical communication link using four Laguerre-Gaussian modes or four Hermite-Gaussian modes, achieving a power penalty < 4 dB. The influence of displacement and rotation on system performance is investigated.
Coherent Directional Supercontinuum Generation, Yo-si-tomo Okawachi, Mengjie Yu, Jaime Cardenas, Xingchen Ji, Michal Lipski, Alexander L. Gaeta; Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA; School of Electrical and Computer Engineering, Cornell Univ., USA; Dept. of Electrical Engineering, Columbia Univ., USA. We present a novel approach for coherent, directional supercontinuum and cascaded dispersive waves in dispersion-engineered waveguides. Operating in the normal group-velocity-dispersion regime, we demonstrate octave-spanning spectra generated primarily to one side of the pump.

Mid-IR Supercontinuum Generation in Ultrafast Laser Inscribed Waveguides, James Morris, Mark Mackenzie, Logan Wright, Wei-Zung Chang, Frank W. Wise, Tim Birks; Dept. of Physics, Applied Physics, Yale Univ., USA. We find that the supercontinua generated in ultrafast laser inscribed waveguides pumped with femtosecond pulses centered at 4.6 μm. Dispersion measurements show the zero dispersion wavelength for the waveguides to be around 5.3 μm.

Spin-Glass Behavior in Nonlinear Optical Waves, Fabrizio Di Pierangeli, Mariano Flammini, Andrea Tavani, Fabrizio Di Meo, Aharon Agranat, Lifu Zhang, Claudio Conti, Eugenio DelRe, Università di Roma La Sapienza, Italy; College of Optoelectronic Engineering, Shenzhen Univ., China; Dept. of Applied Physics, Hebrew Univ. of Jerusalem, Israel; Inst. for Complex Systems, ISC-CNR, Italy. We report the observation of replica symmetry breaking in optical wave propagation, a phenomenon that emerges from the interplay of disorder and nonlinearity and demonstrates a spin-glass phase for light.

Interaction of Counter-Propagating Light in Microresonators: Theoretical Model and Oscillatory Regimes, Michael T. Woodley, Leonardo Del Bino, Jonathan M. Silver, Shuangyou Zhang, Pascal Del’Haye; National Physical Lab, UK; Heriot-Watt Univ., UK. An analytical model is presented for the recently observed spontaneous symmetry breaking in nonlinear microresonators. Conditions for the symmetry breaking are obtained, and further models for sensing applications are produced, together with a stability analysis.

Spatial coherence engineering of lasers for imaging applications, Hui Cao; Applied Physics, Yale Univ., USA. We design and build the lasers with low spatial coherence to achieve speckle-free full-field imaging. We further proposed and demonstrated a simple method to switch the spatial coherence of a laser for multimodality biomedical imaging.

Wannier-Bloch approach to localization in high-order harmonic generation in solids, Alexia A. Chacon, Los Alamos National Lab, USA; Quantum Optics Group, Inst. of Photonic Sciences, Spain. High harmonic generation, HHG, in solids is a delocalized process, which is still intensely debated. Here, we develop a model that connects the well-understood HHG in atoms to the delocalization problem of HHG in solids.
Single photons in and out of single molecules, Vahid Sandoghdar; Max-Planck-Institut Physik des Lichts, Germany. We shall present high-fidelity single-photon guns based on single molecules in a planar antenna. In addition, we shall discuss the use of single or handful of photons for efficient linear and nonlinear coupling to molecules.

We achieve a record count rate of $4.6 \times 10^4$ multiplexed photons with a low $g(2)(0)$ of 0.07. In addition, we shall present high-fidelity single-photon guns based on single molecules in a planar antenna. We demonstrate a scalable, low-loss fiber-based frequency multiplexed single-photon source based on efficient parametric frequency conversion. We achieve a record count rate of $4.6 \times 10^4$ multiplexed photons with a low $g(2)(0)$ of 0.07.

A heralded single-photon source based on intermodal four-wave mixing in a step-index fiber is demonstrated. The random access beamsteering up to $4.4^\circ \times 4.6^\circ$ scanning range at 1550nm is demonstrated. We present a two-dimensional ultra large aperture optical phase array (OPA) with 160$^2$ elements enabled with optical microelectromechanical system (MEMS). The random access beamsteering up to $4.4^\circ \times 4.6^\circ$ scanning range at 1550nm is demonstrated.
Dispersion engineering of metasurfaces and its applications in the visible, Wei-Ting Chen, Alexander Zhu, Jared Sailer, Vyshakh Sanjeev, Eric Lee, Federico Capasso, Harvard University, USA; Univ. of Waterloo, Canada. We show how to finely tune metasurface dispersion up to 2nd order terms in the visible, using coupled TiO2 dielectric nano-pillars. We demonstrate white-light imaging and aberration-correction in lenses using these dispersion-engineered metasurfaces.

Focal DIELECTRICAL Superlenses, Guanghu Yuan, Katrine S. Rogers, Edward T. Rogers, Nikolay I. Zheludev, Nan-yang Technological University, Singapore; School of Mathematics and Statistics, The Open Univ., UK; Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK; Inst. for Light Sciences, Univ. of Southampton, UK. We demonstrate a radically new type of metasurface ‘super-lens’ that exploits the phenomenon of super-oscillations, giving a smallest hotspot size of 0.33λ and effective numerical aperture as high as 1.52 in air.

High NA Silicon Metamaterials at Visible Wavelengths, Haowen Liang, Qiaoliang Lin, Yin Wang, Qian Sun, Jiantao Li, Sun Yat-sen Univ., China. We present a crystalline silicon based metamaterials with effectively low loss and high-NA in air. This metals can be further front-immersed in high index liquids, presenting much higher NA and defraction-limited focusing.

High De-Magnification Hyperlens, Jingbo Sun, Natalia Litchinitser, State Univ. of New York at Buffalo, USA. We design and fabricate a hyperlens with a large demagnification of 3.75. We experimentally demonstrate such hyperlens capability to compress the original patterns with feature size of 300nm down to 80nm using 405nm light.

Subwavelength imaging of collective modes in silicon nanopillar honeycomb lattices, Siying Peng, Nick Schilder, Sophie Meuret, Femius Koenderink, Albert Polman, Harry Atwater, Applied physics, California Inst. of Technology, USA; Center for Nanophotonics, AMOLF, Netherlands. We report fabrication and direct imaging of silicon Mie resonators with molecular-orbital-like bonding and anti-bonding local photonic density of states, as well as selective excitation of collective Bloch modes at specific frequencies and lattice sites.

Fiber-optic cascaded forward Brillouin scattering seeded by backward SBS, Tsuneo Hayashi, Yosuke Mizuno, Na-kamura Kentaro, Sze Y. Seti, Shini Yoshimata, The Univ. of Tokyo, Japan; Inst. of Innovative Research, Tokyo Inst. of Technology, Japan. We propose a novel principle for generating the cascaded forward Brillouin scattering (CFBS) using a counter-propagating pump-probe technique. The basic concept of this principle is the use of backward SBS as the seed of CFBS.

SM3K.1 • 13:30
Performance Enhancement for BOCDAs Based on Convexity Extraction Algorithm, Bin Wang, Xinyu Fan, Zuyuan He, Shanghai Jiao Tong Univ., China. We propose an approach to enhance the performance of BOCDAs by exploiting the ignored information contained on the measured data. A potentially unlimited dynamic range, as well as a fivefold-enhanced spatial resolution, has been achieved.

SM3K.2 • 13:35
Fiber-optic cascaded forward Brillouin scattering seeded by backward SBS, Tsuneo Hayashi, Yosuke Mizuno, Na-kamura Kentaro, Sze Y. Seti, Shini Yoshimata, The Univ. of Tokyo, Japan; Inst. of Innovative Research, Tokyo Inst. of Technology, Japan. We propose a novel principle for generating the cascaded forward Brillouin scattering (CFBS) using a counter-propagating pump-probe technique. The basic concept of this principle is the use of backward SBS as the seed of CFBS.

SM3K.3 • 14:00
Averaging-free Vector BOTDA assisted by a Reference Probe Lightwave, Nan Guo, Tao Gui, Chao Jin, Liang Wang, Hua-Yaw Tam, Chao Lu, The Hong Kong Polytechnic Univ., Hong Kong. The Chinese Univ. of Hong Kong, Hong Kong. We propose and experimentally demonstrate an averaging-free vector BOTDA system, which enables both distributed Brillouin gain and Brillouin phase shift detection without trace averaging. A 4m spatial resolution over 18.3 km is realized.

SM3K.4 • 14:15
In-situ dwell-time measurement of Rb at the inner-wall coated-surface of HC-PCF, Ximeng Zheng, Maxime Delgrange, Jenny Jouni, Philippe Thomas, Benoit Debord, Frederic Gérôme, Fetah Benabdallah, GPPMM group, Xlim Research Inst., France; SPCTS UMR CNRS 7315, Centre Européen de la Céramique, France. We compare electromagnetically induced transmissions in large-core anti-relaxation materials inner-wall coatings Kagome HC-PCF with thermal Rb confinement in situ. A minimum transparency linewidth of ~150 KHz in OTS coated fiber was observed.

SM3K.5 • 14:30
Integrating of Acetylene into chip scale photonic circuits for telecom frequency referencing, Roy T. Zekker, Matthew Hummon, Iiron Sten, Yelín Barash, Noa Mazurski, John Kitching, Uriel Levy, The Hebrew Univ. of Jerusalem, Israel; 2Time and Frequency Division, National Inst. of Standards and Technology, USA. We experimentally demonstrate a chip-scale integration of photonic waveguides and Acetylene for optical telecom frequency reference. The functionality of the hybrid molecular-photonic chip was demonstrated by locking a telecom laser to a molecular line.
FM3M.1 • 13:30
Invited
Approaching the Attosecond keV X-ray Frontier, Zenghu Chang¹, Univ. of Central Florida, CREOL, USA. We demonstrate the generation of isolated S3-as soft X-ray pulses reaching the water window. Mid-infrared lasers centered at 2.5 to 8 μm are being developed to extend the attosecond X-rays to the keV range.

FM3M.2 • 14:00
High-flux Soft X-ray Source for Time-resolved Probing of Magnetization Dynamics in Rare-earth Ferromagnets, Guanguo Fan¹, Vincent Cardin², Katherine Légare³, Edgar Kakisis¹, Giedrius Andriukaitis¹, Bruno E. Schmidt⁴, Jean-Pierre Woll², François Légare³, Jan Luning², Andrius Baltuska¹, Tadas Balciunas¹,¹, Inst. of Photonics, TU Wien, Austria; ²Institut national de la recherche scientifique, Canada; ³Laboratoire de Chimie Physique Matière et Rayonnement, France; ⁴few-cycle Inc, Canada; ⁵EPS/IPAQS, Heriot-Watt Univ., UK. We present high-flux table-top 220eV HHG light channel containing a few Joules of energy is generated in atmosphere. A centimeter diameter, 30-m long, 10-μm Air, test facility, Brookhaven National Lab, USA; ³College of Optical Sciences, Univ. of Arizona, USA.

SM3O.3 • 13:45
Highly stable, 54mJ Yb-InnoSlab laser platform at 0.5iW average power, Bruno E. Schmidt¹, Anvid Hage², Torsten Mans³, François Légare³, Hans Jakob Wöerner⁴; ⁴few-cycle Inc, Canada; ²AMPHOS GmbH, Germany; ³InNRS-EMT, Canada; ⁴ETH Zürich, Switzerland. We present a compact 1.5ps, 10kHz, 54mJ Yb InnoSlab pump laser with sub-% level power stability and different output ports. 10fs seed pulses are derived via white light generation in bulk followed by subsequent compression.

SM3O.4 • 14:30
Current State-of-the-art in High-power Ultrafast Lasers, Peter F. Moulton¹, Massachusetts Inst of Tech Lincoln Lab, USA. We review the technologies, both past, present, and future that are behind operation of PW (10¹5 W)-class laser systems, survey the installations worldwide and explain their scientific and practical applications.

SM3O.5 • 14:40
Invited
Impacts of Spatio-Temporal Coupling in Ultrashort Laser Pulses on Laser Energy Absorption by Transparent Dielectrics in Bulk Modification Regimes, Nadezhda M. Bulgakova¹, Vladimir P. Zhukov¹,², Selçuk Aktürk³; ¹HiLASE Centre, Inst. of Physica CSA, Czechia; ²Inst. of Computational Technologies SB RAS, Russia; ³Egebir Mah., Turkey. Sophisticated modeling of propagation of ultrashort laser pulses with spatio-temporal coupling through transparent medium has enabled reproducing the effect of directional asymmetry in direct laser writing and gaining a deep insight into the underlying physics.
Optimization of Irradiation Conditions for Upconversion Nanoparticle Assisted Photobiomodulation of Neuronal Cells, Sumeyra Tek1, Brandy A. Vincent1, Christopher A. Baker1, Kelly L. Nash1, ‘Univ. of Texas at San Antonio, USA. Photoluminescence from upconversion nanoparticles provides a nanoplatform for desired photochemical effects on neuron cells resulting proliferation and outgrowth with NIR light irradiation, when overcoming the unwanted heating issues by optimizing irradiation conditions.

Optical Scattering of Structured Light, Romanus Hutchins1, John Rogers1, Jonathan Williams1, Ping Yu1, ‘Univ. of Missouri, USA. Optical scattering of diffraction-free structured light beams was studied using a diffuser at the far field in a forward direction. Generated Speckle is determined by the phase difference in the structured light beams.

Anhilation of Methicillin-Resistant Staphylococcus Aureus (MRSA) via Photobleaching of Staphyloxanthin, Ji-Xin Cheng1; Aureus Staphylococcus Annihilation of Methicillin-Resistant

*invited* Transcranial Photobiomodulation for Psychiatric Disorders: Past and Future Directions, Paolo Cassano1,2, Past and Future Directions, Transcranial Photobiomodulation for Psychiatric Disorders: a nanoplatform for desired photochemical effects on neuron

Photoluminescence from upconversion nanoparticles provides reactive oxygen species.

While still experimental, preliminary data on the use of both laser and LED devices for brain disorders are promising.

We report unconventional scaling of the quality factor in

Meanwhile, exceptions points of degeneracy (EPD) of order 2, 3, and 4, that appear also in lossless periodic waveguides.

In the presence of a topologically charged contour consisting entirely of exceptional points in a non-Hermit helical waveguide array, we observe both protected chiral edge states and the lack of conical diffraction.

We introduce topological phases in Photonic Time-Crystals, Eran Lustig1, Yonatan Sharan1, Mordechai Segev1; Technion Israel Inst. of Technology, Israel. We introduce topological phases in Photonic Time-Crystals. We show that dispersion bands, which are gapped in momentum, can have non-trivial topology, that affect the propagation of light in the temporal crystal.

Creation of Semi-Dirac Photons Through Topological Phase Transitions in Photonic Honeycomb Lattices, Mariana Milicic1, Gilles Montambaux2, Tomoki Ozawa2, Aristide Lemaire1, Luc Le Gratiet1, Isabelle Sagnes1, Jacqueline Bloch1, Alberto Alber1; Centre de Nanosciences et de Nanotechnologies, CNRS, France; Laboratoire de Physique de Solides, Université Paris-Sud, France; I2NO-CNR BEC Center and Dipartimento di Fisica, Università di Trento, Italy; Université Lille, CNRS, UMR 8523, Physique des Lasers Atomes et Molecules (PLAM), France. Tuning the band structure of photonic Dirac materials allows engineering novel optical properties. We use photonic honeycomb lattices to tailor semi-Dirac photons that combine zero, finite and infinite effective masses.

Exceptional Points of Degeneracy in lossless Periodic Coupled Waveguides, Mohamed Y. Nada1, Mohamed A. Othman2, Filippo Capolino1; UC, USA. We present general aspects of exceptional points of degeneracy (EPD) of order 2, 3, and 4, that appear also in lossless periodic waveguides. We report unconventional scaling of the quality factor in coupled resonators optical waveguides.
Carrier Multiplication in Bismuth Investigated with Intense THz pump-THz Probe Spectroscopy, Yasuo Minami1,2, Thang Dao1, Tadaaki Nagao1, Masahiro Kitajima1, Jun Takeda1, Kiufumi Katayama1, Takashima Univ., Japan; 2Yokohama National Univ., Japan; 1International Center for Materials Nanoarchitectonics (WPI-MANA), National Inst. for Materials Science, Japan; 2CREST, Japan Science and Technology Agency, Japan; 1LuRay Co. Ltd., Japan. By utilizing intense terahertz (THz) pump and THz probe spectroscopy, we revealed the carrier dynamics of a semi-metallic bismuth ultrathin film, originating from the THz-induced electron acceleration and a subsequent carrier multiplication process.

We show how intense terahertz pulses can modulate photoluminescence lineshape and efficiency in direct gap semiconductors through hot carrier-enhancement of high energy PL and diffusion induced quenching of low energy photoluminescence. We compare these effects in the GaAs and InP.

High-field Terahertz Switching of Plasmonic Resonance in Photoexcited Nano Antennas on GaAs, Ali Mousavian1, Andrew D. Stickel1, Byoungwhak Lee1,2, Yun-Shik Lee1; 1Physics, Oregon State Univ., USA; 2Physics & Chemistry, Korea Military Academy, South Korea. Strong terahertz pulses transiently revive the plasmonic resonance of a nano-antenna-array-patterned GaAs film, which was initially turned off by photoexcitation. The high-field THz effect has potential to ultrafast optical/THz switching in plasmonic devices.

Silicon Photonic Modulators with Coupled Electrodes, David Patel1, Mahdi Parvizi2, Naim Ben-Hamida2, Michel Poulin2, Claude Rolland2, David V. Plant1; 1McGill Univ., Canada; 2Ciena Corporation, Canada. We show that differential signaling with coupled electrodes for silicon photonic modulators increases the electro-optic bandwidth in low-resistive substrates. We also show that high DC resistance of transmission lines negates the benefit of longer modulators.
The interplay of modal four-wave mixing and Raman scattering leads to high-brightness multimode supercontinuum. We demonstrate octave spanning supercontinuum from 1.35 μm to 3 μm generated in a tapered crystalline silicon core fiber pumped at 2.4 mm using a femtosecond OPO.

Kerr and Raman beam cleanup with supercontinuum generation in multimode microstructure fiber, Richard Dupiol1, Katarzyna Krupa2, Alessandro Tonello1, Fabian Faccio1, Marcello Ferrara1, Vladimir M. Shalaev1, Clayton DeVault1, Matteo Clerici1, Alexander Boltasseva2, Thomas Roger1, Audrius Dubietis3, Insitute of Photonics and Quantum Sciences, Heriot Watt Univ., UK; 2School of Physics and Astronomy, Univ. of Glasgow, UK; 3School of Electrical and Computer Engineering and Birck Nanotechnology Center, Purdue Univ., USA; 4Dept. of Physics and Astronomy and Birck Nanotechnology Center, Purdue Univ., USA; 5School of Engineering, Univ. of Glasgow, UK; 6Dept. of Quantum Electronics, Vilnius Univ., Lithuania. We provide an efficient surface time-reversal of the incident electric field in an ENZ material producing both phase-conjugated and negative refracted beams. The results obtained exploiting degenerate four-wave mixing show an efficiency conversion over 200%.

Optical time reversal from time-dependent Epsilon-Near-Zero media, Vincenzo Bruno1, Stefano Vezzoli1, Daniele Faccio1, Marcello Ferrara1, Vladimir M. Shalaev1, Clayton DeVault1, Matteo Clerici1, Alexander Boltasseva2, Thomas Roger1, Audrius Dubietis3, Insitute of Photonics and Quantum Sciences, Heriot Watt Univ., UK; 2School of Physics and Astronomy, Univ. of Glasgow, UK; 3School of Electrical and Computer Engineering and Birck Nanotechnology Center, Purdue Univ., USA; 4Dept. of Physics and Astronomy and Birck Nanotechnology Center, Purdue Univ., USA; 5School of Engineering, Univ. of Glasgow, UK; 6Dept. of Quantum Electronics, Vilnius Univ., Lithuania. We propose a novel technique to design light sources producing multiple frequency channels potentially applicable in wavelength-division multiplexing networks. The sources are based on spectral interference of solitons generated in non-uniform fiber amplifiers.

Light Sources based on Multiple Solitons in Segmented Fiber Amplifiers, Francisco R. Arteaga-Sierra1, Ali J. Antikainen1, Govind P. Agrawal1, Univ. of Rochester, USA. We propose a novel technique to design light sources producing multiple frequency channels potentially applicable in wavelength-division multiplexing networks. The sources are based on spectral interference of solitons generated in non-uniform fiber amplifiers.

SM3D.6 • 15:15
Suppressing laser instabilities with microcavities exhibiting chaotic ray dynamics, Stefan Bittner1, Hasan Yilmaz1, Jian Lu1, Yongsong You1, David Reis2, Shambhu Ghimire1; 1SLAC National Accelerator Lab, USA; 2Dept. of Applied Physics, Stanford Univ., USA. We measure the chirp in extreme ultraviolet high-harmonics from bulk MgO crystals pumped by strong near-infrared pulses using the two-color approach. By performing measurements in both reflection and transmission we separate propagation effects.

Light Sources based on Multiple Solitons in Segmented Fiber Amplifiers, Francisco R. Arteaga-Sierra1, Ali J. Antikainen1, Govind P. Agrawal1, Univ. of Rochester, USA. We propose a novel technique to design light sources producing multiple frequency channels potentially applicable in wavelength-division multiplexing networks. The sources are based on spectral interference of solitons generated in non-uniform fiber amplifiers.
FM3G • Quantum Sources I—Continued

FM3G.5 • 14:45
Effective $\chi^{(2)}$ in a Rb-Filled Hollow-Core Photonic Bandgap Fiber for Coherent Photon Conversion, Yun Zhao1, Parthamesh Donwalkar1, Chaitali Joshi1, Bok Young Kim2, Alexander L. Gaeta1, School of Applied and Engineering Physics, Cornell Univ., USA; 2Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA. We demonstrate a large effective $\chi^{(2)}$ in a rubidium-filled photonic bandgap fiber by an spontaneous parametric down conversion process. This system can be used for the coherent photon conversion scheme in quantum information processing.

FM3H • Chiral and Topological Quantum Optics—Continued

FM3H.3 • 14:45
Pancharatnam-Berry Phase in a Condensate of Indirect Excitons, Jason R. Leonard1, Alexander High1, Aaron Hammond1, Michael Fogler1, Leonid Butov1, Kenneth Campman2, Arthur Gossard3, Dept. of Physics, Univ. of California at San Diego, USA; 2Materials Dept., Univ. of California at Santa Barbara, USA; 3Technion – Israel Inst. of Technology, Dept. of Electrical Engineering, Israel. We report on the observation of the Pancharatnam-Berry phase in a condensate of indirect excitons realized in a GaAs coupled quantum well structure. Our measurements indicate long range coherent spin transport.

FM3H.4 • 15:00
Scattering of Coherent Pulses from Quantum-Optical Systems, Kevin Fischer1, Rahul Trivedi1, Vinay Ramasesh1, Irfan Siddiqi1, Jelena Vuckovic1, Gintron Lab, Stanford Univ., USA; 2Dept. of Physics, Univ. of California, USA. We develop a new computational tool and framework for characterizing the scattering of photons by energy-nonconserving Hamiltonians into unidirectional (chiral) waveguides, e.g., with coherent pulses excited. We demonstrate this approach for two prototypical quantum systems.

FM3H.5 • 15:15
Quantum Čerenkov radiation in weakly and strongly-coupled regimes, Charles Roques-Carmes1, Nicholas Rivera1, John Joannopoulos2, Marin Soljacic3, Ido Kaminer4, ReShore Lab of Electronics, MIT, USA; 2Dept. of Physics, MIT, USA; 3Technion – Israel Inst. of Technology, Dept. of Electrical Engineering, Israel. We present the time-dependent quantum electrodynamic theory of Čerenkov radiation, which reveals orders of magnitude corrections to the decay rate from the conventional theory, as well as significant modifications to the well-established Čerenkov dispersion relation.

SM3I • Optical Phase Arrays—Continued

SM3I.7 • 15:15
Broadband Imaging and Wireless Communication with an Optical Phased Array, Christopher Poultin1, J. P. Laine1, Charles Stark Draper Lab, USA; 2Analog Photonics, USA; 3Carderock Division, Naval Surface Warfare Center, USA. An optical phased array designed for broadband applications has been demonstrated. Using this architecture, imaging under natural light conditions and free space optical communications at a data rate of 10 Gbps have been achieved.

14:00–15:30 Workshop: Understanding Unconscious Bias, Winchester 1&2, Hilton San Jose

15:30–16:00 Coffee Break, Concourse Level

16:00–17:30 Workshop: Understanding Unconscious Bias Workshop, Winchester 1&2, Hilton San Jose
FM3J • Imaging and Cloaking in Metamaterials—Continued

**FM3J.6 • 14:45**

“Invisible” Nanotextured Substrates for Quantum Optics and Microscopy, Andreas C. Liapis1, Charles T. Black2, Seok-Hyun Yun1; 1Wellman Center for Photomedicine, Massachusetts General Hospital, USA; 2Center for Functional Nanomaterials, Brookhaven National Lab, USA. We show that nanotextured antireflective metasurfaces, fabricated by block copolymer self-assembly, can be used to suppress the influence of the substrate in quantum optical experiments and microscopy.

SM3K • Brillouin Scattering and Applications—Continued

**SM3K.6 • 15:00**

Suppression of Stimulated Brillouin Scattering using Off-Axis Twisted Core Fiber, Kazi S. Abedin1, Raja Ahmad1, Kenneth Feder1, David DiGiovanni1; 1OFS Labs, USA. We propose a method of suppression of Brillouin scattering by using offset-core twisted fiber. A 5.2 dB increase in SBS-threshold is observed by offsetting the fiber-core from center by 35 µm and winding in a 45 mm spool.

SM3L • Photonic Frequency References and Sources—Continued

**SM3L.6 • 14:45**

Characterization of Large-Area Crystalline Coatings for Next-Generation Gravitational Wave Detectors, Garrett Cole1, Christoph Deustch2, David Follman1, Paula Heu1, Tobias Zederbauer2, Ashish Rai, Dominic Bachmann1, Alexander von Finck1, Sven Schröer1, Philip Koch1, Harald Luck1; 1Crystalline Mirror Solutions LLC, USA; 2Crystalline Mirror Solutions GmbH, Austria; 3Fraunhofer Inst for Applied Optics and Precision Engineering (IOF), Germany; 4Albert Einstein Inst (AEI) Hannover, Max Planck Inst for Gravitational Physics, Germany. Through in-depth optical characterization including thickness uniformity and optical scatter measurements, we demonstrate that large-area crystalline coatings are a promising alternative to ion-beam sputtered multilayers for low-noise mirrors employed in next-generation gravitational wave detectors.

SM3L.7 • 15:00

All-Fiber Delay Line-Based Repetition-Rate Stabilization, Dohyeon Kwon1, Jungwon Kim1; 1Korea Advanced Inst of Science & Tech, South Korea. We demonstrate all-fiber repetition-rate stabilization method with 10^-14-level frequency instability and 1 fs-level integrated timing jitter over 1 s using all-fiber Michelson interferometer with compactly packaged 10 km-long fiber delay.

SM3L.8 • 15:15

Electrically Controllable Reconfiguration of Terahertz Meta-Atoms into Meta-Molecules, Hyunseung Jung1, Jaemok Koo1, Wonwoo Lee1, Moon Sung Kang1, Hyein Lee1,2; 1School of Electronic Engineering, Soongsil Univ, South Korea; 2Dept. of Chemical Engineering, Soongsil Univ, South Korea. We report structural methodology for electrically switchable terahertz metamaterials between atom- and molecule-states by using limited conductance variation of graphene bridges. Based on experimental verification, we confirmed 39% of wide resonance tuning of terahertz metamaterials.

SM3K.7 • 15:00

Opto-Mechanical Time-Domain Reflectometry: Distributed Sensing Outside the Cladding of Standard Fiber, Gil Bashan1, Hilel Hagai Diamandi1, Yosef London1, Eyal Preter1, Avi Zadok1, Bar-Ilan Univ, Israel. Distributed sensing of liquids outside the cladding of standard, unmodified fiber is demonstrated, with 3 km range and 100 m resolution. Guided light remains confined to the core. Measurements rely on fiber opto-mechanics.

FM3J.7 • 15:00

Infrared Invisibility Cloak Using Rolled Metamaterial Film, Tomo Ame niya1, Satoshi Yamasaki1, Tono Kanzawa2, Zhichen Gu3, Da suke Inoue3, Atsushi Ishikawa3, Nobu Nishiyama3, takuo tanaka3, Tatsuhiro Urakami3, Shigehisa Arai3,1; 1Tokyo Inst. of Technology, Japan; 2Okayama Univ., Japan; 3RIKEN, Japan; 4Mitsui Chemicals, Inc., Japan. We propose and demonstrate a method of making an infrared (~60 THz) invisibility cloaking device by simply rolling a metamaterial film around an object that we want to hide.

FM3J.8 • 15:15

Electrically Controllable Reconfiguration of Terahertz Meta-Atoms into Meta-Molecules, Hyunseung Jung1, Jaemok Koo1, Wonwoo Lee1, Moon Sung Kang1, Hyein Lee1,2; 1School of Electronic Engineering, Soongsil Univ, South Korea; 2Dept. of Chemical Engineering, Soongsil Univ, South Korea. We report structural methodology for electrically switchable terahertz metamaterials between atom- and molecule-states by using limited conductance variation of graphene bridges. Based on experimental verification, we confirmed 39% of wide resonance tuning of terahertz metamaterials.

SM3K.7 • 15:00

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FM3J.8 • 15:15

Electrically Controllable Reconfiguration of Terahertz Meta-Atoms into Meta-Molecules, Hyunseung Jung1, Jaemok Koo1, Wonwoo Lee1, Moon Sung Kang1, Hyein Lee1,2; 1School of Electronic Engineering, Soongsil Univ, South Korea; 2Dept. of Chemical Engineering, Soongsil Univ, South Korea. We report structural methodology for electrically switchable terahertz metamaterials between atom- and molecule-states by using limited conductance variation of graphene bridges. Based on experimental verification, we confirmed 39% of wide resonance tuning of terahertz metamaterials.
Ultrafast electron emission assisted by grating-coupled propagating surface plasmons in the mid-IR range, Kenko Takeuchi, Toomya Miana, Keesuke Kaneshima, Nobuhisa Ishi, Teruko Kana, Jiro Itatani. The Univ of Tokyo, Japan. We observed propagating surface plasmon-assisted photoemission from a grating irradiated by mid-IR laser pulses by measuring the incidence-angle dependence of photoelectron spectra. The results reveal that emitted electrons are further accelerated by locally enhanced electric fields.

Phase-Dependent Dielectric Laser Acceleration of 99keV Electrons with Symmetrically Driven Silicon Dual Pillar Gratings, Kenneth Leedle, Dylan S. Black, Yu Miao, Karel Urbanek, Andrew Celablos, Huyang Deng, James S. Harris, Olav Solgaard, Robert L. Byer. Stanford Univ, USA. We present phase-dependent laser acceleration and deflection of electrons using a symmetrically driven silicon dual pillar grating. We demonstrate cosh accelerator modes and sinh deflecting modes at gradients of 200 MeV/m over 15 um distance.

High Average Power Type II Frequency Doubling with a Predelay for Pulse Compression and Peak Intensity Enhancement, Sabrina Beyr, Christian Grebing, Marcel Schultze, Knut Michel, Georg Kor, Thomas Metzger. TRUMPF Scientific Lasers GmbH + Co. KG, Germany. We present pulse compression and peak intensity enhancement of up to a factor of 10 by inserting a time delay between the orignal and extraordinary fundamental pulses prior to type II frequency doubling in a BBO crystal. Despite a conversion efficiency of 26 %, an increase of peak power of nearly 20 % was achieved.

Femtosecond laser pulses have been used to precipitate active layers with parallel and antiparallel optical axes compare nicely with calculations.

Time-Resolved Surface Microscopy of Single Shot Few-Cycle Pulse Laser Ablation of Single Layer TiO2 Thin Films, Noah Talisa, Kevin Werner, Enam Chowdhury. Dept. of Physics, The Ohio State Univ., USA. The dynamics of the few-cycle pulse laser ablation process of a single layer TiO2 thin film from 6 ps to 1.1 ns after a single pulse hits the surface are studied using time-resolved microscopy.

Femtosecond laser writing of 3-D NLO structures in glass, Carl M. Liebig, Jonathan Goldstein, Sean McDaniel, Douglas Krein, Gary Cook. Air Force Research Lab, USA. General Dynamics Information Technology, USA. Femtosecond laser pulses have been used to precipitate 3-dimensional LiNbO3 structures in supersaturated glass for second harmonic generation (SHG). Measurements for successive layers with parallel and antiparallel optical axes compare nicely with calculations.
AM3P • Photobiomodulation Therapeutics—Continued

AM3P.5 • 15:00
Controlled laser biochemistry in room-temperature polar liquids by ultrashort laser pulses, Vitaly Gruzdev1, Dmitry Korkin2, Brian P. Mooney3,6, Jesper F. Havelund3,4, Ian M. Møller3,4, Jesper F. Havelund5,6, Ian M. Møller5,6, Jay J. Thelen3;1 Univ. of Missouri-Columbia, USA;2 Dept. of Computer Science, Bioinformatics and Computational Biology Program, Worcester Polytechnic Inst., USA;3 Dept. of Biochemistry, Bond Life Sciences Center, Univ. of Missouri, USA;4 Charles W Gehry Proteomics Center, Univ. of Missouri, USA;5 Dept. of Biochemistry and Molecular Biology, Univ. of Southern Denmark, Denmark;6 Dept. of Molecular Biology and Genetics, Aarhus Univ., Denmark. Traditional laser methods to control chemical modifications of biomolecules are not applicable under biologically relevant conditions. We report controlled modifications of peptides and insulin by femtosecond laser in water, methanol, and acetonitrile at room temperature.

AM3P.6 • 15:15
Parylene Photonic Waveguide Arrays: A Platform for Implantable Optical Neural Implants, Jay W. Reddy1;1 Carnegie Mellon Univ., USA. We demonstrate compact, low-loss (<10dB/cm) Parylene-C waveguide arrays in a flexible, biocompatible, polymer platform suitable for implantable neural probes. Mechanisms of optical loss are investigated and fabrication techniques to reduce propagation loss in the optical waveguides are presented.

FM3Q • Topological Photonic Structure—Continued

FM3Q.6 • 14:45
All-dielectric topological meta-optics, Alexey Slobozhanyuk1,4, Alena Shchelokova1,4, Xiang Ni1,2, Hossen Mousavi3,1,3,3, Daria Smirnova1, Pavel Belov3, Andrea Alù2, Yuri S. Kivshar3, Alexander B. Khanikaev2,3,4;1 City College of New York, USA;2 Physics, Graduate Center of CUNY, USA;3 ITMO Univ., Russia;4 Australian National Univ., Australia;5 Univ. of Texas at Austin, USA. We present all-dielectric resonant structured surfaces for the realization of lossless compact photonic topological metadevices. We demonstrate spin-Hall effect of light for spin-polarized topological edge states through proof-of-concept near-field spectroscopy measurements.

FM3Q.7 • 15:00
Photonic Chern insulator through homogenization of an array of particles, Meng Xiao1, Shanhui Fan2;1 Stanford University, USA. We propose a route towards creating a photonic Chern insulator through homogenization with an array of gyromagnetic cylinders. The non-trivial band topology of such a system is independent of the lattice structure.

FM3Q.8 • 15:15
Experiments on topological nodal chains, Qinghui Yan1,2, Rongjuan Liu1, Zhongbo Yan3, Boyuan Liu1, Hongsheng Chen2, Zhong Wang1, Ling Lu2;1 Inst. of Physics, Chinese Academy of Sciences, China;2 College of Information Science and Electronic Engineering, Zhejiang Univ., China;3 Inst. for Advanced Study, Tsinghua Univ., China. We theoretically predicted and experimentally verified mirror-protected nodal chains in a metallic-mesh photonic crystal at microwave frequencies. The bulk states were detected through angle-resolved transmission and drumhead surface states were mapped out by field scans.

14:00–15:30 Workshop: Understanding Unconscious Bias, Winchester 1&2, Hilton San Jose

15:30–16:00 Coffee Break, Concourse Level

16:00–17:30 Workshop: Understanding Unconscious Bias Workshop, Winchester 1&2, Hilton San Jose
SM4A.1  •  16:00  
Terahtertz Wave Generation from Water, Yiwen Fu, Qi Jin, Kaia Williams, Jianming Dai, Xicheng Zhang; 1Univ. of Rochester, USA; 2Tianjin Univ. of China, China; 3Capital Normal Univ., China. Terahtertz wave generation from liquid water has been experimentally demonstrated by focusing femtosecond laser pulses in a water film, which shows that the signal of water is 1.8 times stronger than that of ambient air.

SM4A.2  •  16:15  
Simultaneous generation and compression of broadband terahertz pulses in aperiodically poled crystals, Koultuban Ravi, Franz X. Kaertner; 1MIT, USA; 2Ultrafast optics and X-rays, Center for free electron lasers, Germany. A non-uniform sequence of pump pulses in aperiodically poled crystals is shown to generate transform-limited terahertz pulses. Tunable, compressed terahertz output with single-stage conversion efficiencies > 2% and pulse energies ~ 10 mJ are predicted.

SM4A.3  •  16:30  
Scaling of THz Generation in DSTMS to High Repetition Rates, Matthew Windeler, Katalin Mecseki, Franz Tavella, Matthias C. Hoffmann; 1SLAC National Accelerator Lab, USA; 2Queen’s Univ., Canada. We explore the scaling behavior of THz generation through optical rectification in DSTMS as a function of repetition rate from 100 Hz to 200 kHz. We observe a strong drop-off in conversion efficiency above 10 kHz.

SM4A.4  •  16:45  
Segmented Terahertz driven device for ultrashort electron acceleration, compression, focusing and streaking, Dongfang Zhang, Aya Falahli, Michael Hemmer, Xiaojun Wu, Meen Fahari, Yi Hua, Huseyn Cankaya, Anne-Laure Calendron, Luis Zapatia, Nicholas H. Matlis, Franz X. Kaertner; 1DESY, Germany. We present a novel THz-based device (STEAM) capable of performing multiple high-field operations of electron acceleration, compression, focusing and streaking.

SM4A.5  •  17:00  
Developments and Applications of Echelon-Based Single-shot Terahertz Spectroscopy, Ben Ofori-Okai, Stephanie Teo, Christopher Werley, Zhijiang Chen, Samuel Textelbaum, Brandon Russell, Matthias C. Hoffmann, Keith Nelson, Siegfried Glenzer; 1SLAC National Accelerator Lab, USA; 2Samsung Research America, USA; 3Q-State Biosciences, USA; 4Univ. of Michigan, USA; 5MIT, USA. We present recent advancements in echelon-based single-shot terahertz spectroscopy for broadband spectroscopic applications. We also apply an echelon-based scheme to study photo-induced changes in correlated electron materials and warm dense matter.

SM4A.6  •  17:20  
112-Gb/s PAM-4 using Integrated Germanium on Silicon Franz Keldysh Modulator, Yeyu Tong, Zhouyi Hu, Xinru Wu, Jie Liu, Chun-Ki Chan, Chester Shu, Hon Ki Tsang; 1SLAC National Accelerator Lab, USA; 2Queen’s Univ., Canada; 3Capital Normal Univ., China; 4Capital Normal Univ., China; 5Capital Normal Univ., China. We demonstrate a short-reach optical interconnect with a plasmonic intensity modulator. Data rates of 56 Gbd PAM-4 and 100 Gbd PAM-2 are demonstrated over 2 km and 1 km SSF with direct detection at 1544 nm.

SM4B.1  •  16:00  
Plasmonic-Organic Hybrid Modulators for Optical Interconnects beyond 100G/A, Benedikt Baueuerle, Wolfgang Heni, Yuriy Fedyoshyn, Anne Josten, Christian Haffner, Tatsuhiko Watanabe, Delwin Elden, Lary R. Dalton, Juerg Leuthold; 1ETH Zurich, Switzerland; 2Dept. of Chemistry, Univ. of Washington, USA. We demonstrate a short-reach optical interconnect with a plasmonic intensity modulator. Data rates of 56 Gbd PAM-4 and 100 Gbd PAM-2 are demonstrated over 2 km and 1 km SSF with direct detection at 1544 nm.

SM4B.2  •  16:15  
Electrolytd-Induced Absorption Silicon-Plasmonic Modulator with 70nm Bandwidth, Gian Gao, Erwen Li, Alan X. Wang; 1Oregon State Univ, USA. We present an electrolyte-induced absorption plasmonic modulator on silicon platform with a 3 μm length using transparent conductive oxide filled in Au slot waveguide. We experimentally demonstrated 1.5dB/μm extinction ratio over 70 nm optical bandwidth.

SM4B.3  •  16:30  
Commercializing Silicon Microring Resonators: Technical Challenges and Potential Solutions, Po Dong, Argishti Melikyan, Kwangwoong Kim, Nokia Bell Labs, USA. Silicon microcavities can find a wide range of applications in optical interconnects and communications. However, their resonant wavelengths are extremely sensitive to fabrication and temperature variations. Here we review possible solutions to address this challenge.

SM4B.4  •  16:45  
112-Gb/s PMD-4 using Integrated Germanium on Silicon Franz Keldysh Modulator, Yeyu Tong, Zhouyi Hu, Xinru Wu, Jie Liu, Chun-Ki Chan, Chester Shu, Hon Ki Tsang; 1SLAC National Accelerator Lab, USA; 2Queen’s Univ., Canada; 3Capital Normal Univ., China; 4Capital Normal Univ., China; 5Capital Normal Univ., China. We demonstrate a short-reach optical interconnect with a plasmonic intensity modulator. Data rates of 56 Gbd PAM-4 and 100 Gbd PAM-2 are demonstrated over 2 km and 1 km SSF with direct detection at 1544 nm.

SM4C.1  •  16:00  
Crosstalk Impact on a 535 Tb/s 172 km Transmission Using a Homogeneous 19-Core Multicore Fiber, Ruben S. Lui, Benjamin Putramt, Georg F. Rademacher, Yoshihara Awaji, Naoya Wada; 1National Inst Information & Comm Tech, Japan. We demonstrate a short-crosstalk penalty below 0.25 dB, enabling the transmission of 115x24.5 Gb/s PDM-4QAM signals in the C-band.

SM4C.2  •  16:15  
Modular Crosstalk Mitigated IM/DD Mode-Multiplexed Transmission Based on Pilot Assisted Least Square Algorithm, Qianwu Zhang, Fang Wang, Qiangting Huang, Haozhong Chen, Nicolas K. Fontaine, Roland Ryf, Minwen Liu, Jian Chen; 1Shanghai Univ., China; 2Nokia Bell Labs, USA. We experimentally demonstrated mode group crosstalk mitigation in IM/DD mode-multiplexed QDPM transmission using pilot assisted least square algorithm. Transmission performance is improved through mitigating the crosstalk between the LP01 and LP11 mode groups.

SM4C.3  •  16:30  
Modulation and Detection for Multicore Superchannels with Correlated Phase Noise, Erik Agrell, Arni Alfredsson, Benjamin Putramt, Ruben S. Lui, Georg Rademacher, Matthias Koster; 1Dept. of Electrical Engineering, Chalmers Univ. of Technology, Sweden; 2Photonic Network System Lab, NICT, Japan; 3Dept. of Microtechnology and Nanoscience, Chalmers Univ. of Technology, Sweden. SDM fibers offer new opportunities and challenges for joint transmitter and receiver processing. We review multidimensional modulation and detection theory, describe algorithms for phase tracking and detection over spatial superchannels, and present some experimental results.

SM4C.4  •  17:00  
7x149 Gb/s PAM4 Transmission over 1 km Multicore Fiber for Short-Reach Optical Interconnects, Oskars Ozols, Xiaodan Pang, Aleksejs Udalcovs, Rui Liu, Jonas Van Kerrebrouck, Lin Gan, Lu Zhang, Ming Tang, Songnian Fu, Richard Schatz, Urban Westergren, Gunnar Jacobson, Deming Liu, Weijun Tong, Gyu Yorfi, Johan Bauwelincx, Jiajia Chen, Sergei Popov, Xin Yin, RSE Acero AB, Sweden; 1KTH Royal Inst. of Technology, Sweden; 2Huazhong Univ. of Science and Technology, China; 3Intec, Ghent University – imec, Belgium; 4Yangtze Optical fiber and Cable Joint Stock Limited Company, China. We transmit 172.8 Gb/s PAM-4 using integrated germanium on silicon Franz Keldysh modulator, demonstrating a data rate of 172.8 Gb/s with a bit-error ratio of 1.55% across a 1-km-long fiber.
France; Laboratoire Kastler Brossel, UPMC-Sorbonne universités, CNRS, ENS-PSL Research Univ., France. Upconversion is an promising technique to increase sensitivity in active imaging. We introduce a novel nonlinear optical computing concept that compresses the signal's dynamic range and realizes non-uniform quantization of fully spatially incoherent input light state propagating along coupled conservative and lossy waveguides.

SM4D.3 • 16:30

Intra-cavity Self-illuminated Image Up-conversion System based on SHG in a Compact Laser, Adrian J. Torregoza1, Harolino Maestra1, Maria Luisa Rico1, Juan Capmany1; Universidad Miguel Hernandez, Spain; Universidad de Alicante, Spain. We present a compact laser for image up-conversion from infrared to visible based on intra-cavity SHG by type-II phase matching. Reflected images by Nd3+:YVO4 laser illumination at 1342 are intra-cavity frequency-doubled into a KTP crystal.

SM4D.4 • 16:45

Mid-Infrared (6 - 10 µm) upconversion in LiN3 using 1064 nm CW pump, Ajanta Barh1, Lasse Høegsted2, Peter Tidemand-Lichtenberg1, Christian Federsen1, Technical Univ. of Denmark (DTU), Denmark; NUIR ApS, Denmark. For the first time wide-band mid-infrared (6-10 µm) frequency upconversion in a LiN3 crystal is obtained using a 1064 nm pump. The absorption spectrum of polystyrene is characterized using a near-infrared grating and a Si-CCD.

SM4D.5 • 17:00

Optical Companding, Yuranh Jiang1, Bahram Jalali1; Univ. of California Los Angeles, CA. We introduce a new nonlinear analog optical computing concept that compresses the signal's dynamic range and realizes non-uniform quantization that reshapes and improve the signal-to-noise ratio in the digital domain.

FM4E.1 • 16:00

Manipulation and detection of optical coherence in non-continuous PT symmetric photonic structures, Kai Wang1, Sergey V. Suchkov1, James Titchener1, Steffen Weimann1, Demetrios N. Christodoulides2, Alexander Szameit3, Andrew A. Sukhorukov3; 1Nonlinear Physics Centre, RSPE, Australian National Univ., Australia; 2Inst. for Physics, Rostock Universität, Germany; 3CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA. We predict a periodic variation of the coherence between optical modes in parity-time symmetric photonic structures, and demonstrate experimentally reversible purification of fully spatially incoherent input light state propagating along coupled conservative and lossy waveguides.

FM4E.2 • 16:15

Extreme dynamics near exceptional points, QI ZHONG1, Konstantinos Makris1, Ramy El-Ganainy2; 1Dept. of Physics, Michigan Technological Univ., USA, 2Henes Center for Quantum Phenomena, Michigan Technological Univ., USA; 3Dept. of Physics, Univ. of Crete, Greece. We investigate the extreme dynamics of non-Hermitian photonic systems near higher order exceptional points (EP) and we show that the maximum possible power amplification follows a power-law dependence on the order of the EP.

FM4E.3 • 16:30

Unidirectional Light Generation in PT-Symmetric Microring Lasers, Jinhan Ren1, Mlady Panto1, Steffen Witte1, Mohammad Parvinnezhad Hoskimbadi1, Demetrios N. Christodoulides2, Mercedes Khajavikhan3; 1CREOL UCF, USA. At resonance, microring resonators tend to support two counter-propagating degenerate modes. By incorporating S-bend chiral elements in each resonator, unidirectional single mode lasing below and above PT-symmetry breaking point is experimentally demonstrated.

FM4E.4 • 17:00

Saturation-Induced Perfect Absorbers, Ali Kazemi Jahromi1, Ayman Abouraddy1; Univ. of Central Florida, CREOL, USA. We introduce a new regime of optical absorption where increasing the incoming intensity – equivalently inducing optical saturation – leads to the enhancement of total absorption in a device, and always reaches 100% at a critical value.

FM4E.5 • 17:00

Ultrafast X-ray Diffraction Reveals a Soft-Matter Driven Reversal of Polarity in Ferroelectrics, Christoph Haut1, Antonio-Andres Hernandez Salvador1, Marcel Holtz1, Michael Woerner1, Thomas Elsasser2; 1Max-Born Inst., Germany. Transient charge density maps of photoexcited ferroelectric ammonium sulfate are determined by femtosecond x-ray diffraction. We observe a previously unknown soft-mode that induces a transient reversal of the full macroscopic electric polarization.
FM4G.1 • 16:00
Frequency entanglement swapping, Sofiane Merkouche1, Valerian Theil1, Alex O. Davis1, Brian J. Smith1,2,3, Univ. of Oregon, USA; 2Univ. of Oxford, UK. Entanglement swapping of spectrally-entangled photons is experimentally demonstrated. Idler photons from independent entangled pairs are jointly detected after a beamsplitter and frequency filters, projecting the signal photons onto a frequency-bin singlet state.

FM4G.3 • 16:30
Parallel Characterization of Two-Qubit Frequency-Bin Entanglement, Ogaga D. Odele1, Poolad Imany1, Ogaga D. Odele1, Mohammed S. Al Alshaykh1, Hsuan-Hao Lu1, Daniel E. Leard2, Andrew M. Weiner1,3, Purdue Univ, USA. We demonstrate a Hong-Ou-Mandel interference pattern in the frequency domain with an electro-optic phase modulator and programmable pulse shapers, using energy-time entangled photons.

FM4G.4 • 16:45
Shaping photon-pairs time-frequency correlations in inhibited-coupling hollow-core fibers, Martin Cordier1, Ade-line Oriens1, Benoit Debord1, Frederic Gerome1, Alexandre Gorsse1, Matthieu Chafer1, Eleni Diamanti2, Philippe Delaye3, Fetah Benabid1, Isabelle Zaqurine1, Telecom ParisTech, France; 2LPJ, France; 3UM, France; 4GloFiPhotons, France; 5Laboratoire Charles Fabry, France. We experimentally show how multiband dispersion properties of inhibited-coupling hollow-core fibers allow to control the spectral correlations of photon pairs generated through four-wave-mixing in a fiber filled with non-linear gas.

FM4G.5 • 17:00
Generation of NIR correlated photon pairs in optical nano-fibers, Jin-Hun Kim1, Yong Sup Ihn1, HeeDeuk Shin1, Yoon-Ho Kim1, Po-Hang Univ of Science & Technology, South Korea. We report the generation of near-IR (NIR) nondegenerate correlated photon pairs in an 13-cm-long optical nano-fiber (ONF). The coincidence-to-accidental ratio (CAR) 400 has been achieved at a very low average pump power of 70 μW.
Field confinement, at the same time.

Surface waves with longer propagation distance and stronger free electrons leads to the formation of hyperbolic layers at

Optoelectronic Plasmonic Metamaterials with a Quantum

Absorption bandwidth (>90%) by atomic layer deposition. Absorption bandwidth (>90%) of 214 nm for Berreman-mode and 294 nm for ENZ-mode in NIR region is realized.

Broadband Epsilon Near Zero Conducting Oxide Absorbers Fabricated by Atomic Layer Deposition, Long Tao, Aleksei Anopchenko, Sudip Gurung, Catherine Arndt, Jason Myers, Ho Wai H. Lee1,2, Baylor Univ, USA; 2Optical Sciences Division, U.S. Naval Research Lab, USA. We demonstrate an excitation of broadband epsilon-near-zero resonance in multi-layer conducting oxides grown by atomic layer deposition. Absorption bandwidth (>90%) of 214 nm for Berreman-mode and 294 nm for ENZ-mode in NIR region is realized.

Hyperbolic modes of a metal-dielectric interface, Evgenii E. Narimanov,1 Purdue Univ, USA. The inherent mobility of free electrons leads to the formation of hyperbolic layers at any high-quality metal-dielectric interface, which support new surface waves with longer propagation distance and stronger field confinement, at the same time.

Variable Environmental Index Spectroscopy in Metamaterials, Wen-Yi Tsai1,2, Vassili Savinov1, Jun-Yu Ou1, Din Ping Tsai3,2, Sijing Liang1,2, Lin Xu1, Qiang Fu1, Lincai Zhao1, Hongliang Zeng1,2, Alex Y. Song1,2, Deborah S isco1,2, Claire F. Gmachl1, Princeton Univ, USA; 2Stanford Univ, USA; 3Trumpf Photonics Inc, USA. Through transmission and reflection measurements, we show that optical properties are preserved when a quantum cascade structure is incorporated into a plasmonic semiconductor metamaterial with negative refraction.

Mid-IR Supercontinuum Sources using Double Cascading, Ole. Bang1,2, Christian R. Petersen1, Peter Moselund2, Laurent Brilland2,3, DTU Fotonik, Technical Univ. of Denmark, Denmark; 2NKT Photonics A/S, Denmark; 3SelenOptics, France. Supercontinuum generation in softglass fibers can offer a spatially coherent source covering the spectral region 1-12 um. However, it requires to control double supercontinuum cascading in a setup with 3 or more vastly different fibers.

A Watt-level Supercontinuum Source from a Fiber-laser-pumped Fluorindate Fiber Spanning 750 nm to 5 pm, X. Kaertner1,2, Guoqing Chang1,4, E. Narimanov1, Evgenii Lavrinenko1, Nika Akopian1, Andrei V. Miroshnichenko1,2, University of Delaware, USA; 2NIST Gaithersburg, USA. We present a 100-MHz frequency comb that can be fully stabilized using less than 5 W of electrical power. We demonstrate full repetition-rate and offset-frequency stabilization while powering the comb with a held USB charger.

A low-power CW-laser modulates the fiber gain, achieving 40-times larger modulation bandwidth than standard pump-current control. A tight CEO lock is demonstrated.

We present the first all-fiber-based mode-filtering technique with high side-mode suppression ratio and high multiplication factor, Yuichi Sakaguchi1,2,3, Takeshi Hasegawa1,2, Toru Nishihara1,2, Akira Nunokawa1,2,3, Kazuhiko Fujita1,2,4, Kenji Sato1,2, N/A; 1Univ of Electro-Communications, Japan; 2ERATO MNOSIMA I/O Project, Japan. All-fiber-based mode filtering technique is developed for repetition rate multiplication of fiber-based frequency comb with multiplication factor of 11. Record high side-mode suppression ratio of approximately 40 dB is achieved with 536-MHz repetition-rate fiber-based mode-filtered-comb.

We present full repetition-rate and offset-frequency stabilization while powering the comb with a held USB charger.

We demonstrate all-fiber repetition-rate multiplication of mode-locked laser based on injection-locked slave laser. The fundamental repetition-rate of 78.4 MHz can be multiplied by 150 with high side-mode suppression ratio of 35 dB. We demonstrate full repetition-rate and offset-frequency stabilization while powering the comb with a held USB charger.

We demonstrate all-fiber repetition-rate multiplication of mode-locked fiber laser by cross gain modulation. A low-power CW-laser modulates the fiber gain, achieving 40-times larger modulation bandwidth than standard pump-current control. A tight CEO lock is demonstrated.

We demonstrate a new mode-locking technique that can be fully stabilized using less than 5 W of electrical power. We demonstrate full repetition-rate and offset-frequency stabilization while powering the comb with a held USB charger.

Optoelectronic Plasmonic Metamaterials with a Quantum
SM4N.1 • 16:00  Invited
Novel Solid-state Laser Materials, Christian Kraenkel1,2; Institut für Laser-Physik, Universität Hamburg, Germany; Center for Laser Materials, Leibniz Inst. for Crystal Growth, Germany. Novel materials enable unprecedented laser performance in the visible and near-infrared spectral range. Tm3+LiLuF4 delivers watt-level output in the green and yellow and the first cw Er:Sc2O3 laser emits 0.28 W at 2856 nm.

SM4N.2 • 16:30  Efficient and Broadly Tunable Eye-Safe Laser Operation in a Single Crystal of Tm-Doped Strontium Fluoride (Tm:SF4), Alberto Sottile1,2; Eugene Damiano3,2, Martina Rabe1, Rainer Bertram1, Detlef Klimmt2, Mauro Tonelli2,3; Istituto Nanoscienze - CNR, Italy; Dipartimento di Scienze Fisiche, della Terra e dell’Ambiente – Sez. di Fisica, Università di Siena, Italy; IKZ – Leibniz-Institut für Kristallzüchtung, Germany. We report on the growth, spectroscopic characterization, and first laser operation in this material, with a slope efficiency of 50% at 2015 nm. The laser was also continuously tunable between 1840 and 2020 nm.

SM4N.3 • 16:45  Q-switched Cryogenic Ho:YAG Laser, Militar Ganija1, Alexander Hemminger2, Nikola Simakov3, Neil Carmody3, Peter Veitch1, John Haub1, Jesper Munch1; Univ. of Adelaide, Australia; Cyber and Electronic Warfare Division, Defence Science & Technology Group, Australia. We describe the first power scalable Q-switched, cryogenically cooled, resonantly-pumped, Ho:YAG laser. The output energy was extracted from a confocal resonator with a single-pass pump geometry. Pulsed operation at higher average powers will be reported.

SM4N.4 • 17:00  Electrooptic Active Q switching at the 2 μm Wavelength Range using KLTN:Cu Crystals, Salman Noach1, Rotem Naher1, Yehuda Vidal1, Aharon J. Agranat1; The Hebrew Univ. of Jerusalem, Israel. An actively Q switched Ti:YLF laser operating at 1880 nm, generating 5 mJ, 34 nsec pulse duration is presented. Q switching was done by an electrooptic 2 mm long KLTN crystal driven at 3.6 kV/cm.

SM4O.1 • 16:00  Tutorial
Creation of Structured Materials with Optical Vortices, Takashige Omatsu1,2; Chiba Univ., Japan; Molecular Chirality Research Center, Chiba Univ., Japan. We review optical vortex materials processing, in which the orbital angular momentum twists materials mediated by optical vortices to establish chiral structured materials on the nano-/micro-scale. Also, we address recent progress concerning the optical vortex sources for materials processing.

Prof. Omatsu has been pioneering structured materials fabrication by optical vortex illumination. He published over 150 journal papers. He is serving as a deputy editor of Optics Express, and a director of photonics division, Japan Society of Applied Physics (JSAP). He was elected a OSA fellow and a JSAP fellow.
Miniature Biomedical Optical Sensors and Imaging Systems

Ofer Levi1; Univ. of Toronto, Canada. Miniature integrated optical systems for sensing and imaging can be portable, enabling long-term studies in living tissues. We present our miniature sensitive optical sensors and imaging systems for Lab-on-a-chip and in vivo imaging applications.

Miniature Biomedical Optical Sensors and Imaging Systems

Wei-Ju Lin1, Yu-Ming Liao1, Han-Yi Chou1, Yang-Fang Chen1; 1National Taiwan Univ., Taiwan.

Self-powered Ultrasensitive Glucose Detection Based on Graphene Multi-Heterojunctions

Cheng Han Chang1, Adi Primov-Fever 2, Michael Wolf1, Zeev Zalevsky1; 1Faculty of Engineering and the Nano Technology Center, Bar Ilan Univ., Israel; 2ENT Dept., Sheba Medical Center, Tel-Hashomer, Israel, and Sackler School of Medicine, Tel-Aviv Univ., Israel. The ability to remotely extract vibrations from specific locations on the vocal cords using time varied speckle patterns is innovative. The first step towards characterizing of spatial and temporal vocal cords vibrations remotely is presented.

Self-powered Ultrasensitive Glucose Detection Based on Graphene Multi-Heterojunctions

Ruizhe Yao1, Hang Li1, Jun Ding2, Chi-sen Lee1, Hualiang Zhang1, Wei Guo1; 1Univ. of Massachusetts Lowell, USA; 2East China Normal Univ., China. We demonstrate a topological bound-state laser array in a Su-Schrieffer-Heeger array with topological defect. It is shown experimentally that the phase transition exists between the topological bound and bulk state lasing by adjusting the gain.
SM4A • THz High-field Generation and Detection—Continued

SM4A.6 • 17:30
Single-Shot Electro-Optic Measurement of Mid-Infrared Pulses, Michael Kozina1, Matthias C. Hoffmann1, Linac Coherent Light Source, SLAC National Accelerator Lab, USA. We generate temporally chirped white light through self-phase modulation in glass. By mixing the white light with ultrafast mid-infrared pulses in GaSe via the electro-optic effect, we observe the phase of the mid-infrared light via spectrally resolving the electro-optic signal.

SM4A.7 • 17:45
Single-shot spectral measurement of THz radiation from elliptically focused two-color laser filamentation in air, Yung Jun Yoo1,2, Zheqiang Zhong2, Ki-Yong Kim3,1, Univ. of Maryland, USA,2Thorlabs Imaging Systems, USA. We report a single-shot method to measure the spectrum of THz radiation emitted from two-color laser filamentation in air. This method does not require multi-shot pump-probe scanning, and it is invulnerable to shot-to-shot laser fluctuation.

SM4A.8 • 17:45
InP Based Mach Zehnder Modulators With Ultra-low Vπ, Ye Liu1, Quanan Chen1, Xiang Ma2, Wei Sun1, Gongquan Zhao1, Gonghai Lu1, Qiaoyin Lu1, Weihua Guo1, Wuhan National Lab. For Optoelectronics, China. We designed and fabricated Mach-Zehnder Modulators (MZMs) with 0.65V Vπ based on InP substrate. And the expected bandwidth is >60GHz with a coplanar waveguide electrode (CPW) structure.

SM4B • Microrings and Novel Modulation Schemes—Continued

SM4B.5 • 17:15
Fast and Ultra-compact Multi-channel All-optical Switches Based on Silicon Photonic Crystal Nanobeam Cavities, Dong Gao1, Wentao Deng1, Xinliang Zhang1, Wuhan National Lab of Optoelectronic & School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China. By performing blue-detuned filtering on the output signal light, we achieve multi-channel all-optical switches with a processing density of 320 Tbs/mm², which is the highest processing density shown in silicon based multi-channel switches.

SM4B.6 • 17:30
Monolithically Integrated Stokes Vector Modulator Based on Quantum-Confined Stark Effect, Mohiyuddin Kazi1, Samir Ghosh1, Masakazu Sugiyama1, Takuo Tanemura1, Yoshiaki Nakano1, Univ. of Tokyo, Japan. We demonstrate a monolithically integrated Stokes vector modulator using quantum-confined Stark effect in a simple straight-line configuration. Efficient polarization modulation over Poincaré sphere is observed by applying reverse-bias voltages to MQW-based polarization-dependent phase modulators.

SM4B.7 • 17:45
InP Based Mach Zehnder Modulators With Ultra-low Vπ, Ye Liu1, Quanan Chen1, Xiang Ma2, Wei Sun1, Gongquan Zhao1, Gonghai Lu1, Qiaoyin Lu1, Weihua Guo1, Wuhan National Lab. For Optoelectronics, China. We designed and fabricated Mach-Zehnder Modulators (MZMs) with 0.65V Vπ based on InP substrate. And the expected bandwidth is >60GHz with a coplanar waveguide electrode (CPW) structure.

SM4C • SDM Communication II—Continued

SM4C.5 • 17:15
MCF-Enabled Self-Homodyne 16/64QAM Transmission for SDM Optical Access Networks, Aleksėjs Udalcovs1, Xiaodan Pang2,3, Oskars Ozolins1, Rui Lin2, Richard Schatz3, Anders Djupšjöbacka1, Jonas Märtensson1, Ming Tang3, Songnian Fu1, Deming Liu4, Weijun Tong5, Jiajia Chen6, Sergei Popov7, Gunnar Jacobsen1, RISE Acreo AB, Sweden;3KTTH Royal Inst. of Technology, Sweden;2Huazhong Univ. of Science and Technology, China;*Yangtze Optical Fiber and Cable Joint Stock Limited Company, China. We experimentally demonstrate a 29-Gbaud circular and square 16/64QAM transmission over a 33.6-km long seven-core fiber with the LO passed through one of the cores for self-homodyne coherent detection employing a low-complexity digital signal processing.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, Market 1&2, Hilton San Jose

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, Room 230A
Vezzoli, Thomas Roger, Clayton DeVault, Jongbum Kim, 92% diffraction efficiency of the nonlinear wavefront control. We demonstrate Si-based metasurfaces for third-harmonic generation of an arbitrary wavefront. The nonlinear metasurfaces produce phase gradients within a full 0–2π phase range. We achieve 92% diffraction efficiency of the nonlinear wavefront control.


Optical Technologies—Continued

FM4E.6 • 17:30
Multi-dimensional synthetic space and state measurement with spectral photonic lattices, Kai Wang, James Titchener, Bryn Bell, Alexander S. Solntsev, Dragomir N. Neshev, Beniamin J. Eggleton, Andrey A. Sukhorukov, “Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia; Centre for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS), Inst. of Photonics and Optical Science (IPOS), School of Physics, Univ. of Sydney, Australia; School of Mathematical and Physical Sciences, Univ. of Technology Sydney, Australia. We propose and experimentally realize spectral photonic lattices with pump-induced frequency couplings, which can emulate multi-dimensional dynamics with synthetic gauge fields and enable single-shot measurement of the signal phase and coherence.

FM4E.5 • 17:45
Ultrafast Separation of Photoexcited Electron Cloud, Efrat Lotan, Andrey A. Sukhorukov, Demetrios N. Christodoulides, Mercedeh Khajavikhan, “Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia; Centre for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS), Inst. of Photonics and Optical Science (IPOS), School of Physics, Univ. of Sydney, Australia; School of Mathematical and Physical Sciences, Univ. of Technology Sydney, Australia. We propose and experimentally realize spectral photonic lattices with pump-induced frequency couplings, which can emulate multi-dimensional dynamics with synthetic gauge fields and enable single-shot measurement of the signal phase and coherence.

FM4E.7 • 17:45
Ultrafast quantum interference control of photocurrents beyond the perturbative regime, Rodrigo A. Muniz, Kai Wang, Steven T. Cundiff, John E. Sipe, Mackillo P. Kira, “Univ. of Toronto, Canada; Univ. of Michigan, USA. We explore the use of high-intensity ultrashort lightwave waveforms for quantum interference control of photocurrents in semiconductor quantum wells. We analyze the quantum interference between nonlinear optical absorption processes in real time.
FM4G • Quantum Sources II—Continued

FM4G.6 • 17:15
Real-time spectral characterization of a photon pair source using a chirped supercontinuum seed, Jennifer Erskine1, Duncan England1, Connor Kupchak2, Ben Sussman1; 1Univ. of Ottawa, Canada; 2National Research Council, Canada. We perform joint spectral intensity measurements by studying stimulated four wave mixing in a birefringent fiber photon pair source. Seeding the process with a chirped supercontinuum beam, measurements are acquired in as little as 5 s.

FM4G.7 • 17:30
Quantum interferometry through cascading broadband entanglement sources, Arash Riazi1, Chang J. Chen1, Eric Y. Zhu1, Alexey Gladyshev2, Mili Ng3, Peter Kazansky1, John E. Sipe1, Li Qian1; 1Univ. of Toronto, Canada; 2Univ. of Southampton, UK; 3Russian Academy of Sciences, Russia. We demonstrate broadband (~100nm) quantum interference in telecom frequencies in an all-fiber system with cascaded SPDC sources. Its applications in dispersion metrology and quantum state engineering are also demonstrated.

FM4H • Quantum Optics with Atomic and Molecular Ensembles—Continued

FM4H.6 • 17:15
Wavevector-multiplexed and memory-enabled source of multimode nonclassical light, Michal Pamiak1, Michal Dabrowski1, Mateusz Mazelanik1, Adam Leszczyński1, Michał Lipka1, Wojciech Wasilewski1; 1Univ. of Warsaw, Poland. We demonstrate a quantum memory based on cold atomic ensemble generating and storing nonclassical light in 645 modes. With novel spin-wave manipulation techniques our system surfaces as a universal platform for quantum state preparation.

FM4H.7 • 17:30
Establishing and storing of quantum entanglement among three Rubidium atomic ensembles, Xiaojun Jia1; 1Shanxi Univ., China. Tripartite entanglement of optical modes is mapped into three distant atomic ensembles to establish entanglement of atomic spin waves via electromagnetically-induced-transparency light-matter interaction. Then the stored atomic entanglement is transferred into a tripartite entangled state.

SM4I • Novel Emitters—Continued

SM4L.6 • 17:15
Lasing in Si₃N₄-Organic Hybrid (SiNOH) Spiral Resonators, Daria Kohler2,1, Sentayehu Fetene Wondimu2,1, Lothar Hahn1, Isabel Allegro1, Matthias Blacher1, Wolfgang Freude1, Christian Koos1; 1Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany; 2Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany. We demonstrate lasing in optically pumped hybrid devices that combine passive Si₃N₄ waveguides with active organic cladding materials. Si₃N₄-organic hybrid (SiNOH) lasers lend themselves to low-cost integration and parallel read-out of large-scale sensor arrays.

SM4L.7 • 17:30
Invited
Physics and Applications of Active High-Q Microcavities, Jean-Baptiste Ceppe1,2, Vincent Huet1, Michel Martier3, Philippe Rochard1, Ariel Levenson4, Kamel Bencheikh4, Alejandro Yacomotti4, Patrice Feron1, Yannick Dumeige1; 1Université de Rennes, CNRS, Institut FOTON, France; 2IR-CICA (CNRS USR 3380) - PhLAM (CNRS UMR 8523), France; 3IRCP, Chimie ParisTech, France; 4C2N, France. High-quality factor whispering gallery mode microcavities doped with rare earth materials are used i) to study the dynamical and noise properties of micro-lasers and ii) to demonstrate slow-light effects in miniaturized devices.

SM4L.8 • 17:45
A Compact All-fiber Polarization-Entangled Photon Source Pumped by a Laser Diode, Chang J. Chen1, Arash Riazi1, Eric Y. Zhu1, Alexey Gladyshev2, Mili Ng3, Peter Kazansky1, Li Qian1; 1Univ. of Toronto, Canada; 2Univ. of Southampton, UK. We demonstrate a compact, all-fiber broadband polarization-entangled photon source pumped by a cw Fabry-Perot laser diode. Robust and stable operation yields a concurrence of 0.966 ± 0.015 and a fidelity to $|\Psi^+\rangle$ of 98.1 ± 0.8%.

SM4L.9 • 17:45
Entanglement Generation in Green Fluorescent Proteins, Siyuan Shi1, Kim F. Lee1, Prem Kumar1; 1Northwestern Univ., USA. We demonstrate generating polarization-entangled state through spontaneous four-wave mixing in enhanced green fluorescent proteins. We report coincident-to-accidental ratio of ~145 and entangled state fidelity of ~94% for the generated photon pairs.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, Market 1&2, Hilton San Jose

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, Room 230A
The technique combined with derivation of the analytical dispersion parameters. This formulation enables time domain modeling of the BA homogenized media and allows characterizing the geometry of the nanostructure with the dispersion parameters.

Time Domain Modeling of Bi-Anisotropic Homogenized Media with Analytical Dispersion, Ludmila J. Prokopeva1, Zhaxylyk A. Kudyshev2, Alexander Kildishev1, 1Purdue Univ., USA; 2Univ. of Electronic Science and Technology of China, China. We propose a new mechanism using the constructive interference of resonance transition radiation from photonic crystals to generate Cherenkov radiation into controllable angles with high sensitivity to any desired range of velocities.

We propose a conjugate nonlinear-optical loop mirror pair scheme (Conj-NOLM) for phase-preserving multilevel amplitude regeneration, by cascading two identical NOLMs with an intermediate phase conjugation stage. Q-factor improvements of 2.42% are achieved for 16-QAM signals.

Controlling Cherenkov Angles with Resonance Transition Radiation, Xiaohang Shi1, Xiao Lin1, Sajan Easo2, Yichen Shen3, Hongsheng Chen4, Baile Zhang1, John Joannopoulos3, Marin Soljacic2, Ido Kaminer1; 1Physics and Applied Physics, Nanyang Technological Univ., Singapore; 2Particle Physics Dept., Rutherford-Appleton Lab (STFC), UK; 3Physics, MIT, USA; 4Zhejiang Univ., China. We present a bi-anisotropic (BA) homogenization technique combined with derivation of the analytical dispersion parameters. This formulation enables time domain modeling of the BA homogenized media and allows characterizing the geometry of the nanostructure with the dispersion parameters.

SM4K.7 • 17:45
Fundamental Limits to Duration and Bandwidth of Temporal Cavity Solitons due to Raman Scattering, Yudong Wang1, Miles Anderson1, Stephanie Coen1, Stuart Murdoch1, Miro J. Erkintalo1, Alexander Klenner2, Yoshitomo Okawachi2, Michal Lipson1, Alexander L. Gaeta1, Ursula Keller1; 1Inst. for Quantum Electronics, ETH Zürich, Switzerland; 2Dept. of Electrical and Computer Engineering, Cornell Univ., USA; 3School of Electrical and Computer Engineering, Cornell Univ., USA. We demonstrate pulse repetition rate and carrier-envelope offset (CEO) frequency stabilization of a gigahertz SESAM-modelocked VECSEL. The CEO-detection is enabled by lowpower supercontinuum generation in a silicon-nitride waveguide without external pulse amplification.

We propose a new mechanism using the constructive interference of resonance transition radiation from photonic crystals to generate Cherenkov radiation into controllable angles with high sensitivity to any desired range of velocities.

Example with graphene plasmons.

SM4K.6 • 17:30
Phase-preserving Multilevel Amplitude Regeneration in Conjugate Nonlinear-Optical Loop Mirror Pair, Feng Wen1,2, Maria Sonokina3, Christos P. Tsekrekos1, Yong Geng3, Xingyu Zhou1, Baojian Wu1, Kun Qiu1, Sergei K. Turitsyn1, Stylianos Sygletos1, 1Aston Inst. of Photonics Technologies, UK; 2Univ. of Electronic Science and Technology of China, China; 3Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA. We propose a conjugate nonlinear-optical loop mirror pair scheme (Conj-NOLM) for phase-preserving multilevel amplitude regeneration, by cascading two identical NOLMs with an intermediate phase conjugation stage. Q-factor improvements of 2.42% are achieved for 16-QAM signals.

FM4J • Fundamentals of Metamaterials—Continued

FM4J.7 • 17:30
Controlling Cherenkov Angles with Resonance Transition Radiation, Xiaohang Shi1, Xiao Lin1, Sajan Easo2, Yichen Shen3, Hongsheng Chen4, Baile Zhang1, John Joannopoulos3, Marin Soljacic2, Ido Kaminer1; 1Physics and Applied Physics, Nanyang Technological Univ., Singapore; 2Particle Physics Dept., Rutherford-Appleton Lab (STFC), UK; 3Physics, MIT, USA; 4Zhejiang Univ., China. We propose a new mechanism using the constructive interference of resonance transition radiation from photonic crystals to generate Cherenkov radiation into controllable angles with high sensitivity to any desired range of velocities.

Example with graphene plasmons.
### SM4M • Power Scaling of Ultrafast Sources—Continued

**SM4M.5 • 17:30**
**Two-dimensional, Eight-beam Combination of Ultrashort Pulses Using Two Diffractive Optics**, Tong Zhou1, Qiang Du1, Tyler Sano1, Russell Wilcox1, Wim Leemans1, 1Lawrence Berkeley National Lab, USA. We demonstrate beam combination of eight 120fs pulses, using a diffractive optic pair. This highly scalable technique preserves input pulse width, and achieves 89.5% combining efficiency, limited by the diffractive optic.

**SM4M.6 • 17:45**
**Cavity Phase Measurement via Modulated Impulse Response for Coherent Temporal Pulse Stacking**, Yawei Yang1, Alexander Albrecht1, Junwei Meng1, Samnoo. Shek-Bahae1, 1Univ. of New Mexico, USA. We demonstrate the first radiation balanced thin disk lasers. Ytterbium-doped YLF and YAG thin disks are pumped by a fiber laser in multipass geometry and an InGaAs/GaAs VECSEL in intracavity geometry.

### SM4N • Laser Materials—Continued

**SM4N.5 • 17:15**
**Radiation Balanced Thin Disk Lasers**, Zhou Yang1, Alexander Albrecht1, Junwei Meng1, Samnoo. Shek-Bahae1, 1Univ. of New Mexico, USA. We demonstrate the first radiation balanced thin disk lasers. Ytterbium-doped YLF and YAG thin disks are pumped by a fiber laser in multipass geometry and an InGaAs/GaAs VECSEL in intracavity geometry.

**SM4N.6 • 17:30**
**Q-switched Laser Oscillation in Micro-Domain Controlled Yb:FAP Anisotropic Laser Ceramics**, Yoshio Sano1, Jun Akizuki1, Takunori Taira1, 1Inst. for Molecular Science, Japan. Using polycrystalline YbFAP-doped fluoroapatite (Yb:FAP), we investigated quantum mechanics for orientation-control of microdomains in anisotropic laser ceramics with 4f-electrons of RE3+ ion. Kilowatt-level sub-nsec laser pulses were generated with the extraction density of 0.34 J/cm².

**SM4N.7 • 17:45**
**Inversion caused spectral phase shift in a broadband Ti:Sapphire amplifier at room and cryogenic temperatures**, Roland Nagymihály1,2, Huabao Cao1, Peter Joger1, Viktor Zuba1, Mikhail Kalashnikov1,2, Adam Borzsonyi1,2, Vladimir V. Chvykov1, Karoly Osvay1, 1ELI-HU Non-Profit Ltd., Hungary; 2Dept. of Optics and Quantum Electronics, Univ. of Szeged, Hungary. Spectral phase shift of ultra-broadband pulses due to inversion was measured along the two axes of Ti:Sapphire at room and cryogenic temperatures. Results are crucial for CEP stabilization and compression of high energy few-cycle pulses.

### SM4O • Structured Light for Material Processing—Continued

**SM4O.3 • 17:15**
**Surface Relief Structuring via Multiple Pulse Femtosecond Ablation using an Intensity Spatial Light Modulator**, Benjamin Mills1, Daniel Heath1, Rupert Bapty1, Taimoor Rana1, Behrad Gholipour1, James Grant-Jacob1, Robert Eason1, 1Univ. of Southampton, UK. Subtractive femtosecond laser machining using multiple pulses with different spatial intensity profiles on the same position on a sample enables surface relief structuring with up to 60 layers, 330nm spatial resolution, 3μm maximum depth.

**SM4O.4 • 17:30**
**Two-photon induced ‘super-resolution’ single-armed relief in azo-polymer film**, Keigo Kinea1, Shogo Nakano1, Yoshinori Kinezuka1, Mitsuki Ichijo1, Ryo Shinozaki1, Katsuhiko Miyamoto1,2, Takashige Omatu1,2, Chiba Univ., Japan. We present the formation of a ‘super-resolution’ single-armed chiral relief in an azo-polymer film through a two-photon absorption process by the illumination of circularly polarized picosecond optical vortex pulses.

**SM4O.5 • 17:45**
**STED-inspired Laser Lithography Based on Spirothiopyran Chromophores**, Patrick Mueller1,2, Larissa Hammer1, Rouven Mueller1, Eva Blasco1, Christopher Barker-Kowollek1, Martin Wegener1,2, 1Inst. of Nanotechnology, Karlsruhe Inst. of Technology, Germany; 2Inst. of Applied Physics, Karlsruhe Inst. of Technology, Germany; 3Macromolecular Architectures, Inst. of Technical Chemistry and Polymer Chemistry, Karlsruhe Inst. of Technology, Germany; 4School of Chemistry, Physics, and Mechanical Engineering, Queensland Univ. of Technology, Australia. We present a photoresist based on the photochromic spirothiopyran moiety capable of creating free-standing 3D structures and offering an inhibition channel, which potentially allows for STED-inspired sub-diffraction laser lithography. Reversible inhibition and linewidth narrowing are demonstrated.
AM4P • Biosensing Technologies—Continued

AM4P.5 • 17:15
Multifunctional Optophoresis for Biomolecular Detection by Using Integrated Silicon Photonic Waveguide Arrays, Zhenyu Li1, Haitao Zhao1, Gong Zhang1, Yanyu Chen1, Jian-guo Huang1, Qhua Xiong1, Aiqun Liu1; 1Peking Univ., China; 2Nanyang Technological Univ., Singapore. A multifunctional optophoresis for biomolecular detection in integrated silicon photonic chip is demonstrated. Sample fractionation part is to avoid contamination and reduce interference. Signal is enhanced 5 more times after integrating sensors with waveguide arrays.

AM4P.6 • 17:30
Trapping and Optical Identification of Microparticles in a Liquid with a Functional Optical Fiber Probe, Fredrik Laurell1, Sebastian Etcheverry1, Walter Margulis1; 1Kungliga Tekniska Hogskolan, Sweden. A fiber probe traps single micrometer-particles by fluid suction into a hollow microstruc-ture and enables optical identification by the fluorescence light collected in a fiber core. The probe finds applications in life-science and environmental monitoring.

AM4P.7 • 17:45
All-fiber, Portable, Online Raman Biosensor with Enhancement of Signal Excitation and Collection Efficiency, Qian Chu1, Guanghui Wang1, Zhiqiang Jin1, Jie Tan1, Hao Cai1, Bo Lin1, Xuping Zhang1; 1Nanjing Univ., China; 2China Academy of Electronics and Information Technology, China. We demonstrate an all-fiber online Raman biosensor with enhancement of signal excitation and collection efficiency by inserting a gold-coated-fiber-tip reflector into the metal-lined capillary for transmission mode collection, which provides nearly 2 times of enhancement.

FM4Q • Valley-Hall and Active Topological Photonics—Continued

FM4Q.6 • 17:15
Topological Hybrid Silicon Microlasers, Han Zhao1, Pei Miao1, Mohammad H. Termourpour1, Simon Malard1, Ramy El-Ganainy1, Henning Schomerus1, Liang Feng1; 1Dept. of Electrical and Systems Engineering, Univ. of Pennsylvania, USA; 2Dept. of Materials Science and Engineering, Univ. of Pennsylvania, USA; 3Dept. of Electrical Engineering, The State Univ. of New York at Buffalo, USA; 4Dept. of Physics and Henes Center for Quantum Phenomena, Michigan Techno-logical Univ., USA. We present an active topological hybrid silicon microlaser array respecting the charge-conjugation symmetry. The created symmetry favors the lasing of a protected zero-mode, where robust single-mode laser action prevails even with intentionally introduced perturbations.

FM4Q.7 • 17:30
Robust Radiation from Photonic Topological Insulators, Yaakov Lumer1, Nader Engheta1; 1Electrical and Systems Engineering, Univ. of Pennsylvania, USA. We numerically demonstrate how a photonic topological insulator can be exploited to feed an antenna array, resulting in robust radiation performance free from unwanted interferences, mutual coupling and matching challenges among feed points.

FM4Q.8 • 17:45
Robust non-reciprocal lasing in topological cavities of arbitrary geometries, Babak Bahari1, Abdoulaye Ndao1, Felipe Vallin1, Abdelkrim El Amili1, Yeshaiahu Fainman1, Boubacar Kante1; 1Univ. of California San Diego, USA. We present non-reciprocal topological cavities operating at telecommunica-tion wavelengths. The unidirectional stimulated emission has an isolation ratio of about 10 dB between the output ports.

17:30–18:30 Diversity & Inclusion in Optics and Photonics Reception, Market 1&2, Hilton San Jose

19:00–20:30 OSA Nonophotonics Technical Group 20x20 Talks, Room 230A

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Cladding Waveguides in Aminoacid Crystal: Fabrication and Second Harmonic Generation, Gustavo Almeida1, Renato Martins1, Jonathas Siqueira1, Juliana Almeida1, Jose J. Rodrigues Jr2, Cleber R. Mendonca1, 1USP - Instituto de Fisica de Sao Carlos, Brazil; 2Physics Dept., Federal Univ. of Sao Blegre, Brazil. Cladding waveguides were inscribed in L-threonine aminoacid crystals by fs-laser pulses. Guided second harmonic generation was observed at 390 nm, with an efficiency of 1.36%cm-1. Such results open new opportunities in organic nonlinear photonics.

Optothermal Nanoscissors for Versatile Low-Power Patternning of Atomic-Thin Two-Dimensional Materials, Jingang Liu1, Linhan Lin1,2, Xiaolei Peng1, Yuebing Zheng1,2, Materials Science & Engineering Program, The Univ. of Texas at Austin, USA; 1Dept. of Mechanical Engineering, The Univ. of Texas at Austin, USA; 2National Chiao Tung Univ., Taiwan. We report a new technique - optothermal nanoscissors - to achieve fast, on-demand and arbitrary patternning of different atomic-thin two-dimensional materials using the highly localized plasmonic heating effect.

Free-Space Optical Switching of GST Phase-Change Thin Films via 1550 nm Light, Gary A. Sevison1,2, Joshua Burrow1, Andrea Aboujoudie1, Matthew Mircovich, Andrew Sarangan1, Josh Hendrickson1, Amaq Agha1,2, 1Electro-Optics, Univ. of Dayton, USA; 2Electrical and Computer Engineering, Univ. of Dayton, USA; 2Physics, Univ. of Dayton, USA; 2Sensors Directorate, Air Force Research Lab, Wright-Patterson AFB, USA. We experimentally demonstrate free-space phase change of Germanium Antimony Telluride (GST), switching between the amorphous and hexagonal crystalline states utilizing telecom-band laser pulses.

Graphene/Ill-V Hybrid Diode Optical Modulator, Ruohi Yao1, Bowen Zheng1, Hyun Kum1, Junyi Kim1, Sanghoon Baer1, Jeewhan Kim1, Hualiang Zhang1, Wei Guo1, 1Univ. of Massachusetts Lowell, USA; 2MIT, USA. We demonstrate a graphene/Ill-V hybrid diode optical modulator working over a large frequency range from NIR to THz. The hybrid diode is achieved by heterogeneously integrating of graphene and III-V heterostructures by remote epitaxy growth.

Long-lived Quantum Emitters in hBN-WSe2, Van-Der Waals Heterostructures, Jakob Wierzbowski1, Malte Kremser1, Christian Straubinger1, Florian Sigger1, Julian Klein1, Michael Kaniber1, Kai Müller1, Jonathan Finley1, 1National Chiao Tung Univ., Taiwan; 2Dept. of Mechanical Engineering, The Univ. of Texas at Austin, USA; 3KTH Royal Institute of Technology, Stockholm, Sweden. We demonstrate a large frequency range from NIR to THz. The hybrid diode is achieved by heterogeneously integrating of graphene and III-V heterostructures by remote epitaxy growth.

Mode-switching phenomena in periodic InGaN-based hexagon microcavity array, Chia-Yen Huang1, Tsu-Ying Tai1, Jing-Jie Lin1, Tsu-Chi Chang1, Che-Yu Liu1, Kuo-Bin Hong1, Tien-Chang Lu1, Hao-Chung Kuo1, 1Dept. of Photonics, NCTU, Taiwan. The lasing behavior of InGaN-based microcavity array was strongly relevant to the excitation area. The stronger rod-to-rod optical interaction between the fundamental axial mode resulted its dominance in the collective lasing behavior.

Frequency-Doubled Wafer-Fused 638 nm VCSEL with an Efficiency of 1.3%(MW cm2)-1, Emmi L. Kantola1, Tomi Leinonen1, Andrea Aboujoudie1, Matthew Mircovich1, Andrew Sarangan1, Josh Hendrickson1, Amaq Agha1,2, 1Electro-Optics, Univ. of Dayton, USA; 2Electrical and Computer Engineering, Univ. of Dayton, USA; 2Physics, Univ. of Dayton, USA; 2Sensors Directorate, Air Force Research Lab, Wright-Patterson AFB, USA. We have compared the lasing characteristics between directly bonded InP substrate and directly bonded InPSi substrate, Gandhi Kallarasan1, Piyunyanagare1, Naoki Kamada1, Yuya Onuki1, Kazuki Uchida1, Hirokazu Sugiyama1, Xu Han1, Natsuki Haya-saka1, Masaki Akawa1, Kazuhiro Shimomura1, Sophia Univ., Japan. Crystal growth on the Si substrate for 1.5 µm GaInAsP stripe laser diode has been demonstrated via MOVPE and successfully achieved the lasing operation in the pulse regime. We have compared the lasing characteristics between directly bonded InP substrate and InPSi substrate as a reference.

A Large Area Monolayer WS2 Laser Based on Surface-Emitting Heterostructure Photonic Crystal Cavities, Xiao Chen1,2, Moumouq Minkov2, Xiuling Li3, Shanhui Fan2, 1Univ. of Texas at Arlington, USA; 2Electrical and Computer Engineering, Univ. of Texas at Arlington, USA; 3Electrical and Computer Engineering, Univ. of Illinois Urbana-Champaign, USA. An optically pumped continuous wave room temperature operation monolayer WS2 laser is presented. The cavity is formed around the point above lightline in a large area heterostructure photonic crystal slab for energy efficient surface emission.

High-Power DBR-Free Membrane Semiconductor Disk Lasers, Zhiyang Zhou1,2, David Fellow1, Alexander Albrecht1, Paula Heu1, Garrett Cole1, Mansoor. Sheik-Bahae1, 1Univ. of New Mexico, USA; 2Crystalline Mirror Solutions LLC, USA. We compare the performance of DBR-free membrane semiconductor disk lasers (SDLs) with single and dual SiC intracavity heatpreaders. A record output power of 16.1 W is achieved and a fluorescence-based temperature characterization technique is demonstrated.

Demonstration of 1-um-band Si-Photonics-Based Quantum Dot Heterogeneous Tunable Laser, Atsushi Matsumoto1,2, Jeehwan Kim1,2, Hualiang Zhang1,2, Wei Guo1, 1Tokyo Inst. of Technology, Japan; 2Tohoku Univ., Japan. We present a Si-photonics-based quantum dot heterogeneous tunable lasers in the 1-um band. Optical devices using Si-photonics-based PIC in the 1-um band probably have not been reported yet.
The laser spectrum was narrowed with a Volume Bragg Grating (VBG) to achieve high SMSR and ultra-linear dynamic range. The VBG consists of a Bragg grating with a high reflectivity (>99.9%) at a specific wavelength, which filters out unwanted modes, leaving only the desired mode for lasing. This results in a highly stable and narrow-linewidth emission, which is essential for applications requiring precise tuning and high spectral purity.

To achieve this, the researchers optimized the design parameters of the VBG, such as the grating period and the refractive index of the Bragg grating material. The optimized VBG was then incorporated into the laser cavity, and the laser performance was evaluated. The results showed that the laser could be tuned over a wide range of wavelengths with high SMSR and low phase noise, making it suitable for various applications, including optical communications, sensing, and spectroscopy.
Few-Mode EDFA Based All-Optical Relaying System for PAM4s/PAM8s. 16QAM/64QAM is successfully de-aggregated into two Information and Communications Technology (NICT), Japan. Science and Technology, Tokai Univ., Japan; 3National Inst. of School of Information and Communication Engineering, Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecom., China; 1Inst of Innovative Science and Technology, Tokai Univ., Japan; 1National Inst. of Information and Communications Technology (NICT), Japan. A single-stage phase-sensitive amplifier based quadrature de-multiplexer is proposed and validated for de-aggregating QAM signals into in-phase and quadrature components with wavelength and polarization preserved. A 10Gbaud 16QAM/64QAM is successfully de-aggregated into two PAM4s/PAM8s.

Few-Mode EDFA Based All-Optical Relaying System for Atmospheric Channels, Shanyong Cai1, Zhiguo Zhang1, Xue Chen1; 2Beijing Univ. of Posts & Telecom, China. We present a scheme of all-optical relaying system based on few-mode erbium-doped fiber amplifier (EDFA) to resist turbulence for atmospheric channels with improved bit error rate.

Dual-phase-conjagation Coded Digital Multicarrier Transmission for Long-haul Coherent Optical Systems, Takahiro Kodama1, Masanori Hanawa1, Yamanashi Univ., Japan. A dual phase-conjugated multicarrier OP-QPSK system for chromatic dispersion and nonlinear tolerance transmission has been demonstrated. We show Q-factor improvement by balancing a nonlinear distortion over 10000 km SMF transmission with 6-dB worst case FDL.

S12-Gbit/s PAM-4 Signals Direct-Detection using Silicon Photonics Receiver with Volterra Equalization, Yung Hsu1, Chun-Yen Chang1, Ling-Yu Wei1, Chi-Wai Chow1, Yuxiu Wu2, Han Ki Tsang1, Jyhcheng2, Chen-Hung Yeh2; 1National Chiao Tung Univ., Taiwan, 2Dept. of Electronic Engineering, The Chinese Univ. of Hong Kong, Hong Kong; 3Dept. of Photonics, Feng Chia Univ., Taiwan. A 400-Gbit/s Ethernet (GE) pulse-amplitude-modulation-4 (PAM-4) over 10-km single-mode-fiber (SMF) transmission direct-detected by an integrated silicon-photonics-receiver satisfying the IEEE 880.3b requirement, and its feasibility to support 512-Gbit/s transmission were illustrated.

Silicon Photonics Deserializazation for Energy Efficient Links, Nathan Abrams, Robert Polster1, Michael Okoniewski1, Liang Yuan Dai1, Keren Bergman1; 1Columbia Univ., USA. We develop a novel optical deserialisation system in silicon photonics to reduce electrical deserialisation power consumption and improve receiver sensitivity. Results demonstrate a path to increasing receiver sensitivity by 2.5 dB with improved modulators.

Reduced Complexity Interleaved Multi-Carrier CDMA for Passive Optical Networks, Abdallah M. Abdelaziz1, Mostafa Khalil1, mahamed El-Shimy1, Masoud Alghoniemy1, Hossam M. Shalaby1; 1Electrical Engineering, Alexandria Univ., Egypt; 2Egypt-Japan Univ. of Science and Technology (E-JUST), Egypt. A reduced complexity interleaved multi-carrier CDMA technique is proposed for passive optical networks (PONs). The proposed technique provides performance improvement compared to traditional O-OFDMA with less complexity than MC-CDMA.

RSOP Equalization through an Extended Kalman Filter Scheme in Stokes Vector Direct Detection System, Qisong Shang1, Zibo Zheng2, Nan Cui1, Nannan Zhang1, Wenbo Wang1, Hengyou Xu1, Xianfeng Tang1, Liuxi Xi1, Xiaoguang Zhang1; 1Beijing Univ. of Posts & Telecom, China; 2Shanghai Jiao Tong Univ., China. A new scheme for RSOP equalization in Stokes Vector Direct Detection (S4-DD) is proposed. The scheme is using Extended Kalman Filter (EKF) to tracking and compensation, which has a good performance in fast dynamic RSOP.

Cost-effective Demultiplexing Scheme for Two PDM-PAM4 Joint IM/DD Links Utilizing Stokes Receiver, Yan Pan1, Lianshan Yan1, Anlin Yi1, Lin Jiang1, Wei Pan1, Bin Luo1; 1Southwest Jiaotong Univ, China. We propose a cost-effective demultiplexing scheme for two PDM-PAM4 signals in IM/DD system based on a single Stokes receiver. About 1-dB power penalty is observed after 25 km NZDFF transmission at 160-Gbit/s data rate.

Fine and Coarse Tunability over a Continuous 8.1-ns Delay Line Response with Access to Multiple Possible Delays using a Frequency Comb, Ahmad Almaran1, Yinwen Cao2, Amr Youssef3, Ahmed Mahajerin Ariasi1, Fatemeh Alshahi1, Ahmed Fallahpour1, Dimitry Starodubov1, Khaeng Zhou1, PeiCheng Liao1, Changjing Bao1, Shlomo Zach1, Nadav Cohen1, Mohse Tuz1, Alan E. Willner2; 1Univ. of Southern California, USA; 2School of Electrical Engineering, Tel Aviv Univ., Israel. A continuous delay range of 8.1 ns is achieved with simultaneous access to four different delays. Our system’s penalty is ~2 dB for a 10 Gbaud QPSK signal. We also add a HNLF to convert one of the delays to the original wavelength, adding ~ 0.3 dB penalty.

A Cost-Effective Demodulator for the Next Generation of Optical Access Networks Receivers, Ana R. Bastos1, Ali Shalapin2, Luis D. Carlos1, Mario Lima1, Paulo S. Andre1, Maria R. Ferreira1; Instituto de Telecomunicacoes, Portugal; 2CICECO, Portugal. We introduce a cost-effective organic-inorganic hybrid photonic integrated circuit suitable for coherent access networks and demonstrate a 3×50×3 dB power penalty, relatively to back-to-back, for 20 Gb/s QPSK transmission over 40 km of G.652 fiber.

Programmable sub-harmonic optical clock recovery based on dispersion-induced inverse temporal self-imaging, Jinwoo Jeon1, Reza M. Qartavol2, James van Howe1, Jose Azana1; 1NIRS-Energie Materiaux et Telecom, Canada; 2Dept. of Physics and Astronomy, Augustana College, USA. We propose and experimentally demonstrate the first design of a fiber-optics programmable base/sub-harmonic optical clock recovery circuit, involving a phase modulator and linear dispersion, in which the rate division factor can be electrically reconfigurable.

Impact of differential group-velocity dispersion in intermodal four-wave mixing in few-mode fibers, Georg Rademacher1, Ruben S. Luis, Benjamin Puttmann1, Hideaki Furukawa1, Yoshinari Awai1, Naoya Wada1, Ryo Murayama1, Kazukiko Aikawa1; 1National Inst of Information & Comm Tech, Japan; 2Fujikura Ltd, Japan. We investigate the impact of differential group-velocity dispersion between modes of a few-mode fiber on intermodal four-wave mixing. We find that differences of the chromatic dispersion lead to a reduced bandwidth with full phase-matching.

Enhancing the Performance of an Optical High-Order QAM Communication Channel by Adding Correlated Data to Robust Neighboring Channels in a Heterogeneous Network, Yinwen Cao1, Kaehng Zou1, Ahmed Almaran1, Amr Youssef3, Ahmad Mahajerin Ariasi1, Changjing Bao1, PeiCheng Liao1, Fatemeh Alshahi1, Ahmed Fallahpour1, Alan E. Willner2; 1Univ. of Southern California, USA. An enhanced high-order QAM communication using data correlation with neighboring channels is demonstrated. The effectiveness of this approach is verified by using 10-Gbaud 4/16/64/256-QAM channels in simulation and 5/10-Gbaud 16-QAM channels in experiment.

Single-Source Duplex High-Speed FSO Communications Using Electro-Optic Modulator-Based MRR, Xianglian Feng1, Hexin Jiang1, Zhihang Wu2, TianShu Wang1, Hengwei He1, Shiming Gao1, JieJiang Sun1, ChunQing Sun1, Changshun Univ. of Science and Technology, China. A single-source 10 Gbs/duplex free-space optical communication is demonstrated using electro-optic modulator-based modulating retro-reflector. The power penalty is <2.3 (8.0) dB for downlink DPSK (uplink OOK) signal at 1×110 BER in an atmospheric cell.
JTu2A.55 Nyquist-WDM Super-Channel Using an On-Chip Frequency Comb enabled by a Silicon Dual-drive MZM, Jiachun Lin1, Yelong Xu1, Hassan Sepehrian1, Leslie A. Rusch1, Wei Shi1, 2Université Laval, Canada. We experimentally generate a 20 GHz spaced 5-line comb using a silicon modulator, with good performance to support 16Gbaud 120AM and 20Gbaud 16QAM, aggregating net rates of 667 Gb/s and 747 Gb/s.

JTu2A.56 Terabit optical OFDM data transmission carried by coherent Kerr soliton frequency comb lines, Xiatao Huang1, Yong Geng1, Wenfen Cui1, Yun Ling1, Xingwen Yi1, Baojian Wu1, Hui Chi1, Taylor Allen1, Sepehr Benis4, Natalia Munera4, Joseph W. Ye2, Chaitanya Kumar Suddapalli1,2, Majid Ebrahim-Zadeh2,3; 3Institució Catalana de Recerca i Estudis Avancats (ICREA), Barcelona, Spain; 2DTU, Denmark. We demonstrate seamless multiplexing of 160-channel optical-orthogonal-frequency-division-multiplexing utilizing dissipative Kerr soliton microcomb aided by sinc-pulse modulation. Mutual coherence among Kerr comb lines is exploited for the first time to achieve 6.85 Tbit/s data transmission.

JTu2A.57 214 (=16,384) Level Intensity Modulation at 10 Gbaud for on-chip optical interconnects using mode-division-multiplexing utilizing polarization multiplexing, Yeh3; 1National Chiao Tung Univ., Taiwan; 2Dept. of Electronic Engineering, The Chinese Univ. of Hong Kong, Hong Kong; 2Dept. of Photonics, Feng Chia Univ., Taiwan. 192-Gbit/s pulse-amplitude-modulation-4 (PAM-4) signal transmission for on-chip optical interconnects using mode-division-multiplexing (MDM) is experimentally investigated. 3 channels are successfully mode-multiplexed and de-multiplexed satisfying the forward-error correction (FEC) requirement.

JTu2A.59 Third-Order Nonlinear Optical Coefficients of Si and GaAs in the Near-Infrared Spectral Region, Joel M. Hales1,2,3, San-Hui Chi1,2, Taylor Allen3, Sepher Benis3, Natalia Munera3, Joseph W. Ye2, Dale McMorrow4, David J. Hagan4, Eric W. Van Truyn, Jiachuan Lin1, Yunxiang Chen1, Han Zhang1; 1Université Laval, Canada. We propose an angularly dispersive optical parametric amplifier to compensate the phase mismatch over 1.3-1.4 µm, and generate carrier-envelope phase stable, millijoule, ~1.1 cycle pulses centered of 1128-1243 nm and 1358-1600 nm, and exhibiting interesting spectral features.

JTu2A.61 Compact Femtosecond Optical Parametric Oscillator on an Integration-ready Fiber Retroreflector, Callum F. O’Donnell1, Chaitanya Kumar Suddapalli1, Therese Paolletta1, M. Ebrahim-Zadeh2, Radiantis, Spain; 3ICFO - Institut de Cien onores Fotoniques, Spain. We report a compact femtosecond optical parametric oscillator based on MgO:PPLN, incorporating an integrated-mirror, single-mode fibre-feed back loop, generating up to 50 mW across 1128-1243 nm and 1358-1600 nm, and exhibiting interesting spectral features.

JTu2A.62 Broadband Comb Upconversion in an Apodized Step-Chirped PPLN Waveguide for the Quantum Memories, SuSu He1, Yoo Seung Lee1, Hao Liu1, Jinghu Yang1, Chee Wei Wong2, Kun Qiu1, Shu-Wei Huang3, Chee Wei Wong1; 1UCL, UK. We present theoretical modeling and characterization of an apodized step-chirped PPLN waveguide for efficient and uniform broadband upconversion from 1580-nm comb to ~984-nm comb with a 3dB bandwidth of 48-6 nm, to interface with rare-earth solid-state quantum memories.

JTu2A.63 Four-Wave Mixing in Highly Nonlinear Chalcogenide Glass-in-Silica Waveguides, Moshe Katzman1, Dvir Munk1, Nir Itzir1, Ark Bergman2, Mark Oksanen1, Yuri Kaganovskii1, Michal Rosenbluh1, Avi Zadok1, 1Bar-Ilan Univ., Israel. We show the design and characterization of a silicon-rich chalcogenide glass waveguide fabricated through deposition of chalcogenide glass into pre-patterned trenches in a silica cladding. No processing of the chalcogenide glass is required. Four-wave mixing is demonstrated with nonlinear coefficient of 6.5±1 [W/m].

JTu2A.64 All-optical Wavelength Conversion of Phase-encoded Signals in Silicon-rich Silicon Nitride Waveguides, Cosmo Lacava1, Stuart May1, David Richardson1, Graham T. Reed1, Marc Sorel1, Perklinis Poltropoulos1, 1Univ. of Southampton, UK, 2Univ. of Glasgow, UK. We show the design and characteriza- tion of a silicon-rich silicon nitride-based all-optical wavelength converter, for phase-encoded signals. We demon- strate successful conversion of a 40 Gb/s 16-QAM signal with negligible penalty and no-signs of TF.

JTu2A.65 Millijoule single-cycle angularly dispersed optical parametric amplifier, Xiao Zou1, Hui Xi1, Zhifeng Chen1, Xi Chen1, Jinghu Yang1, Yung Hsu1, Xinru Wu2, Chun-Yen Chuang1, Xiao Zou2,1, Houkun Liang2, Shizhen Qu2,1, 1Physics Dept., Sofia Univ. “St. Kliment Ohridski”, Bulgaria; 2IB Photonics Ltd., Bulgaria. Stable UV-extended supercontinuum generation by self-action of picosecond pulses in bulk materials is demonstrated. The stability and spectral properties of the continuum show a strong dependence on the focusing parameters in 120-mm long CaF2 rod.

JTu2A.66 Harmonic Generation In Cascaded Raman Fiber Lasers, Santosh Aparanji1, V Balaswamy1, S Aunin1, V R Supradeepa1; 1Indian Inst. of Science, India. We report the surprising obser- vation of visible harmonics in an cascaded Raman fiber laser: A transition from 2nd to 3rd harmonic is seen with increasing locally propagating wavelengths, which we attribute to Cherenkov-type phase-matching.

JTu2A.67 Characterization of linear and nonlinear carrier generation in silicon nano-waveguides at 1550 nm, Andres Gil-Molina1,2, Ivan A. Aldaya1, Julian L. Pita1, Lucas Gabrielli1, Hugo Fragot3,1, Paulo C. Daimes1; 1Inst. of Physics, Univ. of Campinas, Brazil; 2School of Engineering, Univ. of Campinas, Brazil; 3State Univ. of Sao Paulo, Brazil; “Mackgraph, Macken- zie Presbyterian Univ., Brazil. We characterize the generation of free-carriers in a silicon nano-waveguide at 1550nm with increasing locally propagating wavelengths, which we attribute to Cherenkov-type phase-matching.

JTu2A.68 Characterization of the Impact of β0 and β1 in Four-Wave Mixing Optical Time Lenses using Input-Output Cross-Correlations, Frederik Kleis1,2, Mads Lillichom1, Michael Galili1, Leif K. Oxenløwe1,2, DTU, Denmark. We propose the use of input-output cross correlations to quantify the performance of four-wave mixing time lenses with dispersion-induced deg- radation. The impact of dispersion variations is investigated.

JTu2A.69 Stable UV-extended Supercontinuum Generation in Bulk Material by Picosescond Pulses, Veselin Aleksandrovy1,2, An- ton Trifonov1,2, Velizar Stoyanov1, Kolyan Georgiev1, Ivan C. Buchvarov1, Physics Dept., Sofia Univ. “St. Kliment Ohridski”, Bulgaria; 198Photonics Ltd., Bulgaria. Stable UV-extended supercon- tinuum generation by self-action of picosecond pulses in bulk materials is demonstrated. The stability and spectral characteristics of the continuum show a strong dependence on the focusing parameters in 120-mm long CaF2 rod.
JTu2A.75
Adaptive Wavefront Control for Optimized Coherent Radiation Multi-sideband Generation, Mania Shatava1, Anton Shutov1, Jonathan Thompson2, Alexandra A. Zhdanova2, Alexei V. Sokolov3; Inst. for Quantum Science and Engineering, Dept. of Physics and Astronomy, Texas A&M Univ., USA. We demonstrate that the wavefront optimization algorithm with feedback loop allows the extension of the total bandwidth of coherent Raman sidebands towards UV wavelengths, which will provide broader bandwidths for subcycle UV-VIS-NIR pulse synthesis.

JTu2A.76
Breath solitons dynamics and period-doubling transitions in 19 GHz microring resonator frequency combs, Wenting Wang1, Abhinav K. Vrinod1, Jinghu Yang1, Mingbin Yu1, Dim-Dim Kwong2, Chee Wei Wong3; Univ. of California, Los Angeles, USA; Inst. of Microelectronics, Singapore. We observed breath soliton dynamics and period-doubling transitions in 19 GHz dispersion-engineered dissipative microring frequency combs. The low-noise comb breath frequency is deterministically controlled via effective pump detuning with 18 kHz/MHz slope efficiencies.

JTu2A.77
Hybrid Silicon-Nitride / Polymer Waveguide for Nonlinear-Optics Applications, Subrata Das1, Brett R. Wenneker2, Jeffery W. Allen3, Monica S. Allen3, Michael Vasilyev2; Univ. of Texas at Arlington, USA; Air Force Research Lab Sensors Directorate, USA; Air Force Research Lab Munitions Directorate, USA. We describe a hybrid silicon-nitride / polymer slab waveguide for generation of second harmonic of a 1550 nm beam. Modal phase-matching and optimized geometry yield order-of-magnitude improvement over a channel waveguide.

JTu2A.79
Efficient tuning of second-harmonic generation in a lithium niobate nonphononic waveguide, Rui Luo1, Ying He1, Harviao Li1, Xingxiao Li1, Qiang Lin1; Univ. of Rochester, USA. We report flexible spectral tuning of second-harmonic generation in a lithium niobate nonphononic waveguide, with a thermal tuning slope of 0.84 nm/k for a telecom pump, by utilizing the significant thermo-optic birefringence of lithium niobate.

JTu2A.80
Distributed Monitoring of Cascaded Four-Wave Mixing due to Kerr and Opto-Mechanical Nonlinearities, Hilel Hagai1,2; Inst. of Photonic System, Taiwan; 1National Tsing Hua Univ., Taiwan. We demonstrate a novel method to measure them using thermal-optical properties of R6G thin film.

JTu2A.81
Continuous-Time Electro-Optic PLL with Decimated Optical Delay/Loss and Spur Cancellation for LiDAR, Jahnavi Sharma1, Sohail Ahasan1, Christopher T. Phare1, Michal Lipson1, Harish Krishnaswamy1; Electrical Engineering, Columbia Univ., USA. Current EO-PLLs for laser chirp modulation require large, lossy delay waveguides in an MZ to detect chirp slope. EO-PLLs, and electronic control loops generally, are dominantly digital. A new analog EO-PLL breaks the trade-off between chirp bandwidth and MZI delay, reducing area and loss by 10x.

JTu2A.82
Absorption-enhanced Imaging through Scattering Medium, Melhuba Farad1, Ashok Veerasinghavan1, Naomis Ha1, Kuo-Ching Huang1; Univ., USA. Using carbon-black absorbers, we show 80% image resolution-enhancement in isotropic polystyrene medium, compared to only 8% in a forward-scattering medium. Subsequently, by increasing imaging wavelength from visible to NIR, resolution enhancement for the forward-scattering medium is increased (4×).

JTu2A.83
A Compact and Portable Laser Radioactive Decontamination System using Femtosecond Laser and a Polygon Scanner, Yu-Chieh Lin1, Yin-Yin Lin2, An-Chang Chiung3; National Tsing Hua Univ., Taiwan. We designed a compact and portable laser radioactive decontamination system using a fiber laser and a polygon scanner. By varying the scanning speed of the polygon mirror, we achieved a processing speed exceeding 88500 mm/s.

JTu2A.84
Level-set Fabrication Constraints for Gradient-based Optimization of Optical Devices, Dines Vercruysse1,2; Logan Su1, Rahul Trivedi1, Neil V. Sapra3, Alexander Y. Piggott1, Jelena Vuckovic4; Stanford Univ., USA; RU Leuven, Belgium. When designing integrated optical devices, fabrication constraints need to be satisfied. We present an analytical constraint for level-set parameterizations that limits the gap/feature size and can be combined with higher order gradient-based optimization algorithms.

JTu2A.85
Kerr-comb generation in a dispersion engineered coupled thick silicon nitride microrings, Ali Eshaghian1, Ali Asghar Eftekhar2, Daniele Romighi3; 1Georgia Inst. of Technology, USA. We numerically demonstrate the first broadband Kerr-comb generation at telecommunication wavelength (1550 nm) using thin silicon nitride platform based on coupled-resonator for dispersion engineering.

JTu2A.86
Silicon Nitride Grating Couplers with High Efficiency and Wide Bandwidth, Chi Xu1, Mercedes Khajavikhan1, Patrick Li Kam-Wa1, Jonathan Thompson1; Creol, Univ. of Central Florida, USA. A grating coupler for coupling vertically emitted laser light into planar silicon nitride waveguides is presented. The waveguide coupling efficiency was measured at 30% with a 3 dB bandwidth of 100 nm using an optical fiber.

JTu2A.87
Long-Term Stable Operation of Coherent Ising Machine for Cloud Service, Toshimori Honjo1, Takahiro Inagaki1, Toshihiko Ito1, Ryo Kobayashi1, Sakae Kawato1, Hikaru Kitadake1; NICT Basic Research Labs, Japan. A 24-hour stable operation of a coherent ising machine, an ising model solver based on a network of degenerate optical parametric oscillators, was successfully demonstrated. The average success probability of computation exceeds 94%.

JTu2A.88
Sub-500 fs pulses from a hybrid architecture for high energy lasers, Damien Sangla1, Pierre Sevillano1, Jean-Gabriel Sugiki1; IEMN, France. We report the first multiplexed static FBG strain sensors by dual-comb spectroscopy, design and implementation. By using hyperspectral band-pass filter integrated on CMOS photo sensor, multi-channel optical fluorescence excitation and detection system are realized in experiments.

JTu2A.89
Laser induced thermomechanical cracking for fatigue life determination of coated steel, Jeffery Warrender1, Gregory Vigliante1; 1US Army, ARDEC RDECOM, USA. A pulsed Yb fiber laser was used to irradiate steel coated with chromium to induce thermomechanical cracks, the resultant part showed a reduced fatigue life. This provides a path to accelerated fatigue tests.

JTu2A.90
Ti:TaN Bilayer for Efficient Injection and Reliable AlGaN Nanowires LEDs, Davide Prianiti1, Bilal Janju1, Aditya Prabawarsa1, Ram Chandra Subedi1, Rami Elalfandy1, Sergei Lopatin1, Dalaver Anjum1, Chao Zhao1, Tian Khee Ng1, Boon S. Ooi1; 1AUSAT, Saudi Arabia; 2Univ. of Toronto, Canada. Reliable operation of UV AlGaN-based nanowires-LED at high injection current was realized by incorporating a Ti-precursor/DTA-nanodiffusion barrier bilayer, thus enhancing external quantum efficiency, and resolving the existing device degradation issue in group-III-nanowires-on-silicon devices.

JTu2A.91
High efficiency continuous-wave Ti:sapphire laser, Tomoki Kanie1, Ken-ichi Hori1, Masashi Nakahara1, Kei Katoh1, Kazumasa Hara1, Yosuke Yamauchi1, Yujiro Abe1, Yoshihiro Narizuka1, Hiroshi Tanaka1; 1NTT Basic Research Laboratories, Japan. We report the first high efficiency continuous-wave Ti:sapphire laser.

JTu2A.92
High efficiency continua-wave Ti:sapphire laser, Tomoki Kanie1, Ken-ichi Hori1, Masashi Nakahara1, Kei Katoh1, Kazumasa Hara1, Yosuke Yamauchi1, Yujiro Abe1, Yoshihiro Narizuka1, Hiroshi Tanaka1; 1NTT Basic Research Laboratories, Japan. We report the first high efficiency continuous-wave Ti:sapphire laser.

JTu2A.93
High efficiency continua-wave Ti:sapphire laser, Tomoki Kanie1, Ken-ichi Hori1, Masashi Nakahara1, Kei Katoh1, Kazumasa Hara1, Yosuke Yamauchi1, Yujiro Abe1, Yoshihiro Narizuka1, Hiroshi Tanaka1; 1NTT Basic Research Laboratories, Japan. We report the first high efficiency continuous-wave Ti:sapphire laser.
In Depth Flow Inspection based on Spatial Analysis of JTu2A.101

In this study, we have developed a novel system for the non-invasive measurement of optical properties of human skin. The system utilizes laser speckle contrast imaging (LSCI) to quantify the scattering properties of the skin, which allows for the analysis of its structural and functional properties.

Dermis-simulating phantom for noninvasive blood glucose sensing.

We have developed a semi-automated system for the non-invasive measurement of blood glucose levels using laser speckle contrast imaging. The system is based on the detection of the changes in the skin's optical properties that occur with variations in blood glucose levels.

Suture Maps Based on Structural Enhanced Imaging JTu2A.106

We have developed a new technique for the generation of suture maps using structural enhanced imaging. This technique allows for the accurate localization of sutures, which can be used to assist robotic surgical manipulation.

Endoscopic optical coherence microscopy with a new detection scheme JTu2A.107

We have developed a novel endoscopic optical coherence microscopy system that allows for the imaging of biological samples with high resolution. The system utilizes a new detection scheme that reduces the noise and improves the contrast of the images.

Lens-less Micro-endoscopy through highly scattering media JTu2A.108

We have developed a new lens-less micro-endoscopy system that allows for the imaging of tissues with high scattering properties. The system utilizes a new detection scheme that improves the resolution and contrast of the images.

High Pulse Energy Supercontinuum Laser for Photoacoustic Detection and Identification of Lipids in the 1650-1850 nm Limit to be extracted JTu2A.109

We have developed a high pulse energy supercontinuum laser system that allows for the photoacoustic detection and identification of lipids. The system utilizes a novel detection scheme that improves the sensitivity and selectivity of the imaging.

Size Dependent Ultra-low Upconverted Lasing Threshold in CsPbBr3 Perovskite Quantum Dots JTu2A.110

We have studied the lasing properties of CsPbBr3 perovskite quantum dots as a function of their size. We have found that the lasing threshold decreases with decreasing size, with a threshold of up-converted lasing in the 500 nm range for 7 nm CsPbBr3 quantum dots.

Negative Irradiance-Dependent Nonlinear Refraction in Single-Layer Graphene JTu2A.111

We have investigated the nonlinear refraction properties of single-layer graphene. We have found that the refraction properties are irradiance-dependent, with a negative refraction effect at low irradiances.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

Exhibit Hall 11:30–13:00 JTu2A • Poster Session I
JTu2A.116  
THz Pulse Generation from CSP and ZOP by Tilted Pulse Front Scheme, Wenchen Qiao1, Huseyn Carikaya1, Anthony Hartin1, Peter G. Schumenn1, Kevin Zawiel1, Nicholas H. Matlis1, Franz X. Kaertner1; DESY, Germany; BAE System, USA. We report single-cycle THz-pulse generation with a 2 μm laser in CdS:P, and ZnGeP, using the tilted-pulse-front scheme and compare with LiNbO3. Initial conversion efficiencies for both crystals are promising relative to LiNbO3.

JTu2A.117  
Experimental Investigation of All-optical Dynamic Photonic Bandgap Control in an All-solid Tellurite Photonic Bandgap Fiber, Tonglei Cheng1, Shunta Tanaka1, Takenobu Suzuki1, Yasunori Kiazane1, Yuma Takida1, Hiroaki Minamide1; Yvind1, Corrado SCIANCALEPORE2; both crystals are promising relative to LiNbO3. Tunable Backward THz-Wave Parametric Oscillation Using in optical fibers.

JTu2A.118  
Tunable Backward THz-Wave Parametric Oscillation Using a Periodically Poled Lithium Niobate, Kouji Navata1, Yu Takizane1, Yuma Takada1, Hiroaki Minamide1; RIKEN, Japan. We demonstrated tunable backward terahertz-wave parametric oscillation using a slant-stripe-type periodically poled lithium niobate with a poling period of 53 μm. A novel noncollinear phase-matching scheme, quasi-collinear phase-matching condition, produces the wide tunability.

JTu2A.119  
Buffering optical topological data using passive Kerr resonators, Bruno Garbin1, Julien Fatome1, Yadong Wang1, François Lé0, Gian-Luca Oppo1, Stuart G. Murdoch1, Miro J. Erkintalo1, Stephanie Coen1; The Dodd-Walls Centre for Photonic and Quantum Technologies, Dept. of Physics, The Univ. of Auckland, New Zealand; Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB), UMR 6303 CNRS, Université de Bourgogne Franche-Comté, France, OPERA-photonique, Université Libre de Bruxelles, Belgium; SUPA and Dept. of Physics, Univ. of Strathclyde, UK. We experimentally demonstrate the existence of dissipative polarization domain walls, in a normally dispersive Kerr resonator. Through deterministic manipulation of the laser driving the resonator, we achieve systematic excitation and locking of the domain walls.

JTu2A.120  
Frequency Comb Generation in Crack-free CMOS Si-photonics Compatible Si,N Microresonator Chip, Ayman N. Kamel1, Houssain El Dirani2, Marco Casale1, Sébastien Kendi1, Carole Socquet-Clerc1, Minhao Pu1, Leif K. Oxenlowe1, Kresten Voll1, Antonio Valenzuela1, Étienne Chantepie1, François Lé0, Laura Vanderhoef1; ALTERA PHOTONIQUE, France; 1National Research Council Canada, 2Univ. of Auckland, New Zealand; 3ofmlab, Japan. We report THz emissions from Air-Plasmas Created by Mid- and Far-Infrared Two-Color Femtosecond Pulses, Alisee Nguyen1, Luc Berge1, Pedro González de Alaíza Martínez1, Illia Thiele1, Stefan Skupien1; CEA, DAM, DIF, France; 1Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan; 2Center for Nonlinear Phenomena and Interfaces, CNRS, Université de Lyon 1 - CNRS, Université de Lyon, France. We study THz emission by two-color femtosecond filamentations in air using mid- to far-infrared pump wavelengths. 3D numerical simulations show that 10.6-μm laser pulses can produce THz fields with unequalized Mn energies and GV/m amplitudes.

JTu2A.122  
Deterministic Single Soliton Formation and Manipulation in Anomalous Dispersion Microresonators via Parametric Oscillation, Jinghao Wang1, Minming Zhang1, Deren Lui1; Huazhong Univ. of Science and Technology, China; 2Huazhong Univ. of Science and Technology, China. We propose a novel method for the deterministic transition from multiple solitons to a single soliton in anomalous dispersion microresonators via parametric seeding. Then the temporal position of the single soliton are flexibly manipulated.

JTu2A.123  
Ten-Fold Enhancement in the Small Signal Modulation of Differentially Pumped Coupled Quantum Well Lasers, Yan-Kun Komin1, Vassilios I. Kovavis1, Tassos Bourdias1; National Technical Univ. of Athens, Greece; 3Physics, Nazarbayev Univ., Kazakhstan; 4Mathematics, Nazarbayev Univ., Kazakhstan. We unexpectedly found theoretically a 10-fold enhancement in the small signal modulation response of differentially pumped coupled quantum well lasers due to the existence of novel stable asymmetric phase-locked states under differential pumping.

JTu2A.124  
Optical Meta-Molecules for Non-Hermitian Photonics, Yan-Kun Komin1, Vassilios I. Kovavis1, Tassos Bourdias1; National Technical Univ. of Athens, Greece; 3Physics, Nazarbayev Univ., Kazakhstan; 4Mathematics, Nazarbayev Univ., Kazakhstan. A photonic dimer consisting of two optically coupled lasers is dissected as an optical meta-molecule for non-Hermitian photonic applications. Spectral signatures of exceptional points and Hopf bifurcations are shown for generic asymmetric configurations.

JTu2A.125  
Ultrafast Mid-infrared Non-Perturbative Nonlinear Optics in Polycrystalline Zinc Selenide, Kevin Werner1, Noah Talsia1, Brian Wilmer1, Laura Vanderhoef1, Aaron Schwarzenberg1, Christopher Wolfe1, Anthony Valenzuela1, Étienne Chantepie1, François Lé0; 1Department of Physics, The Ohio State Univ., USA; 2SURVIVE Engineering, USA; 3Weapons and Materials Research Directorate, U.S. Army Research Lab, USA; 4Oak Ridge Inst. For Science and Education, USA. Strong-field MIR laser-solid interactions have recently generated great interest. Harmonic continuum was generated in ZnSe with MIR pulses. Power scaling of the harmonics was non-perturbative with conversion efficiency as high as 24%.

JTu2A.126  
Near-infrared to Mid-infrared wavelength conversion by chalcogenide suspended-core fiber, Kenshiro Nagasaki1, Tisong Huang1, Yuanen Phouc Trung Hoa1, Morio Matsumoto1, Shigeki Chai1, Takenobu Suzuki1, Yasutake Ohishi1; Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan; 2Furukawa Denshi Co., Ltd., Japan. We experimentally demonstrated mid-infrared wavelength conversion using a chalcogenide-suspended-core fiber pumped with a pico-second pulse.

JTu2A.127  
Highly Coherent Mid-Infrared Supercontinuum Spanning From 1.8-10 μm Pumped By A 2-μm Laser, Hoa P. Nguyen1, Kenshiro Nagasaki1, Hoang Tuan Tong1, Takenobu Suzuki1, Yasutake Ohishi1; Toyota Technological Inst., Japan. We simulated a 2-step supercontinuum generation with tellurite and chalcogenide fibers pumped by a 2 μm femto second laser. The output SC expands from 1.8 to 10 μm with coherence of unity all over the spectrum.

JTu2A.128  
Four-Wave Mixing in a Silicon Self-Pumped Ring Resonator, Micol Previle Massaro1, Federico Sabatelli1, Matteo Galli1, Daniele Bajoni1; Dept. of Physics, Univ. of Pavia, Italy; Dipartimento di Ingegneria Industriale e dell’Informazione, Univ. of Pavia, Italy. We report on four-wave mixing in a silicon micro-ring resonator using a self-pumping scheme instead of an external laser. We study the correlation of the emitted photons.

JTu2A.129  
Consideration on a mechanism of pure circular polarization electroreflectance in a lateral spin-LED, Hiro Munekata1, Nozomi Nishizawa1; Tokyo Inst. of Technology, Japan. A mechanism that the spin axis of minority-spin electrons is converted into majority spin axis with a relatively strong CP light field in the event of radiative recombination in an active layer is addressed.

JTu2A.130  
Epsilon Near-Zero Nonlinear Optical Measurements of Titanium Nitride Thin Films, Manuel R. Ferdinandus1, Jamie Gengler2, Nathan Knowles1; Air Force Inst. of Technology, USA; 2Air Force Research Lab, USA; 3Virginia Commonwealth Univ., USA. Using the optical beam deflection method we measure the transient optical nonlinearity of titanium nitride thin films deposited at 350° and 800° C around their respective epsilon near-zero wavelengths.

JTu2A.131  
Engineered quasi-phase matching for conversion efficiency optimization of coupled X̄0 processes, Cheng-Wei Hsu1, Jui-Yu Lai1, Shing-De Yang1; National Tsing Hua Univ., Taiwan. We propose an algorithm to optimize the efficiency of coupled X̄0 processes in an apodized optical superlattice, achieving record high efficiency of frequency tripling. Feasibility is confirmed by controlled experiment with three different design methods.

JTu2A.132  
Sub-Cycle Light Bulbs in the Long-Wavelength Infrared, Rostislav Grynko1, Garima Nagar1, Bonggu Shim1; Binghamton Univ., USA. Carrier-resolved unidirectional pulse propagation equations are used to model mid- and long-wavelength infrared laser filamentation in ZrSe4, revealing a novel propagation regime where sub-cycle light bullets propagate stably with a critical dependence on plasma.

JTu2A.133  
Second Harmonic Generation from UV to Visible in KDP Single-Crystalline Fibers, Kam Sing Wang1; Hong Kong Univ of Science & Technology, Hong Kong. Second harmonic generation (SHG) from UV to visible in KDP single-crystal fiber without the need of angle or temperature tuning is demonstrated. This wide SHG tunability is attributed to the unique automatic ‘quasi-random’ phase matching.

JTu2A.134  
Non-Resonant Enhancement of Second-harmonic Generation from Metal Nanoslips Coated with Dielectric Layers, Kalle O. Koskinen1, Sergey Scherbak1, Semyon Chevruiskii1, Andrey Lipowsky1, Martti Kauranen1; Lab of Photonics, Tampere Univ. of Technology, Finland; Inst. of Physics, Nanotechnology and Telecommunication, Peter the Great St. Petersburg Polytechnic Univ., Russia; 2Dept. of Physics and Technology of Nanostructures, St. Petersburg Academic Univ., Russia; 3Inst. of Photonics, Univ. of Eastern Finland, Finland. Second-harmonic generation from gold nanoslips films increases with the dielectric TiO2 coating thickness. This occurs although the plasmon resonance shifts away from the second-harmonic wavelength, due to enhanced non-resonant local fields at the fundamental wavelength.
JTu2A.154
Reconstructing band structure of a crystalline solid from drive-laser-intensity dependence of a single harmonic produced by inbandtrain current, Peiyu Xie1, Faming Lu2, Teruo Kanai1, Nobuhisa Ishii1, Jiro Itatani1, Inst. for Solid State Physics, The Univ. of Tokyo, Japan. We present an experimen-
tically simulate all-optical reconstruction of band structure from drive-laser-intensity dependence of a single harmonic produced from crystalline solids. This method assumes that a low-order harmonic is mainly produced by inbandtrain current.

JTu2A.155
Energy of soft-x-ray high harmonics driven by a loosely-focused TW-scale mid-infrared pulse, Kataro Nishimura1,2, Yuxi Fu1, Akira Suda1, Katsumi Midorikawa1, Eiji T. Takahashi3, Toyo Univ. of Science, Japan; 2RIKEN Center for Advanced Photonics, Japan. We establish an energy-scaling strategy of high-order harmonic driven by a loosely focused mid-infrared pulse. Using a 4-cm Ne gas cell with a 3.5-m laser focusing length, soft-x-ray harmonics beyond 200 eV are clearly enhanced by phase-matching effect.

JTu2A.156
High-order Harmonic Generation in Femtosecond laser-Micromachined Devices, Anna Gabriella Criolo1,2, Gabrielle Crippa1, Davide Fascioli1, Matteo Negro1, Michele Devetta1, Diego Pereira Lopes1, Aditya Pusala1,3, Caterina Vozzi1, Roberto Ossella1, Salvatore Del Barrio2,1, Joaquim Sacher1, Sacher Lasertecnik GmbH, Germany; 3Electronic Technology, Universidad Carlos III de Madrid, Spain. MEMS-based tunable diode lasers inherit the benefits of conventional ECDLs while improving the tuning speed. These lasers are here presented with an example and measurements are shown of the spectral characterization of these devices together with switching speed and stability experimental results.

JTu2A.157
A Time-preserving Ultra-narrow-bandwidth Multilayer-Mirror Monochromator for Extreme Ultraviolet Pulses, Yudong Yang1,2, Julia Hengstgcr3, Tanja Neumann1, Roland E. Mann1,2, Oliver Muecke1,2, Franz X. Kaertner1, Thorsten Uphues2,1, Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Germany; 2The Hamburg Centre for Ultrafast Imaging CUI, Univ. of Hamburg, Germany; 3Dept. of Physics, Univ. of Hamburg, Germany; 4Center for Free-Electron Laser Science CFEL, Universitat Hamburg, Germany. We present a multilayer-mirror-based monochromator providing ultra-narrow bandwidth and compact footprint for easy integration into HHG-based or FEL sources. The bandwidth (ΔE<0.5eV, E<65eV) of the monochromator is characterized experimentally in a HHG-based source.

JTu2A.158
Generation of Few-Cycle UV pulses Synchronized with Attosecond XUV Pulses, Vincent Wan12,1, Mara Galli12,2, Erik Månsson1,2, Mattea C. Castrovill12,1, François Légaret1, Fabio Frassetto1, Luca Poletto1, Mauro Nisoli3,1, Francesca Caleri12,1, Inst. for Photonics and Nanotechnologies CNR-IPN, Italy; 2Institut National de la Recherche Scientifique, Canada; 3Dept. of Physics, Politecnico di Milano, Italy; 4Center for Free-Electron Laser Science, DESY, Germany; 5Inst. for the Structure of Matter CNR-ISM, Italy; 6Inst. for Photonics and Nanotechnologies CNR-IPN, Italy. Few-femtosecond UV and isolated attosecond pulses were implemented into a Mach-Zender like interferometer. The ultraviolet light is obtained via frequency up-conversion of few-optical-cycle NIR pulses in a gas medium to achieve an optimal temporal resolution.

JTu2A.159
Scaling and Spectral Structure of Reflective High-Order-Harmonic Generation, Matthew Edwards1, Julia Mikhalova1, 2Princeton Univ., USA. We develop scaling models for the behavior of reflective high-order-harmonic generation, showing how the spectrum, attosecond pulse intensity, and the formation of secondary pulses depend on a simplified set of parameters.

JTu2A.160
TfzEmission by Underdense Relativistic Plasma, Jeremy Dechard1, Arnaud Debayle1, Xavier Davoine1, Laurent Grenli1, Luc Berge1, CEA-DAM, DIF, France. Terahertz emissions by gas-basredirected relativistic plasmas created by two-color laser pulses are investigated. PIC simulations reveal that coherent transition radiation driven by wakefield-accelerated electrons is the dominant process, compared to photocurrents, and they yield unprecedented 10Hz energies.

JTu2A.161
Investigation of the waveguide generated by UV fila-
mantation, Alastregal1, Chengyong Feng1,2, Jean-Claude M. Deli3, UNM, USA; 2Lab for Laser Energics, Univ. of Rochester, USA. The waveguides generated by UV filaments in different focusing schemes have been investigated using the shadowgraphy technique. It was observed that these waveguides have a transverse width of the order of 400nm.

JTu2A.162
MEMS-Based Fast Tunable Laser, Alvaro Jimenez Galindo1, Sebastian Schmidtbradt1, Herrve Tatenguen Fankem1,2, Tobias Michels1, Christian Alfimov1, Guillermo Carpineto del Barrio2, Joachim Sacher1, Sacher Lasertecnik GmbH, Germany; 2Electronic Technology, Universidad Carlos III de Madrid, Spain. MEMS-based tunable diode lasers inherit the benefits of conventional ECDLs while improving the tuning speed. These lasers are here presented with an example and measurements are shown of the spectral characterization of these devices together with switching speed and stability experimental results.

JTu2A.163
A high energy sapphire-cooled multi-slab Nd:glass am-
pulse, Weifeng Huang1, Tingrui Huang2, Jiangfeng Wang1, Xinhuia Li1, Dajie Huang1, Wei Fan1, Xuechun Li1, SIOM, China. We present amplification results for a sapphire-cooled multi-slab Nd:glass amplifier, an output energy of 562 mJ at 1 Hz with energy stability of 0.39% RMS was achieved.

JTu2A.164
210 W kHz-linearly-polarized-all fiber-single-frequency MOPA laser, Changsheng Yang1, Xianchao Fang1, Shanshu Xu1, and Zhongyong Yin1, South China Univ. of Technology, China. An all-fiber high-power kHz-linearly-polarized 1064-nm single-frequency MOPA laser is experimentally demonstrated with a stable CW output power of >210 W and a laser linewidth of <9 kHz.

JTu2A.165
Dual-Pulse Passively Q-switched Microchip Laser for Two-Color Tandem THz-Wave Pulse Generation, Yoshikazu Ike1, Yuma Takida2, Kouji Nawata2, Yasuhiro Higashi1, Hiroaki Teshigawara1,1, Inst. for Solid State Physics, The Univ. of Tokyo, Japan. We propose and nu-
merical simulation, demonstrate the generation of high-order harmonics from crystalline solids. This method assumes that a few-cycle pulse at a 1 mm spectral region by using a phase-locked off-axis modes in an azimuthal symmetric interferometer. The ultraviolet light is obtained via frequency up-conversion of few-optical-cycle NIR pulses in a gas medium to achieve an optimal temporal resolution.

JTu2A.166
High Energy Pulse Compression by a Solid Medium, Alvaro Jimenez Galindo1,2, Yuma Takida2, Kouji Nawata2, Yasuhiro Higashi1, Hiroaki Teshigawara1,1, Inst. for Solid State Physics, The Univ. of Tokyo, Japan. We report laser wavefront degradation of a 200 TW laser from heat absorption by the in-vacuum compressor gratings, while scanning laser energy and rep-rate. Laser induced damages are investigated.

JTu2A.167
Q-switched optical vortex pulses generated by the coher-
ent superposition of off-axis modes in an azimuthal sym-
meter breaking optical resonator. We report on laser performance and modeling of Yb:YAG and Tm:YAG double-clad crystalline fiber waveguide for high power applications, with 53.6% slope efficiency and 27.5 W output for Yb:YAG, and 31.6% and 46.7 W for Tm:YAG.

JTu2A.170
Development of an Auxiliary OPCPA Beamline for the Vulcan PW Laser Facility, Ian O. Musgrave1, Alexis Boyle1, Robert Clarke1, John Collier1, Marco Galimberti1, Cristina Hernandez-Gomez1, Pedro Olivera1, Waseem Shalh1, Adam Wyatt1, Science & Technology Facilities Council, UK. In this paper we present our plans for an auxiliary OPCPA beamline for the Vulcan PW laser facility. It will be capable of delivering 30TW<30fs in combination with the existing beams.

JTu2A.171
Wavefront Degradation of a 200 TW Laser from Heat-
Induced Deformation of In-Vacuum Compressor Gratings, Vincent Leroux1,2, Spencer Jolly1, Matthias Schropp1, Timo Echiner1, Soren Jalal1, Michael Kirchen1, Philipp Messner1, Christian Werle1, Paul Winkler1, Andreas R. Maier1, Center for Free-Electron Laser Science, Germany. 1Institute of Physics of the ASCR, ELI-Beamlines project, Czechia. We report laser wavefront degradation of a 200 TW laser from heat absorption by the in-vacuum compressor gratings, while scanning laser energy and rep-rate. Laser induced damages are investigated.

JTu2A.172
Q-switched optical vortex pulses generated by the coher-
ent superposition of off-axis modes in an azimuthal sym-
meter breaking optical resonator. We report on laser performance and modeling of Yb:YAG and Tm:YAG double-clad crystalline fiber waveguide for high power applications, with 53.6% slope efficiency and 27.5 W output for Yb:YAG, and 31.6% and 46.7 W for Tm:YAG.

JTu2A.173
Radially polarized and wavelength switchable mode locking Yb-doped fiber laser, Fan Shi1, Yingyue Huang1, Teng Wang1, Fufei Pang1, Tingyun Wang1, Xianglong Zeng1, Shanghui Univ., China. We experimentally demonstrated the generation of radially polarized and wavelength switchable mode locking pulse at 1 mm spectral region by using a broadband few mode coupler in a Nonlinear Polarization Rotation fiber ring cavity.
JTu2A.174
Carbon Nanoparticles as an Optical Modulator for Passively Q-switched Fiber Laser, Huia Li1, Jie Ma1, Mengying Zhang1, Jun Wang1, Dingyuan Tang1, Seongwoo Yoo1; 1Nanyang Technological Univ., Singapore. We present the first demonstration of carbon nanoparticles (CNPs) as an optical modulator to generate short laser pulses. An ytterbium-doped fiber ring cavity is successfully Q-switched with CNPs prepared in-house via a simple flame synthesis.

JTu2A.175
10 kHz, 10 ns, 13.4 mJ Burst-mode MOPA Nd:YAG Based Frequency-tripled Source at 355 nm, Wentao Wu1, Xudong Li1, Renpeng Yan1, Deying Chen1; Harbin Inst. of Technology, China. We demonstrated a Nd:YAG based Q-switched burst-mode MOPA laser with ultraviolet output by nonlinear harmonic generation. Single-pulse energy of 13.4 mJ at 355 nm, 10 kHz was obtained. The pulse width reached 10 ns.

JTu2A.176
Gaussian-shaped pulses oscillation of gain-switched Cr:ZnSe laser pumped with nanosecond pulses, Masaki Yumoto1, Norihito Saito1, Satoshi Wada1; RIKEN, Japan. We demonstrated Gaussian-shaped pulses oscillation of gain-switched nanosecond Cr:ZnSe laser based on numerical and experimental research. The Gaussian-shaped pulses with pulse width of 56 ns were obtained without any Q-switch devices inside the laser cavity.

JTu2A.177
Extra-cavity amplification of the digital laser modes using Nd: YAG amplifier, Teboho Bell1; CSIR National Laser Centre, South Africa. In this paper, we demonstrate experimentally how the laser output power of higher-order LG modes generated from the digital laser is amplified by using an extra-cavity Nd: YAG amplifier. Amplification of 42% was realized.

JTu2A.178
Transverse Stimulated Raman Scattering Induced Large Aperture KDP Coating Damages of SG-II Facility, Shunxing Tang1, Yajing Guo1, Qing Jiang1, Lin Yang1, Baoqiang Zhu1; SIOM, China. Coating damage of large aperture KDP crystal on SG-II laser facility is observed. A simulation model is setup, and it indicates that TSRS can induce energy lose and coating damage in large aperture KDP crystals.
Executive Ballroom 210A

13:00–15:00
STu3A • Quantum Photonic Technology
Presider: Jonathan Matthews; University of Bristol, UK

STu3A.1 • 13:00
Invited Scaling Quantum Photonic Technologies, Mark G. Thompson
1 Quantum Engineering Technology Labs, H. H. Wills Physics Lab & Dep. of Electrical and Electronic Engineering, Univ. of Bristol, UK. Silicon Quantum Photonics has emerged as a promising approach to realizing complex large-scale quantum photonic circuits. Here we overview recent developments presenting circuits comprising hundreds of photonic components integrated into single coherent quantum systems.

Executive Ballroom 210B

13:00–15:00
STu3B • OAM and Photodetectorvative
Presider: Richard Penty; Univ. of Cambridge, UK

STu3B.1 • 13:00
Tutorial Advances in Components and Integrated Devices for OAM-Based Systems, Alan E. Willner
1 Univ. of Southern California, USA. This tutorial will highlight various types of compact components that might be important for future deployment of optical systems based on beams carrying orbital-angular-momentum. Such elements may include: generators, (de) multiplexers, detectors, filters, and fibers.

Executive Ballroom 210C

13:00–15:00
STu3C • Advanced Short Reach and Free Space Communications
Presider: David Geisler, Massachusetts Inst of Tech Lincoln Lab, USA

STu3C.1 • 13:00
50 Gb/s Transmission over Uncompensated Link up to 20 km Exploiting DSP-Free Direct-Detection, Francesco Fresi1,2, Mohamed Morsy-Osman1, Enrico Forestieri2, Marco Secondini2,3, Fabio Cavaliere1, David V. Plant1, Stephane Lessard1, Luca Poli1,2; 1TeCIP Inst., Scuola Sant’Anna, Italy; 2PNTLab, CNIT, Italy; 3School of Electrical Engineering, Tel Aviv Univ., Israel. We experimentally transmit 50Gb/s over 20km uncompensated SMF with a conventional DSP-free OOK direct detection receiver, exploiting combined amplitude phase shift codes. A simplified implementation based on analog electronics is also validated at 50Gb/s.

STu3C.2 • 13:15
Carrier Regeneration Assisted Kramers-Kronig Detection of an Independent Sideband Signal, Qiulin Zhang1, Chester Shu1; 1 Chinese Univ. of Hong Kong, Hong Kong. We experimentally demonstrate Kramers-Kronig detection of an independent sideband (ISB) signal by Brillouin amping a weak pilot tone at the receiver side. A 30Gbit/s ISB signal with mixed modulation formats is successfully transmitted over 80 km.

STu3C.3 • 13:30
Invited The Kramers–Kronig Receiver: a Coherent Receiver Based on Intensity Detection and Phase Recovery, Antonio Mezzetti1,2, Cristian Antonelli1, Mark Shatil1,2; 1Univ. of L’Aquila, Italy; 2School of Electrical Engineering, Tel Aviv Univ., Israel. We review the operation principles and the various implementations of the Kramers–Kronig receiver. We will show that this receiver permits to extract the full complex envelope of the optical field by simple intensity detection.
Leif Katsuo Oxenløwe, Ph.D. 2002 from DTU, is Professor of DTU Fotonik, Denmark; ACREO RISE, Sweden; College of Information Science and Engineering, Univ. of Central Florida, USA; and the College of Optics and Photonics, Univ. of Central Florida, USA. He has authored or co-authored more than 350 peer-reviewed publications.

Metafilms for Large Scale Thermal Management, Xiaobo Yin

The platform is based on tens-of-μm long suspended micro heaters at >400°C, placed <100nm away from a room temperature photodetector.

Near-field thermo photovoltaic platform, Gaurang Bhatt, Samantha Roberts, Raphael St-Gelais, Aseema Mohanty, Bo Zhao, Jean-Michel Hartmann, Shihui Fan, Michael Lipson, Columbia Univ., New York, USA; Electrical Engineering, Stanford Univ., USA; Mechanical Engineering, Univ. of Ottawa, Canada; CEA - Laboratoire d'Électronique des Technologies de l'Information (LETI), France. We demonstrate a platform for heat-to-electricity conversion based on near-field radiative heat transfer. The platform is based on tens-of-μm long suspended micro heaters at >400°C, placed <100nm away from a room temperature photodetector.

Aligned and packed single-wall carbon nanotubes as hyperbolic thermal emitters, Wei Liu, Chih-Hung Kao, Xinwei Li, Junichiro Kono, Gunnar Jacobsen, Sergei Popov, 1CEA - Laboratoire d'Électronique des Technologies de l'Information (LETI), France; 2Electrical Engineering, Stanford Univ., USA; 3Mechanical Engineering, Univ. of Ottawa, Canada; 4Nanoscience, Chalmers Univ. of Technology, Sweden. We demonstrate a broadly tunable, polarized and selective thermal emitter from highly aligned and densely packed single-wall carbon nanotubes (SWNTs) operating at >700°C, originating from their optical topological transition.

Invited:

Low Loss Silicon-Rich Silicon Nitride for Nonlinear Optics, Zhichao Ye, Attila Fulop, Oskar B. Helgason, Peter A. Andrekson, Victor Torres-Company

Hyperbolic Thermal Emitters, Weilu Gao, Chloe Doiron, 1Columbia Univ., New York, USA; 2Dept. of Electrical Engineering and Computer Sciences, Univ. of California, USA; 3Optoelectronics Research Centre, Univ. of Southampton, UK; 4Dipartimento di Fisica, Università di Pavia, Italy; 5Faculty of Physical Sciences and Engineering, Univ. of Southampton, UK; 6Centre for Photonic Materials, Imperial College London, UK. We demonstrate the cavity-enhanced second and third harmonic generation in silicon rich nitride 2D photonic crystal resonators under low-power continuous-wave excitation. Results show high generation efficiencies and suggest the absence of two-photon absorption.

On-chip second order nonlinear generation in lithium niobate photonic crystal nanocavities, Haowei Jiang, Xinwei Li, Junichiro Kono, Gunnar Jacobsen, Sergei Popov, 1CEA - Laboratoire d'Électronique des Technologies de l'Information (LETI), France; 2Electrical Engineering, Stanford Univ., USA; 3Mechanical Engineering, Univ. of Ottawa, Canada; 4Nanoscience, Chalmers Univ. of Technology, Sweden. We report the first observation of the second harmonic generation and the sum frequency generation in the one-dimensional lithium niobate photonic crystal nanocavity.
High-rate Time-bin Quantum Key Distribution Using Quantum-controlled Measurement, Nurul T. Islam1, Charles Lim2, Clinton Cahall3, Bing Qi4, Junsang Kim5, Daniel J. Gauthier6, Duke Univ., USA, 2Oak Ridge National Lab, USA, 3The Ohio State Univ., USA. We realize a time-bin qudit-based quantum key distribution system that uses two-photon interference for measuring the phase-basis states, allowing us to generate a secret key at a megabits-per-second rate.

FTu3H.3 • 13:30
A quantum knitting machine generating on demand cluster states of entangled photons, David Gershoni7; Technion Israel Inst. of Technology, Israel. Repeated timed excitations of a quantum dot confined electronic spin is used to entangle the polarization of the emitted photons with that of the precessing spin and thereby also with the polarizations of the previously emitted photons.

FTu3I • OCT and LIDAR
ATu3I • OCT and LIDAR
Presider: Peter Fendel; Thorlabs Inc, USA
High-Speed Coherent and Incoherent Monitoring of Laser Processing: from Closed-Loop Keyhole Welding to Additive Manufacturing, James M. Fraser1, Queen’s Univ. at Kingston, Canada. In-process monitoring capable of fully resolving high-power laser processing has long been the goal of advanced manufacturing. We have achieved kHz-rate micron-resolution morphology and temperature monitoring and applied it to welding and selective laser melting.

Tuesday, 13:00–15:00

CLEO: Applications & Technology
ATu3J.1 • 13:30 • Invited
Interferometric Microscopy for Detection and Visualization of Biological Nanoparticles, M. Selim Ünlü1; Boston Univ., USA. The sensitive detection and quantitative measurement of biological nanoparticles, such as viruses and exosomes, is of growing importance. We present a label-free optical biosensing method based on interferometric reflectance imaging to detect and characterize individual biological nanoparticles.

STu3K.2 • 13:30
Nearly diffraction limited beam qualities in an Anderson localizing optical fiber, Behnam Abaie1, Mostafa Peysokhan1, Jian Zhao2, Jose Antonio-Lopez2, Rodrigo Amezua Correa2, A. Schülzgen2, Arash Mafi1; 1Univ. of New Mexico, USA; 2Univ. of Central Florida, CREOL, USA. Nearly diffraction limited beams are demonstrated in a disordered optical fiber. High quality beams with M2 ~ 1 are obtained at various transverse positions across the output facet of the fiber.

ATu3J.3 • 13:45
Spatial frequency projection super resolution imaging, Randy A. Bartels1, Keith Wernsing1, Patrick Stockton1, Jeff Field1, Jeff Squires1; 1Colorado State Univ., USA. 2Physics, Colorado School of Mines, USA. Spatial Frequency Modulated Imaging (SPFI) with nonlinear excitation is shown to enable super-resolved imaging of specimens via real or virtual state contrast. Extension of 1D enhancement to 2D through inverse domain tomography is discussed.

STu3K.3 • 13:45
Deep-Learning-Based Imaging through Glass-Air Disordered Fiber with Transverse Anderson Localization, Jian ZHAO1, Yangyang Sun1, Zhanyuan Zhu1, Donghui Zheng1, Jose Enrique Antonio-Lopez2, Rodrigo Amezua Correa2, Shuo Pang1, A. Schülzgen1; 1CREOL, College of Optics and Photonics, Univ. of Central Florida, USA; 2School of Electronic and Optical Engineering, Nanjing Univ. of Science and Technology, China. We demonstrate for the first time that deep neural networks (DNNs) can be trained to recover images transported through a 90 cm-long silica-air disordered optical fiber at variable working distances without any distal optics.
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<th>Marriott Salon III</th>
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<td><strong>Stu3M.1 • 13:00</strong></td>
<td><strong>Stu3N.1 • 13:00</strong></td>
<td><strong>JTu3O.1 • 13:00</strong></td>
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<td>PW-class Laser Operation at 3.3 Hz and High Contrast Ultra-intense λ=400 nm Beamline, Shoujun Wang1, Yong Wang1, Alex Rockwood2, Bradley Luther1, Reed Hollingle1, Alden Curtis1, Chase Calvin1, Carmen Menoni1,2, Jorge Rocca1,2</td>
<td>Gas Sensing Using Heterogeneously Integrated Quantum Cascade Lasers on Silicon, Christopher C. Evans1, Alexander Spott1, Charles D. Merritt1, William W. Bewley1, Igor Vurgaftman1, Chul Soo Kim1, Jerry R. Meyer1, Joel M. Hensley1, John E. Bowers1, Michael B. Frish1</td>
<td>Mechanism of Single-pulse Ablative Generation of Laser-induced Periodic Surface Structures, Iaroslav Grinitskyi1,2, Maxim Shugay3, Tommi White1, Leonid Zhigile1,3, UNIMORE, Italy; 1NoviNano Inc., Ukraine; 2Univ. of Virginia, USA, 3Univ. of Missouri, USA. Experimental and computational analysis of the mechanisms of ablative LIPSS formation is reported. The results of large-scale molecular dynamics simulation performed for Cr target reveal a complex interplay of material removal and redistribution in the course of spatially modulated ablation.</td>
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<td><strong>Stu3M.2 • 13:30</strong></td>
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<td><strong>JTu3O.2 • 13:15</strong></td>
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<td>Hybrid OPCA/Glass 10 PW Laser at 1 Shot a Minute, Erhard W. Gaul1,2, Gilles Cheriaux3,3, roman antipenkov1, Frantysek Kiss1, Daniel Kramer2,2, bedrich rus1, Pavel Trojek2,2, stepan vyhlidka1, todd dilmore1,1, National Energetics, USA; 2Inst. of Chemical Technologies and Analytics, Technische Universitaet Wien, Austria. We present a line-locked cavity ring-down Faraday rotation spectrometer for trace gas detection of oxygen. The system reaches a ring-down rate of 8-10 kHz and a noise-equivalent angle of ~πx10⁻¹⁸ rad/Hz.</td>
<td>Self-organized nanogratings induced by femtosecond laser pulse direct writing in optical fibers, Jiafeng Liu1, Qin Li2, Ye Dai1, Yali Zhang1, Chunhua Wang1, Fulei Pang1, Tingyun Wang2, Xianglong Zeng2,3, Key Lab of Specialty Fiber Optics and Optical Access Networks, Joint International Research Lab of Specialty, Fiber Optics and Advanced Communications, Shanghai Univ., China; 2Shanghai Inst. for Advanced Communication and Data Science, Shanghai Univ., China; 3Dept. of Physics, Shanghai Univ., China. Self-organized nanogratings induced by femtosecond laser pulse direct writing are demonstrated in optical fibers. The results reveal strong anisotropic birefringence of nanogratings. Depolarization and retardation of nanograting are investigated through analyzing Mueller matrices method.</td>
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<td><strong>Stu3M.3 • 13:45</strong></td>
<td><strong>Stu3N.3 • 13:30</strong></td>
<td><strong>JTu3O.3 • 13:30</strong></td>
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<td>First Intense, phase controlled, few cycle laser sources in the ELI Attosecond Facility, Karoly Osyay1, Adam Borzsony1, Dimitris Charalambidou2, Eric Cormier1, Lagos Fulop1, Mikhail Kalashnikov1, Christos Kamperidis1, Balint Kiss1, Rodrigo Lopez-Martens1, Giuseppe Sansone1, Zoltan Varalay1, Katalin Varju1,1, ELI-ALPS, Hungary. Laser systems operating in the 100W average power regime provide ELI-ALPS with TW-to-PW peak power pulses for generation of single and few cycle light sources from THz to XUV for basic and applied researches.</td>
<td>Ultrashort-Pulse LIBS for Detecting Airborne Metal Particles from Energetic Material Reactions, Morgan O’Neil1, Nicholas Niemiec1, Andrew Demko1, Eric Petersen1, Waruna Kulatilaka1, Texas A&amp;M Univ., USA. Ultrashort-pulse, femtosecond-duration laser-induced breakdown spectroscopy (Fs-LIBS), has been demonstrated for enhanced detection of metal particles such as Al, Pb, Cu, and Hg, released to the gas phase during energetic material reactions.</td>
<td>Spectrally tunable Airy beam generation using cholesteric liquid crystals, Matthew S. Mills1, Ben Kowalski1,2, Vincent Tandiglia1,2, Kyungmin Lee1, Aubrey Steele1,2, Timothy White1, Dean Evans1, RXA, AFRL, USA; 2Azimuth Corporation, USA. We demonstrate spectrally tunable Airy beams via a chiral Bragg reflector. Specifically, we photo-align a cholesteric liquid crystal such that it conditionally imparts a cubic phase dependent on voltage applied across the sample.</td>
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<td><strong>Stu3M.3 • 13:45</strong></td>
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<td><strong>JTu3O.4 • 13:45</strong></td>
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<td>Standoff detection of bulk and trace elements using laser-induced fluorescence of laser ablation plumes, Sivanandan S. Harlali1, Brian Brumfield2, Mark Phillips3, Pacific Northwest National Lab, USA. We demonstrate 10 m standoff analysis of bulk and trace elements in laser-produced plasmas using tunable laser-induced fluorescence (LIF). LIF of laser-ablation plumes provides emission enhancement, higher spectral resolution in comparison with thermally-excited emission.</td>
<td>Photopolimerization differences by using nanosecond and picosecond laser pulses, Evaldas Stankevicius1,2, FTMC, Lithuania. Formation of polymeric pillars by using laser interference lithography will be compared for nanosecond and picosecond laser pulses. The experimental results will be explained by dynamics of laser-excited radicals.</td>
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We observed the comb spectrum at Okayama graph for radial velocity measurements and tenoptik, Germany; 2Menlo Systems GmbH, Chris Perrella1, Philip Light1, Dong Wei2, Eric Sascha Donath2, Johanna Adelung2, Ronald Rafael Probst 2, Heinar Hoogland 2, Malte Ken Kashiwagi1, Kaoru Minoshima3, Hironori Keisuke Nakamura1, Malte Schramm1, Hiroki thäus Halder 2, Peter Adel 2, Olaf Mandel 2, of Queensland, Australia.

We have developed atomic and molecular spectrometers that deliver quantum-limited measurements of devices emitting at 2.5µm. Adapting this concept to GaAs, even wavelengths of up to 4µm were achieved.

We investi...
Stu3A • Quantum Photonic Technology—Continued

Stu3A.3 • 14:00 Enhanced Silicon Single-photon Avalanche Diode Based on Light Trapping, Kai Zeng1, Xiao Jiang1, Yiye Huo1, Tianrui Zheng2, Yueyi Feng1, Xin Ding1, Matthew Morea2, Miyu Xue1, Cheng-Ying Liu1, Theodore I. Kamins1, Qiang Zhang3, Jian-Wei Pan4; James S. Harris1,4; Electrical Engineering, Stanford Univ., USA; 2HeLe National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China; 3CAS Center for Excellence and Synergetic Innovation Center in Quantum Information and Quantum Physics, Univ. of Science and Technology of China, China; 4Materials Science and Engineering, Stanford, USA. We present a nano-structured light-trapping Si SPAD with improved detection efficiency, without sacrificing jitter distribution or dark count rate. The design can be adopted for CMOS-compatible SPAD imaging sensors and silicon photomultipliers.

Stu3A.4 • 14:15 Metallic Nano-Rings for Efficient, Broadband Light Extraction from Solid-State Single-Photon Sources, Oliver J. Trojak1, Christopher Woodhead1, Jing-Dong Song2, Robert Young1, Luca Sapienza1; Dept. of Physics and Astronomy, Univ. of Southampton, UK; Physics Dept., Lancaster Univ., UK; Center for Opto-Electronic Materials and Devices Research, Korea Inst. of Science and Technology, South Korea. Metallic nano-rings deposited on the sample surface, centered around single InAs/GaAs quantum dots, enhance the brightness of the emission up to ×20, further enhanced by ×10 by epoxy solid-immersion lenses, in a scalable broadband device.

Stu3A.5 • 14:30 CMOS Photonic Circuits for Trapped Ion Quantum Computing and Molecular Sensing, Rajeev Jagga Ram1; MIT, USA. Photonic integrated circuits for UV and visible light offer a scalable approach to the classical optics and electronics required for large-scale trapped-ion quantum information processing as well as for self-contained lab-on-a-chip systems for molecular diagnostics.

Stu3B • OAM and Photodetective—Continued

Stu3B.2 • 14:00 Demonstration of Chip-to-Chip Communication Based on Ultra-Compact Orbital Angular Momentum (de)Multiplexers, Shimao Li1, Zhexiao Nong1, Xiong Wu1, Wen Yu1, Mingbo He1, Yuntao Zhu1, Shengqian Gao1, Jie Liu1, Zhaohui Li1, Liu Liu1, Si-Yuan Yu1, Xinxin Cai1; Sun Yat-sen Univ., China; South China Normal Univ., China. In this work we demonstrate chip-to-chip orbital angular momentum (OAM) multiplexing transmission using a pair of ultra-compact silicon integrated (de)multiplexer. Four OAM beams were multiplexed and then demultiplexed by the devices.

Stu3B.3 • 14:15 Multi-octave image-reject mixer with large suppression of mixing spurs based on balanced photodetectors, Wenjuan Chen1, Dan Zhu1, Shilong Pan1; Nanjing Univ Aeronautics & Astronautics, China. A multi-octave photonic image-reject mixer is proposed based on two balanced photodetectors and an optical hybrid. More than 60-dB image rejection and mixing spurs suppression are realized simultaneously over a wide frequency range.

Stu3B.4 • 14:30 100GHz Balanced Photodetector Module, Patrick Runge1, Gan Zhou1, Tobias Beckerwerth1, Shahram Keyvaninia1, Sven Mutschall1, Angela Seeger1, Robert Klotzer1, Sebastian Wünsch1, Greta Ropers1; Fraunhofer Institut, Germany. We demonstrate a 100GHz balanced photodetector module. Regarding the bandwidth the module exceeds all other state-of-the-art balanced modules. The module focuses on next generation optical networks with 112Gbaud and operates in C-band and L-band.

Stu3B.5 • 14:45 Zero-bias Photovaractor with 60 GHz Resonant Network for Optically Modulated Scattering (OMS) Application, Jesse S. Morgan1, Jiahao Zang1, Keye Sun1, Bassem Tossoun1, Joe C. Campbell1, Andreas Beling1; Univ. of Virginia, USA. We report a zero-bias photovaractor flip-chip bonded to a coplanar-waveguide resonant network for use as a probe designed to measure near-field characteristics of antennas operating at 60 GHz.

Stu3B.6 • 14:45 Directly Modulated Laser Transmitters for Scalable Multi-rate DPSK Communications, David O. Caplan1, P. S. Bedrosian1, Jesse P. Wang1, Barry R. Romkey1, Joe C. Campbell1, Andrew Horvath1, Scott A. Hamilton1; MIT Lincoln Lab, USA. We present a new approach for generating multi-rate burst-mode DPSK waveforms using time and frequency-windowed directly modulated laser transmitters. Near-theoretical performance is demonstrated over a wide range of data rates using a WDM-scalable implementation.

Stu3C • Advanced Short Reach and Free Space Communications—Continued

Stu3C.3 • 14:00 Large Scale Optical Interconnection Using Kerr Frequency Comb and Direct-Detection Kramers-Kronig Receiver, Mingyue Zhu1, Yong Geng1, Xingwen Yi1, Jing Zhang1, Heng Zhou1; Univ. of Electronic Science and Technology of China, China; 2School of Electronics and Information Technology, Sun Yat-Sen Univ., China. We demonstrate large scale optical interconnection using Kerr frequency comb within 1540-1560 nm wavelength. An optical SS-PAM-4 signal with total bitrate of 325-Gb/s (13×25 Gb/s) is successfully transmitted over 80-km SSMF by a Kramers-Kronig receiver.

Stu3C.5 • 14:15 A Phase Retrieval Method Using Dispersion for Direct Detection of Biased QAM Signals, Masayuki Matsumoto1; Wakayama Univ., Japan. Phase retrieval using dispersion in direct-detection receiver for biased Nyquist 16QAM signals is numerically examined. Processing error can be small at high bias power ratio. The continuous wave acting as a bias can be located within the signal spectrum.

Stu3C.6 • 14:30 112 Gb/s PAM-4 Signal Transmission Over 80 km SSMF with Digital CD Pre-compensation Enabled SPM Mitigation, Xiang Li1, Fan Gao1, Ming Luo1, Jianqiang Li3, Songnian Fu2; IWR, China; 2HUST, China; 3BUPT, China. We demonstrate single-lane 112 Gb/s PAM-4 signal over 80 km SSMF by digital CD pre-compensation. Thanks for the residual positive CD enables transmission with 112Gbaud and operates in C-band and L-band.
We report seamless connection between high-speed THz-wave and optical signals with high spectral efficiency, Koichi Takiguchi. Dept. of Electrical and Electronic Engineering, Ritsumeikan Univ., Japan. We demonstrate error-free data links using both line-of-sight and non-line-of-sight configurations.

Seamless connection between high-speed THz-wave and optical signals with high spectral efficiency, Koichi Takiguchi. Dept. of Electrical and Electronic Engineering, Ritsumeikan Univ., Japan. We report seamless connection between THz-wave and optical signals. A 40 Gbit/s THz-wave signal, which was generated from an optical signal shaped with a Nyquist-filter, was flexibly converted into an optical signal through an optical-modulator.

Channel Characteristics for Terahertz Wireless Communications—Continued

Terahertz-to-Optical Conversion Using a Plasmonic Modulator, Sandeep Ummethala, Tobias Harter, Kira Kohlmeier, Sascha Muehlbrandt, Yasar Kutuvantavida, Juned N. Kema, Jochen Schafer, Hermann Maslauer, Axel Tessmann, Suresh Kumar Giriapati, Andreas Bacher, Lothar Hahn, Martin Walther, Thomas Zwick, Sebastian Randel, Wolfgang Freude, Christian Koos. Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany; Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany; Inst. of Applied Solid State Physics, Karlsruhe Inst. of Technology, Germany; Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany; Inst. of Radio Frequency Engineering and Electronics, Karlsruhe Inst. of Technology, Germany; Fraunhofer Inst. for Applied Solid State Physics, Germany; Inst. of Nanotechnology, Karlsruhe Inst. of Technology, Germany. We design an experiment that uses a highly efficient dielectric metasurface to create entanglement on a single photon. The spin-orbit interaction mediated by the metasurface entangles the polarization and orbital angular momentum degrees of freedom.

Angular Momentum Contribution of Topologically Structured Darkness, Samuel N. Alperin, Mark E. Siemens. Univ. of Denver, USA. We introduce photonic Dirac monopoles and strings, proving the existence of a spin-1 bosonic topological phase for light. Fundamentally different from pseudo-spin-1/2-based photonic crystals, we discover quantized spin in symmetry protected helical edge states of continuous media.

Broadband Control of Topological Nodes in Electromagnetic Fields, Alex Y. Song, Peter B. Catrysse, Shanhui Fan. Stanford Univ., USA. The topological nodes in electromagnetic waves are shown to bound to a symmetry plane in a dielectric structure over a broad wavelength range. As an implication, broadband hiding of objects can be realized.

A gallium arsenide nonlinear platform on silicon, Lin Chang, Xiaowen Guo, Daryl Spencer, Jeff Chiles, Abijith Kowligy, Nima Naderi, Daniel Hickstein, John E. Bowers. Univ. of California Santa Barbara, USA; Natl. Inst. of Standards and Technology, USA. A nonlinear platform using gallium arsenide (GaAs) waveguides cladded with SiO₂ has been demonstrated on silicon substrates. It is suitable for efficient nonlinear applications. Second harmonic generation (SHG) with record-high efficiency of 38,000% W^{2} cm^{-2} has been achieved.

Supercontinuum generation in angle-etched diamond waveguides, Pawel Latwiec, Amr Hassan Shams-Ansari, Yoshihito Okawachi, Vivek Venkataraman, Mengjie Yu, Haig Atikian, Gary Harris, Nathalie Picque, Alexander L. Gaeta, Marko Loncar. Harvard Univ., USA; Columbia Univ., USA; Indian Inst. of Technology, India; Howard Univ., USA; Max Plank Inst. for Quantum Optics, Germany. On-chip supercontinuum generation in visible is demonstrated experimentally in angle-etched diamond waveguides. The output spectrum spans from 670-920 nm in response to a 100 femtosecond pulse input at 15 mW average power and 80 MHz repetition rate.

Enhanced four-wave mixing in graphene oxide coated waveguides, Yunyi Yang, Jiayang Wu, Xiuyuan Xu, Sai T. Chu, Brent Little, Roberto Morandotti, Baohua Jia, David J. Moss. Swinburne Univ. of Technology, Australia; City Univ. of Hong Kong, China; Chinese Academy of Science, China; INRS-Énergie, Matériaux et Télécommunications, Canada. We experimentally demonstrate enhanced four-wave mixing (FWM) in an integrated waveguide coated with graphene oxide (GO). Owing to the high Kerr nonlinearity of GO and strong mode overlap, we achieve ~9.5-dB enhancement in FWM conversion efficiency.

Enhanced four-wave mixing in graphene oxide coated waveguides, Yunyi Yang, Jiayang Wu, Xiuyuan Xu, Sai T. Chu, Brent Little, Roberto Morandotti, Baohua Jia, David J. Moss. Swinburne Univ. of Technology, Australia; City Univ. of Hong Kong, China; Chinese Academy of Science, China; INRS-Énergie, Matériaux et Télécommunications, Canada. We experimentally demonstrate enhanced four-wave mixing (FWM) in an integrated waveguide coated with graphene oxide (GO). Owing to the high Kerr nonlinearity of GO and strong mode overlap, we achieve ~9.5-dB enhancement in FWM conversion efficiency.
FTu3G • Quantum Key Distribution—Continued

FTu3G.4 • 14:00
Experimental Demonstration of a 10-Mbit/s Quantum Link using Data Encoding on Orthogonal Laguerre-Gaussian Modes, Kai Pang1, Cong Liu1, Guangdong Xie1, Yongxiang Ren1, Zhe Zhao1, Runzhou Zhang1, Yinwen Cao1, Jiapeng Zhao1, Long Li1, Haoqian Song1, Hao Song1, Moshe Tur2, Robert Boyd1, Alan E. Willner2,3, University of Southern California, USA; 1Tel Aviv Univ., Israel; 2Univ. of Rochester, USA. We experimentally investigate the performance of a quantum communication link using Laguerre-Gaussian (LG) modes with different radial indices. Quantum symbol error rate (QSER) <5% is achieved at an encoding rate of 10 Mbits/s.

FTu3G.5 • 14:15
Experimental Quantum Key Distribution at 1.3 Gbit/s Secret-Key Rate over a 10-dB-Loss Channel, Zhenhai Zhang1,2, Changchen Chen1, Quntao Zhuang1, Jane E. Heyes1, Franco N. Wong1, Jeffrey H. Shapiro1,3, The Univ. of Arizona, USA; 2Research Lab of Electronics, Massachusetts Inst. of Technology, USA. We demonstrate quantum key distribution at a 1.3-Gbit/s secret-key rates over a 10-dB-loss channel. By transmitting many photons per bit with multi-mode encoding our protocol overcomes channel loss to achieve gigabit-per-second rates without compromising security.

FTu3H • Quantum Optics with Solid-state Single Emitters—Continued

FTu3H.4 • 14:00
Colossal Photonic Bunching Driven by Phonon Recombination Dynamics, Matthew A. Feldman1,2, Eugene Dumitrescu1,2, Denzel Bridges1, Matthew Chisholm3, Roderick Davidson3, Phil Evans4, Jordan Hachtel3, Anming Hu4, Raphael C. Pooser4, Richard Hagnild1, Benjamin Lawner1, 1Dept. of Physics and Astronomy, Vanderbilt Univ., USA; 2Quantum Information Science Group, Oak Ridge National Lab, USA; 3Mechanical Engineering, Univ. of Texas, USA; 4Material Science and Technology Division, Oak Ridge National Lab, USA; 5Center for Nanophase Materials Science, Oak Ridge National Lab, USA. We report photon bunching g(2)(0) = 49 due to phonon sidebands in spectrally filtered cathodoluminescence from NV centers in diamond. The result is consistent with fast, phonon-mediated recombination dynamics, and supported by a stochastic model.

FTu3H.5 • 14:15
Strong Cavity Enhancement of Spontaneous Emission from Silicon-Vacancy Centers in Diamond, Jingjuan Linda Zhang1, Shuo Sun1, Michael J. Burek1, Constantin Dory1, Yan-Kai Zeeng1, Kevin Fischer1, Yousif Kelaita1, Konstantinos Lagoudakis1, Marina Radulaski1, Zhu-Xun Shen1,3, Nicholas Melosh1,4, Steven Chu1,5, Marko Loncar6, Jelena Vuckovic1, 1E. L. Ginzton Lab, Stanford Univ., USA; 2School of Engineering and Applied Sciences, Harvard Univ., USA; 3Dept. of Physics, Stanford Univ., USA; 4Geballe Lab for Advanced Materials, Stanford Univ., USA; 5Stanford Inst. for Materials and Energy Sciences, SLAC National Accelerator Lab, USA; 6Dept. of Molecular and Cellular Physiology, Stanford Univ., USA. We demonstrate strong enhancement of spontaneous emission of a single silicon-vacancy (SiV-) center in diamond embedded in a monolithic optical cavity, with 10-fold lifetime reduction and 42-fold enhancement in emission intensity under resonant condition.

FTu3I • OCT and LIDAR—Continued

ATu3I.4 • 14:00
Synthetic-Wavelength-Based Dual-Comb Interferometry for High-Speed and High-Precision Distance Measurement, Zebin Zhu1, Kai Ni2, Qian Zhou1, Guanhao Wu2,1, Dept. of Precision Instrument, Tsinghua Univ., China; 2Division of Advanced Manufacturing, Graduate School at Shenzhen, Tsinghua Univ., China. We propose a dual-comb ranging system based on synthetic-wavelength interferometry. It can realize absolute distance measurement with ~2.7mm ambiguity range, ~3nm precision within ~10ms averaging time.

ATu3I.5 • 14:15
Speckle mitigation in laser Doppler vibrometry based on a compact silicon photonic chip, Yanlu Li1,2, Jinghao Zhu3, Mathieu Duppron1, Peter O’Brien1, Ralf Schüler1, Soren Aasum1, Mirko de Melo1, Roel Baets1,2, 1Photons Research Group, Ghent Univ.-imec, Belgium; 2Center for Nano- and Biophotonics, Ghent Univ., Belgium; 3Tyndall National Inst., Ireland; 4Medtronic Bakken Research Center, Netherlands; 5DIOS Messtechnik GmbH, Germany. A compact six-beam homodyne laser Doppler vibrometry (LDV) system is realized based on a silicon-on-insulator (SOI) photonic integrated circuit. We demonstrate a speckle mitigation method by averaging signals from the six channels.

ATu3J • 14:45
High spatial resolution LIDAR for detection of cracks on tunnel surfaces, Takeharu Murakami1, Norihito Saito1, Yuichi Komachi1, Takashi Michikawa1, Michio Sakashita1, Shigeru Kogure1, Kwamu Kase1, Satoshi Wada1, Katsumi Midorikawa1, 1BKEN, Japan. We developed a high resolution LIDAR to detect cracks on a concrete placed 5 m away. The LIDAR can detect cracks with 200 μm width which is difficult to detect by existing remote inspections.
ATu3J.4 • 14:00  
A Nanoplasmonic Sensor Fabricated by Laser Interference Lithography (LIL) for Immunoglobulin Detection, Chi-Chen Lin1, Jian-Fu Luo1, Lon A. Wang1, Nien-Tsu Huang1; National Taiwan Univ., Taiwan. We fabricated a nanoplasmonic sensor using laser interference lithography (LIL) for label-free biomolecule sensing. This sensor is able to achieve 236 nm/RIU sensitivity and has high uniformity over a large area (~1 cm²).

ATu3J.5 • 14:15  
High-throughput holographic monitoring of nanoparticle degradation for drug delivery applications, Aniruddha Ray1, Shuoran Li1, Tatiana Segura1, Aydogan Ozcan1; Univ. of California, Los Angeles, USA. We present computational holographic imaging methods for high-throughput quantification of nanoparticle degradation for drug delivery applications. These techniques enable accurate monitoring of the dynamics of nanocarrier degradation over a large field-of-view.

ATu3J.6 • 14:30  
Semiconductor Laser Particles in Biological Cells, Sheldon J. Kwok2,1, Nicola Martino2, Andreas C. Liapis2, Sarah Wu1, Sarah Forward2; MIT, USA; 2Wellman Center for Photomedicine, Massachusetts General Hospital, USA. We develop a method for fabricating biocompatible, semiconductor laser particles for integration into biological systems. Micron-sized laser particles coated with a passivating silica shell are readily and safely uptaken by several cell lines in vitro.

ATu3J.7 • 14:45  
Sub-nano-Tesla, Shield-less, Field Compensation-Free Inelastic Wave Mixing Magnetometry for Bio-magnetism, Lu Deng1, Yvonne Y. Li1, Feng Zhou1, Eric Y. Zhu1, Edward W. Hagley1; 1NIST, USA; 2Dana-Farber Cancer Inst., Harvard Medical School, USA; 3Univ. of Toronto, Canada. We report an inelastic-wave-mixing-enhanced Zeeman-coherence atomic magnetometry scheme that results in sub-T magnetic field detection at human-body temperatures without employing magnetic field shielding, field compensation, and RF-modulation spectroscopy.

STu3K.4 • 14:00  
Demonstration the single mode performance of all-solid large mode area center-sunken cladding-trench fiber, Liu Yehui1, Fangfang Zhang1, Nan Zhao1, Haiqing Li1, Luyun Yang1, Nengli Dai1, Jinyan Li1, Wang Yibo1; Huazhong Univ of Science and Technology, China. We report a novel center-sunken and cladding-trenched Yb-doped fiber. A 456 W laser output was observed in a MOPA structure. The laser slope efficiency was measured to be 77% and the M² was 1.17.

STu3K.5 • 14:15  
115 W Large-mode-area Multi-core Fiber Laser with All Solid Structure, Junhua Ji1, Raghuraman Sidharthan1, Xiaosheng Huang1, Jiahao Zang1, Daryl Ho1, Yehuda Benudiz2, Udi Ben Ami2, Amiel Ishaaya2, Seongwoo Yoo1; 1The Photonics Inst., Nanyang Technological Univ., Singapore; 2Dept. of Electrical and Computer Engineering, Ben-Gurion Univ. of the Negev, Israel. We demonstrate a multicore Yb-doped fiber laser with an all-solid large-core fiber fabricated in-house and an external Talbot resonator for mode selection. 115W output power with an overall 61% slope efficiency was achieved.

STu3K.6 • 14:30  
Low Quantum Defect Fiber Lasers via Yb-Doped Multi-component Fluorosilicate Optical Fiber, Nanjie Yu1, Maxime Cavillon1, Courtney Kucera1, Thomas Hawkins1, John Ballato1, Peter Dragic1; 1Univ. of Illinois Urbana Champaign, USA; 2Center for Optical Materials Science and Engineering Technologies, Clemson Univ., USA. A low quantum defect (QD <1.5%) fiber laser based on an Yb-doped multicomponent fluorosilicate optical fiber is presented. Modeling results indicate that the fiber laser is scalable and that QD values below 1% are feasible.
STu3M.6 • 14:15
High-Speed Line-Locked Heterodyne Phase Sensitive Dispersion Spectroscopy, Pedro Martin-Mateos1, Jakob Hayden1, Bernhard Lendl1, Pablo Acedo1; Universidad Carlos III de Madrid, Spain. We present a method for high-speed optical gas analysis based on an line-locked HPSDS system that enables data output rates that are unmatched by any directly comparable optical gas detection and analysis technique.

STu3N.5 • 14:30
Pulse-Compressor Grating-Alignment Tolerances for Varied Geometries and Bandwidths, Benjamin Webb1, Mark J. Guadalben1, Christophe Dorrer1, Sara Bucht1, Jake Bromage1; Lab for Laser Energetics, Univ. of Rochester, USA. The effects of pulse compressor grating misalignment on pulse duration and focussability are simulated in FRED and MATLAB to specify tolerances over a broad range of design parameters.

STu3N.6 • 14:45
Variable Astigmatism Corrector for High-Power Lasers, Seung-Whan Bahn1, Brian Kruschwitz1, Amy Rigatti1, Jim Oliver1, Jake Bromage1; Univ. of Rochester, USA. We present a variable astigmatism corrector whose magnitude and sign in the astigmatism can be deterministically adjusted without separate wavefront measurement. The experimental results agree well with the calculation.

STu3N.7 • 14:45
Optical Cavity Mode Measurements at Hz-Level Precision With a Comb-Based VIPA Spectrometer, Gregganz A. Kowzan1, Dominik Chancun1, Agata Cygan1, Ryszard S. Trawinski1, Daniel Lisak1, Piotr Maslowski1; INPHYNI - CNRS - UNS, France; INPHYNI - CNRS - UNS, France. A compact, integrable and low-cost hyperspectral imaging device is proposed. It relies on cascaded liquid-crystal cells dynamically driven, calibrated through broadband spectral interferometry. 6 nm spectral resolution is demonstrated over 400–1000 nm.

STu3N.8 • 14:45
Rapid Scanning Cavity Ring-down Spectrometer for the Precision Measurement of \( ^{13}C/^{12}C \) for CO2 in Air, Adam J. Fleisher1, Hongming Yi1, Abneesh Srivastava1, Hodges Jeffery Warrender1, Renee Sher1; NIST, USA. We report a dual-wavelength rapid scanning spectrometer with < 0.1% measurement reproducability for \( ^{12}C/^{13}C \) isotope ratios in air. Initial evaluations of accuracy were performed using gas samples with known \( ^{12}C/^{13}C \).

JTu3O.6 • 14:30
Evaluating carrier lifetimes in laser hyperdoped silicon using terahertz spectroscopy, Senali Dissanayake1, Philippe Chowi1, Shao Qi Lim2, Matthew Wilkins3, Eduard Dumitrescu4, Wenjie Yang1, Quentin Hudspeth1, Jacob Krich3, Jim Williams1, Jeffrey Warrender1, Renee Sher1; Dept. of Physics, Wesleyan University, USA; US Army ARDEC - Benet Labs, USA; Re- search School of Physics and Engineering, The Australian National Univ., Australia; Dept. of Physics, Univ. of Ottawa, Canada. Silicon doped with gold at supersaturated concentrations is promising for infrared photodetectors and photovoltaic applications. Ion implantation followed by pulsed laser processing creates high quality hyperdoped material, and we investigate material properties using terahertz spectroscopy.

JTu3O.7 • 14:45
Silicon nanofibers formed at room temperature following laser irradiation of silicon in SF6, Jeffrey Warrender1, Quentin Hudspeth1, Philippe Chowi1, Stephen Bartolucci1, Joshua Maurer1; US Army ARDEC RDECOM, USA. Silicon nanofibers were observed to form after several months at room temperature following laser irradiation of silicon in SF6 in an aluminum chamber.

JTu3O.8 • 14:45
Laser Hyperdoping of Silicon for Infrared Optoelectronics, Jeffrey Warrender1, US Army ARDEC RDECOM, USA. Silicon may be laser hyperdoped with transition metals above the equilibrium solubility. I will describe this process and the optical and optoelectronic properties of layers fabricated with it, emphasizing the most promising hyperdopant, gold.
STu3P • Precision Spectroscopy—Continued

STu3P4 • 14:00 Broadband Complex Refractive Index Spectroscopy via Measurement of Cavity Modes, Alexandra C. Johansson1, Lucie Rutkowski2, Anna Filipsson1, Thomas Hausmann-inger1, Gang Zhao2, Ove-Andre1, Aleksandra Foltynowicz2,1, Uméa Univ, Sweden; 2Shanghai Univ., China. We retrieve high precision absorption and dispersion spectra of the 3V + ν3 band of CO2, from direct measurement of cavity transmission modes using an optical frequency comb and a mechanical Fourier transform spectrometer with sub-normal resolution.

STu3P5 • 14:15 Application of Cavity-Enhanced Combined Fourier-Transform Spectroscopy to Line Shape Study of Carbon Monoxide in Argon, Akiko Nashiyama1, Grzegorz Kow- zan2, Dominik Charczuk2, Yniccias S. Oliveira3, Axel Ruehli2,4, Ingmar Harlf1, Kaoru Minoshima1, Ryssard S. Trawiński2, Piotr Masłowski2,1, Univ. of Electro-Communications, Japan; 2Inst. of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus Univ. in Toruń, Poland; 3Deutsches Elektronen-Synchrotron (DESY), Germany; Leibniz Univ. Hannover, QUEST-Leibniz-Research School, Inst. for Quantum Optics, Germany. We performed measurements of overtone band of CO using cavity-enhanced Fourier-transform spectrometer with sub-normal resolution. The system’s performance allows to study collisional effects not described by the Voigt profile and precise determination of line parameters.

STu3P6 • 14:30 CO2 Line Parameter Retrieval Beyond the Voigt Profile Using Comb-Based Fourier Transform Spectroscopy, Alexandra C. Johansson1, Anna Filipsson1, Lucie Rutkowski2, Piotr Masłowski2, Aleksandra Foltynowicz2,1, Uméa Univ, Sweden; 2Shanghai Univ., China. We measure absorption spectra of the CO2 3V + ν3 band at 1.57 μm using optical frequency comb Fourier transform spectroscopy with sub-normal resolution and retrieve line shape parameters using multpline fitting with the speed-dependent Voigt profile.

STu3Q • Advances in VCSELs—Continued

STu3Q2 • 14:00 36 GHz Error Free Modulation of 850nm Monolithic Injection Locked VCSEL Arrays, Harshil Dave1, Peicheng Liu1, Hongjun Yang2, Stewart Fryslie1, Zhie Gao3, Bradley J. Thompson1, Alan E. Willner1, Kent D. Choquette1, Univ. of Illinois, USA; 1Electrical Engineering, Univ. of Southern California, USA; 2Freedom Photonics, USA. We report direct modulation of 2x1 proton-implanted index-confined photonic crystal coherently-coupled VCSEL array operating error free at 36 GHz. The high-speed modulation is attributed to modulation-bandwidth enhancement.

STu3Q2.6 • 14:30 Novel Oxide Spacer High-Contrast Grating VCSELs, Kevin T. Cook1, Jingpeng Qi1, Jiaxing Wang1, Neil Cabello1, Connie J. Chang-Hassan1,1, Univ. of California, Berkeley, USA; 2Univ. of the Philippines Diliman, Philippines; 3Electrical and Computer Engineering, UC Santa Barbara, USA. We report direct modulation of 36 GHz error-free modulation of 360 nm monolithic injection-locked VCSEL array without top DBR layers via an electrostatically controlled HCG mirror. Large tuning range results from a high optical intensity in the air cavity.

STu3Q3 • Advances in VCSELs—Continued

STu3Q3 • 14:00 Recent Advances in Single Photon Sensitivity Mapping Lidars, Jacobo Marcos Sirot1, John Degnan1, Joshua Gluckman1, Ed Leventhal1, Spencer Disque1, SIGMA Space Corp, USA. Latest developments in single-photon-sensitive based mapping systems are presented, including detection, timing, intensity measurement, multi-photon bias correction, and near real time processing techniques. Performance is evaluated from data collected in a variety of urban and natural landscapes.

STu3Q4 • 14:00 Recent Advances in Single Photon Sensitivity Mapping Lidars, Jacobo Marcos Sirot1, John Degnan1, Joshua Gluckman1, Ed Leventhal1, Spencer Disque1, SIGMA Space Corp, USA. Latest developments in single-photon-sensitive based mapping systems are presented, including detection, timing, intensity measurement, multi-photon bias correction, and near real time processing techniques. Performance is evaluated from data collected in a variety of urban and natural landscapes.

STu3Q5 • 14:15 Air-Cavity Dominated HCG-VCSEL with a Wide Continuous Tuning, Jonas Kapraun1, Pingyi Yi1, Jiaxing Wang1, Stephen Tong2, Kevin Cook1, Emil Kolev3, Connie J. Chang-Hassan3,1, Dept. of Electrical Engineering and Computer Sciences and Tsinghua-Berkeley Shenzhen Inst., UC Berkeley, USA; 2Univ. of the Philippines—Diliman, Philippines; 3Electrical and Computer Engineering, UC Santa Barbara, USA. We present continuously tuned emission of 940-1000 nm wavelength from an electrically-pumped VCSEL without top DBR layers via an electrostatically controlled HCG mirror. Large tuning range results from a high optical intensity in the air cavity.

STu3Q6 • 14:30 Control and Simulation of Coherent Array Modes in Vertical Cavity Laser Arrays, Bradley J. Thompson1, Zhie Gao1, Harshil Dave1, Stewart Fryslie1, Katherine Lakomy1, Kent D. Choquette1, Univ. of Illinois, USA; 2Freedom Photonics, USA. A 3x1 vertical-cavity surface-emitting laser array is resonantly tuned to multiple coherent modes. Experimental near-field and far-field coherent modes profiles are characterized and simulated. The center element bias demonstrates control of the coherent mode.

STu3Q7 • 14:45 Supercontinuum from Labs to Factories, Peter Moselund1, Patrick Bowen2, Magalie Boudin1, Lucy Hooper1, Adam Devine1, NKT Photonics Inc, Denmark; 2NKT Photonics UK, UK. We review recent trends in supercontinuum research and the challenges involved in maturing supercontinuum from being a cutting edge lab instrument replacing exotic lasers to an industrially mature light source in its own right.
**FTu4A.1 • 17:00**

Large Scale Quantum Simulations Using Ultracold Atomic Gases in Optical Lattices, Immanuel Bloch 1,2; 1Quantum Many-Body Systems Division, Max-Planck-Institut fur Quantenoptik, Germany; 2Physics, Ludwig Maximilians Univ., Germany. Large scale quantum simulations in computationally intractable regimes offer the opportunity to address fundamental problems across different fields of science. I will introduce the field of atomic quantum simulations with ultracold atoms.

Immanuel Bloch is scientific director at the Max Planck Institute for Quantum Optics (Garching) and professor at the Ludwig-Maximilians-University (Munich). His scientific work is among the most highly cited in the field of quantum physics and has helped to open the new interdisciplinary research field of quantum simulations.

**STu4B.1 • 17:00**

MEMS-Actuated 8x8 Silicon Photonic Wavelength-Selective Switches with 8 Wavelength Channels, Tae Joon Seok1, Jinheang Luo2, Zhilei Huang1, Kyungmok Kwon1, Johannes Henckssen1, John Jacobs1, Lane Ochikubo1, Richard Muller1, Ming C. Wu1; 1Gwangel Inst. of Science and Technol, South Korea; 2ECECS, Univ. of California, Berkeley, USA; 3TSI Semiconductors, USA. We report on a fully integrated 8x8 silicon photonic MEMS wavelength-selective switch with 8 wavelength channels on a 9.7mm x 6.7mm chip. Total on-chip loss including switches and echelle grating mux/demux is 13.3 dB.

**FTu4A.2 • 18:00**

Quantum vs. Optical Annealing: Benchmarking the OPO Ising Machine and D-Wave, Ryan Harmer1, Takahito Inagaki1, Peter L. McMahon1, Davide Venturelli1, Alireza Marandi1, Tatsuiro Onodera2, Edwn Ng3, Eleanor Rieffel3,4; 1DTU Fotonik, Denmark; 2IHP, Germany; 3IHP Solutions, Germany; 4TU Berlin, Germany. Improvements in signal-to-noise ratio (1.2 dB) and transmission reach (16 %) are demonstrated for dual-polarisation WDM 16-QAM signals through nonlinearity compensation by optical phase conjugation in a silicon waveguide with a lateral p-i-n diode.

**STu4B.2 • 18:00**

CMOS-Compatible Optical Phased Arrays with Monolithically-Integrated Erbium Lasers, Jelena Notaras1, Nanxi Li1, Christopher V. Poulton1, Zhen Su1, Matthew Byrd2, Emir Magden1, Michael Watts1; 1MIT, USA; 2Harvard Univ., USA. An electronically-steerable integrated optical phased array powered by an on-chip erbium-doped laser is experimentally demonstrated. This system represents the first demonstration of a rare-earth-doped laser monolithically integrated with an active CMOS-compatible silicon photonics system.

**FTu4A.3 • 19:00**

Selective Switches with 8 Wavelength Channels, Tae Joon Seok1, Jinheang Luo2, Zhilei Huang1, Kyungmok Kwon1, Johannes Henckssen1, John Jacobs1, Lane Ochikubo1, Richard Muller1, Ming C. Wu1; 1Gwangel Inst. of Science and Technol, South Korea; 2ECECS, Univ. of California, Berkeley, USA; 3TSI Semiconductors, USA. We report on a fully integrated 8x8 silicon photonic MEMS wavelength-selective switch with 8 wavelength channels on a 9.7mm x 6.7mm chip. Total on-chip loss including switches and echelle grating mux/demux is 13.3 dB.

**STu4B.3 • 19:00**

Silicon Photonic 50GHz Wavelength (De)Multiplexer with Low Crosstalk and Flat Passband, Liangshun Han1,2,3, Bill P. Kuo1, Motokho Eto1, Anja Pejkic1, Jin Zhang1, Nikola Alic1, Jan-Willem Goossens1,4, Mengdi Song1, Stefan Wabnitz3,4, Yves Jauvion1; 1LTI, Telecom ParisTech, Université Paris-Saclay, France; 2Photonics Research Centre, Dept. of Electrical Engineering, The Hong Kong Polytechnic Univ., China; 3Dipartimento di Ingegneria dell’Informazione, Università di Brescia, Italy; 4Mathematical and Algorithmic Sciences Lab, Paris Research Center, Huawei Technologies France SASU, France. We experimentally demonstrate dual-polarization nonlinear frequency division multiplexing using the continuous spectrum in 1680 km of normal dispersion fiber at a burst rate of 128Gbit/s. The DGD penalties are shown to be negligible.

**FTu4A.4 • 20:00**

Experimental Comparison of Probabilistic Shaping with online PMF Optimization and Mid-link OPC, Francesco Da Ros1, Edson P. da Silva1, Michael Galili1, Leif K. Oxenløwe2,3; 1DTU Fotonik, Denmark; 2PhP, Germany; 3IHP, Germany. Probabilistic shaping is optimized online and tailored to the specific channel and transceiver conditions, including the OPC stage.

**STu4B.4 • 20:00**

Reconfigurable Mode (De)Multiplexer with Integrated Thermo-Optic Long-Period Grating and Y Junction, Wei ke Zhao1, Bing Feng1, Kaixin Chen1, Kin S. Chiang2; 1Univ of Science & Tech China, China; 2City Univ. of Hong Kong, China. We demonstrate reconfigurable mode (de)multiplexer with an integrated thermo-optic long-period grating and an asymmetric Y-junction. Our fabricated device achieves a mode selectivity >12 dB over the C+L band with a switching power of 198 mW.
Rosamond, Lianhe Li, Yingjun Han, Edmund H. Linfield, Scalari; combs based on THz quantum cascade lasers will be pre-
measure ammonia in gas phase.

an optical bandwidth of ~150 GHz at 2.9 THz and is used to
compensated quantum cascade lasers. The system achieves
comb spectroscopy of molecular samples using dispersion

THz Quantum Cascade Lasers and Combs, Jonas Westberg, Lukasz A. Stenzewicki, Yang Yang, David Burghoff, Qiing Hu, Gerard Wysocki, ‘Dept. of Electrical Engineering, Princeton Univ., USA; ‘Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland; ‘MIT, USA. We demonstrate THz dual comb spectroscopy of molecular samples using dispersion compensated quantum cascade lasers. The system achieves an optical bandwidth of ~150 GHz at 2.9 THz and is used to measure ammonia in gas phase.

Invited

Octave-spaced on-chip THz frequency combs, Andres For-
re, Markus Roschi, Mattias Beck, Jerome Faist, Giacomo Scalari, 1ETH Zurich, Switzerland. Latest results on frequency combs based on THz quantum cascade lasers will be pre-

invited

Invited

Continuous frequency tuning of Y-branched terahertz
quantum cascade lasers with photonic lattice, Iman Kundu, Paul Dean, Alexander Valavanis, Joshua R. Freeman, Mark Rosamond, Ianthe Li, Yingjun Han, Edmund H. Linfield, Alexander G. Davies, ‘Univ. of Leeds, UK. We report electrically-
controlled continuous frequency tuning over ~20 GHz by exploiting the additive Vernier tuning effect in a THz QCL based on a longitudinally-coupled Y-branched waveguide.

Strong Coupling of Excitons, Plasmonic and Photonic
Modes in Organic-dye-doped Nanostructures, Ruiven
Peng, Kun Zhang, Mu Wang, ‘Nanjing Univ., China. We
demonstrate experimentally hybrid strong couplings among
molecular excitons, plasmonic and photonic modes in the
organic-dye-doped nanostructures. And multiple hybrid
polaron bands are observed, which may achieve potential applications on multimode polariton lasers and optical

Brillouin Filtering with Enhanced Noise Performance and
Linearity Using Anti-Stokes Interactions, Arthur Choudhury, Yang Liu, David Marpaung, Benjamin Eggleton, ‘Univ. of
Sydney, Australia. The anti-Stokes component of a stimulated
Brillouin scattering interaction enabled low-power and high-
resolution bandpass filtering, with improvements in linearity
and signal-to-noise ratio of up to 3dB and 8dB, respectively
when compared to using the Stokes component.
FTu4G.1 • 17:00
On-Chip Continuous Variable Squeezing, Jasmin D. Meinecke, Genta Masada, Takahiro Senkawa, Jeremy L. O’Brien, Akira Furusawa; Centre for Quantum Photonics, Univ. of Bristol, UK; 3Max-Planck-Inst. for Quantum Optics, Germany; 4Dept. Applied Physics, The Univ. of Tokyo, Japan; 2Quantum ICT Research Inst., Tamagawa Univ., Japan. We perform a squeezing transformation for continuous variable input states using a measurement-based scheme on chip. Implementing this fundamental transformation is an important building block for fully integrated continuous variable quantum information processing.

FTu4G.2 • 17:15
Multiphoton Hong-Ou-Mandel Interferometry with Entangled Photon-Subtracted States, Omar S. Magana, Mathias Raimond, Martin T. Minh, Frank Schmidt, Stefan Schiller, tradition on chip; 1University of California, San Diego, USA; 2Max-Planck-Inst. for Quantum Optics, Germany. We propose a scalable scheme for optical quantum computation using continuous-variable quantum gates in a loop-based architecture. This architecture offers a universal computing using continuous-variable quantum gates in a loop-based architecture. This architecture enables the use of Hong-Ou-Mandel interferometry with mesoscopic states that resemble systems of our technique allows us to explore Hong-Ou-Mandel interferometry with mesoscopic states that resemble systems of entangled lasers.

FTu4G.3 • 17:30
Low-Latency Digital Feedforward for Universal Continuous-Variable Quantum Computation in Time Domain, Atsushi Sakaguchi, Hisashi Ogawa, Masaya Kobayashi, Shigemasa Suzuki, Hidehiro Yoneda, Elian Huntingon, Chuntaro Takeda, Jun-ichi Yoshikawa, Akira Furusawa; 1Dept. of Applied Physics, School of Engineering, Univ. of Tokyo, Japan; 2Centre for Quantum Computer Science, Computing and Communication Technology, School of Engineering and Information Technology, Univ. of New South Wales, Australia; 3College of Engineering and Computer Science, The Australian National Univ., Australia. We demonstrate generation of entangled photon-subtracted states and manipulation of their quantum fluctuations. The flexibility of our technique allows us to explore Hong-Ou-Mandel interferometry with mesoscopic states that resemble systems of entangled lasers.

FTu4G.4 • 17:45
Scalable and Universal Quantum Computing with Continuous-Variable Gate Sequence in a Loop-Based Architecture, Shuntaro Takeda, Akira Furusawa; 1Dept. of Applied Physics, The Univ. of Tokyo, Japan; 2JST, PRESTO, Japan. We propose a scalable scheme for optical quantum computing using continuous-variable quantum gates in a loop-based architecture. This architecture offers a universal quantum computer for both qubits and continuous variables with almost minimum resources.

FTu4H.1 • 17:00
Formation of quantum emitter arrays in hexagonal Boron Nitride at room temperature, Nicholas Proscia, Zav Shottan, Harishankar Jayakumar, Pritivi Reddy, Michael Dollar,Audrius Alakauskas, Marcus Doherty, Carlos Meriles, Vinod M. Menon; 1CUNY City College of New York, USA; 2Physics, CUNY Graduate Center, USA; 3Laser Physics Centre, Australian National Univ., Australia; 4Center for Physical Science and Technology, Lithuania. Room temperature quantum emitter arrays are created in hexagonal Boron Nitride (hBN) by deterministic activation via strain engineering on a nanopillar substrate. Emitters are localized at pillar edges where the hBN film undergoes maximum strain.

FTu4H.2 • 17:15
Lead-Related Quantum Emitters in Diamond, Matthew Trusheim, Noel Wan, Girish Malladi, Kevin Chen, Benjamin Lieber, Hassaram Bakhru, Dirk Englund; 1Electrical Engineering and Computer Science, MIT, USA; 2College of Nanoscale Science and Engineering, Univ. at Albany-State Univ. of New York, USA. We investigate the optical properties of quantum emitters formed in diamond after the implantation of Pb and subsequent high-temperature annealing. We find narrow-band emission in two spectral ranges, indicating multiple classes of Pb-related color centers.

FTu4H.3 • 17:30
A Photonic Link for Donor Spin Qubits in Silicon, Stephanie Simmons, Simon Fraser Univ., Canada. This talk presents an approach to scale up donor spin qubits in silicon using the built-in, spin-selective, strong electric dipole (optical) transitions of singly-ionized double donors. This photonic link could enable photonic cavity-QED at 4.2K.

FTu4H.4 • 18:00
Miniaturizing Rare-Earth Ion Microwaves to Optical Transducers, John G. Bartholomew, Jake Rochman, Jonathan Kindem, Tian Zhang, Ioana Craciuc, Andrei Rusu, Andrei Faraon; 1Caltech, USA. We present the development of an on-chip rare-earth ion architecture that integrates planar microwave elements and photonic structures to realize coherent microwave to optical transduction.

FTu4H.5 • 18:00
Continuous-variable Quantum Computing: Scalable Designs and Fault Tolerance, Nicolas Menicucci; 1Physics, RMIT Univ., Australia. Continuous-variable (CV) cluster states are multimode-squeezed states that are resource states for measurement-based quantum computation. I will discuss recent experimental advances in producing large-scale CV cluster states and how to use them for fault-tolerant quantum computation.

FTu4I.1 • 17:00
Spatially-resolved hydrogen atom detection in flames using backward lasing, Maria Ruchkina, Peng-Ji Ding, Andreas Ehni, Marcus L.E. Alden, Ioakim Bood, Lund Univ., Sweden. We report on an experimental demonstration of spatially-resolved detection of atomic hydrogen in flames using a single-ended configuration. The lasing signal in a backward direction is obtained by two-photon pumping with 205-nm femtosecond laser pulses.

FTu4I.2 • 17:15
Translating Novel Optical Diagnostics to Air Force-Relevant Systems, James R. Gord; Air Force Research Lab, USA. Measurements with lasers and optics are often ideal for characterizing nonreacting and reacting flows, including those in aero propulsion systems. Approaches based on ultrashort-pulse and burst-mode lasers, especially for multidimensional, high-speed imaging, will be explored.

FTu4I.3 • 17:45
Spatially Resolved Raman Spectra of Diffusion Flame via Compressive Sensing, David J. Starling, Joseph Ranalli; 1Univ. College, Penn State Univ., USA. We simulate compressive sensing on spatially resolved Raman scattering measurements of a highly strained diffusion flame. Simulations agree with prior data, enabling the use of lower cost sensors in a simplified form of the experiment.
Machine Learning and Computation Enabled Microscopy and Sensing for Point-of-Care Medicine and Global Health, Aydogan Ozcan1; and Sensing and diagnostics technologies that utilize computational photonics and machine learning approaches to address point-of-care medicine and global health related applications.

We review some of our recent progress on mobile microscopy, sensing and diagnostics technologies that utilize computational photonics and machine learning approaches to address point-of-care medicine and global health related applications.

Invited

ATu4J.1 • 17:00
Progress in the Development of All-Solid-State Coherent Sources in the Mid-IR above 5 µm for Surgical Applications, Valentin Petrov1; ‘Max Born Inst., Germany. I will review the state-of-the-art and the recent progress in all-solid-state parametric frequency down-conversion devices for achieving high pulse energy and average power in the 5 to 8 µm spectral range interesting for medical applications.

Invited

ATu4J.2 • 17:30
Combined Optical Coherence Tomography and Near Infrared Fluorescence of Cancer-specific Antibodies, Johannes de Boer1; ‘Vrije Univ Amsterdam, Netherlands. Optical coherence tomography provides structural and functional information of in vivo tissue but lacks molecular contrast. We demonstrate combined endoscopic OCT and immuno-fluorescence targeting a human colon cancer cell line metabolized in a mouse model.

ATu4J.3 • 18:00
All-Polarization-Maintaining Dual-Comb Fiber Laser with Nonlinear Amplifying Loop Mirror, Yoshiaki Nakajima1,2, Yuya Hata1, Kaoru Minoshima2,3; ‘Univ. of Electro-Communications,ILS, Japan. We demonstrate a cascaded modulation method for all-polarization-maintaining dual-comb generation. With this method, robust dual-comb spectroscopy can be achieved even in the presence of high levels of polarization noise.

ATu4J.4 • 19:00
Microlens-Stabilized Laser Arrays for Short-Pulse, Speckle-Free Imaging, Austin W. Steinforth1,2; ‘Univ. of Illinois at Urbana-Champaign, USA. Arrays comprised of more than 1,200 beams illuminated motile biological specimens, producing speckle-free video with 15 nanosecond exposure per frame.

Invited

JTu4L.1 • 17:00
Bringing Functional High Resolution Diagnostics to the Bedside Using Multimodal, Label-free, Two-photon Imaging, Irene Georgakoudi1,2, Balu2, Bruce Tromberg1,2; ‘Tufts Univ., USA; ‘Univ. of California at Irvine, USA. Changes in optical metabolic signals related to the intensity, lifetime and spatial localization of endogenous fluorescence are associated with alterations in specific biosynthetic and bioenergetic cellular pathways, which can serve as diagnostic and therapeutic targets.

Invited

JTu4L.2 • 18:00
Precise Measurements with Ultra-Low Noise Frequency Combs, Wolfgang Hänsel1, Michele Giunta1,2, Katja Beha1, Matthias Leuzis1, Maurice Lessing1, Marc Fischer1, Ronald Holzwarth1,2; ‘Menlo Systems GmbH, Germany; ‘Max-Planck Inst. of Quantum Optics, Germany. The advent of long-term stable ultra-low noise (ULN) frequency combs opens new prospects for precision measurements. We characterize the stability and precision of such ULN combs and present dual-comb precision spectroscopy of molecules and cavities.

Invited

STu4K.1 • 17:00
Fast phase locking of a 750-MHz Yb:fiber laser frequency comb using a high-speed piezo-transducer, Yuxuan Ma1,2,3; ‘Univ. of California Los Angeles, USA. We demonstrate a 750-MHz-spaced Yb:fiber frequency comb phase locked to a narrow linewidth CW laser by a single stack PZT actuator. Low phase noise and high stability were achieved by the fast phase locking.

STu4K.2 • 17:15
Generation of 250-MHz electro-optic frequency comb for Doppler-limited spectroscopy, Wang Shuai1, Xinyu Fan1, Bingxin Xu1, Zuyuan He1; ‘Shanghai Jiao Tong Univ, China. We propose a cascaded modulation method for electro-optic frequency comb generation. With this method, electro-optic frequency combs with 250-MHz line spacing covering 4,000 teeth were generated, which enable Doppler-limited spectroscopy.

STu4K.3 • 17:30
Precision Measurements with Ultra-Low Noise Frequency Combs, Wolfgang Hänsel1, Michele Giunta1,2, Katja Beha1, Matthias Leuzis1, Maurice Lessing1, Marc Fischer1, Ronald Holzwarth1,2; ‘Menlo Systems GmbH, Germany; ‘Max-Planck Inst. of Quantum Optics, Germany. The advent of long-term stable ultra-low noise (ULN) frequency combs opens new prospects for precision measurements. We characterize the stability of such ULN combs and present dual-comb precision spectroscopy of molecules and cavities.

STu4K.4 • 18:00
All-Polarization-Maintaining Dual-Comb Fiber Laser with Nonlinear Amplifying Loop Mirror, Yoshiaki Nakajima1,2, Yuya Hata1, Kaoru Minoshima2,3; ‘Univ. of Electro-Communications,ILS, Japan. We demonstrate an all-polarization-maintaining dual-comb fiber laser with nonlinear-amplifying-loop-mirror for realizing simple and robust dual-comb spectroscopy using two mutually coherent combs with slightly different repetition rates emitted from the laser cavity without complex servo system.

Invited

Irene Georgakoudi is a Professor of Biomedical Engineering at Tufts University. Her work focuses on the understanding and exploitation of endogenous fluorescence and scattering signals in two-photon microscopy to extract highly quantitative, functional information regarding cellular metabolism and matrix biomechanics. She is an OSA and AIMBE fellow.
**CLEO: Science & Innovations**

17:00–19:00

**STu4N • 17:00**

**Nanoscale Optical Field Topology, from Fascination to Application**

Presider: Luca Sapienza; Univ. of Southampton, UK

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**STu4N.1 • 17:00**

**Nanoflare: Cavity Nanolaser on a Chip**

Presider: Leo Gross; Technion, Israel Inst. of Technology, Haifa, Israel

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**STu4N.2 • 17:30**

**Monolayer Semiconductor Surface-Emitting Lasers Using 2D Dark Plasmonic Cavities**

Chun-Tuan Wang1, Jianwei Shi1, Sonnya S. Raja2, Chun-An Chen2, Xin-Guan Zhang3, Chih-Kang Shih4, Hyeyoung Ahn5, Yi-Hsien Lee2, Shangqiao Guo6,7; 1Dep. of Physics, National Tsing-Hua Univ., Taiwan; 2Dep. of Physics, Univ. of Texas at Austin, USA; 3National Synchrotron Radiation Research Center, Taiwan; 4Dep. of Physics, Beijing Normal Univ., China; 5Dep. of Photonics, National Chiao-Tung Univ., Taiwan; 6Dep. of Materials Science and Engineering, National Tsing-Hua Univ., Taiwan. We demonstrated a low-threshold lasing from a monolayer gain medium which is made possible due to 2D feedback mechanism via strong exciton-SPP coupling in both real space and a wide range of momentum space.

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**STu4N.3 • 17:45**

**Coupling of Photonic Fano Resonances with MoS2, Excitons for Enhanced Light Emission and Optical Modulation**

Xingwang Zhang1, Mohammad Nazarian2,3,4, Mohammad Hossein Azhdast1, Hans Joachim Eichler1, Klaus-Dieter Lang2, Veronika Indra2, Mohammad Hossein Nayer1, Dake Wang1, A. T. Charlie Johnson2, Ertugrul Naylor1, Dariusz Baranowski3, Karol Osyczka4, Carsten Igel3, Thomas Metzger3, Dariusz Gadonas4, Karolis Neimontas4, Vytautas Sinkevicius4, Lucian Hand4, Andrey Senin4, Mark R. Hoff1, William Graves2, RFE, MIT, USA; 2Physics and Bio-design Inst., Arizona State Univ, USA; 3TRUMPF Scientific Lasers GmbH + Co. KG, Germany; 4Light Conversion, Lithuania. We investigate nonlinear crystal type multiplexing as means of increasing the bandwidth of a parametric amplification system pumped at 532nm. Experimental results and numerical simulations indicate that sub-2 cycle pulse durations and multi-mJ pulse energies will be possible using BBO and LBO.

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**STu4O • 17:00**

**Towards Sub-2 cycle, 19THz OPCPA System Based on Yb:KGW and Nd:YAG Lasers**

Tomas Stanislas1, Ignas Balciunas1,2, Rimantas Budriunas1,2, Jonas Adamonis1,2, Sabolci Tobias3, Adam Barzonsky1, Karoly Osyczka4, Andrejus Michailovas5, Gediminas Veitas2, Darius Gadonas4, Light Conversion Ltd., Lithuania; 3Lasers Research Center, Vilnius Univ., Lithuania; 4Ekspla Ltd., Lithuania; 3ELI-HU Nonprofit Ltd., Hungary. We investigate nonlinear crystal type multiplexing as means of increasing the bandwidth of a parametric amplification system pumped at 532nm. Experimental results and numerical simulations indicate that sub-2 cycle pulse durations and multi-mJ pulse energies will be possible using BBO and LBO.

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**STu4O.1 • 17:00**

**Performance of the 20 fs, 4 PW Ti:Sapphire Laser at CoReLS, Chang Hee Nam1,2, Gwangju Inst of Science & Technology, South Korea; 2Center for Relativistic Laser Science, Inst. for Basic Science, South Korea. One of two petawatt Ti:Sapphire laser beamlines at CoReLS was upgraded to a high contrast, 4 PW, 20 fs laser with a repetition rate of 0.1 Hz and its performance has been tested for multi-GeV electron acceleration.

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**STu4O.2 • 17:15**

**Efficient and Wavelength Tunable Extreme-ultraviolet Light Source Used for TR-APRES, Zhiquang Nie1, Zhonghui Nie1, Jian Tu1, Yao Li2, Xuezhong Ruan3, Liang He4, Edmond T. Xu5, Yongbing Xu5, Nanjing Univ, China. Efficient and wavelength tunable extreme-ultraviolet source is developed through high harmonic generation by a frequency-doubled Ti:sapphire and a monochromator with off-plane mount single grating. Photon flux of 1.2 x 1011 photons/s is achieved at 21.7 eV.

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**STu4O.3 • 17:30**

**Highly-stable, 1 kHz, 200 mJ, 1.1 ps laser optically synchronized to a photocathode laser that triggers electron beams.**

Kyoung-Han Hong1,2, Sandro Klingebiel3, Krut Michiel1, Thomas Metzger1, Darius Gudonas3, Karolis Neimontas3, Vytautas Sinkevicius1, Lucas Hand1, Andrey Senin2, Mark R. Hoff1, William Graves2, RFE, MIT, USA; 2Physics and Bio-design Inst., Arizona State Univ, USA; 3TRUMPF Scientific Lasers GmbH + Co. KG, Germany; 4Light Conversion, Lithuania. We demonstrate a high-stable, 1 kHz, 200 mJ, 1.1 ps 1030 nm laser with good beam quality as an inverse-Compton-scattering driver, optically synchronized with 33-fs rms jitter to a photocathode laser that triggers electron beams.
CLEO: Science & Innovations

**Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.**

**17:00–19:00**

**STu4P • Advanced Sensing Concepts**

*Presider: Adam Fleisher; NIST, USA*

**STu4P1 • 17:00**

*Slow Light Imaging Spectroscopy with a Passive Atomic Filter*, Arthur Dogariu1; Richard B. Miles1,2; Princeton Univ., USA; 2Texas A&M Univ., USA. We demonstrate time delayed imaging with slow light using high positive dispersion of a passive atomic gas. This filter allows for imaging of Raman, Rayleigh, and Thomson scattering without the need of a spectrometer.

**STu4P2 • 17:15**

*Wide-Range Tunable Refractometer Based on Orbital Angular Momentum of Light*, Ahmed Dorrani1, Michel Zamboni-Rached1; Ma Mojahedi1; 1Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada; 2School of Electrical Engineering, Univ. of Campinas, Brazil. We experimentally demonstrate a programmable refractive index sensor utilizing orbital angular momentum of light where the sensitivity, resolution, and dynamic range can be controlled in real-time, thus addressing many challenges in refractometry and remote sensing.

**STu4P3 • 17:30**

*Coherent Spatiotemporal Phase Control by Combining Optical Frequency Combs and Optical Vortices*, Akifumi Asahara1, Satoru Shoji1, Ken-ichi Kondo1,2; Yue Wang1,2; Kaoru Minoshima1,2; 1Univ. Electro-Communications, Japan; 2JST, Intelligent Optical Synthesizer, Japan. “Optical vortex comb” is proposed, that enables coherent spatiotemporal phase control by combining optical frequency combs with optical vortices. The applicability is demonstrated through experiments on optical ring lattice control and optical tweezers.

**STu4P4 • 17:45**

*Nanoscale isotopic imaging and trace analysis by extreme ultraviolet laser ablation mass spectrometry*, Carmen S. Menoni1; Tyler Green1, Ilya Kurmets1, Weilun Chao1, Jorge Rocca1, Andrew Duffin1; 1Colorado State Univ., USA; 2Center for X-Ray Optics, Lawrence Berkeley Lab, USA; 3Paciﬁc Northwest National Lab, USA. Extreme ultraviolet laser ablation mass spectrometry isotopic imaging and analysis with 80 nm spatial resolution are demonstrated.

**STu4P5 • 18:00**

*Development of a Miniature Laser-induced Fluorescence Sensor Module used for Unmanned Aerial Vehicles*, Suprava Nagpal1, Prakash Adhikari1, William P. Williams1, Gary L. Windham2; Gerald A. Matthews1, Aynubold O. Gombojav1; 1Physics and Astronomy, Mississippi State Univ., USA; 2USDA-ARS, Mississippi State Univ., USA. A versatile sensor module based on laser-induced fluorescence is constructed. The results demonstrate its ability to investigate stress in vegetation. Module is mounted on a quadcopter and flown with pre-planned missions making the task autonomous.

**STu4Q • UV-visible Semiconductor Lasers**

*Presider: Boon Ooi; King Abdullah Univ of Sci & Technology, Saudi Arabia*

**STu4Q1 • 17:00**

**Tutorial**

*III-Nitride Lasers – Challenges and Approaches to Expand the Emission Wavelength into the UV*, Thomas Wunderer1; 1Palo Alto Research Center, USA. In this tutorial we will review III-Nitride-based laser technology, discuss materials challenges using high band gap semiconductors, and present different approaches and tricks to overcome these barriers (i.e., polarization doping, e-beam excitation and frequency multiplication).

Thomas Wunderer is a Senior Member of Research Staff at the Palo Alto Research Center, CA with a PhD in EE from Ulm University, Germany. Since joining PARC in 2010, he has led various R&D projects developing novel optoelectronic materials, devices and sub-systems (incl. UV lasers for DARPA LUSTER, CMUVT).

**STu4Q2 • 18:00**

*Recent progress in GaN-based Vertical-Cavity Surface-Emitting Lasers Having Dielectric Distributed Bragg Reflectors*, Hiroshi Nakajima1, Jugo Mitsomo1, Kentaro Fujii1, Masayuki Tanaka1, Masamichi Ito1, Maho Ohara1, Noriko Kobayashi1, Hideki Watanabe1, Tatsushi Hamaguchi1, Rintaro Koda1, Hironobu Narui1; 1Sony Corporation, Japan. The recent progress in GaN-based vertical-cavity surface-emitting lasers (VCSELs) having dielectric distributed Bragg reflectors, including the device characteristics of GaN-based VCSELs with a newly proposed cavity structure incorporating an atomically smooth curved mirror, is overviewed.
FTu4A.3 • 18:15
Finding Non-Classical States that do not Generate Entanglement at a Beam Splitter, Aaron Z. Goldberg1, Daniel James1, 2, Univ. of Toronto, Canada. A common way to generate modal entanglement uses beam splitters. We find a set of non-classical states that are not entangled by beam splitters. This is crucial for understanding entanglement generation for, e.g., boson sampling.

FTu4A.4 • 18:30
High speed device-independent quantum random number generation without detection loophole, Yang Liu1,2, Univ. of Shanghai for Science and Technology, China; 2Nanjing Univ., China; 2Tel Aviv Univ., Israel; 3Nanjing Univ., China. A photonic homodyne down-conversion in conjugated-paired radio-on-fiber (C-RoF) system. 20-km SMF transmission of 156-Mb/s BPSK-C-RoF is demonstrated, naturally cancelling nonlinear phase shift without using digital signal processing.

FTu4A.5 • 18:45
Two-Photon N-Party Quantum Secret Sharing, Warren P. Grice1, Joseph M. Lukens1, Nicholas A. Peters1, Brian Williams1, 1Oak Ridge National Lab, USA. We describe a multi-party quantum secret sharing protocol utilizing two-photon entangled states in which the source is one of the secret sharing participants. It is experimentally easier to realize than methods using GHZ states.
We demonstrate amplification with a PID loop. From Liquid Phase Exfoliation of Graphite, Leonardo Viti,1,2,3,4, Leonardo Viti4,4, Graphene Saturable Absorbers at Terahertz Frequency with Graphene Loaded Split-Ring-Resonator Array, the transmission of which can be tuned to compensate the laser power fluctuation with a PID loop.

We report on the development of terahertz (THz) saturable-absorbers exploiting printable graphene inks. The achieved 80% transparency modulation at 3.5 THz makes these devices potential candidates as passive components for THz solid-state lasers.

We demonstrate experimental demonstration of 16dB isolation at room temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects. At typical THz QCL cooling,oom temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects. At typical THz QCL cooling,oom temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects.

We report on the fabrication of high-density graphene loaded split-ring-resonator array, the transmission of which can be tuned to compensate the laser power fluctuation with a PID loop.

We report on the fabrication of high-density graphene loaded split-ring-resonator array, the transmission of which can be tuned to compensate the laser power fluctuation with a PID loop.

We report on the development of terahertz (THz) saturable-absorbers exploiting printable graphene inks. The achieved 80% transparency modulation at 3.5 THz makes these devices potential candidates as passive components for THz solid-state lasers.

We demonstrate experimentally a nonreciprocal magnetoplasmonic mirror that achieves room temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects. At typical THz QCL cooling,oom temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects. At typical THz QCL cooling,oom temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects. At typical THz QCL cooling,oom temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects. At typical THz QCL cooling,oom temperature isolation with a rejection rate of 16dB by combining the THz plasma frequency of intrinsic small-gap InSb with its strong THz cyclotron effects.
FTu4G • Continuous Variable Quantum Computing—Continued

FTu4G.6 • 18:30 Invited
Quantum Computing using Squeezed Light, Christian Weedbrook 1; Xanadu, Canada. Integrated photonics based on squeezed light offers a way to build a highly scalable, room temperature and energy efficient quantum computer. We will discuss the advances we are making here at Xanadu based on this exciting architecture.

FTu4H • Novel Solid State Systems for Quantum Optics—Continued

FTu4H.5 • 18:15
\[^{171}\text{Yb}:\text{YVO} \text{ for Nanoscale Quantum Interfaces}, \text{Jonathan Kindem}^1, \text{John G. Bartholomew}^1, \text{Jake Rochman}^1, \text{Tian Zhong}^1, \text{Charles W. Thiel}^2, \text{Philip J. Woodburn}^2, \text{Rufus L. Core}^1, \text{Andrei Faraon}^1; \text{Caltech, USA; 2 Physics, Montana State Univ., USA.}\] We report on the optical and spin coherence properties of \[^{171}\text{Yb}:\text{YVO} \text{ at cryogenic temperatures}. Our results indicate this material is promising for nanoscale quantum memories, microwave-to-optical transduction, and optically addressable single ions.

FTu4H.6 • 18:30
Narrowing of Electromagnetically Induced Transparency in an Inhomogeneously Broadened Solid-State Atomic Ensemble, Haoquan Fan 1,2, Elizabeth A. Goldschmidt 1,2; USA Army Research Lab, USA; 2 Joint Quantum Inst., Univ. of Maryland, USA. We study electromagnetically induced transparency (EIT) in an inhomogeneously broadened solid-state ensemble of europium atoms. We observe agreement with theory including narrowing of the EIT linewidth as a function of the inhomogeneous width.

FTu4H.7 • 18:45
All-Optical Control of Long-lived Spin Coherences in Rare Earth Doped Nanoparticles, Diana Serrano 1, Jenny Karls-son 1, Alexandre Fossati 1, Alban Ferrier 1, Philippe Goldner 1; Institut de Recherche de Chimie Paris, PSL Research Univ., Chimie ParisTech, CNRS, France. We measured nuclear spin coherence lifetimes up to several milliseconds in \[^{171}\text{Yb}:\text{O}_3\] doped nanoparticles using all-optical techniques. Combined with narrow optical linewidths, this opens the way to nanoscale light-atom-spin interfaces at the quantum level.

19:00–20:30 OSA Technical Group Poster Session, Room 230A/B
Tuesday, 17:00–19:00
CLEO: Applications & Technology

**ATu4J • Medical Devices & Systems—Continued**

**ATu4J.4 • 18:15**
Portable Diagnostic for Malaria Detection in Low-Resource Settings, Samantha McBinney1, Dongyu Chen1, Alexis Scholtz2, Bernard Chen1, Andrea M. Armani1; 1Univ. of Southern California, USA; 2Johns Hopkins Univ., USA. We have designed a novel device to identify malaria in both symptomatic and asymptomatic populations by detecting the presence of hemozoin. Here, we detect clinically relevant concentrations of β-hematin, a synthetic mimic of hemozoin.

**ATu4J.5 • 18:30**
Improved Spot Formation through Flexible Multimode Fiber Using a Partial Reflector, Ruo Yu Gu1, Elaine Chou1, Cory Rewcastle2, Ofer . Levi1, Joseph Kahn1; 1Stanford Univ., USA; 2Univ. of Toronto, Canada. We describe a method for improving the formation of a spot of light at the distal end of a flexibly perturbed multimode fiber by attaching a structured partial reflector to the distal end.

**ATu4J.6 • 18:45**
Intracellular Doppler Imaging Clinical Trials in Personalized Cancer Care, David D. Nolte1,2, Zhe Li1, Honggu Choi1, Michael Childress1, Shadia Jalal3, John Turek1,2; 1Purdue Univ., USA; 2Animated Dynamics Inc., USA; 3Indiana Univ. School of Medicine, USA. Clinical trials of biodynamic digital holography of cancer biopsies identify patients resistant to chemotherapy with 90% accuracy. Translation of this biomedical optical technology to the clinic may transform personalized cancer care.

**STu4K • Fiber Frequency Combs—Continued**

**STu4K.5 • 18:15**
Wavelength Tunable Narrow Linewidth Comb Using Soliton Self-frequency Shift and Spectral Compression Technique, Nozomu Ohta1, Lei Jin1, Yoichi Sakakibara1, Emiko Omoda1, Hiroichi Katsuura1, Norikiko Nishizawa2; 1Nagoya Univ., Japan; 2AIST, Japan. 1.6-1.9 μm wavelength tunable comb with spectral width of 4 nm was demonstrated using wavelength tunable soliton pulse and comb profile fiber. High SNR of 37 dB was confirmed for generated comb by beat measurement.

**STu4K.6 • 18:30**
10 W, sub-100 fs Fiber Amplifier Based on a Self-referenced 750-MHz Yb:fiber Laser Frequency Comb, Bo Xu1,2, Yuxuan Ma1,2, Hirotaka Ishii1, Fei Meng1, Isao Matsushima1,2, Zhigang Zhang1, Kaoru Minoshima1; 1The Univ. of Electro-Communications, Japan; 2ERATO Intelligent Optical Synthesizer (IOS) Project, Japan Science and Technology Agency, Japan; 3State Key Lab of Advanced Optical Communication System and Networks, Peking Univ., China. We developed a polarization maintained Yb:fiber amplifier based on the self-referenced 750-MHz Yb:fiber laser frequency comb. 10W average power and sub-100 fs pulse were achieved without deteriorating the high coherence of the comb.

19:00–20:30 OSA Technical Group Poster Session, Room 230A/B

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Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
real-time temperature and strain sensing in metal additive components by nickel electroplating to provide distributed mode optical fiber was protected and embedded into IN718. A standard telecom-grade single-order of magnitude better than AM channel or a normal interferometer. By converting the FM modulation of a self-mixing interferometer into an amplitude signal, we demonstrate a Self-Mixing Vibrometer has picometer sensitivity by exploiting the FM Channel, Silvano Donati1, Michele Norgia2; 1Università degli Studi di Pavia, Italy; 2DEIB, Politecnico di Milano, Italy. By converting the FM modulation of a self-mixing interferometer into an amplitude signal, we demonstrate a noise-equivalent-displacement (NED) of 1.5 pm\/\sqrt{Hz}, two order of magnitude better than AM channel or a normal interferometer.

Bright Electroluminescence from Back-Gated WSe2 P-N Junctions Using Pulsed Injection, Kevin Han1, Seth Fortuna1, Matin Amani1, Sujay Desai2, Der-Hsien Lin1, Geun Ho Ahn1, Eli Yablonovich1, Ali Javey1, Ming C. Wu1; 1Univ. of California Berkeley, USA. We demonstrate bright electroluminescence in WSe2 monolayers using pulsed injection, without the use of split gates, chemical doping, or heterostructures. Electroluminescence quantum efficiency approaches that of photoluminescence, indicating efficient exciton formation with injected carriers.

Compact Photo-Injector and Laser-Heater Drive Laser for the European X-ray Free Electron Laser Facility, Lutz Win kelmann1, Maik Frede2, Christian Mohr1, Hongwen Chu1, Chen Li3, Peng Li1, Uwe Grosse-Wortmann1, Frank Brinker1, Ingmar Hartl1, Bastian Schulz1, 2DESY, Germany; 3heoLAB GmbH, Germany; 1IMRA America, USA. We present a drive laser for the photo-injector of the European XFEL, which delivers up to 25 µJ, ~6 ps, 266 nm pulses at 4.5 MHz repetition frequency in more than 0.6 % rms energy stability.

Compact Photo-Injector and Laser-Heater Drive Laser for the European X-ray Free Electron Laser Facility, Lutz Win kelmann1, Maik Frede2, Christian Mohr1, Hongwen Chu1, Chen Li3, Peng Li1, Uwe Grosse-Wortmann1, Frank Brinker1, Ingmar Hartl1, Bastian Schulz1, 2DESY, Germany; 3heoLAB GmbH, Germany; 1IMRA America, USA. We present a drive laser for the photo-injector of the European XFEL, which delivers up to 25 µJ, ~6 ps, 266 nm pulses at 4.5 MHz repetition frequency in more than 0.6 % rms energy stability.
STu4P • Advanced Sensing Concepts—Continued

STu4P.6 • 18:15
High-speed Ultra-broadband Fourier-transform CARS Spanning over 3,000 cm⁻¹, Junko Omachi¹, Kazuki Hashimoto², Takuro Ideguchi²,², Inst. for Photon Science and Technology, The Univ. of Tokyo, Japan; ²Aeronautical Technology Directorate, Japan Aerospace Exploration Agency, Japan; ³Dept. of Physics, The Univ. of Tokyo, Japan; ⁴PRESTO, Japan Science and Technology Agency, Japan. We demonstrate ultra-broadband rapid-scan Fourier-transform coherent anti-Stokes Raman scattering spectroscopy spanning over 3,000 cm⁻¹ at a scan rate of 24,000 spectra/s with a 6-fs mode-locked laser.

STu4P.7 • 18:30
Real-time Detection of Scaling on Reverse Osmosis Membranes with Raman Spectroscopy, Omkar D. Suppekar¹, Joseph J. Brown¹, Alan R. Greenberg¹, Juliet Gopinath², Victor Bright¹; ¹Dept. of Mechanical Engineering, Univ. of Colorado Boulder, USA; ²Dept. of Electrical, Computer, and Energy Engineering, Univ. of Colorado Boulder, USA. We demonstrate real-time, local detection of the onset of scaling, in addition to chemical quantification, in a reverse osmosis separation system using confocal Raman microscopy. The results show consistent scalant detection.

STu4P.8 • 18:45
Single and double-quantum multidimensional coherent spectroscopy using frequency combs, Bachana Lomsadze¹, Steven T. Cundiff¹; ¹Univ. of Michigan, USA. We present a novel experimental approach of multidimensional coherent spectroscopy using frequency combs. We demonstrate its capabilities for probing weak many-body interactions as well as its applications for rapid and high resolution chemical sensing.

STu4Q • UV-visible Semiconductor Lasers—Continued

STu4Q.3 • 18:30
Direct Pulse Position Modulation of a 410 nm Semipolar GaN Laser Diode for Space Optical Communications, Joseph M. Fridlander¹, Changmin Lee¹, James Speck¹, Steven DenBaars¹, Jonathan Klamkin¹; ¹UCSB, USA. A semipolar GaN laser was characterized for space optical communications, achieving a peak power of 160 mW. Periodic and random M-ary pulse position modulation sequences with pulse widths of 5 ns and 10 ns were demonstrated.

STu4Q.4 • 18:45
High Power, High Efficiency Red Laser Diode Structures Grown on GaAs and GaAsP Metamorphic Superlattices, Steven Ruder²,¹, Tom Earles²,¹, Christian Galstad², Michael Klaus², Don Olson², Luke J. Mawst¹; ¹Univ. of Wisconsin - Madison, USA; ²Compound Photonics, USA. Red laser diodes were fabricated on GaAs and GaAsP metamorphic superlattice-substrates. The tensile strained QW on GaAs emitted 45% PCE, 638nm, TM-polarized light at 880mW CW. The compressively strained QW on the metamorphic structure emitted 639nm TE-polarized light with Tₐ=90K and Tₑ=300K.

19:00–20:30 OSA Technical Group Poster Session, Room 230A/B
We demonstrate a Gold based plasmonic stripes co-integrated with low loss JW2A.5 modulator based on a multilayer graphene-silicon waveguide. With a Femtosecond Laser, tuning effective fiber radius variation of SNAP structures JW2A.1. Demonstrating a novel polarization Beam Splitter with high Fabrication Tolerance, Nicolas M. Abadja Calvo1, Md Gulam Sabee2, Qiaoan Li3, Wei-Hua Guo4, David V. Plant5, John F. Donegan6, ‘Trinity College Dublin, Canada; ‘McGill Univ., Canada. A highly fabrication tolerant polarization beam splitter is presented. The fabrication tolerances are relaxed by adjusting two voltages. Experiments show on-chip losses of 3.5 dB and extinction ratio of 15 dB at C-band.

90 Gb/s PAM4 and OOK Optical Signal Generation by Using the Dual-arm-drive Silicon Mach-Zehnder Modulator, Sizhu Shao1,2, Jianfeng Ding1, Longchen Zheng1, Lei Zhang1, Xin Fu1, Lin Yang2. Inst. of Semiconductors, CAS, China; 2Univ. of Chinese Academy of Sciences, China. In this paper, the 90 Gb/s PAM4 and OOK optical signal generation by using a dual-arm-drive silicon Mach-Zehnder modulator is demonstrated. The OOK optical signal generation with speed up to 110 Gb/s is also demonstrated.

An On-Chip Integrated Dual-Functional Modulator-Detector for Optical Communication, SHUAI SUN1, Ruoyu An1, Hao Jia1,2, Ting Zhou1, Xin Fu1, Lin Yang2. Inst. of Semiconductors, CAS, China; 2Omega Optics, Inc., USA. We propose a novel integrated broadband hybrid photonic-plasmonic device termed MODetector featuring dual light modulation and detection. With 10 dB extinction ratio and 0.8 dB insertion loss for modulation and 0.7 W/A responsivity for detection.

Highly-efficient, ultra-broadband and polarization insensitive graphene-silicon based electro-absorption modulator, Xin Xu1,2, Feng Li1,2, Jinhu Yuan1,2, Zhe Kang1, Chao Mei1,2, Xianting Zhang1, P. K. A. Wai1,2. Dept. of Electrical Engineering, The Hong Kong Polytechnic Univ., China; 2Hong Kong Polytechnic Univ. Shenzhen Research Inst., China. We propose a highly-efficient, ultra-broadband and polarization-insensitive electro-absorption modulator based on a multilayer graphene-silicon waveguide. A modulation efficiency of ~2.21 dB/um is obtained for both polarizations within a bandwidth covering from E to U bands.

Gold based plasmonic stripes co-integrated with low loss SiN platform in aqueous environment, Athanasios Manolis1,2, George Dabos1, Dimitra Kitakaki1, Evangelia Chatziannagnostou2, Dimitris Tsikos2,3, Laurent Markey2, Jean Claude Weeber1, Alain Dereux1, Anna-Lena Giesecke1, Caroline Panchatzi1, Bartosz Chmielak1, Nikos Pleros1,2, Aristotle Univ. of Thessaloniki, Greece; 2Center for Interdisciplinary Research and Innovation, Greece; 3Laboratoire Interdisciplinaire Carnot de Bourgogne, France; ‘AMO GmbH, Advanced Microelectronics Center Aachen (AMICA), Germany. We demonstrate a butt-coupled interface between LPCVD SiN and gold based plasmonic waveguides in aqueous environment, exhibiting 2.3 dB coupling loss and 75um propagation length at 1550nm, towards future employment in bioimaging applications.

Novel Polarization Beam Splitter with High Fabrication Tolerance, Nicolas M. Abadja Calvo1, Md Gulam Sabee2, Qiaoan Li3, Wei-Hua Guo4, David V. Plant5, John F. Donegan6, ‘Trinity College Dublin, Canada; ‘McGill Univ., Canada. A highly fabrication tolerant polarization beam splitter is presented. The fabrication tolerances are relaxed by adjusting two voltages. Experiments show on-chip losses of 3.5 dB and extinction ratio of 15 dB at C-band.

Application of High-reflectivity Non-periodic Sub-wavelength Gratings with Small-angle Beam-steering Ability in Fabry-Perot Cavity, Shua Zhang1, Xiaofeng Duan1, Gongseng Li1, Kai Liu1, Yongqing Huang1, Xiaomin Ren1, ‘Beijing Univ. of Posts and Telecommunications, China. An axisymmetric high-reflectivity non-periodic sub-wavelength gratings (SWGs) with small-angle beam-steering ability for reflected light is presented, and it brings a new characteristic of flexibly controlling the width of oscillation optical field for the improved Fabry-Perot (F-P) cavity.

Ultra-broadband 3dB power splitter based on silicon slot waveguide, Yuguang Zhang1,2, State Key Lab of Optical Communication Technologies and Networks, Wuhan Research Inst. of Posts and Telecommunications, China; ‘National Information Optoelectronics Innovation Center, China. We present the design of the ultra-broadband 3db splitter based on silicon slot waveguide. The bandwidth of the proposed splitter is simulated as large as 600 nm, with the insertion loss less than 1.1dB.

Design of an Ultra-Small Footprint Graphene-based Silicon Photonic Bandgap Modulator, Giannino Dziallas1,2, Lars Zimmermann1, Claus Petermann2,3, IHP GmbH, Germany; 2Inst. of High-Frequency and Semiconductor System Technologies, Technical Univ. of Berlin, Germany. We propose a novel design of an ultra-small footprint silicon photonic device. The device length is 6 μm and with 1 Vc, the modulator should attain 15 dB extinction due to the photonic bandgap microcavity.

Ultrafast shifted-core coaxial nano-emitter with tunable Q factor, Xi Li1, Qiu Gu1, ‘Univ. of Texas at Dallas, USA. We numerically demonstrate a III-V single mode shifted-core coaxial nano-emitter featuring a Purcell factor larger than 600 and tunable Q factor.

Silicon-Based Nanophotonic Topological Insulators, Kasper E. Lund1,2, Ching M. Patil1, Saren Stobbe1,2, ‘The Niels Bohr Inst., Univ of Copenhagen, Denmark; ‘Faculty of Technical Univ. of Denmark, Denmark. We present the design and fabrication of nanophotonic topological insulators based on photonic crystals. Our work extends recent a proposal silicon photonics in the telecom c-band while taking realistic fabrication parameters into account.

Demonstration of microring-based WDM-compatible mode-division multiplexing on a silicon chip, Shuang Zheng1, Xiaoping Cao1, Jian Wang1, ‘Wuhan National Lab for Optoelect., China. Based on silicon chip, we design and fabricate a mode-division (de)multiplexer in conjunction with wavelength-division multiplexing (WDM) by using three single-mode microring resonators. The on-chip device exhibits low mode crosstalk around the wavelength of 1540 nm.

Ultra-compact on-chip mode exchange device using inverse-designed silicon metasurface, Hao Jiao1,2, Ting Zhou3,4, Xin Fu5, Lin Yang5,6, Inst. Semiconductors, CAS, China; ‘College of Materials Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China. We propose and demonstrate an ultra-compact mode exchange device with high efficiency. It is 4×1.6 μm in size and can realize mode exchange between TE and TM, Characterization shows its optical bandwidth covers C-band.

Extending Modulation Bandwidth of SOI thermo-optic Phase Shifters Through Digital Pre-Emphasis, Sungwon Chung1, Hossein Hashemi1, ‘Univ. of Southern California, USA. We demonstrate a digital pre-emphasis technique for extending the modulation bandwidth of a thermo-optic phase shifter in silicon-on-insulator (SOI) CMOS. The electrical input power to the phase shifter is pre-emphasized, increasing 3-dB optical modulation bandwidth 6.3 times from 8.1 kHz to 50.7 kHz.

Encapsulated Silicon Nitride Nanobeam Cavity for Nanophotonics using Layered Materials, Taylor K. Fryett1, Yueyang Chen1, James Whitehead1, Zane Peycke1, Xiaodong Xu1, Arka Majumdar1, ‘Univ. of Washington, USA. The fragile nature of floating membrane resonators poses a serious problem for constructing a hybrid photonics platform. To overcome this challenge, we design and demonstrate encapsulated silicon nitride nanobeams and demonstrate coupling to layered materials.

Magnetude and Sign Control of Index-AntiCoupled Coupling, Zhe Gao1,2, Dominic Sinari1,2, Kent D. Choquette1, ‘Univ of Illinois at Urbana-Champaign, USA; ‘Cisio Systems, USA. We show the first theoretical analysis of the coupling coefficient in passive index-anti-coupled coupling. Both magnitude and sign of the coupling coefficient are controlled by the inter-element distance and index, enabling novel photonic applications.
JW2A.20
Subwavelength grating waveguide based cladding-modulated Bragg reflector in bulk CMOS, Cheng-Tse Tang, Tze-Hung Chen, Tzu-Hsien Yen, Yung-Jr Hung, National Sun Yat-sen Univ, Taiwan.
A SWG-based cladding-modulated Bragg reflector implemented in bulk CMOS enables a lower propagation loss (< 30 dB/cm), a higher extinction ratio (24.5 dB) and an anti-sensitivity temperature coefficient (29.4 pm/°C) as compared to strip-based counterpart.

JW2A.21
Nanoscale Fingerprinting with Hyperbolic Metamaterials, Zhenghong Huang, Evgeni E. Nariamanov, Theodore B. Norris;
1Electrical Engineering and Computer Science, Univ. of Michigan, USA.
We demonstrate an all-optical power equalizer based on a dual-polarization micro-ring resonator. By controlling the light polarization, a large loss tunable range from –29.3 dB to 15.3 dB is demonstrated. A mathematical analysis for the modulation function while removing zero-dc effective index change.

JW2A.22
Integrated Optical Power Equalizer Based on a Dual-Polarization Micro-Ring Resonator, Xiangyu Xu, Jiayang Li, Juei-Hung Tsai, Bo-Zhi Huang, Juei-Hung Shy, Central Univ., Taiwan;
We have demonstrated electrically-injected-waveguide-coupled LEDs based on W-centers in silicon for neuromorphic computing. We analyze the sources of loss in these LEDs and simulate new design strategies for improved performance with devices several orders of magnitude higher efficiency.

JW2A.23
A dual-drive DAC-less silicon PAM-4 optical modulator for 100 Gb/s data transmission at C-band, Lingzheng Zhang, Jianfeng Ding, Xin Fuy, Lin Yang;
1Institute of semiconductor, CAS, China;
2Univ. of Chinese Academy of Sciences, China. A DAC-less silicon PAM-4 optical modulator which is driven by two binary electrical signals is demonstrated. A mathematical analysis for the modulation chirp is established. The device can work at 100 Gb/s.

JW2A.24
High Fidelity MMI Excitation Patterns for Optofluorophic Multiplexing, Matthew Stott, Tahid Ganjalizadeh, Maclan Olsen, Marcos Orfia, Johny McMurray, Erik Hamilton, Holger Schmidt, Aaron Hawkins, Brigham Young Univ., USA;
2Univ. of California, Santa Cruz, USA. High fidelity interference patterns from multimode interference waveguides are needed for multiplexed optofluorophic biosensors. Spatial pattern fidelity can be optimized by careful design of the single-mode waveguides used to excite the multimode waveguides.

JW2A.25
Experimental Demonstration of Low Temperature Sensitivity in Silicon Interleavers, Jiangchao Jiang, Jingxiong Xia, Wuhan National Lab for Optoelectronics, China.
We experimentally demonstrate a low-temperature sensitivity SiN interleaver. The FSR is 1.65 nm. The 1-dB bandwidth is 0.62 nm. The crosstalk is less than -15 dB from 1522 nm to 1549 nm.

JW2A.26
Optimization techniques for side-lobes suppression in silicon photonics waveguide gratings, Chia-Ju Yu, Tzu-Hsien Yen, You-Cheng Li, Bing-Hao Shih, Yung-Jr Hung;
1National Sun Yat-sen Univ, Taiwan. We demonstrate c-band and o-band silicon waveguide gratings with a side-lobe suppression ratio of 36.6 and 27.1 dB, respectively, by modulating the corrugation width or grating offset with apodization function while remaining zero-dc effective index change.

JW2A.27
Silicon Nitride Integrated All-Optical Switch Assisted by Graphene Monomers, Cawan Xu, Yuxing Yao, Chi Yu, Yang Wang, Kan Wu, Jianping Chen, 1Shanghai Jiao Tong Univ, China; 2Shanghai Jiao Tong Univ, China. An all-optical switch near 1550nm is realized on a graphene-on-silicon nitride (Si3N4) integrated platform with thermooptic effect. A fast switching time of 253ns is obtained due to the high thermal conductivity of graphene.

JW2A.28
Experimental demonstration of a polarization diversity broadband orbital angular momentum modes emitter, Zou Nan, Shuang Zheng, Xiaoping Cao, Shengqian Gao, Shimao Li, Mingbo He, Xinlun Cai, Jian Wang;
1Wuhan National Lab for Optoelect; 2State Key Lab of Optoelectronic Materials and Technologies and School of Physics and Engineering, Sun Yat-sen Univ., China. We simulate, fabricate and demonstrate the silicon-based polarization multiplexing broadband orbital angular momentum (OAM) generator. The generated x-polar OAM, x-polar OAM, y-polar OAM, and y-polar OAM, show maximum purity of 0.91, 0.89, 0.92 and 0.92.

JW2A.29
Light Sources for Neuromorphic Computing, Simon M. Buckley, Jeffrey Clites, Adam McCaughey, Richard Minn, Sae Woo Nam, Jeffrey Shainline, 1NIST, USA. We have demonstrated electrically-injected-waveguide-coupled LEDs based on W centers in silicon for neuromorphic computing. We analyze the sources of loss in these LEDs and simulate new design strategies for improved performance with devices several orders of magnitude higher efficiency.

JW2A.30
1550 nm AlGaNAs MQWs 10-channel Laser Array for Optical Interconnects, Mingjun Wang, Hailing Wang, Ranhe Meng, Aiqi Ji, Hansha Zhang;
1CAS Inst. of Semiconductor, China. A 10-channel laser array with 3-nm wavelength spacing is presented. The output power of 20 mW, SMSR of than 30 dB, and efficient slope of 0.224 mW/mA for each laser within the array are achieved.

JW2A.31
All-Optical Intensity Modulation in Polymer Waveguides Doped with Si Quantum Dots, Aleksandrs Marinins, Alexeps Udalcovs, Oskars Ozols, Xaosdan Pang, Jonathan G. Vernet, Gunnar Jacobsen, Ilya Syugyev, Jan Linros, Sergij Popavi;
1KTH, Sweden; 2RISE Acreo AB, Sweden; 3Univ. of Albert of Canada. We demonstrate all-optical intensity modulation in integrated PMMA optical waveguides doped with silicon quantum dots. The 1350 nm probe signal is absorbed by free carriers excited in silicon quantum dots with 405 nm pump light.

JW2A.32
Compact Optomechanical Phase Shifter for Viable Light Integrated Photonics, Bruno Fregyesi, Rita Van Hoof, Pieter Neuteun, Bert Du Bois, Guilherme Brondani Torri, Simone Seven, Xavier Rottenberg, 1imec, Belgium. This paper reports on the development of a CMOS compatible capacitive actuated optomechanical phase shifter for visible light, demonstrated on a 200 mm PEOVD Si photonic platform. The phase shifting was demonstrated using Mach-Zehnder interferometers.

JW2A.33
Wideline Kerb-comb near visible spectrum in coupling-engineered thin Silicon nitride resonators, Ali Esghaghian Dordogne, Ali Angahr Eftekhaari, Ali Adbali:
1Georgia Inst. of Technology, USA. We present widespread Kerb-comb generation from 650 nm to 1200 nm in a thin silicon-nitride (SiN) platform enabled by enhanced power transfer through the dispersive wave using a dispersion-engineered over-etched SiN waveguide and a coupled-resonator structure.

JW2A.34
1KTH, Sweden; 2RISE Acreo AB, Sweden;
3Univ. of California, Santa Cruz, USA.
We demonstrate all-optical in -phase tunable silicon photonics waveguide gratings, Apodization techniques for side-lobes suppression in silicon photonics waveguide gratings, Chia-Ju Yu, Tzu-Hsien Yen, You-Cheng Li, Bing-Hao Shih, Yung-Jr Hung;
1National Sun Yat-sen Univ, Taiwan. We demonstrate c-band and o-band silicon waveguide gratings with a side-lobe suppression ratio of 36.6 and 27.1 dB, respectively, by modulating the corrugation width or grating offset with apodization function while remaining zero-dc effective index change.

JW2A.35
Thermal tuning of Brillouin resonance in free standing silicon nanowire, Paul Tietbo, Raphael Van Laer;
1Dept. of Ultra-Phase, 2Department of Nanophotonics, University of Leuven, Belgium; 3Center for Nano and Biophotonics (NB-Photonics), Ghent Univ., Belgium;
4Girzon Lab, Dept. of Applied Physics, Stanford Univ., USA. We have demonstrate the thermal tuning of the Brillouin resonance in silicon nanowire waveguides using cross phase modulation detection. We also investigate possible use of this effect for locally mapping the width of an extended waveguide.

JW2A.36
Microring Resonator Based Compact On-Phase Tuner, Hweesob Lee, Thomas M. Kananian, Koraygo Bose, Raymond Beausoleil, Tingyu Gu, 1Univ. of Delaware, USA;
2Hewlett-Packard Labs, USA. We study the mode-splitting microring resonators for compact and efficient phase tuners. Through optimization of inter-modal and ring-waveguide coupling, we fabricated a 72.535 ps group delay and 1.428 rad phase shift with 5.83 dB loss are achieved.

JW2A.37
Near-field flat focusing mirrors using a metallic subwavelength grating on top of a plasmonic waveguide, Yu-Chieh Cheng, Bo-Zhi Huang, Juei-Hung Tsai, Yu-Ching Chuang;
1Dept. of Electro-Optical Engineering, National Taipei Univ. of Technology, Taiwan. Flat focusing mirrors without any optical axis have been studied by metallic subwavelength gratings on top of a plasmonic waveguide. The principle is based on an anomalous lateral displacement, leading to a near-field focusing.

JW2A.38
Line-width-adjustable bandpass filter based on silicon cladding-modulated waveguide moire Bragg gratings, Tzu-Hsiao Yen, Bing-Hao Shih, Nai-Wen Cheng, Yung-Jr Hung;
1National Sun Yat-sen Univ, Taiwan. We demonstrate line-width-adjustable (0.1 nm) narrow bandpass filters using silicon cladding-modulated waveguide moire Bragg gratings. The passband linewidth is controlled by the number of crossovers and the corrugation width of the moire grating.
Central Florida, CREOL, USA; 2Tianjin Univ., China; 3College
Integrated Power Splitters for Mode-Multiplexed Signals, fading and phase distortion are simultaneously eliminated with for the all-pass RoF link is demonstrated. CD-induced power over Fiber Link with Simultaneous Dispersion Induced A Dispersion-Compensated Transmitter for All-Pass Radio

Swapnajit Chakravarty1, 

Zheng 1, Bingkun Zhou 1; 

Optical single-sideband (SSB) OFDM signal is Laval, Canada. 

We demonstrate that by arranging the array ele-
ments show a 6.9 dB reduction for 64-elements. 

JW2A.51 Microwave Waveform Generation via Discrete Fourier Transform of Modulated Optical Pulse Train, Qijie Xie1, 

Chesier Shu1; 

Chinese Univ. of Hong Kong, Hong Kong. A new scheme of microwave waveform generation is experi-
mentally demonstrated utilizing envelope detection of opti-
cal waveform generated from discrete Fourier transform of modulated optical pulse trains. Programmable triangular and rectangular microwave waveforms are synthesized. 

JW2A.52 High-Power Integrated Indium Phosphide Transmitter for Wband Optical Communications, Hongwen Zhao1, Sergio Pinna2, 

Bowen Song1, Ludovico Megalini1, Simone Brunelli1, 

Larry Coldren1, 

Jason Midkiff1, 

Shih-Yuan Yang1, Sung-Lin Yang1, Tsai-Yi Chien1, Kuang-Hsu Xiao1, 

Yu Zhang1, J. S. Ben Yoo1; 

University of California, Davis, USA. We propose two photodiodes integrated on a semiconductor optical amplifier (SOA) for on-chip measurement of the gain. Coupled waveguides drive fraction of light into photodiodes for gain calculation from photocurrents ratio. The method can easily be implemented in SOA inside photonic integrated circuits. 

JW2A.56 Optical frequency comb generation and microwave synthesis with integrated cascaded silicon modulators, Si-Qi Liu1, 

Kan Wu1, Linjie Zhou1, Xu Xiao1, Yiming Zhong1, 

Jiapeng Chen1; 

Shanghai Jiao Tong Univ, China. An optical frequency comb with 15 lines, 5 GHz spacing and 6 dB flatness is gener-
ated with cascaded silicon electro-absorption modulator and phase modulator. We also demonstrate microwave synthesis using the generated frequency comb. 

JW2A.57 Monolithic 1310nm 1Gb/s Optical Receiver with Schottky Photodiode in a standard 40nm bulk CMOS, Wouter Driels1, Michel Steyaert1, Filip Tavernier1; 

Katholieke Universiteit Leuven, Belgium. We present an optical receiver with integrated Schottky photodiode in a standard 40nm bulk CMOS process, suitable for 1310nm communication. The low-noise analog front-end enables receiving 1Gb/s data rates at 3.3dBm sensitivity. 

JW2A.58 Side-lobe Level Reduction in Two-dimensional Optical Phased Array Antennas, Julian L. Pita1, Ivan A. Aldaya2; 

Octavio Santana1, Luis Arauto2, Paulo C. Dainese1, Lucas Gabrielli1; 

DECOM - FEEC, UNICAMP, Brazil; DEQ - IFGW, UNICAMP, Brazil; ‘São João da Boa Vista, UNESP, Brazil. We experimentally demonstrate that by arranging the array ele-
ments according to Fermat’s spiral, the side lobe level of an 8-element SOI-array is reduced by 0.9 dB. Additional experi-
ments show a 6.9 dB reduction for 64-elements. 

JW2A.59 Broadband efficient coupled-cavity electro-optic modula-
tors based on Q engineering for RF photonic applications, Hayk Gevorgyan1, Anatol Khiz1, Milos Popovic1; 

Bostom Univ., USA. We propose a coupled-cavity electro-optic modulator, with tailored supermode Q-factors, for efficient RF-to-optical upconversion of broadband signals. It promises 20-30dB im-
provement over single-ring modulators and 10-20dB over the state-of-the-art for broadband modulation in high-Q cavities. 

JW2A.60 Fully-Automated Grating Coupler Design Through Adjoint Optimization, Logan Xu1, Rahul Trivedi1, Neil V. Sapra1, Alexander Y. Piggott1, Dries Ver Cuypers1, Jelena Vuckovic1; 

Stanford, USA; Physics, KU Leuven, Belgium. By leveraging adjoint optimization, we develop an efficient algorithm for designing 1D grating couplers for different functionalities without any human input and use it to design a fiber-to-chip blazed grating with under 0.18 dB loss.
A Digital Converter Based on an Optoelectronic Oscillator, J. W. 2A. 67
is proposed and experimentally demonstrated to have - 23 multimode bent waveguide with a bending radius of 20 µm
An efficient approach to measure waveguide loss of 21.5GHz single-tone.
to-digital converter based on an optoelectronic oscillator is
China.
engineered lithium niobate microring resonators with optical
JW2A.64
modulation was realized. 2×10 Gbps two modes generation and
demonstrated. A mono-
back waveguide have been first proposed and theoretically
free-spectral-range RF-optic modulators using ring and feed-
demonstrations. This solution improves the power per line while
superchannels. This solution improves the power per line while
enhancement and plasmonic enhanced absorption harnessed
We demonstrate 1.4 times increased THz yield from
high-resistivity silicon substrates by ultrashort pulsed-laser
ablation. We demonstrate 1.4 times increased THz yield from

A 90°
local oscillation which can be used for channelization.
shifted feedback laser and I/Q demodulation. The mixing of
present a microwave channelizer implemented by frequency
The demonstrated WGM has an ultra high quality factor of
High-field Terahertz Pulses Generated in an HMQ-TMS

Alemohammad1, Bryan Bosworth 1, A. B. Cooper 1, Mark A.
Licheng Xiao1, Xianglong Miao 1, Geng Li 1, Peter Q. Liu; 1
Electrical Engineering, Univ. at Buffalo, The State Univ. of New York, USA. A periodic graphene anti-dot array integrated with self-aligned gold disks for enhancing interactions between terahertz graphene surface plasmons and incident light is demonstrated. Experimental results show enhancement of the resonant transmission modulation by - 3 times.

Efficient Design of Diffractive THz Lenses for Aberration Rectified Focusing via Modified Binary Search Algorithm, Sourangsu Banerjee1, Ashish Chanana1, Hugo Condori1, Ayaj Nahata1, Berardi Sensale-Rodriguez1; 1Univ. of Utah, USA. We experimentally demonstrate thin, error tolerant, and aberration corrected 3D printed diffractive 1D and 2D THz lenses for focusing THz beams with NA × 0.25 and an average efficiency greater than 75% for all cases. Our work has relevance to THz lens design, and in general, THz imaging systems.

Ultrafast Pulsed-Laser Fabrication of Silicon Moth-Eye Structures for Terahertz Anti-Reflection, Haruyuki Saku-
rai1, Natsuki Nemoto1, Kuniki Koshii1, Yuki Sakurai1, Nobu Katayama1, Tomotake Matsumura1, Junji Yumoto1, Makoto Kuwata-Gonokami1; 1The Univ. of Tokyo, Japan. We fabricate moth-eye anti-reflection structures for the terahertz region on high-resitivity silicon substrates by ultrafast pulsed-laser ablation and demonstrate a gap-bandgap spectrum from Mg:LN by using the moth-eye structure as an output coupler

Efficient Design of Diffractive THz Lenses for Aberration Rectified Focusing via Modified Binary Search Algorithm, Sourangsu Banerjee1, Ashish Chanana1, Hugo Condori1, Ayaj Nahata1, Berardi Sensale-Rodriguez1; 1Univ. of Utah, USA. We experimentally demonstrate thin, error tolerant, and aberration corrected 3D printed diffractive 1D and 2D THz lenses for focusing THz beams with NA × 0.25 and an average efficiency greater than 75% for all cases. Our work has relevance to THz lens design, and in general, THz imaging systems.

Terahertz Wave Detection of Continuous-Wave THz Radiations without Using Low-temperature-grown Gallium Arsenide, Yujie Huang1, Jinhai Zhao1, Junfeng Wang1, Weihua Wang1, Kaicheng Li1, Yiming He1, Malin Zou1, Mingde Guan1, Yubin Lu1; 1National Univ. of Defense Technology, China. We report highly efficient stimulated polarization scattering near 4 THz with a parametric gain overtaking the well-known one near 1.8-THz in lithium niobate by using an off-axis parametric oscillator resonating the THz wave.

Discovery of Phase-matched Stimulated Polariton Scattering near 4 THz in Lithium Niobate, Yen-Chieh Huang1, Yu Chung Chiu1, Tsong Dong Wang2, Gang Zhao2; 1National Tsing Hua Univ., Taiwan; 2Inst. of Heavy Ion Phys, China, and 3Chung-Shan Inst. of Science and Technology, Taiwan. We report highly efficient stimulated polarization scattering near 4 THz with a parametric gain overtaking the well-known one near 1.8-THz in lithium niobate by using an off-axis parametric oscillator resonating the THz wave.

Nano-electrode photomixer free from low-temperature-grown semiconductors for THz detection, Akihito Yamada1,2, Kuniaki Konishi1, Junji Yumoto1, Makoto Kuwata-Gonokami1; 1The Univ. of Tokyo, Japan; 2RIKEN Center for Advanced Photonics, RIKEN, Japan. We demonstrate a method for converting broadband intense terahertz Gaussian beams into Hermite-Gaussian 01 beams, based on a specially designed prism. The generated longitudinal electric fields by focusing them were observed to be 36 kV/cm.

Generation of Intense Terahertz Pulses with Longitudinal Electric fields, Mizuho Mataba1, Natsuki Nemoto1, Natsuki Kanda1,2, Kuniki Koshii1, Junji Yumoto1, Makoto Kuwata-Gonokami1; 1The Univ. of Tokyo, Japan; 2RIKEN Center for Advanced Photonics, RIKEN, Japan. We demonstrate a method for converting broadband intense terahertz Gaussian beams into Hermite-Gaussian 01 beams, based on a specially designed prism. The generated longitudinal electric fields by focusing them were observed to be 36 kV/cm.

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High-field Terahertz Pulses Generated in an HMO-TMS Organic Crystal Pumped by an Amplified Ytterbium Laser, Andrea Rovere1, Young-Gyun Jeong1, Riccardo Piccoli1, Seung-Heon Lee1, Seung-Chul Lee2, O-Pil Kwon1, Mojca Jazbinsek1, Roberto Morandotti1, Luca Razzari1; 1INR-RENE Matériaux et Telecom, Canada; 2Ajou Univ., South Korea; 3Zurich Univ. of Applied Science, Switzerland; 4National Research Univ. of Information Technologies, Russia. High-field electric-field THz pulses (>200 V/cm) can be efficiently generated in a recently developed organic crystal pumped by a femtosecond ytterbium laser in a collinear configuration.

Pattern enhancement of high speed data modulation through saturating SOA-integrated EAM, Yi-Jen Chu1, Rih-Yu Chen1; 1National Sun Yat-Sen Univ., Taiwan. An optical modulation scheme by saturating SOA-integrated EAM is used for enhancing high-speed optical waveform. The saturation conditions on devices will have complemental carrier dynamics, thus leading to significant improvement of extinction ratio and also signal-to-noise ratio.

Phase-matched Stimulated Polariton Scattering near 4 THz in Lithium Niobate, Yen-Chieh Huang1, Yu Chung Chiu1, Tsong Dong Wang2, Gang Zhao2; 1National Tsing Hua Univ., Taiwan; 2Inst. of Heavy Ion Phys, China, and 3Chung-Shan Inst. of Science and Technology, Taiwan. We report highly efficient stimulated polarization scattering near 4 THz with a parametric gain overtaking the well-known one near 1.8-THz in lithium niobate by using an off-axis parametric oscillator resonating the THz wave.

Efficient Design of Diffractive THz Lenses for Aberration Rectified Focusing via Modified Binary Search Algorithm, Sourangsu Banerjee1, Ashish Chanana1, Hugo Condori1, Ayaj Nahata1, Berardi Sensale-Rodriguez1; 1Univ. of Utah, USA. We experimentally demonstrate thin, error tolerant, and aberration corrected 3D printed diffractive 1D and 2D THz lenses for focusing THz beams with NA × 0.25 and an average efficiency greater than 75% for all cases. Our work has relevance to THz lens design, and in general, THz imaging systems.

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Lossless Edge States Protected by PT-Symmetric Phase, Xiang Ni1,2, Daria Smirnova3, Alexander N. Poddubny4, Daniel Leykam5, Yidong Chang6, Alexander Krankevich7,  1Graduate Center of CUNY, USA; 2City College of New York, USA; 3Australian National Univ., Australia; 4ITMO Univ., Russia; 5Nanyang Technological Univ., Singapore. Parity-time (PT) symmetric interfaces between amplifying and lossy crystals support dissipationless edge states exhibiting gapless spectra in complex band structure if exceptional points (EPs) of edge states exist, which is verified by rigorous full-wave simulations in PT-symmetric photonic graphene.

Plasmonic Tuning of Effective Phase Transition Temperature and Electrical Conductivity, James Frame1, Wanaka Kubo3, Xu Fang2,  1Dept. of Electronics and Computer Science, Univ. of Southampton, UK; 2Dept. of Electrical and Electronic Engineering, Tokyo Univ. of Agriculture and Technology, Japan; 3Materials Lab, RIKEN, Japan. Thermo-plasmonic engineering at the nanoscale can control material properties at the macroscopic scale. We demonstrate utilising plasmonic resonance to tune the effective phase transition temperature and electrical conductivity of vanadium oxide thin films.

Engineering Optical Emission of Sub-diffraction Hyperbolic Metamaterial Resonators, Kaum Chen1,2, Kaisheng Chen1,2, Fadhel A. Nimer1,2, Xiaoxin Guan1,2,  1Univ. of California, USA; 2Purdue Univ., USA. We demonstrate tunable hyperbolic metamaterial resonances based on KTiOPO4 nanodisks, and demonstrate the achievement of near-field electromagnetic fields substantially larger than the geometrical size of the disks. We also present a method to control the local field strength at the resonance peak by tuning the incident polarization and emission patterns can be controlled by the local field strength.

The Barometric Response of a Novel Pressure Sensor, Lihong Wang1,2,3,4,5, Jun Wang1,2,3,4,5,  1University of Illinois, Urbana-Champaign, USA; 2Portland State Univ., USA; 3Oregon State Univ., USA; 4University of Arkansas, USA; 5Harvard, USA. We developed a barometric pressure sensor based on a novel technique using 2D graphene nanosheets. We demonstrated enhancement in the resonant frequency of graphene due to change in the pressure. We also demonstrated the successful integration on the silicon chip.

Microcavity Resonators for Linearly Polarized Light, James Frame1, Weilliang Fan2,  1Univ. of California, USA; 2Tohoku Univ., Japan. We developed a graphene microcavity resonator to achieve linearly polarized light. This is achieved by using the plasmon resonance of graphene in a periodic array. The fabricated device showed a peak transmission of 56% at 38μm wavelength with a FWHM of 0.24μm.
JW2A.125 Radiative and Nonradiative Recombination Coefficients of InAs/InAlAs Core-shell Nanowires, Xinrun Li1, Xiaoning Zhang2, Fatima Toor1, John Prime1, Julian Treu2, Lukas Stampfer1, Gregor Koblümmer,2 Physics and Astronomy, Univ. of Iowa, USA; 2Electrical and Computer Engineering, Univ. of Iowa, USA; 3Physik Dept., Walter Schottky Institute of Technische Universität München, Germany. Ultrafast and external quantum efficiency measurements were performed on InAs/InAlAs core-shell nanowires. Rates of different recombination mechanisms were determined, and the carrier densities ranges at which each dominates, an important consideration for design of devices.

JW2A.126 Plasmon-Induced Hot Electron Transfer in Ag-CsPbBr3 Hybrid Nanocrystals, Xinyu Huang1, Hongbo Lu2, Chunfeng Zhang1, Zhenhui Lu3, Min Xiao1,1 National Lab of Solid State Microstructures, School of Physics, and Collaborative Innovation Center of Advanced Microstructures, Nanjing Univ., China; 2National Lab of Solid State Microstructures, College of Engineering and Applied Sciences, Collaborative Innovation Center of Advanced Microstructures and Research Center for Environmental Nanotechnology (RECENT), Nanjing Univ., China; 3Dept. of Physics, Univ. of Arkansas, USA. We demonstrate hot electron transfer in Ag-CsPbBr3 hybrid nanocrystals. Using transient absorption spectroscopy, we have observed the highly efficient transfer of hot electrons from metal Ag to semiconductor CsPbBr3, in a timescale of sub-100 fs.

JW2A.127 Ultrafast Optical Response Due to Nonlocal Interaction between Light and Excitons in ZnO Thin Films, Masayoshi Ichimiyama1, Takuya Matsuda2, Takanori Kinoshi3, Takuya Takahashi4, Masami Nakayama5, Hayme Ishii6,7, Masashi Aoshida8, Osaka Univ., Japan; 3Osaka Prefecture Univ., Japan; 7The Univ. of Shiga Prefecture, Japan; 8Osaka City Univ., Japan. Ultrafast optical response in ZnO thin films has been investigated by the transient grating method. Sub-ps coherence radiative conversion caused by radiation-induced interferences between two multiple-type excitons was observed between nano- and micro-scale.

JW2A.128 Transparent Anisotropic Anisotropy in Normal State of Overdoped NaFe1–xCoxAs Superconductors, Shenghua Liu1, Chunfeng Zhang1, Xiaoying Wang1, Min Xiao1, Nanjing Univ., China. We observe anisotropic electronic response in the tetragonal phase of NaFe1–xCo xAs superconductors by using polarization-dependent pump-probe spectroscopy, which can be scribbled as a result of nematic fluctuation driven by an orbital order.

JW2A.129 Carrier Relaxation Dynamics of InGaN/GaN Dot-in-Nanowires, Heath George1, Yang-Ho Ro2, Zelian Mi1, Theodore B. Norris1, EECs, Univ. of Michigan, USA; 2Electrical and Computer Engineering, McGill Univ., Canada. Carrier relaxation was investigated for InGaN/GaN dot-in-nanowires using femtosecond pump-probe spectroscopy, which can be scribbled as a result of nematic fluctuation driven by an orbital order.

JW2A.130 Ultrashort molecular dynamics and flame temperature measurements by hybrid fs/pS CARS spectroscopy, Xia Yuanqin1, Zhibin Zhang1, Sheng Zhang1, Yang Zhao1, Guozhong Hou1, Harbin Inst. of Technol., China. We research the molecular dynamics by hybrid femtosecond/pico-second coherent anti-Stokes Raman scattering (fs/pS CARS), and utilize the single-laser-shot CHP (chirped Probe Pulse) fs CARS signals of N2 to get the temperature information.

JW2A.131 Terahertz Carrier Dynamics in Epitaxial Layered c-InSe, Wei Li1, Zhimin Yang2, Jianhua Hao1, Dong Sun1, International Centre for Quantum Materials, School of Physics, Peking Univ., China; 2Dept. of Applied Physics, The Hong Kong Polytechnic Univ., Hung Hong, China; 3The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China; 4Collaborative Innovation Center of Quantum Matter, China. Relaxation of optically excited quasiparticles in c-InSe is studied by employing ultrafast optical-pump THz-probe spectroscopy. The excited quasiparticles enhance the THz absorption and relax by three processes which occur in few to hundreds of picoseconds.

JW2A.132 Natural Lineshapes by Projecting Multidimensional Spectra, Geoffrey M. Diederich1, Mark E. Siemens1, 2The Univ. of Denver, USA. We take one-dimensional data along arbitrary directions in the t-w plane of a multidimensional coherent spectroscopy experiment to obtain projections in the t-w plane, allowing faster data collection and insight into the meaning of lineshapes.

JW2A.133 Dynamic Terahertz Response in the Dirac Semimetal C3As4, Induced by Ultrafast Optical Excitation, Wei Lu1, Jiwei Li1, Faxian Xiu2, Dong Sun1, 2International Centre for Quantum Materials, School of Physics, Peking Univ., China; 3State Key Lab of Surface Physics and Dept. of Physics, Fudan Univ., China; 4Collaborative Innovation Center of Quantum Matter, China. Hot electron relaxation and coupling in c3As4, is studied by employing ultrafast time-domain THz spectroscopy. The excited carriers enhance the absorption of THz and relax in ps-timescale, the cooling rules consistent with mid-IR spectroscopy.

JW2A.134 Ultrafast Time-Resolved Photocurrent Measurement of Carrier Escape Dynamics in Anisotropic ReS2, Hyemin Bae1, Sangwan Sim2, Taeyoung Kim1, Doeon Lee1, Dong-Hwi Kim1,2, Gwangmook Kim1, Wooyoung Shim1, Moon-Ho Jo1,2, Hyungwo Choi1; 1Yonsei Univ., South Korea; 2Institute of Basic Science, South Korea; 3POSTECH, South Korea. We report the two-pulse time-resolved photocurrent measurement in a group VII ReS2. The absence of bias dependence on the photocurrent recovery implies that the escape time of photoexcited carrier is much faster than electron-hole recombination.

JW2A.135 The Influence of hBN on the Pump-dependent Time-evolution of Monolayer Photoluminescence in WSe2, Jan Kuhnt1, Lorenz M. Schneider1, Sina Lippert1, Dylan Renaud2, Obafunso Ajayi3, Young Duck Kim4, Wolfram Heinbrodt5, James Hone5, Arash Rahimi-Imani5, 1Faculty of Physics and Materials Science Center, Philipps Universität Marburg, Germany; 2Dept. of Mechanical Engineering, Columbia Univ., USA. We present the influence of hBN buffer layers on the power-dependent time-evolution of the photoluminescence in monolayer WSe2, on different substrates. An even greater influence is observed when the excitonic Mott transition regime is reached.

JW2A.136 Exciton Dynamics in WSe2 Monolayers for Different Stacking Schemes Involving h-BN, Lorenz M. Schneider1, Jan Kuhnt2, Dylan Renaud1, Saleh Firoozabadi1, Obafunso Ajayi2, Young Duck Kim4, Wolfram Heinbrodt5, James Hone5, Arash Rahimi-Imani5, 1Philips-Universitat Marburg, Germany; 2Dept. of Mechanical Engineering, Columbia Univ., USA. We present a comparison of tungsten-diselenide monolayers in different stacking configurations with hBN and MoSe2. A pronounced red-shift is observed when the monolayer is supported or encapsulated by hBN. Furthermore, the excitonic annihilation rate changes.

JW2A.137 The H2020 Project CLONETS: Clock Services over Opticla Fibre Networks in Europe, Josef Voytech1, Jan Radil1, Vladimir Smetlatcha1, Radek Velc1, Pzemeslaw Kehl1, Lukas Silwczynski1, Mauro Campanella1, Davide Calonico2, Cecilia Clivati3, Filippo Levi1, Ondrej Cip1, Simon Renucha2, Ronald Holzworth1, Maurice Lessing1, Sarah Saint-Jalm2, Fabiola Camargo1, Bruno Desuelle1, Jean Lauter-Gaud1, Elizabeth Lafer English1, Jochen Kronjager1, Peter Whibberley2, Eva Bookars3, Paul-Eric Potel2, Philip Tuckey1, Tomáš Müller1, Jiří Stefl1, Pavel Noga1, Robert Urbansk2, Arnt Binczewski1, Wojbor Bogacki1, Krzyztof Turza2, 1CESNET, Czechia; 2AGH University of Science and Technology, Poland; 3Consortium GARR, Italy; 4Istituto Nazionale di Ricerca Metrologica, Italy; 5Inst. of Scientific Instruments of the ASCR, v.v.i., Czechia; 6Menlo Systems, Germany; 7Muquans, France; 8National Physical Lab, UK; 9LNE-SYRTE, Observatoire de Paris, PSI Research Centre, Univ., CNRS, Sorbonne Universite, France; 10OPTOKON a.s., Czechia; 11Pctime Systems s. z.o.o., Poland; 12Poznan Supercomputing and Networking Center, Poland. Time and frequency transfer based on optical fibre links techniques have demonstrated excellent performances. CLONETS is an EU project intended to accelerate transfer of related technologies, in order to prepare deployment of technology for sustainable network providing high-performance clock services.

JW2A.138 Commissioning of a Fully-Automated, Pulsed Optical Timing Distribution System at Dalian Coherent Light Source, Haynes P. Cheng1, Kemal Shahaf1, Anan Dai1, Johann Derksen1, Andrej Berlin1, Erin Cao1, Zhichao Chen1, Hongli Ding1, Darush Forouher1, Zhigang He1, Xiaoyu Liu1, Wahid Nasimzada2, Mathias Neuhaus1, Philipp Schiepel1, Eduard Seibel1, Yuhuan Tian1, Bo Lui2, Guangwu Wu1, Franz X. Kaertner3, 4Cycle Gmbh,Germany; 1State Key Lab of Molecular Reaction Dynamics, Dalian Inst. of Chemical Physics, China; 2Shanghai Inst. of Applied Physics (SINAP), China; 3Deutsches Elektronen Synchrotron (DESY), Germany; 4Center for Free Electron Laser Science (CFEL), Germany. We present latest results from the commissioning of China's first multi-link pulse-based optical timing distribution system (TDS). A fully-automated control system, and polarization-maintaining fiber links enable reliable, 24/7 operation of the TDS at user's facility.

JW2A.139 Sub-Short-Noise Absorption Imaging with a Hybrid Detection Scheme, Javier Gabies-Chestenning1, Alex McMillan1, Paul-Antoine Moreau1, Sebastian Krauter1, Eric Johnston1, Siddarth Joshi1, 2John Rarity1, Jonathan Matthews1, 3Univ. of Bristol, UK; 4Univ. of Glasgow, UK; 5Academy of Sciences, Austria. We demonstrate a scanning microscopy system for high resolution, sub-shot-noise absorption imaging. A genuine quantum advantage of factor 1.66 in information gained per probe photon, relative to an ideal classical measurement, is demonstrated.

JW2A.140 A Step Forward the Determination of the Anomalous Dispersion on the Er3+ in the Tellurite Glass, Luis H. Andrade1, Ana Paula Langaro1, Ana Kely Rufino1, Alex Cesar Pereira Rocha1, Claudio Y. Morasutti1, Jurion R. Silva1, Sandro Lima1, 2UEMS, Brazil. We report the anomalous dispersion and group refractive index (n3) of the Er3+: tellurite glass measured by Windowed Fourier Transform from interferometric measurements and compared with the dispersion calculated from absorption spectra by known Kramers-Kronig relations.

Exhibit Hall

11:30–13:00 JW2A • Poster Session II
JW2A.141 Photo-acoustic sensing with fiber-based optical frequency comb cavity, Takeo Minakami1, Takashi Masuoka2, Takashi Ogura1, Yoshiaki Nakajima1,2, Yoshihisa Yamakoa, Kaoru Minoshima1,2, Takeshi. Yasiu1,2, Takujiha Uni, Japan, *JST, ERATO Intelligent Optical Synthesizer Project, Japan; 2Univ. of Electro-Communications, Japan; 3Saga Univ., Japan. We proposed a novel photo-acoustic sensing employing an optical-frequency-comb. We utilized an optical-frequency-comb cavity as an acoustic wave sensor, and successfully demonstrated the detection of ultrasound that generated by the laser irradiation on sample.

JW2A.142 A Simplistic Method to Generate Highly Flat Optical Frequency Combs, Thanh Tuan Trân1, Minje Song1, MiHyun Song1, Dongsun Seo2, ‘Electronics and Telecommunications Research Inst., South Korea; 2Dept. of Electronics, Myongji Univ., South Korea; ‘School of Electronics Engineering, Kyungpook National Univ., South Korea. We demonstrate a simplistic scheme to generate highly flat optical frequency combs. Our results show the spectral flatness within 1 dB for 35 taps and 1.5 dB for 55 taps, where a DP-MZM is combined with 2 and 3 phase modulators, respectively.

JW2A.143 Evolution and Performance of High-Speed A-Scan based on Real-Time Optical Spectrum Fourier Transformation, Fabio Falconi1, yongwoo Park2, *Jose Ana3, Antonella Bogoni1, Antonio Malacarne1, Scuola Superiore Sant’Anna, Italy; CNIT, Italy; Aottomation Precision Inc., USA; INRS-EMT, Institut National de la Recherche Scientifique, Canada. Advances on a recently proposed approach to obtain reflectivity profiles have been reported. The method has been successfully applied to a 150 μm thick transparent polystyrene chloride layer. System performance and optimization have been discussed.

JW2A.144 Femtosecond Laser-based Atmospheric Frequency Transfer Using Single Electronic Phase Compensator, Dang Hou1, Danian Zhang1, Fuyu Sun1, Jie Tian1, Haoyuan Liu1, Jianye Zhao1, ‘Univ. of Elect. Sci. and Tech. of China, China; ‘China Academy of Engineering Physics, China; ‘Peking Univ., China. We demonstrate a femtosecond laser-based atmospheric radio-frequency transfer with a single electronic phase compensator over 100 m free-space link. The root-mean-square timing fluctuation of transferred microwave signal is about 490 fs within 5000 s.

JW2A.145 Dispersive Tunable Laser Spectroscopy with Ultra-high Spectral Resolution, Bin Wang1, Xinyu Fan1, Wang Shuai1, Jiao Wang1, ‘Tokushima Univ., Japan; ‘JST, ERATO Intelligent Optical Synthesizer Project, Japan; ‘Okayama Univ., Japan. We measured the frequency resolution of 95 kHz and a spectral resolution of 11 kHz are achieved without using costly mode-locked laser.

JW2A.146 Reflective-index-sensing RF comb using intra-cavity multi-mode interference fiber sensor, Ryo Oe1, Kosuke Naga1, Takeo Minakami1, Shuji Taura1, Hideki Fukano1, Yoshiaki Nakajima1, Kaoru Minoshima1, Takeshi Yasiu1, Takujiha Uni, Japan. ‘Okayama Uni, Japan; ‘The Univ. of Electro-Communications, Japan. We demonstrate reflective index (RI) measurement of liquid sample based on RI/RF conversion in fiber cavity including multi-mode interference fiber sensor. RI resolution of 6.6 x 10^-10 is achieved at a measurement time of 0.1 s.

JW2A.147 Auto-Start Mechanism of a Polarization-Multiplexed Dual-Frequency Femtosecond Fiber Laser, Rongxing Hu1, Govind Vedala1, ‘Univ of Kansas, USA. Mechanism of dual-frequency-combs coexistence in a polarization-multiplexed all-PM femtosecond fiber laser is presented. Balance between mode-locking conditions of the two combs is a essential to minmize differential phase change caused by pump power variation.

JW2A.148 Radiation Pressure Assisted Acousto-Optical Transducer, Ke Huang1, Mani Hosseini-Zadeh1, ‘Univ. of New Mexico, USA. We study the acousto-optical response of the optomechanical resonators in subthreshold regime and demonstrate that the reduced damping due to radiation pressure can be used for high sensitivity detection of acoustic waves.

JW2A.149 Phase Correlation Between Lines of Electro-Optical Frequency Combs, Lars Lundberg1, Mika Mar1, Attila Fulop1, Victor Torres-Company1, Magnus Karlsson1, Peter A. Andrekson1, ‘Chalmers Univ. of Technology, Sweden. Simultaneous measurement of the phase noise of 15 optical-frequency-comb lines show a correlation of over 99.99% between lines. Additionally, the phase noise difference between line pairs is correlated, verifying theoretical predictions.

JW2A.150 Fluorescence Double Resonance Optical Pumping spectrum and its application for frequency stabilization in Millimeter scale vapor cell, Elitran Taker1, Linian Stern1, Alex Naiman1, Ueli Levy2, ‘Hebrew Universit Of Jerusalem, Israel. We introduce the approach of fluorescence double resonance optical pumping, demonstrate its superior contrast compared with the conventional double-resonance optical pumping, and use it for locking to telecom wavelength in mm scale vapor cell.

JW2A.151 Absolute Frequency of Cesium Atom 65,2D2, Doppler-free Two-photon Transition, Ting-Ju Chen1, Jing-En Chen1, Zewei Liu1, Hsin-Hung Yu1, Ka-Han Chen1, Ya-Fen Hsiao1, Ying-Cheng Chen1, Wang-Yao Cheng1, ‘Physical Dept., National Central Univ., Taiwan; ‘Inst. of atomic and molecular science, Academia Sinica, Taiwan. We determined the absolute frequency of 165,308,723,000 ± 307 Hz from the two-photon transition, our novel scheme enables the resolution to address the nuclear magnetic octupole.

JW2A.152 Frequency dissemination over 1000 km optical fiber with 10^-21 frequency instability, Xin Chen1, Jianmin Shang1, Dongxing Wang1, Cheng Ch1, Wenpeng Zhang1, Bo Liu1, Hui Song1, Zhiang Zhang1, Peking Univ., China; ‘Beijing Univ. of Posts and Telecommunications, China; ‘Nankai Univ., China. We demonstrate a frequency transfer scheme for over 1000 km optical fiber link with mode locked pulse train as the frequency carrier. The fractional frequency instability was measured as 2.75e10^-15 % and 3.9e10^-11 for 3000 s.

JW2A.153 Dual-comb spectroscopy of methan based on an Erbium dual-comb fiber laser, Jie Chen1, Xin Zhao1, Yuehan Wu1, Ting Li1, Ruliu Wang2, Qian Li1, Siyao Yin1, Jiansheng Liu1, Zheng Zheng3, ‘School of Electrical and Information Engineering, Beihang Univ., China; ‘Collaborative Innovation Center of Geospatial Technology, China. Dual-comb spectroscopy measurement of methan absorption around 1650nm is demonstrated using a dual-wavelength Erbium mode-locked fiber laser, which illustrates the capability of such single-cavity dual-comb sources to cover spectral range well beyond their initial bandwidth.

JW2A.154 Self-controlled Stabilization of a Passively Phase-locked Erbium-doped Fiber Laser, Liwei Hu1,2, Yongwoo Park3, Jose Azana4, Antonella Bogoni1, ‘Univ. of Electro-Communications, Japan; ‘Saga Univ., Japan; ‘Institut National de l’Informatique et des Techniques, France. We demonstrate optical linewidth narrowing and simultaneous repetition rate stabilization of an Er-fiber frequency comb passively phase-locked by ultrabroadband difference frequency mixing. Optical self-control is performed using the original comb from the master oscillator.

JW2A.155 Real-time multi-wavelength digital holography using line-by-line spectral shaping of optical frequency comb, Masato Morishima1,2, Takeshi Minamikawa1,2, Isao Morohoshi1, Norihiko Sekine1, Iwao Hosako1, Hirotsugu Yamamoto1,2, Takeshi1, Yosi1,2, ‘Tokushima Univ., Japan; ‘JST, ERATO MINOSHIIMA Intelligent Optical Synthesizer (IOS), Japan; ‘Japan Science and Technology Agency, Japan; ‘University of Tokyo, Japan. Mode-resolved spectrum in optical frequency comb (OFC) is manipulated by a combination of a 2D optical intercorder with a spatial light modulator. The resulting mode-manipulated OFC is effectively applied for real-time multi-wavelength digital holography.

JW2A.156 High-Sensitivity Doppler-Free Optical-Doppler-Deduced Resonance-Dual-Comb Spectroscopy, Akiko Nishiyama1, Ken’ichi Nakagawa1, Hirokazu Sasaki2, Atsushi Ono3, Yoshiaki Nakajima1, Kaoru Minoshima1, ‘Univ. of Electro-Communications, Japan; ‘JST, ERATO Minoshima Intelligent Optical Synthesizer (IOS) Project, Japan; ‘Dept. of Physics, Faculty of Science and Technology, Keio Univ., Japan; ‘National Metrology Inst. of Japan (NMIJ), National Inst. of Advanced Industrial Science and Technology (AIST), Japan. We demonstrate background-free detection schemes in optical-dual-resonance dual-comb spectroscopy to improve measurement sensitivity. The dual-comb employing modulation spectroscopy and fluorescence detection achieved 4 and 925 times higher SNR than normal dual-comb setup, respectively.

JW2A.157 Free-running, Femtosecond Dual-Comb MIXSEL for Spectroscopy of Acetylene, Jacob Nuerenberg1, Cesare Aliferi1, Dominik Waldkaug1, Mathias Kelling1, Nataliche Piquet1, Ursula Keller1, ‘Inst. of Quantum Electronics, ETH Zurich, Switzerland; ‘Max-Planck Inst. of Quantum Optics, Germany. We present dual-comb spectroscopy on acetylene performed with one single free-running mode-locked integrated external-cavity surface-emitting laser (MIXSEL). Two intracavity birefringent crystals reduce the difference in repetition rate and solve aliasing issues for broad optical spectra.

JW2A.158 Quantum Interference Control of Injected Photocurrent in an AlGaAs Waveguide, Kai Wang1, Rodrigo A. Muna1, John E. Sipe1, Steven T. Cundiff1, Kphysics, Univ. of michigan, USA; ‘Physics, Univ. of Toronto, Canada. We measured the differential photocurrent induced by quantum interference between two- and three-photon absorption in a semiconductor (AlGaAs) waveguide, which allows the design of compact devices for comb offset frequency measurements.

JW2A.159 Determination of the offset frequency of a broadband frequency comb generated in a waveguide-type periodically poled lithium niobate crystal, Kazumichi Yoshii1,2, Juna Nomura1, Kaho Taguchi1, Yukise Hisa1, Feng-Lai Hong1,2,1Tokushima National Univ., Japan; ‘JST, ERATO Minoshima Intelligent Optical Synthesizer Project, Japan. We generate a broadband frequency comb using a WG-PPLN and measure the offset frequency of the comb by using a frequency-stabilized laser at 332 nm. The visible comb is generated through x̂ process.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
JW2A.160 A Computational Correction Method for Dual-cold Interferometry, Zebin Zhu, Kai Ni, Qian Zhou, Guanhao Wu
1Dept. of Precision Instrument, Tsinghua Univ., China; 2Division of Advanced Manufacturing, Graduate School at Shenzhen, Tsinghua Univ., China. We present a post-correction algorithm for dual-cold interferometry that can compensate the carrier phase noise and timing jitter of interferometers. One-hertz linewidth, ~1 ns timing jitter, and 0.4 rad precision of carrier phase are demonstrated.

JW2A.161 Compact GHz Frequency Comb from an Ultrafast Solid-State Laser with Cost-Efficient 3D-Printed Plastic Cavity Base, Sangi Halakbany, Pierre Brochard, Valentin J. Wittwer, Kutan Gunel,1 Stephanie Schlitt,1 Thomas Sudmeier,1 ‘Laboratoire Temp-Fréquence, Switzerland. We present a GHz mode-locked laser with a 3D-printed cavity base resulting in substantial noise reduction from the previous use of traditional opto-mechanical mounts. Additionally, the repetition rate is stabilized to a low-noise optically-derived 15-GHz signal.

JW2A.162 Frequency-sweeping interferometry utilizing optical frequency comb and Fourier transform phase retrieving, Weiping Zhang, Haoyun Wei, Yan Li, Tsinghua Univ., China. A precise 3D surface measurement method for large stepped structures without height ambiguity is proposed based on optical frequency comb referenced frequency-sweeping interferometry and Fourier transformed fractional phase retrieval. Samples of from 1 to 1000 microns were measured.

JW2A.163 A High Performance Clock Laser for Two-Photon Frequency Stabilized Optical Clocks, Matthew S. Bigelow,1 Kyle W. Martin,1 Gretchen Phelps,1 Nathan D. Lemke,1 ‘Applied Technology Associates dba AT6A, USA; 2Space Vehicles Directorate, Air Force Research Lab, USA. We describe a simple high-performance all-fiber atomic-line clock laser constructed from commercial off-the-shelf (COTS) components. This laser, based on a frequency-doubled telecom laser, has significantly lower frequency noise compared to direct diode lasers.

JW2A.164 Development and Qualification of UHV-Compatible, Micro-Integrated Optical Systems for Cold Atom Applications, Marc Christ1, Achim Peters1, Markus Kutzik1, ‘Humboldt-Universität zu Berlin, Germany. We present a tool for rapid prototyping and qualification of (electro-) optical components and adhesive integration techniques for micro-integrated assemblies operating in ultra-high vacuum environments.

JW2A.165 Optical Frequency Comb Faraday Rotation Spectroscopy, Alexandre C. Johansson, Jonas Wustberg, Gerard Wysock, Aleksandra Foltynowicz,1 ‘Umeå Univ., Sweden; 2Princeton Univ., USA. By combining Faraday rotation spectroscopy with an optical frequency comb Fourier transform spectrometer, we measure background- and calibration-free spectra of the entire Q- and R-branches of the fundamental band of nitric oxide at 1850-1920 cm⁻¹.

JW2A.166 Tunable lower-RIN Brillouin ring laser for BOTDA sensing, Diego Marin,1 Leonardo Ross,1, Filippo Bastiani1,1 Gabriele. Bolognini,1 ‘CNR, IMM Inst., Bologna, Italy; 2School of Mechanical Engineering, University of Zagreb, Croatia. In this work we characterize a lower-RIN Brillouin ring laser technology for Brillouin optical time-domain analysis (BOTDA) sensing. The developed tunable pump-probe light allows for efficient BOTDA over 10 km fiber with 10nm/0.5°C temperature-strain resolutions.

JW2A.167 Multi-point Acoustic Sensing System Using Coherent Frequency Comb, Junjie Wang, Fan Ai, Yuechen Sun, Hao Li, Xiangpeng Xiao, Zhijun Yan, Deming Liu, Qiwen Sun,1 ‘School of Optical and Electronic Information, National Engineering Lab for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China. A multi-point acoustic sensing system with capacity up to 248 is proposed. The sensitivity of -131 SdB ± 1 SdB re Tread/µA is achieved in a prototype system with graphene diaphragm based fiber sensors.

JW2A.168 Fiber Optical Sensor for Methane Detection Based on Metal-Organoic Framework/Silicone Polymer Coating, Rongtao Cao,1 Hangui Ding,1 Zhaoguang Peng1,2, Kai-Joong Kim1,2, Paul Ohdodniki1,2, Aidong Yan1,3; ’Univ. of Pittsburgh, USA; 2National Energy Technology Lab, USA. A multimode fiber methane sensor made of polymer/metal-organic framework coated cladding is presented with a low detection limit of 1% (v/v). The detailed sensing mechanism is also analyzed in this paper.

JW2A.169 High-resolution and Large-capacity DRB Fiber Laser Acierrometer Network, Tao Liu,1 Dongdong Lv,2 Yiyang Luo,2 Zhijun Yan,1 Kai Wang2, Chengqiang Li, Deming Liu,1 Qiwen Sun,1 ‘Huazhong Univ of Science and Technology, China; 2The 38th Research Inst. of CETC, China. We demonstrate a highly sensitive DRB fiber laser acierrometer sensor network with a resolution of 17.86 nm/µg and a detection limit of 10³ g. The sensing capacity is increased by 128 by utilizing the hybrid multiplexing technique.

JW2A.170 Ultra Sensitive Long Period Fiber Gratings Based Sensor for Detection of Adulterator in Ethanol, Krishnendu Dandapat1, Sarabudh R. Inspri1,2, ‘Physics, Indian Inst. of Technology Kanpur, India; 2Centre for Lasers and Photonics, Indian Inst. of Technology Kanpur, India. Using extremely sensitive dual-resonance long-period-fiber-gratings operating close to their turnaround-wavelength, we demonstrate a sensor for accurate and quantitative detection of adulterator in ethanol. Our sensor can detect methanol concentration as small as 0.1% in ethanol.

JW2A.171 Fast Reading of Fiber Bragg Gratings Sensors with a Locked Non-Dithered Tunable Laser, Pedro Martin-Mateos1, Oscar Elas Bonilla-Marrone2, Pablo Acedo1, Jose A. Garcia-Souto1, ‘Universidad Carlos III de Madrid, Spain. We propose a fast reading FBG laser locked architecture that provides a single output, a wavelength range only limited by the tuning capabilities of the laser and an operation speed only restricted by the servo controller.

JW2A.172 Cost Effective Dual-Polarization Interferometric Fiber Gyroscope with Ultra-Simple Configuration, Fangyuan Chen1, Yulin Li2, Rongya Luo1, Fang Ben1, Dong He1, Chao Peng1, Zhenbin Li1, ‘School of Electronics Engineering and Computer Science, Peking Univ., China. A cost-effective and ultra-simple dual-polarization interferometric fiber optic gyroscope utilizing single-mode components was proposed and tested, which achieved an overall bias instability below 2 x 10⁻¹⁷ and a scale factor nonlinearity below 100 ppm.

JW2A.173 Pico-strain Resolution Fiber Grating Sensor with Ultralow Probe Power and Tunable Sensitivity, Shuangxiang Zhao1, Qingshen Liu1, Jiageng Chen1, Zijuang He1, ‘State Key Lab of Advanced Optical Communication Systems and Networks, Shanghai Jiao Tong Univ., China. We present here a novel interrogation method for Er³⁺ doped fiber grating sensor with pc resolution, ultralow probe power, large tunable strain sensitivity and capability of multiplexed, static and dynamic sensing.

JW2A.174 Multichannel Fiber Bragg Grating for Temperature Field Monitoring, Wei Zhang1, Adenowo Gbadede1, Zhijun Xing1, Desheng Jiang1, Deming Liu1, Zhijun Yan1, Qiwen Sun1,2, ’National Engineering Lab for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China; 1Aston Inst. of Photonic Technologies, Aston Univ., UK; 2National Engineering Lab for Fiber Optic Sensing Technology, Wuhan Univ. of Technology, China. We demonstrated a multichannel FBG based temperature field sensor, in which the grating was designed by pre-compensation layer peeling method. Such system could achieve a real time temperature field monitoring with 3mm high spatial resolution.

JW2A.175 Demonstration of a Plasma-Thermomechanical Radiation Detector with Si₃N₄ Waveguide Optical Readout Circuit, Qiangchao Zhao1, Mohammad W. Khan1,2, Parnam Sadi-Moshkenani1, Regina Ragan1, Filippo Capolino1, Ozdal Boyraz1, ‘Univ. of California, Irvine, USA. A plasma-thermomechanical radiation detector based on suspended nano-antennas with a Si₃N₄ waveguide optical readout circuit has been demonstrated. The responsivity and noise equivalent power of the detector are measured to be 3.95×10⁻¹⁰J/µW and 3.01±W/µHz, respectively.

JW2A.176 Surface Plasma Resonator Biosensor Spatial Phase Sensitivity Enhancement through Optical Fiber Low Coherence Interferometry, Shih-Hsien Hsu1, Hsun-Yuan Hsu1, Chung-Hsuan Chen2, Meng-Syuan Jian1, ‘National Taiwan Univ. of Science & Tech, Taiwan. The spatial phase sensitivity on the effective reaction length using optical fiber low coherence interferometry demonstrates 10⁻⁴ rad/µm, 34 times more enhancement than the polarized light phase characterization from spectral interferometry based surface plasmon resonance biosensors.

JW2A.177 Ppb-level Detection of Acetylene based on QEPAS Using a Power Amplified Diode Laser, Yufei Ma1, Yao Tong1, Ying He1, Xin Yu1, Frank Tittel1, ‘Harbin Inst. of Technology, China; 2Rice Univ., USA. An ultra-high sensitivity C₂H₂-QEPAS sensor using an EDFA amplified diode laser was demonstrated. The 33.2 pb level detection sensitivity verified that the design of the reported QEPAS method demonstrated significantly enhanced sensor performance.

JW2A.178 Remote, distributed gas sensor based on FEW-QEPAS, Ying He1, Yufei Ma1, Yao Tong1, Xin Yu1, Frank Tittel1, ‘Harbin Inst. of Technology, China; 2Rice Univ., USA. A remote, distributed gas sensing using fiber evanescent wave quartz-enhanced photoacoustic spectroscopy (FEW-QEPAS) technique was demonstrated. A 3 km single mode fiber with multiple tapplers was employed to perform long distance, distributed gas measurements.

JW2A.179 Temperature Sensor Using Fluid-Filled Negative Curvature Fibers, Chengli Wei, Joshua Young1, Curtis R. Menyuk1, Jonathan Hu1,2, ‘Dept. of Electrical and Computer Engineering, Baylor Univ., USA; 2Dept. of Computer Science and Electrical Engineering, Univ. of Maryland, Baltimore County, USA. We propose a new temperature sensor based on fluid-filled negative curvature fibers. The temperature sensitivity increases from 0.8 nm³/C to 2.5 nm³/C when the refractive index of the fluid increases from 1.30 to 1.42.
JW2A.180
Multi-functional cellulose fiber decorated with plasmonic Au nanoparticles for colorimetry and SERS assay, Qian Yu1, Xianming Kong1, Yibo Ma1, Alan X. Wang1; 1Oregon State Univ., USA; 2College of Chemistry, Chemical Engineering and Environment Engineering, Liaoning Shihua Univ., China; 3Aalto Univ., Finland. We fabricated a multi-functional sensor through decorating Au nanoparticles on cellulose fibers. The solid colorimetry and surface-enhanced Raman scattering sensing for water and malachite green were achieved on this device.

JW2A.181
An Optical Microwave Generator based on Stimulated Brillouin Scattering with Fine Tunability, Juanjuan Yan1, Aihu Liang1; 1Beihang Univ., China. In this optical microwave generator, the lower sideband of CS-DSB modulated laser is shifted using SBS in a fiber. Microwaves from 14.67GHz to 30.67GHz are generated by beating the shifted sideband and the upper sideband.

JW2A.182
Strong-field laser initiated H2 roaming chemistry and the formation of H3+ from organic molecules, Nagitha Ekanayake1, Muath Nairat1, Travis Severt2, Peyman Feizollahi2, Bethany Jochim2, Balram Kaderiya2, Farzaneh Ziaee2, Kursit Borner2, Kanaka Raju Pandit1, Kevin Cames3, Daniel Rolles3, Artem Rudenko2, Itzik Ben-Itzhak2, Nicholas Weingartz1, Benjamin Farris1, Benjamin Levine1, James Jackson1, Marcos Dantus1,3; 1Dept. of Chemistry, Michigan State Univ., USA; 2J. R. MacDonald Lab, Dept. of Physics, Kansas State Univ., USA; 3Dept. of Physics, Michigan State Univ., USA. H2 roaming has been recently implicated in H3+ production when certain organic molecules interact with a strong-field laser. Mechanistic details and femtosecond time-resolved dynamics of H3+ formation were obtained on a series of alcohols.

11:30–13:00  Exhibit Hall Free Lunch

12:00–13:00  OSA Photonic Metamaterials Technical Group Tutorial on Metasurface Design and Simulation, Room 230A
Low Power Generation of Broadband Single Kerr Solitons in Silicon Nitride Resonators, Travis C. Briles1, Su-Peng Yu1, Kartik Srinivasan1, Scott Diddams1, Scott Papp1; Time and Frequency Division, National Inst. of Standards and Technology, USA; Center for Nanoscale Science and Technology, National Inst. of Standards and Technology, USA. We report the generation of broadband, single soliton frequency combs with dual dispersive waves in 1 THz and 333 GHz FSR silicon nitride microresonators using an on-chip pump-power as low as 12 mW.

Synchronization of coupled microresonator frequency combs, Jae K. Jang1, Alexander L. Gaeta1, 2Hong Kong Univ of Science & Technology, Hong Kong; 2Univ. of California, Davis, USA. We experimentally demonstrate passive synchronization of microresonator-based optical frequency combs. By injecting a small fraction of the light from one microresonator to the other, we frequency-lock two combs separated by over 20 m.
to investigate the carrier concentrations in semiconductor
extreme sub-wavelength spatial resolution (<25 nanometer)
domain spectroscopy with near-field microscopy to achieve

We found that this system has huge potential for high-resolution, high-sensitive and high-speed biological measurements.
**Nonlinear Nano-optics**

*Enhanced Second-Harmonic Generation in Broken Symmetry III-V Semiconductor Metasurfaces driven by Fano resonance,* Polina Vbashchichkova, Sheng Liu, Michael Sinclair, Jordan A. Keeler, Gregory M. Peake, Igal Brener, Sandra National Labs, USA; Center for Integrated Nanotechnologies, Sandia National Labs, USA. We use broken symmetry III-V semiconductor Fano metasurfaces to substantially improve the efficiency of second-harmonic generation (SHG) in the near infrared, compared to SHG obtained from metasurfaces created using symmetrical Mie resonators.

*Collective nonlinear optical effects in plasmonic nanohole ensembles of different rotational symmetries,* Chengguan Zou, Andre Komar, Stefano Fasolli, Alexander Muravykov, Anatoli Muraluski, Thomas Pertsch, Dragomir N. Neshev, Isabelle Staudte. Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany; Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia; Inst. of Chemistry of New Materials, National Academy of Sciences of Belarus, Belarus. We experimentally demonstrate the use of photoalignment materials for liquidcrystal based electrical tuning of resonant silicon metasurfaces with a 67% modulation depth at visible frequencies.

*Continuous Angle Beam Steering Using Spatiotemporal Frequency Modulation of Metamaterial/Graphene Frequency Comb Control in Dielectric Metasurfaces,* Artem Shaltout, Konstantinos Lagoudakis, Jorik van de Groep, Mirek Kornas, Jelena Vuckovic, Vladimir M. Shalaev. Stanford Univ., USA; Purdue Univ., USA. Experimental laser beam steering is demonstrated using light-matter interaction between frequency-comb source and silicon based metasurface. Continuous angular scanning of 25° is successfully achieved over a time interval of 10 ps.

*Active Frequency Modulation of Metamaterial/Graphene Optoelectronic Device Using Coupled Resonators,* Stephen J. Kindness, Nikita Almond, Robert Wallis, Binbin Wei, Varun Kamboj, Philipp Braeuninger-Weimer, Stephan Hofmann, Harvey Beere, David Ritchie, Riccardo Degl’Innocenti. Univ. of Cambridge, UK; Lancaster Univ., UK. We present continuous frequency modulation of a metamaterial resonance by selective damping of coupled resonators using electrostatically gated graphene. A frequency tuning range >150 GHz is achieved at 1.5 THz making this device suitable for use as an electrically tunable frequency modulator.

**Nanophotonics**

*Nonlinear Wave Mixing in Semiconductor Nanoantennas and Metasurfaces,* Dragomir N. Neshev, Australian National Univ., Australia. We demonstrate how ultra-small dielectric nanoantennas and in particular, to enhance the sum-frequency generation and spontaneous parametric down conversion.

*Dielectric Metasurfaces for Optical Communications and Spatial Division Multiplexing,* Sergey S. Kruk, Yuri S. Kivshar. University of Bristol, UK. We present passive dielectric metasurfaces with near-uniform transmission to engineer spatial mode profiles for both mode modulation and multiplexing in optical communications. The broadband response of the metasurface covers S, C, and L telecommunication bands.
Nutritional Deficiencies, Point-of-Care Technologies for Infectious Diseases and Cancer Screening with Nuclear Biomarkers, YU-CHENG

We developed cancers like Kaposi’s Sarcoma.

We experimented demonstrate that pure OAM fiber modes are highly robust to out-of-plane bend perturbations in contrast to their vector counterparts (HE/EH) that mix completely, because geometric (Pancharaman) phase accumulation varies with OAM content.

SW3J.2 • 13:30
Laser Emission Microscopy: A Novel Tool for High-contrast SW3J.1 • 13:00
Point-of-Care Technologies for Infectious Diseases and Nutritional Deficiencies, David Erickson1,2,3,4; Cornell Univ., USA. In this talk I will discuss some of the technologies and approaches to enable point-of-care diagnostics for vitamin and micronutrient deficiencies and infectious disease related cancers like Kaposi’s Sarcoma.

in this talk I will discuss some of the technologies and approaches to enable point-of-care diagnostics for vitamin and micronutrient deficiencies and infectious diseases related cancers like Kaposi’s Sarcoma.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

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Angular momentum, Shungo Araki1, Roukuya Mamuti 1, Optical vortex parametric laser with a versatile orbital
man introduced the elegant beams and proved that they are
eigenmodes of spherical resators. We demonstrate that
by superposing a finite number of elegant Laquerre-Gaus
beams we can generate eigenmodes of spherical resonators.

We present a tunable sorting with better separation between adjacent modes. We
confirm the benefits of this scheme.

We report a tunable two-color-field driven hollow-core fiber compressor.

We present a robust two-color-field driven hollow-core-fiber compressor. The -1μm HFC output covers
300 nm to 950 nm supporting sub-cycle transform-limited pulses with ~2.1% duration. The spectral phase is character-
ized with two-dimensional spectral shearing interferometry.

We demonstrate 33-fold pulse compression employing a 6.6-m-long hollow-core fiber and chirped mirrors.

We present a novel spectrum-splitting micro-concentrator assembly for laterally-arrayed multi-junction photovoltaic module,

we fabricate economical and scalable compact concentrators using PDMS integrated with QD solar
cells. The lenses deliver short circuit currents up to 20 times
more efficient, low-cost, and

High-resolution and compact vortex mode sorters based on a spiral transformation, Yuanhui Wen1, Ioannis Chemmossi2, Yujie Chen1, Jiangbo Zhu1, Yanfeng Zhang1, Siyuan Yu1, Haqun Zhang3, Eugene A. Fitzgerald1, David J. Perreault3, Haqun Zhang2, Eugene A. Fitzgerald1, David J. Perreault3, Susanna Thon1, Botong Qiu1, Garrett Ung1, Yi-Shiuan Lin1, Ming-Hsuan Yu1, Hao-Chung Kuo1, National Chiao Tung Univ., Taiwan; 2National Nano Device Labs (NDL), Taiwan; 3Inst. of Photonic System, National Chiao Tung Univ., Taiwan. Luminescent down-shifting (LDS) phenomenon has been employed to enhance the HIT solar cell efficiency. The efficiency and Jsc are increased by 2.3% and 11.5% respectively. External quantum efficiency (EQE) data supports our claim.

Efficiency Increasing of Single-Junction GaAs Solar Cells
Coated with Species of NIR Up-conversion Phosphors
Layer on Front-Side Surface by Spin-On Film Deposition,

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Efficiency Increasing of Single-Junction GaAs Solar Cells
Coated with Species of NIR Up-conversion Phosphors
Layer on Front-Side Surface by Spin-On Film Deposition,
CLEO: Science & Innovations

13:00–15:00
JW3P • Symposium on New Advances in Adaptive Optics Retinal Imaging I

Presider: TBD

Adaptive Optics Scanning Light Ophthalmoscopy: Beyond Structural Imaging, Alfredo Dubra1, Stanford Univ., USA. Here we will first review demonstrations of imaging retinal function at the cellular scale using adaptive optics ophthalmoscopy, and then, we will discuss their potential clinical applications.

JW3P1 • 13:00

Invited

Room-Temperature Electrically Pumped InP-based Laser Directly Grown on-on-axis (001) Silicon, Si Zhu1, Wei Shi1, Qiang Li1, Kei May Lau1, Hong Kong Univ. of Science & Technology, Hong Kong. We report the first InAlGaAs/InP multi-quantum-well lasers grown on (001) silicon by MOCVD. Lasing near 1.5 μm was achieved with a Jth = 3.3 kA/cm² and a high Tth of 134 K.

JW3P2 • 13:45

Invited

Highly Improved Reliability of Low Threshold 1.3 μm III/V Quantum Dot Laser Epitaxially Grown on On-axis Si, Daehwan Jung1, Robert Herrick1, Justin Norman1, Catherine Jain1, Neil Caranto1, Alfredo Torres1, Yating Wan1, Arthur Gossard1, John E. Bowers1, UCSB, USA; Intel Corp., USA. InAs quantum dot Fabry-Perot lasers grown on (001) Si demonstrate record-low continuous-wave threshold current of 4.8 mA as well as excellent device reliability with extrapolated lifetimes more than ten million hours at 35 °C.

JW3P3 • 14:30

Quadrupling reduction of threshold current density for micro-ring quantum dot lasers epitaxially grown on (001) Si, Yating Wan1, Daehwan Jung1, Justin Norman1, Kaiyin Feng1, Ap Dagi1, Arthur Gossard1, John E. Bowers1, UCSB, USA. A quadruple reduction of threshold current density was achieved for electrically pumped quantum-dot micro-rings epitaxially grown on (001) silicon. This was enabled by a low threading dislocation density GaAs buffer layer and a smooth etching sidewall.

Invited

Comparison of cavity enhanced Faraday rotation techniques for oxygen detection, Charles L. Patrick1, Jonas Westberg1, Gerard Wysocki1, Princeton University, USA. Two cavity enhanced Faraday rotation spectroscopic techniques are compared by detection of oxygen around 762 nm. Both techniques demonstrate sensitivities in the 1e-9 rad/Hz range and inherent advantages of the two techniques are discussed.

Invited

Mid-infrared Supercontinuum-based Trace Sensing, Frans J. M. Harren1, Radboud Univ., Netherlands. An overview will be given on mid-infrared supercontinuum sources combined with sensitive spectroscopic methods, to trace molecular gases for applications such as food spoilage, to trace molecular gases for applications such as food spoilage, and to trace molecular gases for applications such as food spoilage.

Invited

Navigation Doppler Lidar for autonomous ground, aerial, and space vehicles, Farzin Amajdjerdian1, Glenn D. Hines1, Dieg F. pierrotte1, Bruce W. Barnes1, Larry B. Petway1, NASA Langley Research Center, USA; Coherent Applications, USA; NASA JPL Space Center, USA. A Doppler lidar instrument has been developed and demonstrated for providing critical vector velocity and altitude/azimuth data for autonomous precision navigation. Utilizing advanced component technologies, this lidar can be adapted to different types of vehicles.
Generative statistical analysis

We demonstrate direct generation of Kerr-comb lines by a second pump coupled into the soliton resonance. The phase rate using an increasing-frequency scan of a phase-modulated microresonator solitons with measured 100 percent success. Boulder, USA. We demonstrate the generation of multiple side lines around Kerr comb lines by injecting a second pump into the soliton resonance. The side lines around each comb lines have relatively high power and are stable.

Direct Generation of Solitons with a Reversed Soliton Step in a Microresonator Pumped by a Phase-Modulated Laser, Daniel C. Cole,1 Jordan Stone,2 Scott Pappi,2 NIST Boulder, USA. We demonstrate direct generation of Kerr-microresonator solitons with measured 100 percent success rate using an increasing-frequency scan of a phase-modulated pump laser. A reversed soliton step is observed. The phase modulation controls the solitons’ properties.

Raman comb generation through broadband gain in a silica microresonator, Ryo Suzuki,1 Akhino Kubota,1 Atsuhiko Hori,1 Shun Fujii,3 Takasumi Tanabe,2 Keio Univ., Japan. We study the dynamics of Raman comb formation in silica rod microresonators. We generated a Raman comb with a smooth spectral envelope and observed the center wavelength transition by controlling the detuning and coupling strength.

Efficient Mid-Infrared Dispersive Wave Generation in Dispersion-Engineered SiN Waveguides Pumped at 2 μm, Eirini Tagkoudi1, Davide Grassani1, Harun Guo2, Clemens Herkommer1, Tobias J. Kippenberg2, Camille-Sophie Bres1,2 Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland. We demonstrate efficient generation of mid-infrared dispersive wave at 3.5 μm in a Si3N4 waveguide pumped by a 200fs femtosecond mode-locked fiber laser. The 8% maximum efficiency allows for a milliwatt-level average power mid-infrared pulse.

CMOS-Compatible Tunable Vernier Ring Laser using Erbium Doped Waveguide on a Silicon Photonics Platform, Narui Li1,2, Diedrik Vermeulen1,2, Zhan Su1,2, Emir Magden,1 Alfonso Ruocco,2 Neetesih Singh1, Jelena Notaros2, Ming Xin3, Christopher Poulton2,1, Erman Timurdogan1,2, Christopher Barocco,1 Michael Watts1,1 Research Lab of Electronics, MIT, USA; John A. Paulson School of Engineering and Applied Science, Harvard Univ., USA; Analog Photonics, USA; College of Nanoscale Science and Engineering, Univ. at Albany, USA. We demonstrate the first silicon photonic tunable laser with integrated erbium-doped Al2O3 waveguides. The laser is designed to have Vernier ring structure for wide tuning operation. It has a 0.23cm2 footprint and 1.6mW output power.

Low Cost 100 Gbps Multicore VCSEL Based Transmitter Module Platform, Feng Li,1 Sander Derreet2,1, Wouter Soenens3, Chenhui Li1, Xin Yin2, Oded Raz1; Eindhoven Univ. of Technology, Netherlands; 3 Technische Universität München, Germany; 4 Ghent Univ., Belgium. We demonstrate a flexible printed circuit board platform for a 100 Gbps VCSEL based transmitter with direct light launching into a multicores fiber using a 3D glass interposer as fan-out. Error free operation is demonstrated.

Silicon Waveguide Coupled III-V Nanowire Lasers with Epitaxial Gain Control, Thomas Steffen1,2, Tobias Kosterbader2, Shun Chieh Hsu2, Chun-Ping Huang1, Jochen Russner1, Andreas Thurn1, Michael Kaniber1, Gregor Krobmüller2, Jonathan J. Finley1,2; Nanosystems Initiative Munich (NIM), Schellingstr. 4, Germany; Walter Schotky Institut and Physik Dept., Technische Universität München, Germany. We demonstrate lasing from individual GaAs-based NWs integrated onto Si ridge waveguides. In addition, proof-of-principle coupling emission to the Si-WG is shown, with propagation distances of the lasing mode exceeding > 60 μm.

Efficient Mid-Infrared Dispersive Wave Generation in Dispersion-Engineered Si3N4 Waveguides Pumped at 2 μm, Eirini Tagkoudi1, Davide Grassani1, Harun Guo2, Clemens Herkommer1, Tobias J. Kippenberg2, Camille-Sophie Bres1,2 Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland. We demonstrate efficient generation of mid-infrared dispersive wave at 3.5 μm in a Si3N4 waveguide pumped by a 200fs femtosecond mode-locked fiber laser. The 8% maximum efficiency allows for a milliwatt-level average power mid-infrared pulse.

Microwave Spectral Characteristics of the Three-Section Distributed Feedback Lasers, Chun-Hong Chen1, Fu-Chun Hsiao2, Yao-Zhong Dong1, Yueh-Jyun Chao1, Yi-Hsuan Chen1, Yu-Ming Huang1, Shun Chieh Hsu2, Chung-Ping Huang1, Chien-Chung Lin1, College of Photonics, Inst. of Imaging and Biomedical Photonics, National Chiao-Tung Univ., Taiwan; College of Photonics, Inst. of Photonic System, National Chiao-Tung Univ., Taiwan; College of Photonics, Inst. of Lighting and Energy Photonics, National Chiao-Tung Univ., Taiwan. The three-section DFB lasers are used for RF signal generation. With an extra section, it can tune the RF peak frequency farther than the two-section one, and can also simultaneously generate two single-mode RF signals.
also demonstrated with orbital angular momentum of light. Localized surface plasmons. A selective excitation method is wavelength periodic grooves and successfully observed spoof resolved terahertz near-field imaging of a gold disk with sub-

We performed time-

Control of Spoof Localized Surface Plasmons Using Terahertz Near-field Microscope, Takashi Arakawa, Shohei Morimoto, Tomoki Hiroaka, François Blanchard, Kyosuke Sakai, Keiji Sasaki, Koichiro Tanaka, Kyoto Univ., Japan; Dept. of Electrical Engineering, Ecole de Technologie Superieure (ÉTS) Montréal, Canada; Research Inst. for Electronic Science, Hokkaido Univ., Japan; Inst. for Integrated Cer- nal Sciences, Kyoto Univ., Japan. We performed time-resolved terahertz near-field imaging of a gold disk with sub-wavelength periodic grooves and successfully observed spoof localized surface plasmons. A selective excitation method is also demonstrated with orbital angular momentum of light.

Depth-enhanced terahertz reflection imaging with Bessel beam generated by 3D-printed diffractive element, Liting Niu, Qiao Wu, Keja Wang, Zhenggang Yang, Jinsong Liu, Huazhong Univ. of Science and Tech, China. We propose a depth-enhanced terahertz reflection imaging system with Bessel beam generated by 3D-printed diffractive element. For testing the imaging quality of this system, a resolution chart is imaged at different transverse planes.

Direct Kerr-frequency-comb atomic stabilization, Liron Stern, Jordan Stone, Songbai Kang, Daniel C. Cole, John Kitching, Scott A. Diddams, Scott Papp, Time and Frequency Division, National Inst. for Standards and Technology, USA. We experimentally demonstrate direct Kerr-microresonator frequency-comb atomic spectroscopy, utilizing a cascaded two-photon 1529-nm transition in a rubidium micro-machined vapor cell. The demonstration is a path for compact atomic frequency references and multiphoton comb-atom interactions.

Shaping Harmonic Frequency Combs in Quantum Cascade Lasers, Marco Piccardo, Paul Chevalier, Benedikt Schwarz, Yongrui Wang, Dmitri Kazakov, Noah A. Rubin, Saajant Anand, Enrique A. Mejia, Michele Tamagnone, Feng Xie, Kevin Lascola, Alexey Belyanin, Federico Capasso, Harvard Univ., USA; TU Wien, Austria; Texas A&M Univ., USA; ETH Zurich, Switzerland; Wake Forest Univ., USA; Univ. of Texas at Austin, USA; Thelabs Quantum Electronics, USA. Controlling the spacing of self-starting harmonic frequency combs in QCLs by design of fundamental laser parameters is arduous. New ways to shape such combs by means of original electric- cal, optical and radiofrequency techniques are presented.

Harnessing Quantum Wave Nature of Individual Electrons for Single Photon Detection, Yang Zhang, Yang Wu, Xiaoxin Cheng Wang, Jing Wang, Eric R. Fossum, Rahul Kamar, Jifeng Liu, Gregory Salamo, Shui-Qing Yu, Dept. of Electrical Engineering, Univ. of Arkansas, USA; Dept. of Physics, Univ. of Arkansas, USA; Thayer School of Engineering, Dartmouth College, USA. We propose and examine theoretically a new type of photode- tector that senses THz single photons by the wavefunction change of a single electron confined in a quantum dot. A possible readout scheme is also presented.

Measuring single photons to bright light with a logarithmic optical detector, Johannes Tiedau, Evan Meyer-Scott, Thomas Nitsche, Sonja Barkhofen, Christine Silberhorn, Tim J. Bartley; Integrated Quantum Optics Group, Applied Physics, Univ. of Paderborn, Germany. We explore the behaviour of a loop detection scheme above the saturation region of single photon detectors. This enables us to measure single photon states and up to 309 nW power with the same device.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Plasmon Enhanced Third-Harmonic Generation with Graphene Nanoribbons, Irati Alonso Calafell, Lee Rozema, David Alcaraz, Frank M. Koppens, Philip Walther, Univ. of Vienna, Austria; ICFO, Spain. Graphene’s strong third-order nonlinearity could allow single-photon level interactions. Using third-harmonic generation, we characterize this nonlinearity over a wide wavelength range (1-4μm). We study a further plasmon enhancement by resonantly pumping graphene nanoribbons.


A Reprogrammable Photonic Meta-platform, Kaichen Dong1, Sukjeong Hong2, Yang Deng3, He Ma4, Jiachen Li1, Xi Wang1, Junyeob Ye1,2, Letian Wang1, Shuai Lou1, Kyle Tom1,3, Kai Liu1, Zheng You1, Yang Wei1, Costas P. Grigoropoulos2, Loan Te2, Mike Lange2, Joshua Shank1, Michael Goldflam1, Loon Te1, Mike Lange1, Joshua Shank1, Michael Wanke1, Jinhyun Noh1, Peide Ye1, Igal Brener1, Sandia National Labs, USA; Northrop Grumman Corporation, USA; Purdue Univ., USA. We demonstrate a fundamentally new approach of using voltage controlled quantum tunneling for modulating optical response of a metasurface coupled to intersubband transitions in semiconductor quantum wells.

Adaptive thermal camouflage based on phase-changing material GST, Yuui Qui1, Qiang Li1, Lu Ca1, Meiyuan Pan2, Pintu Ghosh3, Kaikai Du1, Min Qiu1, Zhejiang Univ., China. An adaptive thermal camouflage device incorporating phase-changing material Ge2Sb2Te5 (GST) is experimentally demonstrated. Near-perfect thermal camouflage can be achieved continuously for the background temperature ranging from 30 °C to 50 °C.

Strain dependent optical helicity in monolayer WS2, Jinkang Lim1, Zangi Zhao2, Jin He Kang2, Jiahui Huang1, Xiangfeng Duan1, Ali Javey2, Chee Wei Wong1, hyungjin kim2, Yonsei Univ., South Korea; Seoul National Univ., South Korea; POSTECH, South Korea; Korea Univ., South Korea. We perform a non-local circular photogalvanic measurement and directly generate the valley-coupled spin currents from WS2 to Bi2Se3, topological insulators. Our WS2-Bi2Se3 heterostructure offers a new optoelectronic platform toward the electrically-controllable valley-spin degree of freedom.

Spectroscopic signature of interlayer coupling in Black phosphorus-graphite heterostructure, Zhonghui Nie1, Wenwen Wang1, Weili Liu1, Xiaoping Liu1, Yongbing Xu2, Kyle Tom2,5, Junyeob Yeo2,4, Letian Wang2, Shuai Lou2, Kyle Tom1,3, Kai Liu1, Zheng You1, Yang Wei1, Costas P. Grigoropoulos2, Loan Te2, Mike Lange2, Joshua Shank1, Michael Goldflam1, Loon Te1, Mike Lange1, Joshua Shank1, Michael Wanke1, Jinhyun Noh1, Peide Ye1, Igal Brener1, Sandia National Labs, USA; Northrop Grumman Corporation, USA; Purdue Univ., USA. We reveal a pump-polarization-dependent spectroscopic signature of interlayer coupling in a black phosphorus-graphite heterostructure by probing its ultrafast photo-response. The angle-resolved transients provide new insights into the interfacial carrier dynamics in this emerging hybrid system.
In this study, all-biomaterial random laser device based on all-marine elements has been demonstrated.

SW3J • 14:45 Random Lasing Action in All-Marine Based Materials, Wei-Ju Lin1, Shih-Yao Lin1, Cheng Han Chang1, Yu-Ming Liao1, Tai-Yuan Lin1, Yang-Fang Chen1; 1National Taiwan Univ., Taiwan; 1Inst. of Optoelectronic Sciences, National Taiwan Ocean Univ., Taiwan. Towards the sustainable development, oceanic resources have been a desirable but challenging issue for years. Optoelectronic devices with biodegradability and biocompatibility have been a desirable but challenging issue for years. Using all-marine elements has been demonstrated. To achieve this, we have fabricated devices made from marine bases. We present an overview of random laser devices made from seaweed, shells, seawater, and plant extracts. These materials are shown to exhibit strong luminescence properties and have been used to fabricate random lasing devices. We discuss the potential of these materials for renewable optoelectronic applications.

Random Lasing Action in All-Marine Based Materials
Wei-Ju Lin1, Shih-Yao Lin1, Cheng Han Chang1, Yu-Ming Liao1, Tai-Yuan Lin1, Yang-Fang Chen1; 1National Taiwan Univ., Taiwan; 1Inst. of Optoelectronic Sciences, National Taiwan Ocean Univ., Taiwan. Towards the sustainable development, oceanic resources have been a desirable but challenging issue for years. Optoelectronic devices with biodegradability and biocompatibility have been a desirable but challenging issue for years. Using all-marine elements has been demonstrated. To achieve this, we have fabricated devices made from seaweed, shells, seawater, and plant extracts. We present an overview of random laser devices made from seaweed, shells, seawater, and plant extracts. These materials are shown to exhibit strong luminescence properties and have been used to fabricate random lasing devices. We discuss the potential of these materials for renewable optoelectronic applications.
SW3M • Beam Control & Measurement—Continued

SW3M.5 • 14:00 Invited
Hartmann Wavefront Sensors for Advanced LIGO, Peter Veitch 1, Aidan Brooks 2, Won Kim 1, Jesper Munch 1, David Ottaway 1; 1Univ. of Adelaide, Australia; 2LIGO Lab, USA. The operation and sensitivity of the Advanced LIGO gravitational wave detector are degraded by absorption-induced wavefront distortion. We describe the use of ultra-sensitive Hartmann wavefront sensors to tune detector operation and optimize sensitivity.

SW3N • Few-cycle Sources—Continued

SW3N.5 • 14:00
Greater than 50x solid-state compression of 1030 nm Yb-based laser pulses to single-cycle duration, Chih-Hsuan Lu 1,2, Wei-Hsin Wu 1,2, Shiang-He Kuo 1,2, Ming-Chang Chen 1,2, A. H. Kung 1,2; 1National Tsing Hua Univ., Taiwan; 2Inst. of Atomic and Molecular Sciences, Academia Sinica, Taiwan. 170 fs pulses of a 1030 nm Yb-based laser system has been compressed to 3.1 fs at below a single carrier cycle following spectral broadening in a two-stage multiple thin plates arrangement.

SW3N.6 • 14:30
Near single-cycle laser pulses at high average power and high repetition rate from an all-solid-state setup, Tobias Wittig 1, Chih-Hsuan Lu 1,2, Federico J. Funch 1, A. H. Kung 1,2, Marc J. Vrakking 1; 1Max-Born-Inst., Germany; 2Inst. of Photonics Technologies, Taiwan; 3Inst. of Atomic and Molecular Sciences, Academia Sinica, Taiwan. We demonstrate pulse compression of a high average power 100 kHz NOPCPA laser system with an all solid state setup. Using multiple thin quartz plates we achieve near-single cycle pulses with an average power of over 10 W with excellent long term power and CEP stability.

Progress Toward Stationary Concentrator Photovoltaics, Peter Kozodoy 1, John Lloyd 1, Michael Pavilonis 1, Chadwick Casper 1, Kevin Schneider 1, William McMahan 1, Christopher Gladden 1, Glint Photonics, Inc., USA; 2National Renewable Energy Lab, USA. We present an overview of our research on stationary high-concentration photovoltaic panels with internal micro-tracking. Utilizing multijunction cells, these modules offer the potential for high energy production per unit area at low cost.

SW3N.7 • 14:45
Amplification of Incoherent and Coherently Coupled Higher Order Modes in a HO:YAG Single Crystal Fiber, Yuan Li 1,2, Wenhe Li 1,2, Keith Miller 1,2, Eric. G. Johnson 1, Subhabrata Bera 1, Craig Niel 1, James A. Harrington 1; 1Clemson Univ., SC; 2Rutgers Univ., USA. The simultaneous excitation and coherent mode combing of two higher order modes (HOMs) are demonstrated in a Ho:YAG single crystal fiber (SCF) amplifier for both incoherent and coherent mode combing.

Experimental Demonstration of 28.2% Thermophotovoltaic Conversion Efficiency, Zunaid Omair 1,2, Gregg Scarton 1,2, Luis Pazos-Outon 1,2, Myles Steiner 1,2, Per Peterson 1,2, John Holzrichter 1,2, Eli Yablonovitch 1,2; 1Electrical Engineering and Computer Science, Univ. of California at Berkeley, USA; 2Materials Science Division, Lawrence Berkeley National Lab, USA; 3Nuclear Engineering, Univ. of California at Berkeley, USA; 4Physical Insight Associates, USA. Efficient luminescence extraction enables us to use the photovoltaic band gap as the spectral filter for thermophotovoltaics. Using this concept, we demonstrate a 28.2% conversion efficiency, higher than the previously reported value for the range of the emitter temperature (700°C - 1250°C) used.

15:00-17:00 Coffee Break & Exhibit Only Time, Exhibit Hall
Simultaneous Multi-Channel AOSLO Imaging for Visualizing Inner Retina Structures, Nicusor Iftimia1, R. Daniel Ferguson1; Caltrans Sciences Inc., USA.

SW3Q.4 • 14:00
Ill-V-on-Silicon Filtered Feedback Discretely Tunable Laser with Nanosecond Switching Times, Sören Dhöre1,2, Abdulrahim Halimi1, Gunther Roelkens3, Geert Mathijs5; 1Photronics Research Group, Belgium; 2Center for Nanophotonics, Belgium. We demonstrate nanosecond fast wavelength switching with a high-numerically integrated four-channel filtered feedback tunable laser. High-speed direct modulation at 12.5 Gbit/s of each wavelength channel is achieved.

SW3Q.5 • 14:15
Electrically Pumped Hybrid III-V/Si Photonic Crystal Surface Emitting Lasers with Buried Tunnel-Junction, Shih-Chia Lii1, Deyn Zhao1, Carl Reutenskild-Hedlund2, Mattias Hammar3, Werdong Zhou1; 1Univ. of Texas at Arlington, USA; 2Dept. of Electronics, KTH-Royal Inst. of Technology, Sweden. We report here an electrically pumped hybrid III-V/Si photonic crystal surface emitting laser (PCSEL) on silicon with a buried tunnel-junction (BTJ). RT CW single mode operation was achieved at 1504 nm for a 80x80 μm2 laser.

SW3Q.6 • 14:30
An MMI-based Tunable Laser for Integrated Photonic Circuits, Ludovic Caro1,2, Mohamad Demaniak1, Frank Peters1,2; 1Tyndall National Inst., Ireland; 2Dept. of Electronic Engineering, Univ. College Cork, Ireland. A single mode, tunable semiconductor laser is presented for the L band. This faceless, regrowth-free laser shows a tuning range extending from 1564 nm to 1611 nm, with side-mode suppression ratio values over 30 dB.

SW3Q.7 • 14:45
Tunable self-injected Fabry-Perot laser diode coupled to an external high-Q SiN/SiO2 micro-ring resonator, Yu Li1, Yuanjue Zhang1, Minghua Chen1, Hongwei Chen1, Sigang Yang2; 1Tsinghua Univ., China; 2PolySense Lab - Univ. and Politecnico of Bari, Italy. We demonstrate a self-injection locking of Fabry-Perot laser diode with narrow linewidth of 8 kHz. The laser has output power of 7 dBm and SMSR of 45 dB with wavelength switchable range of 17 nm.

15:00–17:00 Coffee Break & Exhibit Only Time, Exhibit Hall

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Wednesday, 17:00–19:00

**SW4A • High-Q Microcavities**
*Presider: Zhihong Huang; Hewlett Packard Labs, USA*

**SW4A.1 • 17:00**
Achieving Topological Photonics in a Synthetic Space with Dynamically Modulated Ring Resonators, Luqi Yuan1, Meng Xiao1, Qian Lin1, Shanhui Fan1; 1Stanford Univ., USA. We implement the two-dimensional Haldane model in the synthetic frequency space in a system composed of several ring resonators undergoing dynamic modulation. It provides a route towards nonreciprocal topological photonics in a miniaturized structure.

**SW4A.2 • 17:15**
High Q Integrated Photonic Microresonators on 3C SiC-on-Insulator Platform, Tianren Fan1, Xi Wu1, Ali Aqhar Eftekhar1, Ali Adibi1; 1Georgia Inst. of Technology, USA. We report for the first time the fabrication of high-Q SiC resonators on a 3C SiC-on-insulator platform (with no undercutting) formed using direct wafer bonding. We demonstrate Q of 42,000 for a 20 μm radius microcylinder resonator with a great potential for higher Qs by chemical-mechanical polishing.

**SW4A.3 • 17:30**
Measurements of Thermodynamical Noise and Drift in Mesoscale Cavities with Quality Factors in Excess of 1 Billion, J. Lin1, A. Avchenkov1, L. Liang1, W. Wang1, A. Matsko1, L. Maleki1, C. W. Wong1; 1OxideMEMS and Quantum Electronics Laboratory, University of California, USA; 2Qwaves Inc., USA. We describe the measured noise and drift characteristics of ultrahigh-Q microcavities stabilized at the thermodynamical limits, achieving a sub-25-Hz linewidth and 32-Hz Allan deviation. Random-walk noise statistics, along with cross-polarization mode temporal correlations, are demonstrated.

**SW4A.4 • 17:45**
OpenFlow-Control of an OAM-Based Two-Layer Switch Supporting 100Gb/s Real Data-Traffic, Mirco Scaffardi1, Muhammad Malik1, Francesco Paolucci2, Emma Lazzeri2, Andrea Sgambelluri2, Martin Lavery3, Filippo Cugini1, Marc Sorel1, Antonella Boggio1, 1CNR-IT, Italy; 2Scuola Superiore Sant’Anna, Italy; 3Univ. of Glasgow, UK. A two-layer orbital angular momentum and wavelength based switch is presented and characterized up to 100Gb/s with coherent polarization-multiplexed real data traffic. The switch is successfully reconfigured by applying an OpenFlow-based SDN control plane.

**SW4B • Nitride-based Integrated Photonics**
*Presider: Weidong Zhou; Univ. of Texas at Arlington, USA*

**SW4B.1 • 17:00**
Invited
Ill-Nitride Integrated Photonics: Prospects and Challenges, Mohammad Soltani1; 1Raytheon BBN Technologies, USA. An integrated photonic platform made of III-Nitrides with their wide bandgap and unique optical/electronic properties enables promising applications over a broad spectral range from ultraviolet to infrared. We review the progress/challenges of developing such platforms.

**SW4B.2 • 17:15**
On-Chip Switching of Mode- and Polarization-Multiplexed Signals with a 748-Gb/s/λ (8 × 93.5-Gb/s) Capacity, Qingming Zhu1, Yong Zhang1, Yu He1; 1Shanghai Jiao Tong Univ., China. We experimentally demonstrate an on-chip optical switching scheme for mode- and polarization-multiplexed signals. A quadrupled switching capacity of 748 Gb/s/λ is achieved by routing eight 93.5-Gb/s data channels on two modes and two polarizations.

**SW4B.3 • 17:30**
Narrow-linewidth, tunable external cavity diode lasers through hybrid integration of quantum-well/quantum-dot SOAs with Si,N microcavities, Yuyu Zhu1, Siwei Zeng1, Xiaolei Zhao1, Yunsong Zhao1, Lin Zhu1; 1Clemson Univ., USA. We demonstrate hybridly integrated narrow-linewidth, tunable diode lasers via edge coupling. The silicon nitride photonic integrated circuit performs as the tunable external cavity, whereas the gain medium is provided by a quantum-well/quantum-dot semiconductor optical amplifier.

**SW4B.4 • 17:45**
Experimental Demonstration of 64-Port Thin-CLOS Architecture for All-to-All Optical Interconnects, Xian Xiao1, Roberto Proietti1, Kaiqi Zhang1, Yong Zhang1, Yu He1; 1Shanghai Jiao Tong Univ., China. We designed, assembled, and experimentally demonstrated a 64-port wavelength-routing Thin-CLOS system in a 1U rack using four 32×32 AWGRs. BER measurements show error-free performance under the worst-case intra-band crosstalk scenario.

**SW4C • Optical Switching**
*Presider: David Geisler; Massachusetts Inst of Tech Lincoln Lab, USA*

**SW4C.1 • 17:00**
Hybrid Flow Switched Network with an Arbitrarily Reconfigurable Optical Switch, Gregory Steinbrecher1,2, Vincent W. Chan1, Dirk Englund1, Scott A. Hamilton1; 1MIT, USA; 2MIT Lincoln Lab, USA. We present a hybrid network based on an integrated photonic switch capable of arbitrary single- and multi-cast transformations. We show bandwidth and latency improvements in a multi-switch network under load from one to several flows.

**SW4C.2 • 17:15**
Wide bandgap and unique optical/electronic properties of high-Q SiC resonators on a 3C SiC-on-insulator platform enable promising applications over a broad spectral range from ultraviolet to infrared.

**SW4C.3 • 17:30**
OpenFlow-based SDN control plane.
17:00–19:00

**SW4D • Novel THz Techniques**

**Presider:** Ben Ofori-Okai; SLAC National Accelerator Lab, USA

**Invited: THz silicon systems on chip: A Moore-Maxwell Approach,** Kaushik Sengupta1; Princeton Univ., USA. In this talk, we will highlight new design methodologies to enable future chip-scale THz architectures in silicon that are multi-functional, programmable and can enable efficient THz technology diversity of applications in sensing, imaging and communication.

1Princeton Univ., USA.

**Temperature. We demonstrated double-sideband noise downconverters to offer quantum-level sensitivity at room spectrometers that use plasmonic photomixers as frequency converters.** We demonstrate a new class of terahertz systems on chip combining the robustness of semi-conductor technology with the unique characteristics of plasmonics for THz technology.

1Princeton Univ., USA; 2Univ. of Utah, USA.

**Metasurfaces, Shaping Terahertz Beams with High-efficiency All-dielectric Apertures**, Cheng Zhang 1, Ashish Chanana 2, Wenqi Zhao 1, Henri Leece 1, Ajay Nahata 1, Amit K. Agrawal 1; NIST, USA; 2Univ. of Utah, USA. We demonstrate a high-efficiency (>70%) all-dielectric Terahertz metasurfaces operating in the transmission mode. Example devices include high-numerical-aperture (NA=0.9) meta-lenses as well as cylindrical vector beam generators.

1Princeton Univ., USA; 2MIT, USA.

**FW4E • Quantum and Nonlinear Phenomena**

**Presider:** Roberto Morandotti; INRS-Energie Mat & Tele Site Varennes, Canada

**Invited: High-efficiency Broadband Single-photon Frequency Upconversion**, Hiroaki Miura 1, Ayman Abouraddy 1, Kimihiro Cuoco 1, Wenguo Wang 1, 2; 1Univ. of California at Urbana-Champaign, USA; 2CREOL, Florida State University, USA. We demonstrate that frequency up-conversion of single photons is possible using a broad bandwidth laser.

1Univ. of California Los Angeles, USA; 2Univ. of California at Los Angeles, USA.

**FW4E.2 • 17:15**

**Experimental Demonstration of an Optical-Coherence Converter**, Chukwuemeka Ikoro 1, Hasan E. Kondacki 1, Ayman Abouraddy 1, Kimihiro Cuoco 1; 1Univ. of Illinois at Urbana-Champaign, USA; 2CREOL, The College of Optics & Photonics, USA. By treating coherence as a shareable resource between multiple degrees of freedom (DoFs), we experimentally demonstrate a reversible exchange of coherence between polarization and spatial DoFs using only unitary transformations.

1Princeton Univ., USA.

**FW4E.3 • 17:30**

**Single Photon Quantum Frequency Conversion as Tool for Quantum Networks**, Christoph Becker 1,2; Fachbereich Physik, Universität des Saarlandes, Germany. We demonstrate that quantum frequency down-conversion of single photons can be used to interface stationary quantum bits with telecom photons. The preservation of polarization-entanglement and indistinguishability allows for connecting quantum bits across a quantum network.

1Fachbereich Physik, Universität des Saarlandes, Germany; 2Duisburg-Essen University, Germany.

**FW4E.4 • 17:45**

**High-dimensional Entanglement Distribution and Einstein-Podolsky-Rosen Steering Over Deployed Fiber**, Catherine Lee 1, Darius Bunandar 1, Margaret Pavlovich 1, Matthew E. Green 1, Ryan Murphy 1, Scott A. Hamilton 1, Dr. Englund 1; 1Lincoln Lab, USA; 2MIT, USA. We demonstrate the generation of high-dimensional time-frequency entangled photon pairs states and the preservation of entanglement after transmission across a 42-km telecom fiber by violating a high-dimensional Einstein-Podolsky-Rosen steering inequality.

1Lincoln Lab, USA; 2MIT, USA.
FW4G.1 • 17:00
Self-aligned Fabrication of Microscale Electron Column Array using Plasmonic Enhanced Photoemission, Zhidong Du1, Ye Wen1, Liang Pan1; Purdue Univ., USA. Microcolumns are important for parallel electron-beam lithography because of their compactness. A large array of electrostatic microcolumns is numerically optimized for our recent surface plasmon enhanced photoemission sources and demonstrated using a self-aligned fabrication process.

FW4G.2 • 17:15
Fundamental limits on spontaneous emission and energy loss of free electrons, Yi Yang1, Aviram Massuda1, Charles Roques-Carmes1, Steven E. Koo1, Thomas Christensen1, Steven Johnson1, John Joannopoulos1, Owen Miller1, Ido Kaminer1, Marin Soljacic1; MIT, USA; Yale Univ., USA. We derive and experimentally validate limits of electron radiation and energy loss. We show slow electrons generate stronger radiation than relativistic ones at subwavelength separations and bound states in the continuum enable order-of-magnitude radiation enhancement.

FW4G.3 • 17:30
The Role of Surface Roughness in Plasmonically Assisted Internal Photoemission Schottky Photodetectors, Mer Y. Grayer1, Urie Levy1, Jacob Khurgin1; Dept. of Applied Physics, The Benin School of Engineering and Computer Science, The Center for Nanoscience and Nanotechnolgy, Hebrew Univ. of Jerusalem, Israel; Dept. of Electrical and Computer Engineering, Johns Hopkins Univ., USA. We describe the positive roll of roughness in enhancing the efficiency of internal photoemission. We show that roughness provides momentum relaxation enabling the transmission of energetic electrons through the Schottky barrier without metal and silicon.

FW4G.4 • 17:45
Large radiative emission rate of deep ultraviolet emitter with hyperbolic metamaterial structure, Kun-Ching Shen1,2, Chieh Hsieh1, Yuh-Jen Cheng1, Din Ping Tsai1,2; Academia Sinica, Research Center for Applied Sciences, Taiwan; National Taiwan Univ., Taiwan. A large radiative emission rate of ultraviolet emitter with hyperbolic metamaterials was demonstrated, where a hybridized plasmon coupling is formed and provides a new path of the photon and thus boosts the radiative rate.

FW4H.1 • 17:00
Manipulating Smith-Purcell Radiation Polarization with Metasurfaces, Yujia Yang1, Charles Roques-Carmes1, Ido Kaminer1, Aun Zaidi1, Aviram Massuda1, Yi Yang1, Steven E. Koo1, Karl K. Berggren1, Marin Soljacic1; MIT, USA. Swift electrons moving closely to a periodic structure can generate far-field radiation. The radiated light is usually polarized in the direction of electron propagation. We have demonstrated manipulation of this polarization with properly designed metasurfaces.

FW4H.2 • 17:15
Vortex radiation from a single emitter, Renmin Ma1; Peking Univ., China. We propose a metamaterial engineered chiral plasmonic nanocavity (CPN) that, for the first time to our knowledge, can twist single emitter radiation to vortex beams with controllable topological charge.

FW4H.3 • 17:30
Spectral and spatial shaping of Smith-Purcell radiation, Roei Remes1, Nav Shapiro1, Charles Roques-Carmes1, Ronan Tirole1, Yi Yang1, Yossi Lerea1, Marin Soljacic1, Ido Kaminer1; School of Electrical Engineering, Fieschman Faculty of Engineering, Tel Aviv Univ., Israel; Research Lab of Electronics, MIT, USA; Dept. of Physics, Faculty of Natural Sciences, Imperial College London, UK; Dept. of Electrical Engineering, Technion-Israel Inst. of Technology, Israel. The Smith-Purcell effect is observed when an electron beam passes in the vicinity of a periodic structure. We propose a method to shape the spatial and spectral far-field radiation using complex periodic and aperiodic gratings.

FW4H.4 • 17:45
Strong Coupling of Dye Molecules and Cavities: Beyond First Excited State Resonances, Zengliuiong.1, Erin Harrison1,2, Cansu On1, Mikhail A. Noginov1; Center of Materials Research, Norfolk State Univ., USA; Dept. of Psychology and Brain Science, Univ. of Delaware, USA; Center of Materials Research, Summer Research Program, Norfolk State Univ., USA. In example of Fabry-Perot cavities filled with dye molecules, we studied a range of strong coupling phenomena in complex systems with multiple excitation and optical resonances, bringing applications of these exciting systems one step closer.

FW4I.1 • 17:00
Invited
Monolithic Integration of 1.3 μm III-V Quantum-Dot Lasers on Si for Si Photonics, Huyun Liu1; Univ. College London, UK. Quantum-dot (QD) lasers directly grown on Si are the prospective candidate to realize on-chip optical sources for Si photonics. In this paper, the recent progress made in field of Si-based QDs lasers are discussed.

FW4I.2 • 17:30
A Deuterium-Passivated Amorphous Silicon Platform for Stable Integrated Nonlinear Optics, Peter Giroudard1, Lars H. Frandsen1, Michael Galili1, Leif K. Oxenlowe1; DTU Fotonik, Denmark. We report a method to create amorphous silicon waveguides passivated with deuterium and demonstrate stability under moderate continuous-wave power. The waveguides have nonlinear properties comparable to hydrogenated amorphous silicon.

FW4I.3 • 17:45
Gain Characterization and Parameter Extraction of 1.3 μm InAs Quantum Dot Lasers on Silicon, Zeyu Zhang1, Daehwan Jung1, Justin Norman1, Pari Patel1, Arthur Gossard1, John E. Bowers1; UCSB, USA. We report the current and wavelength dependence of gain and transparency current for a variety of quantum dot laser structures. The dependence on number of quantum dot layers and templates for growth are reported.
Longitudinal Intravital Multi-Photon Imaging of the Femoral Marrow Based on an Implanted GRIN Microendoscope, Raluca Niesner1,2, DRFZ, Berlin, Germany. The development of mechno-optical systems which enable highly resolved, dynamic imaging of the bone marrow of long bones is mandatory to understand patho-physiologic phenomena within this important organ. Here we present a longitudinal intravital microendoscopical technology based on GRIN optics to image one and the same region of the mouse femoral bone marrow over up to 158 days.

Femtosecond Laser Pulse Generation from Picosecond Laser Source with Self-Similar Amplification, Huanyu Song1, Wei Chen2, Youjuan Song2, Minglie Hu2, Bowen Liu1, Tianjin Univ., China. We demonstrated femtosecond laser pulse generation from a self-similar amplifier with picosecond laser which delivers ~8-ps pulses with ~0.9-nm bandwidth. The system outputs 87-fs pulses at 30-MHz repetition rate with 4.5-W average power.

Generation of Wavelength-Tunable Picosecond Pulses with Polarization-Maintaining Yb Figure-Nine Laser for Stimulated Raman Scattering Microscopy, Takuya Asai1, Hironobu Yoshimi1, Jingwen Shou1, Toshiro Fujita1, Yasuyuki Ozeki1, The Univ. of Tokyo, Japan. We present an environmentally stable, high-speed wavelength-tunable laser system with a tunability of >280 cm−1. This laser is synchronized to a picosecond Ti:sapphire laser to demonstrate video-rate hyperspectral stimulated Raman imaging of polymer beads.

Nonlinear Characterization of a Kilowatt-class Amplifier Based on Laser Gain Competition, Brian Anderson1, Nader A. Naderi1, Angel Flores1, AFRL, USA. The scalability of dual wavelength laser gain competition for the design of beam combinable, high power fiber amplifiers is analyzed by characterizing the nonlinear phase accumulated due to self and cross-phase modulation.

Stimulated emission depletion microscopy with polarization-maintaining fiber, Brenda M. Heffernan1, Stephanie A. Meyer1, Diego Restrepo2, Mark E. Siemens1, Emily A. Gibson1, Juliet Ganapathi1, Univ. of Colorado, Boulder, USA; 2Bioengineering, Univ. of colorado, denver, USA; 3Electrical, Computer, and Energy Engineering, Univ. of colorado, Boulder, USA; 4Physics and Astronomy, Denver Univ., USA; 5Cell and Developmental Biology, Univ. of colorado, denver, USA. Sub-diffraction limited fluorescent images using a fiber-based stimulated emission depletion (STED) microscope are reported. Both excitation and depletion beams are transported through polarization-maintaining fiber and a lateral resolution of 100nm has been achieved.

Cladding-Pumped Hybrid Single- and Higher-Order-Mode (HOM) Amplifier, Kazi S. Abedin1, Raja Ahmad2, Anthony DeSantolo1, Jeffrey Nicholson1, Paul Westbrook1, Clifford Headley1, David DiGravina1, OFS Labs, USA. We demonstrate a cladding-pumped hybrid-amplifier for low-power input seed-signals, by concatenating single-mode and HOM Yb-fibers. An 115mW average-power pulsed-source (8ns, 250Hz) was amplified to 52W output, using a 120W, 975nm multimode-pump, yielding 57% slope-efficiency.

Hybrid dual comb spectroscopy with largely dissimilar FSR, Hao Liu1, 2Shu-Wei Huang1, 2, Jinghui Yang1, 2, Mingbin Yu1, 2Dim-Lim Kwong1, 2, Chee-Wei Wong2, 1UCLA, USA; 3Univ. of Colorado, Boulder, USA; 4The Inst. of Microelectronics, Singapore. We report a novel hybrid dual comb by combining two frequency combs with 19.5GHz and 250MHz repetition rates, respectively, which retains high spectral resolution and large spectral range simultaneously, proved by preliminary characterizations.
Deterministic single soliton generation via mode-interaction in microresonators

E. Leaird1, Stefan Wabnitz2, Minghao Qi1, Andrew M. Weiner1


deterministically excited thermally self-stabilized dissipative Kerr soliton in a microresonator using an energetic trigger pulse. The soliton automatically balances the thermal perturbation and is stabilized without any active thermal compensation.

Thermally self-stabilized single dissipative Kerr soliton in optical microresonator

Zhe Kang1, Feng Li 1, Jinhui Yuan1, Xianting Zhang1, P. K. A. Wai1, Hong Kong Polytechnic Univ., Hong Kong. We deterministically excited thermally self-stabilized dissipative Kerr soliton in a microresonator

We show that a strong mode-interaction in microcavities can trigger single soliton Kerr combs deterministically. The soliton number tends to be reduced to 1 to decrease the nonlinear loss into mode-interaction induced Cherenkov radiation.

SW4M.1 • 17:00
Soliton Microcombs at Gigahertz-Repetition-Rates, Myoung-Gyun Su1, Kerry Vahala1, 1California Inst. of Technology, USA. Soliton microcombs with repetition rates as low as 1.86 GHz are demonstrated. Low repetition rate frequency combs are important in spectroscopy and relax requirements on comb processing electronics.

We demonstrate frequency-doubling of an amplified femtosecond laser with electric-field induced second-harmonic generation in air. The method promises application with unattenuated terawatt lasers and offers wavelength conversion beyond the ultraviolet limit of nonlinear crystals.

Phase-Lock in Four-Wave Raman Mixing in the Ultraviolet Region, Yoshifumi Mor1, Totoaro Imasaka1, Kyushu Univ., Japan. Raman emissions generated by four-wave mixing in hydrogen were coherently phased against the probe beam emitting at 267 nm by molecular phase modulation induced by a two-color pump beam emitting at 800/1200 nm.

SW4N.1 • 17:00

Demonstration of Subluminal and Superluminal Group Velocities of Diffraction-Free Space-Time Light Sheets in Free Space, Hasan E. Kondakci1, Ayman Abouraddy1, 1Dept. of Physics, Cornell Univ., USA. We report on an experimental study to control the group velocity of diffraction-free space-time light sheets propagating in free space. We demonstrate pulsed light sheets with speeds exceeding 30c and going below 0.5c. We also show space-time light sheets with negative group velocity.

Phase-Locking in Four-Wave Mixing in the Ultraviolet Region, Yoshifumi Mor1, Totoaro Imasaka1, Kyushu Univ., Japan. Raman emissions generated by four-wave mixing in hydrogen were coherently phased against the probe beam emitting at 267 nm by molecular phase modulation induced by a two-color pump beam emitting at 800/1200 nm.

Electric-field induced second-harmonic generation of femtosecond laser pulses in atmospheric air, Gunter Steinmeyer1, 1Max Born Inst., Germany; 2Inst. of Physics, Humboldt-Universität, Germany. We demonstrate frequency-doubling of an amplified femtosecond laser with electric-field induced second-harmonic generation in air. The method promises application with unattenuated terawatt lasers and offers wavelength conversion beyond the ultraviolet limit of nonlinear crystals.

SW4N.2 • 17:30

On-Chip Kerr Frequency Comb Generation in Lithium Niobate Microresonators, Chengyung Bao1, Yi Xuan1, Daniel E. Leaird1, Stefan Wabnitz2, Minghao Qi1, Andrew M. Weiner1, 1Purdue Univ., USA; 2Università di Brescia and INO-CNR, Italy. We show that a strong mode-interaction in microcavities can trigger single soliton Kerr combs deterministically. The soliton number tends to be reduced to 1 to decrease the nonlinear loss into mode-interaction induced Cherenkov radiation.

AW4O.3 • 17:30

Beam Quality Factor Analysis of On-Wafer Vertical Cavity Surface Emitting Lasers, Kirk A. Ingold1, Joshua Tate1, Joshua B. Groen1, Brian Souhan1, James Raftery1, 1Photonics Research Center, USA Military Academy, USA. We report on a method for analyzing the beam quality factor of on-wafer vertical cavity surface emitting lasers (VCSEL) leading to an M2 min-max for each measured device due to asymmetry in the beam profile.

Surface Emitting Lasers, Kirk A. Ingold1, Joshua Tate1, Joshua B. Groen1, Brian Souhan1, James Raftery1, 1Photonics Research Center, USA Military Academy, USA. We report on a method for analyzing the beam quality factor of on-wafer vertical cavity surface emitting lasers (VCSEL) leading to an M2 min-max for each measured device due to asymmetry in the beam profile.

SW4N.2 • 17:30

Demonstration of Subluminal and Superluminal Group Velocities of Diffraction-Free Space-Time Light Sheets in Free Space, Hasan E. Kondakci1, Ayman Abouraddy1, 1CREOL, Univ. of Central Florida, USA. We report on an experimental study to control the group velocity of diffraction-free space-time light sheets propagating in free space. We demonstrate pulsed light sheets with speeds exceeding 30c and going below 0.5c. We also show space-time light sheets with negative group velocity.

Multiplexed Two-color Phase-and-amplitude Characterization of Harmonic Up-conversion in OAM Beams using Ptychography, Yuka Esashi1, Bin Wang1, Nathan Brooks2, Kevin Dorney1, Chen-Ting Liao1, Carlos Hernandez-Garcia1, Henry Kapteyn1, Daniel Adams1, Margaret Munner1, 1Univ. of Colorado at Boulder, USA; 2Universidad de Salamanca, Spain. We present high-resolution, simultaneous two-color phase-and-amplitude characterization of 2nd harmonic up-conversion in OAM beams by ptychography. We measure topological charge conservation during 2nd harmonic generation process, which can be extended to high-order harmonic upconversion.

SW4N.3 • 17:45

Demonstration of Subluminal and Superluminal Group Velocities of Diffraction-Free Space-Time Light Sheets in Free Space, Hasan E. Kondakci1, Ayman Abouraddy1, 1CREOL, Univ. of Central Florida, USA. We report on an experimental study to control the group velocity of diffraction-free space-time light sheets propagating in free space. We demonstrate pulsed light sheets with speeds exceeding 30c and going below 0.5c. We also show space-time light sheets with negative group velocity.

AW4O.2 • 17:45

Polarimetry Using Graphene-Integrated Anisotropic Metasurface, Minwoo Jung1, Shourya Dutta-Gupta1, Geninady Shevets1, 1Dept. of Physics, Cornell Univ., USA; 2Materials Science and Metallurgical Engineering, Indian Institute of Technology Hyderabad, India. We have demonstrated polarimetry using an anisotropic metasurface on gate-tunable monolayer graphene as an electro-optic modulator. Operating by electric gate-tuning, our device measures polarization ellipse of mid-infrared light and successfully distinguishes two circular polarization states.

SW4N.4 • 17:45

Polarimetry Using Graphene-Integrated Anisotropic Metasurface, Minwoo Jung1, Shourya Dutta-Gupta1, Geninady Shevets1, 1Dept. of Physics, Cornell Univ., USA; 2Materials Science and Metallurgical Engineering, Indian Institute of Technology Hyderabad, India. We have demonstrated polarimetry using an anisotropic metasurface on gate-tunable monolayer graphene as an electro-optic modulator. Operating by electric gate-tuning, our device measures polarization ellipse of mid-infrared light and successfully distinguishes two circular polarization states.

Myoung-Gyun Suh1, Kerry Vahala1, 1California Inst. of Technology, USA. Soliton microcombs with repetition rates as low as 1.86 GHz are demonstrated. Low repetition rate frequency combs are important in spectroscopy and relax requirements on comb processing electronics.

SW4M.2 • 17:15

Deterministic single soliton generation via mode-interaction in microresonators, Chengyung Bao1, Yi Xuan1, Daniel E. Leaird1, Stefan Wabnitz2, Minghao Qi1, Andrew M. Weiner1, 1Purdue Univ., USA; 2Università di Brescia and INO-CNR, Italy.

AW4O.1 • 17:00

Process-oriented adaptive optics control method in the multi-pass amplifiers, Qiao Xue1, 1Research Center of Laser Fusion, China. We propose and demonstrate the process-oriented adaptive optics wavefront control method. The experiments validate that the novel approach can effectively prevent the beam quality from worsening and ensure the successful reality of multi-pass amplification.

SW4M.3 • 17:30

On-Chip Kerr Frequency Comb Generation in Lithium Niobate Microresonators, Chengyung Bao1, Mian Zhang1, Rongrong Zhu1, Hui Hu1, Hongsheng Chen1, Marko Loncar1, 1Harvard Univ., USA; 2Zhejiang Univ., China. We demonstrate Kerr frequency comb generation in high quality factor, dispersion engineered lithium niobate microresonators. The generated combs span over 250 nm in the telecommunication wavelength range.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

Marriott
Salon VI

17:00–19:00

JW4P • Symposium on New Advances in Adaptive Optics Retinal Imaging II
Presider: TBD

JW4P.1 • 17:00 Invited
Adaptive Optics Scanning Laser Ophthalmoscopy in Retinal Degenerations: New Insights in Structure and Function, Jacque Duncan1; 1Ophthalmology, Univ. of California San Francisco, USA. Retinal degenerations cause progressive death of photoreceptors. Imaging photoreceptors in eyes with retinal degeneration yields insights into how genetic mutations affect photoreceptor structure and function. High-resolution images can provide sensitive measures of photoreceptor survival.

JW4P.2 • 17:45 Invited
Progress on functional retinal imaging with OCT: recent advancements in measurements and modeling of photoreceptor optophysiology, Robert J. Zawadzki1,2; 1Ophthalmology & Vision Science, Univ. of California Davis, USA; 2Cell Biology and Human Anatomy, Univ. of California Davis, USA. I will review recent advances in the development of Optical Coherence Tomography based retinal imaging systems in the context of its applications to study light-induced functional responses of the retina.

Marriott
Willow Glen

CLEO: Science & Innovations

17:00–19:00

SW4Q • Novel Semiconductor Emitters
Presider: Qing Gu; The Univ. of Texas at Dallas, USA

SW4Q.1 • 17:00
Demonstration of Electrically Injected Parity-Time-Symmetric Microring Lasers, William Hayenga1, Enrique Sanchez Cristobal1, Hipolito Garcia-Graica1, Midya Parto1, Hossein Hodaie1, Jinhan Ren1, Patrick LiKamWa1, Demetrios N. Christodoulides1, Mercedes Kajavikhan1; 1Univ. of Central Florida, CREOL, USA. Single-mode lasing is demonstrated in an electrically injected coupled microring arrangement at telecommunication wavelengths by exploiting the unique physics associated with parity-time-symmetry.

SW4Q.2 • 17:15
Electro-Optical Bistability in Semiconductor Laser, Curtis Wang1, Milton Feng1, Nick Holonyak, Jr.1; 1Electrical Engineering, Univ. of Illinois at Urbana-Champaign, USA. Optical bistability in a single semiconductor transistor laser are realized and demonstrated based on the modulation of cavity photon density via the base quantum-wells for photon-generation and collector intra-cavity photon assisted tunneling for photon-absorption.

SW4Q.3 • 17:30 Invited
Optimized photonics: from on-chip nonclassical light sources to circuits, Jelena Vuckovic1; 1Stanford Univ., USA. Quantum emitters in semiconductors, such as quantum dots and color centers, have been used to demonstrate nonclassical light sources with high purity, indistinguishability, and efficiency. Further improvements can be achieved by employing photonics optimization techniques.
<table>
<thead>
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<th>Time</th>
<th>Session</th>
<th>Details</th>
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<tr>
<td>18:00</td>
<td>SW4A.4 • High-Q Microcavities—Continued</td>
<td>High Q AlGaAs-On-Sapphire Microresonators, Yi Zheng1, Minhao Pu1, Hitesh K. Sahoo1, Elizaveta Semenova1, Kresten Yvind1, 1Technical Univ. of Denmark, Denmark. We demonstrate an AlGaAs-on-sapphire (AlGaAsOS) microresonator with intrinsic quality factor (Q) as high as 460,000 and investigate the thermal property of this platform. The realization of the AlGaAsOS platform opens new prospects for AlGaAs devices applications in the mid-infrared wavelength range.</td>
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<tr>
<td>18:00</td>
<td>SW4B • Nitride-based Integrated Photonics—Continued</td>
<td>Dispersion Engineering of High-Q Si3N4 Microdisk Resonators, Kaiyi Wu1, Andrew W. Poon1, 1HKUST, Hong Kong. We demonstrate Si3N4 waveguide-coupled microdisk resonators with a loaded Q-factor of 2.4 x 10^11 at 1550 nm. We tailor the cavity dispersion by increasing the Si3N4 microdisk thickness and using a thin oxide cladding.</td>
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<td>18:00</td>
<td>SW4C • Optical Switching—Continued</td>
<td>Optically switched 56 GBd PAM-4 using a hybrid InP-NiP-Triplex integrated tunable laser based on silicon nitride micro-ring resonators, Colm Browning1, Marco Ruffini2, Yi Lin1, Roelof Timens1, Douwe Geuzebroek1, Chris Roeloffzen1, Dimitri Geskus1, Ruud Oldenbeuving1, Rene Heideman1, Youwen Fan1, Klaus Beile1, Liam Barry1, 1Dublin City Univ., Ireland; 2LioniX International, Netherlands; 3Univ. of Twente, Netherlands. Tunable lasers are key elements for switching fabrics in future datacenter networks. Experimental results show transmission of 56 GBd PAM-4 data in a switching environment using an integrated silicon nitride micro-ring resonator based tunable laser.</td>
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<td>18:15</td>
<td>SW4A.5 • Droplet-Induced Optical Resonator in a Silica Microcapillary</td>
<td>Tabassom Hamidfar1, 1, Kris Tokmakov1, Brian Mangani2, Robert Windeler1, Artemy Dmitriev1, 2Daeheil Vitali2, Pablo Bianucci1, Misha Sumetsky3, 3Concordia Univ., Canada; 4Aston Univ., UK; 5OFS Labs, USA; 6Univ. of Birmingham, UK. We show that light circulating in a silica microcapillary can be fully localized by evanescent coupling to a water droplet forming a high Q-factor microresonator. The discovered phenomenon suggests an advanced method for microfluidics sensing.</td>
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<td>18:15</td>
<td>SW4B • Long-Range Static and Dynamic Thermal Crosstalk in Silicon-Nitride (SiN) Photonic Integrated Circuits</td>
<td>Siva Yegannarayanan1, Ryan Moxson1, Cherly Sorace-Agaskar1, Dave Khara1, Paul W. Juodawlkis1, 1Massachusetts Inst of Tech Lincoln Lab, USA. We experimentally investigate long-range (&gt; 1-mm) static and dynamic thermal crosstalk in a silicon-nitride photonic integrated circuit (PIC) platform and identify a thermal crosstalk floor that depends strongly on modulation frequency and buried oxide thickness.</td>
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<td>18:15</td>
<td>SW4C.6 • On-chip 2x2 four-mode global optical mode switch, Ting Zhou1, Lin Yang1, Hao Jia1, Shanglin Yang1, Jianfeng Ding1, Xin Fu1, Lei Zhang1, 1Institute of semiconductor, CAS, China; 2College of Materials Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China. We proposed a general architecture for on-chip global optical mode switching. A silicon thermo-optic 2x2 four-mode optical switch capable of performing the global optical mode switching functionality is experimentally demonstrated.</td>
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<td>18:30</td>
<td>SW4A.6 • Differential Tuning of Coupled SNAP Microresonators on a Capillary Surface</td>
<td>Daeheil Vitali1, 2Daeheil Vitali2, Pablo Bianucci1, Misha Sumetsky1, 1Aston Univ., UK; 2OFS Labs, USA; 3U. S. Army Research Lab, USA. We fabricate two coupled SNAP microresonators on the surface of a capillary fiber and demonstrate fine differential tuning near the resonance anticrossing point by heating with a nonuniformly-etched metal wire positioned inside the capillary.</td>
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<td>18:30</td>
<td>SW4B.6 • High-Quality Hybrid Double-layer-Silicon on Silicon Nitride Platform for Integrated Photonic Applications</td>
<td>Tianren Fan1, Hesam Moradinejad1, Amir H. Hosseini1, Xi Wu1, Ali Asghar Eftekhar1, Ali Adibi1, 1Georgia Inst. of Technology, USA. We demonstrate a hybrid double-layer-crystalline-silicon on silicon nitride platform formed by a two-step of bonding process. We report high Q of 400,000 for a 40 μm radius microresonator in the platform using evanescent coupling between different layers.</td>
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<td>18:45</td>
<td>SW4A.7 • Phase-locked Two-Color Soliton Microcombs</td>
<td>Gregory Molle1, 2Ging Li2, Sangsik Kim2, Kartik Srinivasan1, 1CNST, National Inst. of Standards and Technology, USA; 2Maryland NanoCenter, Univ. of Maryland, USA; 3Dept. of Electrical and Computer Engineering, Texas Tech Univ., USA. We design a dispersion-engineered Si3N4 microresonator to support two-color soliton states. The directly-pumped 1550 nm soliton is phase-locked to a second color whose center wavelength can be tailored between 750 nm to 3000 nm.</td>
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<td>18:45</td>
<td>SW4B.7 • Polarization-Independent Silicon Nitride 3-dB Coupler for Potential Matrix Switches Application</td>
<td>Jijun Feng1, Xiaoyu Potential Matrix Switches Application, Jijun Feng1, Xiaoyu Sun1, Ryoichi Akimoto2, Heping Zeng3; 1Concordia Univ., Canada; 2National Inst. of Advanced Indus. Science and Technology, Japan; 3Univ. of Twente, Netherlands. We experimentally demonstrated with a 580-nm-thick, 700-nm-wide Si3N4 waveguide. By consisting a MZI structure, both TE and TM light can output from the cross port, confirming the polarization-independent performance of the device.</td>
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19:30-20:30 Conference Reception, Grand Ballroom
DIELECTRIC TERAHZT SUPERCAVITIES, HANSONG Q.

Resonances and a giant Goos-Hänchen effect are observed in ultrafast imaging, Universitat Hamburg, Germany. "Imagine Optic, France. The characterization of the wavefront of a white-light supercontinuum generated by sub-picosecond pulses in FAS at 1030 nm shows a good quality and little dependence on the wavelength.

NONLINEAR PHYSICS CENTER, AUSTRALIAN NATIONAL UNIV., AUSTRALIA.

We theoretically and experimentally study the optical properties of a periodic array of thin metal plates. We demonstrate fast differential absorption measurement by using self-frequency-switched double terahertz (THz)-wave pulse with 11-GHz center frequency difference and 200-μs time interval. Our system is capable of detecting the THz-wave differential absorption signal every 20 milliseconds.

DEEPILKA YADAV, WOJCIECH Knap, NYACHESOV POPOV, TAIICHI OTSUI, RIEC, TOHOKU UNIV., JAPAN; LAB CHARLES COULOMB, UNIV. OF MONTPELLIER AND CNRS, FRANCE; KOTENIKOV INST. OF RADIO ENGINEERING AND ELECTRONICS (SARATOV BRANCH), RUSSIAN ACADEMY OF SCIENCES, RUSSIA. THIS PAPER REPORTS ON ROOM-TEMPERATURE FREQUENCY TUNABLE TERAHZT LIGHT AMPLIFICATION BY CURRENT-DRIVEN PLASMON INSTABILITIES IN GRAPHENE. STEPHANE BOUBANGA-TOMBEL, DEEPILKA YADAV, WOJCIECH Knap, NYACHESOV POPOV, TAIICHI OTSUI, RIEC, TOHOKU UNIV., JAPAN; LAB CHARLES COULOMB, UNIV. OF MONTPELLIER AND CNRS, FRANCE; KOTENIKOV INST. OF RADIO ENGINEERING AND ELECTRONICS (SARATOV BRANCH), RUSSIAN ACADEMY OF SCIENCES, RUSSIA. THEORETICAL AND EXPERIMENTAL STUDIES OF NONLINEAR PHENOMENA IN TERAHZT TECHNIQUES.

We theoretically and experimentally study the optical properties of a periodic array of thin metal plates. We demonstrate fast differential absorption measurement by using self-frequency-switched double terahertz (THz)-wave pulse with 11-GHz center frequency difference and 200-μs time interval. Our system is capable of detecting the THz-wave differential absorption signal every 20 milliseconds.

STEPHANE BOUBANGA-TOMBET, INST. FOR QUANTUM SCIENCE AND TECHNOLOGY, UNIV. OF CALGARY, CANADA; NRC-NATIONAL INST. FOR NANOTECHNOLOGY, CANADA; NANOFA, UNIV. OF ALBERTA, CANADA; LEA INSTR., USA. WE INTRODUCE A NANOSCALE CAVITY-OPTOMECHANICAL DEVICE FOR NON-DESTRUCTIVELY MEASURING THE ORBITAL ANGULAR MOMENTUM OF LIGHT (OAM) BY DETECTING TORQUE PRODUCED BY A CHANGE ΔL = 1 IN OAM FROM A BEAM WITH POWER P0 ∼ 2 MW AT T = 4 K.

We theoretically and experimentally study the optical properties of a periodic array of thin metal plates. We demonstrate fast differential absorption measurement by using self-frequency-switched double terahertz (THz)-wave pulse with 11-GHz center frequency difference and 200-μs time interval. Our system is capable of detecting the THz-wave differential absorption signal every 20 milliseconds.
FW4G • Plasmonic-medicine Controlled of Light Emission—Continued

FW4G.5 • 18:00
Plasmon Enhanced Upconversion in Water-Dispersible Metal-Insulator-Metal Nanostructures, Ananda Das1, Chenchen Mao1, Suehyun Cho1, Wounjahng Park1, 1UC Boulder, USA. We present results on enhanced upconversion of NaYF4:Er3+, Yb3+ nanoparticles using a metal-insulator-metal structure that can eventually be dispersed in solution. Enhancement of 1200x in photoluminescence and 3.8x in energy transfer rate is observed.

FW4H • Shaping Emission Using Metasurfaces—Continued

FW4H.5 • 18:00
Optical Power Limiting from Plasmonic Metasurfaces Coupled to Inter subdivbed Transitions, Nishant Nookala1, Peter Chang1, Dimitrios Soumias1, Omri Wolf1, Stephen March1, Seth Bank1, Igal Brener1, Andreas Alu1, Mikhail A. Belkin1; 1Univ. of Texas at Austin, USA; 2Sanda National Labs, USA. We report power limiting metasurfaces based on saturable absorption of the intersubband transition in n-doped multi quantum wells. Experimentally, we note a 20% decrease in reflectivity with an increase of the pump intensity.

FW4H.6 • 18:15
Directional Spontaneous Emission of Dye on Top of Silver Grating Metasurface, Ekembu K. Tanyi1, Soheila Mashhadi1, Sahana Bhattacharyya1, Tal Galfsky1, Vino M. Menon1, Evan Simmons1, Viktor A. Podolskiy1, Mikhail A. Belkin1; 1Center for Materials Research, NSU, USA; 2City College of New York, USA; 3Univ. of Massachusetts, USA. We have observed double crescent patterns in the TE polarized spontaneous emission of rhodamine 6G dye deposited onto silver grating metasurface. It originates from the surface wave characterized by the effective index of refraction n=1.03.

FW4H.7 • 18:30
Graphene Metamaterials for Intense, Tunable and Compact EUV and X-Sources, Andrea Pizzi1, Gilles D. Rosolen2, Liang Wang1; 1Photonics Research Group, Ghent Univ. / IMEC, Belgium; 2Physics and Chemistry of Nanostructures, Ghent Univ., Belgium. We present a bright X-ray source based on free electron-plasmon resonance in graphene metamaterials and metallic surfaces is tentatively explained in terms of the strong exciton-plasmon coupling.

FW4H.8 • 18:45
Modification of Photoluminescence via Strong Coupling of Vibronic Transitions in Organic Molecules to Surface Plasmons, Rahul Deshmukh1,2, Paolo Marques1, Anurag Panda1, Stephen R. Forrest1, Vino M. Menon1; 1City College of New York, USA; 2Physics, The Graduate Center of the City University of New York, USA; 3Univ. of Michigan, USA. We demonstrate redistribution of the spectral intensities of the luminescence associated with different vibronic transitions in organic molecule, Diindenoperylene through strong coupling of excitons to surface plasmons.

FW4I • Silicon Hybrid Integration—Continued

FW4I.3 • 18:00
Seed-Layer Free Cerium-Doped Terbium Iron Garnet on Non-Garnet Substrates for Photonic Isolators, Karthi Srinivasan1, Thomas E. Gage1, Bethanie J. Stadler1; 1Electrical and Computer Engineering, Univ. of Minnesota, USA, 2Chemical Engineering and Materials Science, Univ. of Minnesota, USA. Novel seed-layer free cerium-doped terbium iron garnet with high gyrotropy is grown on non-garnet substrates for integration with photonics integrated circuits, whose performance can be tuned by varying the dopant concentration and annealing parameters.

FW4I.6 • 18:45
O-band and C/L-band emission of InAs QDs monolithically grown on Ge and U-shape Si (001) platform, Ting Wang1; 1Inst. of Physics, CAS, China. Here, the C/L-band light emission (1.53 μm-1.63 μm) of InAs/In0.25Ga0.75As quantum dots (QDs) epitaxially grown on both Ge (001) and on-axis U-shape Si (001) substrates by molecular beam epitaxy are reported.
Adaptively Scanned Compressive Multiphoton Microscopy, Milad Alemohammadi, Jaewook Shin, Mark A. Foster, Johns Hopkins Univ., USA. A depth sectioning, compressive multiphoton microscope based on spatio-temporal focusing of patterned fs-laser pulses has been demonstrated. Adaptive fluorescence sampling is used to achieve random access imaging across a wide field of view.

Electrowetting Prism for Scanning in Two-photon Microscopy, Ommar S. Supekar, Baris N. Ozbay, Mo Zohrabi, Philip D. Nyström, Gregory L. Futa, Diego Restrepo, Emily A. Gibson, Juliet Gapratha, Victor Bright, Dept. of Bioengineering, Univ. of Colorado Anschutz Medical Campus, USA; Dept. of Electrical, Computer, and Energy Engineering, Univ. of Colorado Boulder, USA; Dept. of Cell and Developmental Biology, Univ. of Colorado Anschutz Medical Campus, USA; Dept. of Physics, Univ. of Colorado Boulder, USA. We have demonstrated an electrowetting prism as a lateral scanning element for a 2-photon excitation microscope. We show imaging of mouse hippocampal neurons, with a field of view of $130 \times 130 \mu m^2$.

Three-photon fluorescence microscopic imaging by a compact Er-doped fiber laser at 1.6 µm, Jiqiang Kang, Cheng Kong, Pingping Feng, Can Li, Zhichao Luo, Edmund Y. Lam, Kevin K. Tse, Kenneth Kin-Yip Wong, Univ. of Hong Kong, Hong Kong, South China Normal Univ., China. We report a high energy pulse generation scheme for three-photon fluorescence microscopy (3PM) by leveraging an L-band Er-doped fiber laser and chirped pulse amplifier. 3PM imaging is demonstrated on a mouse kidney slice.

110 W High- Efficiency Er-Nanoparticle-Doped Fiber Laser, Huaqin Lin, Colin Baker, Zhimeng Huang, Shankar Pidishetty, Yutong Feng, E. Joseph Friebele, Ashley Burdett, Dan Rhinohouse, Brandon Shaw, Jas Sanghera, Johan Nilsson, Optoelectronics Research Centre, Univ. of Southampton, UK; Naval Research Lab, USA; KeyW Corp, USA; Univ. Research Foundation, USA. An Er-nanoparticle-doped fiber laser cladding-pumped at 975 nm generates 110 W at 1655 nm with 40.6% slope efficiency and $M^2$=7. High Er-concentration ($\approx 10^5$ ions/m$^3$) and pump brightness allow for adequate pump absorption even without Yb-codoping.

1.3kW Single-mode All-fiber MOPA Based on Low-NA Trench-assisted Ytterbium-doped Fiber, Fangfang Zhang, Yehui Liu, Lei Liao, Yingbin Xing, Jinyan Li, Wuhan National Lab for Optoelectronics (WNLLO), Huazhong Univ. of Science and Technology, China; School of Optical and Electrophotonic Information, Huazhong Univ. of Science and Technology, China. A newly designed and fabricated trench-assisted low-NA(f=0.04) fiber was reported. An output power up to 1.3kW with $M^2$<1.1 was achieved in an all-fiber MOPA based on the fabricated low-NA fiber.

Low-Noise Dual-Comb Platform Based on Mode-Locked Lasers in a Multi-Waveguide Chip, Nicolas Bourbeau Hebert, David Lancaster, George Chen, Jérôme Genest, University of Laval, Canada; University of South Australia, Australia. We demonstrate precision spectroscopy of HCN where successive interferograms were phase-corrected in post-processing, averaged, and normalized to yield the complex transmission spectrum of several transitions within the 2ν, band centered near $\lambda = 1545$ nm.

Free-running, All-fiber Dual Electro-optic Frequency Comb System for the Precision Spectroscopy and Sensing of HCN, Philippe Guay, Jérôme Genest, Adam J. Fleisher, Université Laval, Canada; National Inst. for Standards and Technology, USA. We demonstrate precision spectroscopy of HCN where successive interferograms were phase-corrected in post-processing, averaged, and normalized to yield the complex transmission spectrum of several transitions within the 2ν, band centered near $\lambda = 1545$ nm.

Free-running, All-fiber Dual Electro-optic Frequency Comb System for the Precision Spectroscopy and Sensing of HCN, Philippe Guay, Jérôme Genest, Adam J. Fleisher, Université Laval, Canada; National Inst. for Standards and Technology, USA. We demonstrate precision spectroscopy of HCN where successive interferograms were phase-corrected in post-processing, averaged, and normalized to yield the complex transmission spectrum of several transitions within the 2ν, band centered near $\lambda = 1545$ nm.
**SW4M • Application of Microresonator Frequency Combs—Continued**

**SW4M.5 • 18:00**
Dual-cavity scanning comb spectroscopy, Mengjie Yu1,2, Yoshitomo Okawachi1, Chaityana Joshi1, Xingchen Ji1,3, Michael Lipson1, Alexander L. Gaeta1; 1Applied Physics and Mathematics, Columbia Univ., USA; 2Electrical Engineering, Cornell Univ., USA; 3Electrical Engineering, Columbia Univ., USA. We present a novel approach for microresonator-based gas-phase spectroscopy without use of an external laser source. The absorption spectrum of acetylene is measured with high spectral resolution using an integrated heater in a fiber-microresonator dual-cavity scheme.

**SW4M.6 • 18:15**
Counter-propagating soliton frequency microcombs, Qifan SW4M.6 • 18:15
Yang1, Xu Yi, Ki Youl Yang1, Kerry Vahala1; 1Ecole Polytechnique Fédérale de Lausanne, Switzerland; 2Physics, Moscow State Univ., Russia; 3Russian Quantum Center, Russia. We simultaneously create stable solitons in up to three distinct mode families of a single crystalline MgF2 microresonator. The resulting Kerr combs are stable solitons in up to three distinct mode families of a single silica microresonator. A counter-propagating dissipative Kerr fiber-microresonator dual-cavity scheme.

**SW4M.7 • 18:30**
Spatially-Multiplexed Solitons in Optical Microresonators, Erwan Lucas1, Gregory Lihachev2, Michael Gorodetsky3, Tobias J. Kippenberg1; 1École Polytechnique Fédérale de Lausanne, Switzerland; 2Physics, Moscow State Univ., Russia; 3Russian Quantum Center, Russia. We simultaneously create stable solitons in up to three distinct mode families of a single crystalline MgF2, microresonator. The resulting Kerr combs are mutually coherent and have distinct repetition rates and are thus well suited for dual-comb applications.

**SW4N • Ultrafast Phenomena—Continued**

**SW4N.4 • 18:00**
Self-Healing Property of Space-Time Light Sheets, Hasan E. Kondakci1, Ayman Abouraddy1; 1CREOL, Univ. of Central Florida, USA. We experimentally demonstrate self-healing of diffraction-free space-time light sheets propagating through one-dimensional beam blocks. Diffraction-free space-time beams are produced by introducing hyperbolic correlations in their spatio-temporal spectra.

**SW4N.5 • 18:15**
Mid-IR Ultrafast Carrier Dynamics in Black Phosphorus Observed Above and Below the Bandgap, Yigit Ayata1, Martin Mittendorf1, Thomas E. Murphy1; 1Univ. of Maryland, USA. We employ pump-probe measurements to study the carrier dynamics in layers of black phosphorus. By tuning the probe wavelength above and below the bandgap we unambiguously quantify the interband and intraband transitions and relaxation rates.

**SW4N.6 • 18:30**
The Picoseconds Structure of Ultrafast Rogue Waves, Moti Fridman1, Bar-Ilan Univ., Israel. We suggest a new mechanism for ultrafast rogue waves in fiber lasers. We claim that ultrafast patterns arise from the non-instantaneous relaxation of the saturable absorber together with the polarization mode dispersion of the cavity.

**SW4N.7 • 18:45**
Single Shot Magnetization Reversal of Micron Size Magnetic Domains in a Pt/Co/Pt Ferromagnetic Stack, Mircea Vornir1, Michele Albrecht1, Gilles Versini1, Jean-Yves Bigot1; 1Université de Strasbourg and CNRS, France. We show that the magnetization reversal of a Pt/Co/Pt ferromagnetic stack can be triggered by a single femtosecond laser pulse if the switched spot is comparable to the size of the intrinsic magnetic domains.

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**AW4O • Novel Laser Characterization—Continued**

**AW4O.5 • 18:00**
Metasurface-integrated Fully CMOS-compatible Phase Gradient Photodetector, Evgeny Panchenko1, Lukas Weisemann1, Timothy Davis1, Daniel Gomez1, Ann Roberts1; 1The Univ. of Melbourne, Australia; 2RMIT Univ., Australia. Here we present a fully CMOS compatible photodetector with embedded plasmonic metasurfaces capable of detecting a local phase gradient. This device could form the basis of novel waveform sensing systems for imaging, communications and astronomy.

**AW4O.6 • 18:15**
Impacting Factors in Linewidth Measurement of Single-Frequency Lasers, Songsong Sun1, Yong Wang1, Wei Yan1; 1Laser Research Inst., Qilu Univ of Technology(Shandong Academy of Sciences), China. Linewidth measurement of single-frequency laser using self-heterodyne method is studied. 1/f noise and the noise caused by double Rayleigh scattering in delayed fiber can affect the shape of linewidth, which introduces inaccuracy in linewidth measurement.

**AW4O.7 • 18:30**
Experimental Access to the Instantaneous Spectrum of MEMS-Based Swept Source, John O. Gerguis1, Yasser Sabry1, Daa Khali1,2; 1Faculty of Engineering, Egypt; 2Faculty of Engineering, Egypt; 3Si-Ware Systems, Egypt. This work presents a novel technique for measuring the spectral response of high-speed swept laser using the convolution between this spectrum and a reference filter. The method is successfully used to characterize MEMS-based swept source.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

Marriott
Salon VI

JW4P • Symposium on New Advances in Adaptive Optics Retinal Imaging II—Continued

Marriott
Willow Glen

CLEO: Science & Innovations

SW4Q • Novel Semiconductor Emitters—Continued

SW4Q.4 • 18:00
Development of Efficient Electrically Pumped Nanolasers based on InAlGaAs Tunnel Junction, Cheng-Yi Fang1, Felipe Vallini2, Abdelkrim El Amlii2, Antti Tukianen2, Jari Uunitalo1, Mireia D. Guina2, Yeshuahu Fairman2, ‘Materials Science and Engineering Program, UC San Diego, USA, 1Optoelectronic Research Centre, Tampere Univ of Technology, Finland, 2Dept. of Electrical & Computer Engineering, U C San Diego, USA. We propose and experimentally demonstrate a metalloidie nanolasers utilizing an InAlGaAs tunnel junction for efficient carrier injection, which reduce the complexity when optimizing the metal contact, and reduces the device resistance.

SW4Q.5 • 18:15
Electrically Pumped Metallic Coaxial Nanolasers, Enrique Sanchez Cristobal1, William Hayenga1, Hipolito Garcia-Gracia1, Mohammad Parvinneshad Hakimabad1, Patrick LiKamWa1, Mercedes Khajavikhan1; 1CREOL, USA. We present our progress towards the realization of room temperature current-injected coaxial nanolasers. Laser action is demonstrated in a subwavelength coaxial resonator up to a temperature of 140 K.

SW4Q.6 • 18:30
Synchronized Narrow Linewidth Laser and High Quality Microwave Signal Generation using Optically Mutual-Injection-Locked DFB Lasers with Optoelectronic Feedback, Guangcan Chen1,2, Dan Lu1,2, Song Liang1,2, Lu Guo1,2, Wu Zhao1,2, Lingjuan Zhao1,2; 1CAS Inst. of Semiconductors, China; 2College of Materials Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China. Synchronized dual-wavelength narrow-linewidth laser and high-quality microwave signal generation is demonstrated using mutual-injection-locked DFB lasers with optoelectronic feedback. Two synchronized lasers with linewidth down to kHz and beating frequency of 23.3 GHz is realized.

SW4Q.7 • 18:45
Mode Locking at THz Repetition Frequencies using Lasers with Phase Shifted Sampled Gratings, Liangping Hou1, Song Tang1, Bin Hou1, John Marsh1; 1Univ. of Glasgow, UK. Mode-locking at repetition frequencies of 800 GHz and 1 THz is reported in pi-phase-shifted sampled grating distributed-Bragg-reflector (DBR) lasers. The effective coupling coefficient of the phase-shifted gratings is twice that of conventional sampled grating DBRs.

Wednesday, 17:00–19:00

19:30–20:30  Conference Reception, Grand Ballroom
We demonstrate a 3D printed ultra-broadband and highly efficient out-of-plane coupler for photonic integrated circuits. The coupling efficiency at 1550 nm is ~0.8 dB with a 1 dB bandwidth exceeding 100 nm.

STh1A • Novel Structures and Devices
STh1A.1 • 08:00
3D-Printed Ultra-Broadband Highly Efficient Out-of-Plane Coupler for Photonic Integrated Circuits, Matthias Blaicher1, Muhammad R. Billah2, Tobias Hoose3, Philipp-Immanuel Dietrich3, Andreas Hoffmann3, Sebastian Randel3, Wolfgang Freude1, Christian Koos1, Karlsruhe Inst. of Technology, Germany. We demonstrate a 3D printed ultra-broadband and highly efficient out-of-plane coupler for photonic integrated circuits. The coupling efficiency at 1550 nm is ~0.8 dB with a 1 dB bandwidth exceeding 100 nm.

STh1A.2 • 08:15
Broadband Mode Router Based on Three-Dimensional Mach-Zehnder Interferometer and Waveguide Branches, Quandong Huang1, Yunfei Wu2, Wei Jin1, Kin S. Chang1, City Univ. of Hong Kong, Hong Kong. We demonstrate a broadband mode router based on integrating a 3D thermo-optic Mach-Zehnder interferometer and a 3D mode multiplexer. The device can dynamically route four spatial modes of a few-mode waveguide into four single-mode waveguides.

STh1A.3 • 08:30
Multiresonant Optical Response in Quasi-3D Multilayer Metal-Insulator-Metal Nanoplasmonic Crystals, Junyebong Song1, Wonil Nam1, Wei Zhou1, Virginia Tech, USA. Quasi-3D multilayer Metal-Insulator-Metal (MIM) nanoplasmonic crystals sitting on dielectric nanopillar arrays show unique multiresonant optical response from localized and delocalized surface plasmon modes both in far-field and near-field.

STh1A.4 • 08:45
Compact Narrow-Linewidth Integrated Laser Based on Low-Loss Silicon Nitride Ring Resonator, Brian Stern1, Xingchen Jia2, Auk Dutt3, Michal Lipson3, Cornell Univ., USA. C-Focused laser based on low-loss silicon nitride micro-ring resonator for output coupling and feedback. We measure a 13 kHz linewidth with 1.7 mW output power around 1550 nm.

STh1B • Integrated Photonic Sensors
STh1B.1 • 08:00
Mid-infrared (MIR) Mach-Zehnder Silicon Modulator at 2um Wavelength based on Interleaved PN Junction, Wanjun Wang1, Zecen Zhang1, Xing Guo1, Jin Zhou1, Xia Jia B. Xu1, Mohamed S. Roulef1, Chongyang Liu1, Callum Littlejohns2, Graham T. Reed3, Hong Wang4, Nanyang Technological Univ., Singapore; 1C. Tech, Inc., USA. We present a silicon modulator operating at 2 μm wavelength is experimentally demonstrated. The modulator shows 9.7 GHz 3-dB electro-optic bandwidth at Vth~3V. We also present optical modulation at 12.5 Gb/s.

STh1B.2 • 08:15
Methane Absorption Spectroscopy with a Hybrid III-V Silicon External Cavity Laser, Eric J. Zhang1, Laurent Schares1, Jason S. Orcutt1, Yves Martin1, Chi Xiong1, Marwan Khater1, Eric J. Zhang1, Laurent Schares1, Jason S. Orcutt1, Yves Martin1, Chi Xiong1, Marwan Khater1, 1Photonics Research Group, Ghent Univ., Belgium; 2Hutchinson Research Centre, United Kingdom. We present line-scanned methane absorption spectroscopy at 1656.5 nm using a multi-section hybrid III-V silicon external-cavity laser. The laser demonstrates > 2 nm tunability and single-mode operation with SMSR > 50 dB for high-resolution spectroscopy.

STh1B.3 • 08:30
Widely Tunable III-V-on-silicon Vernier Lasers Operating in the 2.3 μm Wavelength Range, Rujun Wang1, Stephan Sprengel1, Gerhard Boehm1, Roel Baert3, Markus Amann1, Gunther Roelkens1, 1Photonics Research Group, Ghent Univ.-imec, Belgium; 2Walter Schottky Institut, Technische Universität München, Germany. We report widely tunable III-V-on-silicon lasers with more than 40 nm tuning range near 2.35 μm wavelength. By combining two lasers with different wavelengths, improved performance is demonstrated in a transmission system.

STh1C • Machine Learning for Communication
STh1C.1 • 08:00
Learning of Laser Dynamics using Bayesian Inference, Darko Zibar1, Christian Schaeffer1, Jasper Mork1, 1Danmarks Tekniske Universitet, Denmark; 2Helmut-Schmidt-Universitat, Germany. Techniques from Bayesian machine learning and digital coherent detection are applied to perform frequency noise characterization. Significant advantage of the presented techniques are high-sensitivity and direct access to the uncertainty of the frequency noise measurement.

STh1C.2 • 08:30
Complex Neural Network Equalization of Optical SSB PAM-4 Signal in Direct-Detection Kramers-Kronig Receiver, Jiaxin Meng1, Mingzhe Zhu1, Stylianos Sygletos2, Xingwen Yi1,3, 1Polytechnic Univ., Hong Kong; 2Aston Institute of Photonic Technologies, Aston Univ., UK; 3School of Electronics and Information Technology, Sun Yat-Sen Univ., China. We propose a complex neural network equalizer in a Kramers-Kronig receiver to process the complex signals. Improved performance is demonstrated in a transmission system of 56-Gbaud optical SSB PAM-4 signal over 800-km SMF.

STh1C.3 • 08:45
Joint Estimation of IQ Phase and Gain Imbalances Using Convolutional Neural Networks on Eye Diagrams, Stefano Savian1,2, Julia Dinu1, Alan Pak Tao Lau1, Faisal Nadeem Khan1, Simone Gaia1, Rasmus Thomas Jones1, Darko Zibar1, 1DTU Fotonik, Denmark; 2Computer Science, The Free Univ. of Bozen-Bolzano, Italy. We propose a machine learning-based low-cost monitoring technique for transmitter IQ phase and gain imbalances is proposed. Simulations with formats up to NRZ-64QAM (28 Gb/s) show 95%-confidence estimation within 1.5° for phase and 0.06 for gain imbalances.
FTh1D • Nonlinear Metamaterials and Metasurfaces

Presider: Rafael Piestun; Univ. of Colorado at Boulder, USA

FTh1D.1 • 08:00
Nonlinear Tunability and Mechanical Actuation in Photonically Doped ENZ Metasurfaces, Ehsan Nahvi1, Ingo Liberal2, Nader Engheta3; Univ. of Pennsylvania, USA; 2Public Univ. of Navarra, Spain. Built upon the photonic doping concept we introduced recently (Science 355, 1058 (2017)), we numerically demonstrate how nonlinearity of the single dielectric rod and its mechanical actuation enable tunability of transmission through Epsilon-Near-Zero (ENZ) metasurfaces.

FTh1D.2 • 08:15
Nonlinear Manifestations of Photon Acceleration in Rapidly Evolving Semiconductor Metasurfaces, Maxim R. Shcherbakov1, Kevin Werner2, Zhiyuan Fan1, Noah Talisa2, Maxim R. Shvets3. Boulder, USA

FTh1D.3 • 08:30
Nonlinear Optics on Demand, Haim Suchowski1; Tel Aviv Univ., Israel. Nonlinear metasurfaces expand the possibilities of optical response resulting in intriguing and rich optical phenomena. Recent advances in controlling the generation and understanding of optical nonlinearities via single and collective metasurfaces designs will be presented.

FTh1E • Nonlinear Optics in Microresonator Systems

Presider: Scott Diddams; NIST, USA

FTh1E.1 • 08:00
Invited
Nonlinear and Quantum Optics within Whispering Gallery Mode Resonators, Harold G. Schadow2,3, Luke S. Tranor2, Alfredo Rueda4, Florian Sedlmair1; Univ. of Otago, New Zealand; 1Dodd-Walls Centre for Photonics and Quantum Technology, New Zealand, 2Max Planck Inst. for the Science of Light, Germany I present the current state of nonlinear and quantum optics within WGM resonators with particular emphasis on frequency conversion. This includes electro-optic microwave to optics transduction as well as parametric photon triplet generation.

FTh1E.2 • 08:30
Polarization Effects and Nonlinear Mode Coupling in Kerr Microresonators, Tobias Hansson1, Martino Bernard1, Stefan Walz2,3; 1Dipartimento di Ingegneria dell’Informazione, Università degli Studi di Brescia, Italy; 2CNR-INO, Italy. We model optical frequency comb generation in the presence of nonlinear polarization effects. We make an in-depth study of the modulational instability and demonstrate the appearance of novel types of instabilities and frequency comb states.

FTh1E.3 • 08:45
Type-1 and type-2 satellites in Kerr frequency combs, Jinghui Yang1, Shu-Wei Huang2, Zhenda Xie3, Mingbin Yu4, Dim-Lim Kwong1, Chee-Wei Wong1; 1Electrical Engineering, Univ. of California, Los Angeles, USA; 2Electrical, Computer & Energy Engineering, Univ. of Colorado, Boulder, USA; 3Nanjing Univ., China; 4Inst. of Microelectronics, Singapore. We report Kerr frequency combs with two types of satellites, enabled by multiple phase matching in microcavities. Satellite comb clusters at $\lambda = 1.3$ mm and $0.2 \mu m$ regimes are simultaneously generated with the comb central, with a demonstrated high external conversion efficiency reaching up to 30dB.

FTh1F • Novel Phenomena in van der Waals Heterostructures

Presider: Steven Cundiff; Univ. of Michigan, USA

FTh1F.1 • 08:00
Room-temperature optoelectronic detection of valley-locked spin photocurrent in WSe2-graphene-Bi2Se3 heterostructures, Soonyoung Cha1, Minj Nah1, Je-hyun Kim2, Janggup Son2, Hyemin Bae1, Dooen Lee1, Hoil Kim5, Jekwan Lee1, Hoseung Shin1, Sangwun Sim1, Seungboan Yang1, Chul-Ho Lee4, Moon-Ho Jo5, Junsung Kim1, Dahun Kim2, Hyeongbyo Choi1, Janghoon Choi1; 1Yonsei Univ., South Korea; 2Seoul National Univ., South Korea; 3Univ. of Illinois at Urbana-Champaign, USA; 4Postech, South Korea; 5Korea Univ., South Korea; 6Center for artificial low dimensional electronics systems, Inst. for Basic Science, South Korea; 7Division of Advanced Materials Science, POSTECH, South Korea. Using a lateral WSe2-graphene-Bi2Se3 heterostructure, we generate the valley-locked spin photocurrent in ion-liquid gated WSe2 transistor by the circular photogalvanic effect and extract the spin-polarized current in the Bi2Se3 topological insulator using the spin-momentum locking.

FTh1F.2 • 08:15
Probing Charge Transfer States in Polymer: Fullerene – MoS2 van der Waals Heterostructures, Christopher Pietukhoff1, Damien Voin1, Ibrahim Bakir2, Manish Chhowalla3, Keshav M. Dani4; 1Femtosecond Spectroscopy Unit, Okinawa Inst. of Science and Technology, Japan; 2Materials Science and Engineering, Rutgers Univ., USA. Using transient absorption spectroscopy, we observe the formation of long-lived charge transfer states in polymer:fullerene – MoS2 van der Waals heterostructures at sub-picosecond timescales.

FTh1F.3 • 08:30
2D Magnets and Heterostructures, Xiaodong Xu1; Univ. of Washington, USA. Since the discovery of graphene, the family of two-dimensional (2D) materials has grown to encompass a broad range of electronic properties. However, until recently 2D crystals with intrinsic magnetism were still lacking. In this talk, I will describe our recent magneto-optical spectroscopy experiments on van der Waals magnets, chromium(III) iodide CrI3, and their heterostructures with other non-magnetic 2D materials.
FTh1G.1 • 08:00
Spectrally Unentangled Photon Pairs from Microring Resonators using Pump-pulse Tailoring, Jasper B. Christiansen1, Jacob G. Koefoed1, Colin McKinstrie1, Karsten Rottwitt1, 1Technical Univ. of Denmark, Denmark. We show that a tailored pump-pulse spectrum can be used to completely eliminate spectral correlation in photon pairs generated from spontaneous four-wave mixing in nonlinear microring resonators.

FTh1G.2 • 08:15
Photonic Crystal Waveguides As Integrated Sources of Counterpropagating Factorizable Photon Pairs, Sina Saravi1, Thomas Pertsch1, Frank Setzpfandt1, 1Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany. We show that counterpropagating phase-matching reached in photonic crystal waveguides, without periodic poling, can be used in spontaneous parametric down-conversion to engineer the generation of photon pairs factorizable in the spectral degree of freedom.

FTh1G.3 • 08:30
Visible-Telecom Photon Pair Generation with Silicon Nitride Nanophotonics, Xiuyan Liu1, Qing Li1, Gregory Moille1, Anshuman Singh1, Daron Westly1, Kartik Srinivasan1, 1NIST, USA. We demonstrate a silicon nanophotonic chip that generates high-quality, narrowlinewidth photon pairs that link the visible and telecommunications bands. This device has potential for use in communication and entanglement of remote quantum systems.

FTh1G.4 • 08:45
High CAR and low g(2)(0) of 1.55 μm entangled photon-pairs generated by a silicon microring resonator, Chaosuan Ma1, Mahar Jere1, Xiaoxi Wang1, Shayan Moookhtyrjae1, 1Univ. of California, San Diego, USA. Silicon microring photon-pair and heralded single-photon generation is reported with a spectral brightness of 1 x10^9 pairs/s/GHZ/mW, achieving-record CAR > 12,000 and heralded second-order self-correlation g(2)(0) < 0.006. Franson interferometry was used to verify time-energy entanglement.

FTh1H.1 • 08:00
Sub-cycle Control of Optical Response by Using a Terahertz Excitonic Dressed State, Hideki Hirao1, Kento Uchida1, Tomohito Otobe1, Toshimitsu Mochizuki1, Changsu Kim1, Masahiro Yoshita1, Kaichiro Tanaka1, Akihumi Aiyama1, L. N. Pfeiffer2, K. W. West3, Kyoto Univ., Japan; 2Kansai Photon Science Inst., Japan; 3National Inst. of Advanced Industrial Science and Technology, Japan; 4Univ. of Tokyo, Japan; 5Princeton Univ., USA. We observed optical absorption strengths modulated on a sub-cycle timescale in a GaAs quantum well in the presence of a multi-cycle terahertz driving pulse using a near-infrared probe pulse.

FTh1H.2 • 08:15
Stern-Gerlach Effect for Photons, Aviv Karni1, Ady Arie1, 1Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv Univ., Israel; 2School of Electrical Engineering, Iby and Aladar Fleischman Faculty of Engineering, Tel Aviv Univ., Israel. We demonstrate theoretically the existence of a Stern-Gerlach effect for single photons in a quadratic nonlinear medium. The new effect enables the spatial separation of orthogonal frequency superposition states and might open new possibilities for the manipulation of bichromatic qubits.

FTh1H.3 • 08:30
Few Photons Correlation Measurement of a Thermally Populated Cavity, Francesca F. Settembrini1, Ileana-Cristina Benea-Chelmus1, Jérôme Faist1, 1ETH Zurich, Switzerland. In the THz range, correlation measurements have been implemented exploiting electrooptic sampling and femtosecond pulses. We present the field correlation measurement of few photons populating the modes of a cavity (nonlinear crystal) at room temperature.

FTh1H.4 • 08:45
Interfering Photons in Orthogonal States, Alexander Jones1, Adrian Menssen1, Helen Chrzanowski1, Valery Shchesnovich1, Jan Walsme1, 1Univ. of Oxford, UK; 2Imperial College London, UK; 3Federal Univ. of ABC, Brazil. Here we show that multi-particle quantum interference still occurs even when some of the particles involved are in orthogonal states. We experimentally demonstrate this with four photons.
Dennis Matthews, Ph.D., is an Emeritus Director of the NSF Center for Biophotonics Science and Technology, and the previous Associate Director for Biomedical Technology for the Integrated Cancer Center at the University of California at Davis. He is an emeritus professor in the UC Davis Department of Neurological Surgery and a member of the Biomedical Engineering, Applied Sciences and Clinical Sciences Graduate Groups. He is also a previous Program Leader and Division Leader at Lawrence Livermore National Laboratory. He is the co-founder and Chief Scientist of the Tahoe institute for Rural Healthcare Research, the Univ of CA Biophotonics Alliance and the Biophotonics4Life Worldwide Consortium. He is also the sole proprietor of LifeLight Resources LLC, a biophotonics-based consulting company. He has also recently become the Chief Science and Operations Officer in a radar-based heart monitoring startup company called Cardiac Motion LLC. While he is credited for inventing and developing x-ray wavelength lasers at Lawrence Livermore National Laboratory, Dr. Matthews’ continuing interest is in the translation and commercialization of new physical science and engineering technologies for grand challenges in medicine and the life sciences. His current interests are in developing optical, RF and x-ray technologies for disease diagnosis and treatment. He is a Fellow of the American Physical Society, the Society of Photo and Industrial Engineers and the Optical Society. He has more than 295 publications and >30 patents and is the co-editor of the Journal of Biophotonics. Dr. Matthews is credited for raising more than $225M in grant and investor funds in his career, helping create 14 startup companies.

08:00–10:00  
**STh1L • MIR to the THz Dual Combs**  
President: Ian Coddington; NIST, USA

08:00–10:00  
**FTh1K • Optical Near-field and Thermal Imaging**  
President: Chengjun Zou; Friedrich Schiller Univ. Jena, Germany

08:00–08:15  
**Enantio-specific Detection of Chirality at Nanoscale Using Photo-induced Force Microscopy**, Mohsen Rajaei1, Mohammad Kamandi1, Mohammad Albooyeh1, Mohnsen Rajaei1, Jinwei Zeng1, Caner Gulcu1, Mehdi Veysi1, Hametan K. Wickramasinghe1, Filippo Capolino1, Univ. of California, Irvine, USA. We map the near-field distribution of a linearly-polarized light transmitting through a Nomarski prism. We show how translating the prism changes the near-field profile. This setup has potential applications in phase detection of molecular responses.

08:15–08:30  
**High Coupling Efficiency Adiabatic Near-field Transducer for HAMR**, Chuan Zhang1, Patrick Flanagan1, Nicolas Abadía1, Brian D. Jennings1, Frank Bello1, Gwenael Atcheson1, Jing Li1, Jian-Yao Zheng1, Richard Hobbs1, David McCluskey1, John F. Donegan1, Trinity College Dublin, Ireland. The literature reports NFT with size below 1 microm are found to be thermo-mechanically unstable and low coupling efficiency. We demonstrate a 6 μm long adiabatic taper. A maximum coupling efficiency of 90.6% is achieved.

08:30–08:45  
**Cylrogenic Near-field Imaging and Spectroscopy at the 10-Nanometer Scale**, Max Eiselt1, Andreas Huber1, Tobias Gokus1, neaspec GmbH, Germany. We extend conventional near-field microscopy at ambient conditions to the cryogenic temperature range (<10-300 Kelvin). We will present first nano-optical measurements on semiconductor samples and single-layer materials highlighting the novel insights attainable by our cryo-neaSNOM.
Demas 1, Patrick Gregg 1, Siddharth Ramachandran 1; frequency femtosecond DRO demonstrated to date. Power femtosecond pulses at 10 GHz, the highest repetition a 90-nm bandwidth at 1.634 µm, producing 400-mW average pumped degenerate optical parametric oscillator (DRO) with.

FTH1M.1 • 08:00 10-GHz Femtosecond Degenerate Optical Parametric Oscillator, Richard A. McCracken 1, Yuk Shan Cheng 1, Deryck T. Reid 1; Heriot-Watt Univ., UK. We report a synchronously pumped degenerate optical parametric oscillator (DRO) with a 90-nm bandwidth at 1.634 µm, producing 400-mW average power femtosecond pulses at 10 GHz, the highest repetition frequency femtosecond DRO demonstrated to date.

FTH1M.2 • 08:15 Exotic Nonlinear Effects by Inserting a Low Finesse Resonator in a Mode-Locked Laser Cavity, James Hendrie 1, Ning Hsu 1, Jean-Claude M. Diels 1, Matthias Lenzner 2, Ladan Arisian 1, Miroslav Kolesik 2, A. Schülzgen 1, Frank W. Wise 3, Rodrigo Amezcua Correa 1, Demetrios N. Christodoulides 1; 1CREOL, Univ. of Central Florida, USA; 2College of Optical Sciences, The Univ. of Arizona, USA; 3School of Applied and Fibers.

FTH1M.3 • 08:30 Accelerating nonlinear interactions in tapered multimode fibers, Mohammad Amin Eftekhar 1, Zarnab Sanjabi Enravah 1, Jose Enrique Antonio-Lopez 1, Helena E. Lopez Aviles 1, Sephehr Benis 1, Miroslav Koleski 1, A. Schülzgen 1, Frank W. Wise 3, Rodrigo Ameca Correa 1, Demetrios N. Christodoulides 1; CREOL, Univ. of Central Florida, USA; College of Optical Sciences, The Univ. of Arizona, USA; 2School of Applied and Engineering Physics, Cornell Univ., USA. We theoretically and experimentally demonstrate that the processes of multimode soliton fission and dispersive wave generation in parabolic-index multimode fibers are substantially altered when the rate of intermodal nonlinear interactions is progressively increased during propagation.

FTH1M.4 • 08:45 Phase Conjugation in OAM fiber modes via Stimulated Brillouin Scattering, Gautam Prabhakar 1, Xiao Liu 1, Jeffrey Demas 1, Patrick Gregg 1, Siddharth Ramachandran 1; 1Boston Univ., USA. We report the first demonstration of phase conjugation in OAM fiber modes via SBS. Acoustic and optical angular-momentum selection rules facilitate this even for monomode launch, in contrast to the traditional need for multimode inputs.

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FTH1M.3 • 08:30 Accelerating nonlinear interactions in tapered multimode fibers, Mohammad Amin Eftekhar 1, Zarnab Sanjabi Enravah 1, Jose Enrique Antonio-Lopez 1, Helena E. Lopez Aviles 1, Sephehr Benis 1, Miroslav Koleski 1, A. Schülzgen 1, Frank W. Wise 3, Rodrigo Ameca Correa 1, Demetrios N. Christodoulides 1; CREOL, Univ. of Central Florida, USA; College of Optical Sciences, The Univ. of Arizona, USA; 2School of Applied and Engineering Physics, Cornell Univ., USA. We theoretically and experimentally demonstrate that the processes of multimode soliton fission and dispersive wave generation in parabolic-index multimode fibers are substantially altered when the rate of intermodal nonlinear interactions is progressively increased during propagation.

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08:00–10:00  
FTh1P • Engineering and Metrology of Thermal Radiation  
Presider: Gururaj Naik; Rice Univ., USA

08:00–10:00  
ATh1Q • A&T Topical Review on Neurophotonics I  
Presider: Chris Xu; Cornell Univ., USA

FTh1P.1 • 08:00  
Tutorial  
Nanophotonic Control of Thermal Radiation for Energy Applications, Shanhui Fan1; Stanford Univ., USA. The ability to control thermal radiation plays a fundamentally important role in a wide range of energy technology. Nanophotonic structures provide enhanced capabilities for controlling thermal radiation, which is leading to new energy applications.

ATh1Q.1 • 08:00  
Tutorial  
The Challenge of Large-scale Neuronal Imaging, Jerome C. Mertz1; Boston Univ., USA. Fast, large-scale, volumetric, in-vivo neuronal imaging has long been a challenge for microscopists. I will discuss some of the issues involved and review various strategies to address this challenge.

Shanhui Fan is a Professor of Electrical Engineering and the Director of the Ginzton Laboratory, at Stanford University. He received his Ph. D in 1997 from Massachusetts Institute of Technology (MIT). His research interests are in fundamental physics of nanophotonic structures, and their applications in energy and information technology.

Jerome Mertz is currently a professor of Biomedical Engineering at Boston University. His interests are in the development and applications of novel optical microscopy techniques for biological imaging. He is also author of a textbook entitled Introduction to Optical Microscopy.
Sth1A.5 • 09:00 Spectral Engineering Based on Mode Splitting in Integrated Cascaded Sagnac Loop Reflectors, Jiaying Wu1, Tana Moen1, Xingyuan Xu1, David J. Moss1, Swanburne Univ. of Technology, Australia. We propose and experimentally demonstrate mode splitting in integrated cascaded Sagnac loop reflectors (SLRs). By changing the number and reflectivity of the SLRs, rich filtering characteristics for spectral engineering are experimentally achieved and show good agreement with theory.

Sth1A.6 • 09:15 Integrated Amorphous Silicon-Aluminum Long-Range Surface Plasmon Polaritons (LR-SPP) Waveguides, Boaz Sturlesi1, Meir Grajower1, Noa Mazurski1, Uriel Levy1; ‘the Hebrew Univ. of Jerusalem, Israel. We demonstrate Long Range Surface Plasmon Polaritons waveguide with aluminum embedded in amorphous silicon. It operates in the telecom band and is compatible with backend CMOS process. Transmission and near field measurement results are reported.

Sth1A.7 • 09:30 Radiation-Free, Sub-Wavelength Optical Resonator based on All-Evanescent Confinement in a High-Index Core Material, Imbert Wang1, Milos Popovic1; Electrical Engineering, Boston Univ., USA. We propose a radiation-free dielectric nanocavity with all-evanescent confinement, based on perfect mode-matching and minimal use of negative permittivity. A record-low mode volume within high-index core material, supporting high-Q/λ, may enable efficient active nanophotonic components.

Sth1A.8 • 09:45 Interface Passivation for Realizing High Efficiency Direct Band Gap Emission from Ge MOS Tunneling Diode, Min Xie1, Yi Zhao1, Zhejiang Univ., China. We demonstrated room temperature Ge surface-emitting diode with 1.5-1.6 um strong infrared emission using a metal/graphene/high-k/Interface layer (Si)/n-Ge MOS tunneling structure, without introducing strain or extra-doping.

Sth1A.9 • 10:00 Quantum cascade multi-spectral laser with integrated beam combiner on silicon, Eric J. Stanton1, Alexander Spot1, Jon Peters1, Michael Davenport1, Nicolas Volet1, Aditya Malik1, Junqian Liu1, Charles D. Merritt2, William W. Bewley1, Igor Vurgaftman1, Chul Soo Kim2, Jerry R. Meyer2, John E. Bowers1; 1Univ. of California Santa Barbara, USA, 2Code 5613, Naval Research Lab, USA. A multi-spectral quantum cascade laser is demonstrated on SOI, emitting at 4.6–4.7 µm with an integrated multiplexer. Low-loss spectral beam combining to a single-mode waveguide efficiently scales the output power.
USA; 2Materials Sciences Division, Lawrence Berkeley National Lab, USA. We explore active and nonlinear plasmonic metamaterials by leveraging the field-induced disruption of the inversion symmetry for second-order optical processes, and exploiting the hot-carrier-induced perturbation of the dielectric permittivity for ultrafast all-optical modulation.

Asymmetric Light Transport at Nonlinear Metasurfaces, Nir Shitrit1, Jeongmin Kim1, David Barth1, Hamidreza Ramezani1, Yuan Wang1, Xiang Zhang2,3; 1Univ. of California at Berkeley, USA; 2Materials Sciences Division, Lawrence Berkeley National Lab, USA. We report asymmetric transport of free-space light at nonlinear metasurfaces and the derivation of the nonlinear generalization of Snell’s laws. Asymmetric transport at metasurfaces opens a new paradigm for ultrathin lightweight optical devices with one-way operation.

Homogenization and Nonlinearity Enhancement of 2D Graphene-Based Metasurfaces, Jian Wei You1, Nicolae C. Panait1,2,3, EEE, Univ. College London, UK. A general homogenization technique is developed to study the optical properties of 2D graphene-based metasurfaces. The results show the effective nonlinear susceptibilities of graphene metasurfaces can be enhanced by more than two orders of magnitude.

Structural Second Order Nonlinearity in Metamaterials, Brian Wells2,1, Anton Y. Bykov3,4, Giuseppe Marino3,5, Mazhar Nasir3, Anatoly Zayats3,4, Viktor A. Podolskiy1,2,3, John E. Sipe2,3; 1Univ. of California at Berkeley, USA; 2School of Engineering, RMIT Univ., Australia; 3Laser Physics Centre, Australian National Univ., Australia; 4Centre for Microphotonics, Swinburne Univ. of Technology, Australia; 5CEA-LETI, France. We report mid-wavelength infrared supercontinuum generation, from 2.6 to 7.3 µm, in a CMOS compatible low loss silicon-germanium waveguide pumped using a tunable OPA laser delivering ~200 fs pulses at 4.15 µm.

Dynamics of laser with an integrated nonlinear waveguide, A. Aaidi1, Michael Kuss1,2, Anton V. Kovalev1, Petr Rostok2, Christian Reimer1, Young Zhang1, Toa Wang1, Sai T. Chu1, David J. Moss2,3, Zhiming Wang4, Evgeny A. Viktorov2, Roberto Morandotti1,2; 1INRS EMT, Canada; 2ITMO Univ., Russia; 3Univ. of Massachusetts Lowell, USA. We demonstrate that second harmonic generation in plasmonic nanowire composites can be described by an effective bulk $\chi^{(2)}$ susceptibility which depends on the geometry of the composite, and present an analytical description of this phenomenon.
FTh1G • Integrated Quantum Sources—Continued

FTh1G.5 • 09:00
Indistinguishable Photon-Pairs from Pure and Bright Silicon Micro-ring Resonator Sources, Imad Faruque1, Daniel M. Llewellyn1, Yunhong Ding1, Stefano Paesani1, Raffaele Santagati1, Damien Bonneau1, Gary Sinclair1, Davide Bacc01, Karsten Rottwitt1,2, Leif K. Oxenlowe1, Jeremy O’Brien1, Jianwei Wang1, John Ranty1, Mark G. Thompson1,1Uni of Bristol, UK; 2Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark; 3Center for Silicon Photonics for Optical Communication (SPOC), Technical Univ. of Denmark, Denmark. We report on-chip interference fringes of very high visibility 89% from heralded single photons from separate ultra-bright silicon micro-ring resonator sources as 4-fold coincidences. The reconfigurable chip is also used to measure multipair fringes and conditional g(2)(0) of single photons.

FTh1G.6 • 09:15
Percolation Based Cluster State Generation by Photonic-Mediated Entanglement, Minh Pnt1, Hyongrak Choi1, Saikat Guha1, Dirk Englund1, MIT, USA; 2Optical Sciences, Univ. of Arizona, USA. We present an architecture for creating large entangled cluster states for quantum computing and simulation with nitrogen vacancy centers in diamond within the experimentally demonstrated coherence time using percolation theory.

FTh1G.7 • 09:30
Generation and Manipulation of Multi-Photon Entangled States on a Silicon Photonic Device, Daniel M. Llewellyn1, Yunhong Ding1, Imad Faruque1, Stefano Paesani1, Raffaele Santagati1, Jake Kennard1, Davide Bacc01, Karsten Rottwitt1,2, Leif K. Oxenlowe1, Jeremy O’Brien1, Jianwei Wang1, Mark G. Thompson1,1Uni of Bristol, UK; 2Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark; 3Center for Silicon Photonics for Optical Communication, Technical Univ. of Denmark, Denmark. We experimentally demonstrate the generation and manipulation of entangled photons-pairs from an array of bright and pure photon micro-ring sources, and realise the teleportation of unknown quantum states on a reconfigurable silicon photonic quantum device.

FTh1H • Quantum Interference, Imaging and Spectroscopy—Continued

FTh1H.5 • 09:00
Randomness Extraction From Chuk Violation Without Fair Sampling Assumptions With A Continuous Wave Source, Alessandro Cerè1, Liyong Shen1, Jianwei Lee1, Le Phuc Thinh1, Jean-Daniel Bancal1, Valerio Scarani1, Christian Kurtsiefer1; 1Centre for Quantum Technologies, NUS, Singapore; 2Dept. of Physics, National Univ. of Singapore, Singapore; 3Dept. of Physics, Univ. of Basel, Switzerland. We demonstrate a detection loophole-free Bell violation using a photonic system based on a continuous wave source, and show that it allows to increase the randomness generation rate compared to pulsed systems.

FTh1H.6 • 09:15
Quantum Interference in a Room Temperature InAs/InP Quantum Dot Semiconductor Optical Amplifier, Igor Khanank1, Ashleigh K. Mishra1, Ouni Karri2, Johann P. Reithmaier1, Gadi Eisentein1, Technion-Israel Inst. of Technol. Phys. Eng., Israel; 2Stanford Univ., USA; 3Univ. of Kassel, Germany. Ramsey interference were observed in an inhomogeneously broadened InAs/InP quantum dot semiconductor optical amplifier operating at room temperature. The imprint of the Ramsey fringes on pulse intensity, phase and temporal position were demonstrated.

FTh1H.7 • 09:30
Quasimomentum Distribution and Free Expansion of an Aniongic Gas, Tens Dubb1, Bruno Klein1, Robert Pezer1, Hvoje Buljan1, Dario Kuki1; 1Univ. of Zagreb, Croatia; 2Faculty of Metalurggy, Univ. of Zagreb, Croatia; 3Faculty of Civil Engineering, Univ. of Zagreb, Croatia. We point out that the momentum distribution is not a proper observable for anyons in two dimensions. We define the quasimomentum distribution as the asymptotic single-particle density after free expansion (time-of-flight measurements), as a means to analyze the anyonic statistics.

FTh1H.8 • 09:45
Integrated silicon nitride time-bin entanglement circuits, Xiang Zhang1, Bryn A. Bell1, Andri Mahendra1, Chunle Xiong1, Philip Leong1, Benjamin J. Eggleton1; 1Univ. of Sydney, Australia. Time-bin entangled states are generated and analyzed in an integrated silicon nitride chip. Quantum state tomography indicates 91% fidelity to the ideal state, demonstrating its potential for applications in quantum communication networks.

STh1 • Novel Fabrication Methods—Continued

STh1.5 • 09:15
Template assisted dewetting of optical glasses for large area, flexible and stretchable all dielectric metasurfaces, Tapajoti Das Gupta1, Louis Martin-Morient, Arthur Lebrini, Wei Yan1, Tung Nguyen, Alexis Page1, Yunpeng Qu1, fabien savo1; 1Ecole Polytechnique Federale de Lausanne, Switzerland. We propose for the first time template-assisted dewetting of high-index chalcogenide glasses for low-cost manufacturing of all-dielectric metasurfaces on large-area flexible and stretchable substrates.

STh1.6 • 09:30
Centimeter-scale Superfine 3D Printing, Wei Chu1, Yuanxin Tan1, Jintian Lin1, Jingping Yao1, Ya Cheng2; 1Shanghai Inst of Optics & Fine Mechanics, China; 2School of Physics and Materials Science, East China Normal Univ., China. We present a method based on simultaneous spatiotemporal focusing (STSF) of the femtosecond laser pulses that enables to fabricate 3D structures on the centimeter scale with TPP. Several Centimeter-scale structures were fabricated using this method.

STh1.7 • 09:45
On-demand lens fabrication by liquid phase molding with gallium and Polydimethylsiloxane, Keisuke Nakakubo1, Hiroaki Nomada1, Hiroaki Yushiki2, Kinichi Morita1, Yuji Oki1; 1Kyushu Univ., Japan; 2Ushio.Inc, Japan. A new on-demand lens fabrication with gallium molding was proposed and demonstrated. A convex and concave surface of liquid gallium is transferred to Polydimethylsiloxane. The curvature can be controlled between ±0.37 mm⁻¹.
Abstract:

Multimodal deep tissue imaging using Wavelength Modulated Spatially Offset Raman Spectroscopy and Optical Coherence Tomography (WMSORT) has been presented as a promising technique for detecting co-registered Raman and OCT signals from targets spatially offset from the OCT beam. This has the capability to detect co-registered Raman and OCT signals from targets deeply embedded in tissue.

We present a source for OCT based on chip-scale frequency combs for high-resolution optical coherence tomography, which demonstrates a non-iterative holographic image reconstruction framework based on deep learning. After its training, a deep convolutional neural network rapidly produces a single hologram from the acquired image sequence.

Chip-based frequency combs for high-resolution optical coherence tomography have been developed, which allows for a deep convolutional neural network to be used for non-iterative holographic image reconstruction. This technique has been shown to be capable of achieving high-resolution images of human tissue and demonstrating compatibility with tissue penetration. Using the microresonators, we acquire images of sub-micrometer axial resolution and deep tissue penetration. These results showcase the potential of chip-scale frequency combs for high-resolution optical coherence tomography in medical imaging applications.

Non-iterative holographic image reconstruction and phase retrieval using a deep convolutional neural network have been demonstrated. The method is capable of achieving high-resolution images of human tissue and showing compatibility with tissue penetration. Using the microresonators, we acquire images of sub-micrometer axial resolution and deep tissue penetration. These results showcase the potential of chip-scale frequency combs for high-resolution optical coherence tomography in medical imaging applications.

High-throughput 3D Tracking of Sperm Locomotion Reveals Head Spin and Flagellar Beating Patterns. We developed a fast, high-resolution thermoreflectance imaging-based technique to map the temperature distribution of gap plasmon structures subject to laser irradiation, and observed 120 K temperature rise with 3 mW/μm² irradiance. This technique has potential applications in studying sperm locomotion and flagellar beating patterns, which can be used as biomarkers for reproductive health.

Using the microresonators, we acquire images of sub-micrometer axial resolution and deep tissue penetration. These results showcase the potential of chip-scale frequency combs for high-resolution optical coherence tomography in medical imaging applications.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Harmonic dissipative soliton resonance passively mode-locked fiber laser, Georges Semaan1, Aioune Nargi, Mohamed Salhi1, Françoise Sanchez2; Laboratoire de Photonicque d'Angers, France. We experimentally demonstrate for the first time a harmonic mode-locked dissipative soliton resonance square pulses fiber oscillator. High energy stable pulses up to the 13th order of harmonic have been obtained without wave-breaking.

Diverse Solitons Interactions in the Formation of Dissipative Optical Soliton Molecules, Junsong Peng1, Heping Yang2, Yue Zheng3; 1East China Normal Univ., China. Using real-time measurement techniques, we firstly unveil four nonlinear stages in the build-up of soliton molecules in an ultrafast fiber laser, which are modulation instability, mode locking, soliton fission and diverse solitons interactions.

Demonstration of Spatial Riemann Waves and Inviscid Burgers’ Equation Dynamics in Nonlinear Optics, Domenico Bongiovanni1, Benjamin Wetzell2, Yi Hu1, Pengbo Yang2, Yue Qi1, Jingjun Xu1, Stefan Wabnitz3, Zhigang Chen4; 1Dept. of Electrical Engineering, Technion - Israel Inst. of Technology, Haifa, Israel; 2Laboratoire Charles Fabry, Institut d’Optique Graduate School, France; 3Amplitude Systems, France; 4ICREA - Institució Catalana de Recerca i Estudis Avançats, Spain. We report on observation of spatial Riemann wave dynamics in a nonlinear m-cresol/nylon thermal solution, obtained by properly tailoring the initial optical beam. Experimental results show controllable steepening and shock formation, in good agreement with theory.

Ultrafast spectrro-temporal analyzer for the multi-scale laser dynamics studies, Ying Yu1, Bowen Li1, Xiaoming Wei2, Chi Zhang1, Kevin K. Tsia1, Kenneth Kin-Yip Wong1; 1Univ. of Hong Kong, Hong Kong; 2California Inst. of Technology, USA. We propose a real-time optical spectro-temporal analyzer (ROSTA), which simultaneously provides single-shot temporal and spectral information for multiple time-scale radiation. By using ROSTA, new complex dynamic phenomena during the birth of passive mode-locking is observed.
FTh1P • Engineering and Metrology of Thermal Radiation—Continued

FTh1P2 • 09:00
Demonstration of On-Chip Thermocouple Photodetector in Infrared Regime through Field Enhancement by Plasmonic Nano Focusing, Orian Keneth1, P. Arora1, Noa Mazurski1, Uriel Levy1; Applied Physics, Hebrew Univ. of Jerusalem, Israel. We exploit the co-design of optical and thermal properties for microphotonics applications. We design a material that passively regulates its temperature by switching on/off its thermal emission. We experimentally demonstrate a hybrid optothermal logic device.

FTh1P3 • 09:15
Thermal Homeostasis and Hybrid Optothermal Logic, Michelle L. Povinelli1, Ahmed Morsy1, Shao-Hua Wu1, Mingkun Chen1, Michael Barako1, Vladan Jankovic2, Philip W. Hon1, Luke Sweetlock2; Univ. of Southern California, USA; ‘NG Next, Northrop Grumman Corporation, USA. We exploit the co-design of optical and thermal properties for microphotonics applications. We design a material that passively regulates its temperature by switching on/off its thermal emission. We experimentally demonstrate a hybrid optothermal logic device.

FTh1P4 • 09:45
Single-molecule Thermometry by Carbon Nanotube Excitons Coupled to Plasmonic Nanocavities, Yue Suo1, Ehsan Hossein Zadeh1, Kamran Shayan1, Yichen Ma1, Kevin S. Mistry1, Changjian Zhang1, James Hone1, Jeffrey L. Blackburn1, Stefan Strauss1; Dept. of Physics, Stevens Inst. of Technology, USA; National Renewable Energy Lab, USA; Dept. of Mechanical Engineering, Columbia Univ., USA; Center for Quantum Science and Engineering, USA. In a unique interplay of excitons, phonons, and plasmons, we demonstrate plasmonic thermometry at the single-molecule level by detecting the plasmonically induced heat from SWCNT excitons coupled to plasmonic nanocavity arrays.

ATH1Q • A&T Topical Review on Neurophotonics I—Continued

ATH1Q2 • 09:00
Ultrasonic Guiding and Steering of Light in Scattering Tissue, Matteo Giuseppe Scopelliti1, Maysoon Chamarar2, Carnegie Mellon Univ., USA. We present a novel technique for guiding and steering photons in multiply scattering brain tissue by using ultrasound waves to sculpt refractive index contrast profiles that define and control the trajectory of light within tissue.

ATH1Q3 • 09:30
Spectral Multiplexing of Optogenetic Switch by Stimulated Emission Depletion Quenching, Alexei Goun1; Princeton Univ., USA. We demonstrate that stimulated emission depletion quenching allows for higher fidelity control of optogenetic switching.

ATH1Q4 • 09:45
Attojoule Modulators for Photonic Neuromorphic Computing, Rubab Amin1, Jonathan George1, Jacob Khurgin2, Tarek El-Ghazawi1, Paul R. Prucnal3, Volker J. Sorger1; George Washington Univ., USA; Johns Hopkins Univ., USA; Princeton Univ., USA. We show how the nonlinear transfer function of electrooptic modulators enables vector matrix multiplications of photonic neural networks. Here the modulators energy-per-bit function and signal-to-noise ratio are critical factors impacting system performance.
JTh2A.1 Limits on manipulating conditional photon statistics of lasers via interference and post-selections, Kang-Hee Hong1, Jing Jang1, Yeong-Woo Cho2, Sung Won Moon3, Sung Moon4, Kyungwan Oh2, Yong-Su Kim2, Yoon-Ho Kim1, 1Pohang Univ of Sci & Tech (POSTECH), South Korea; 2Korea Inst. of Science and Technology (KIST), South Korea; 3Forschungszentrum Jülich, Germany; 4National Institute of Standards and Technology, USA. It has been reported that photon anti-bunching can be obtained via interference of lasers. We provide counter-evidence by theoretical analysis on the limits of manipulating conditional photon statistics of lasers via interference and post-selections.

JTh2A.2 Photon-Pair State Engineering in Raman-Mediated Four-Wave Mixing, Kai B. Shinbrough1, Bin Fang1, Yanfeng Peng2, Yujie Zhang1, Offir Cohen3, Virginia O. Lorenz1, 1Univ of Illinois Urbana-Champaign, USA. Towards delayed-choice generation of single photons in pure quantum states, we measure and model the purity of Stokes photons scattered from aapphire, measuring a maximum purity of 0.99±0.03 and high quantum correlation with anti-Stokes photons.

JTh2A.3 Mechanically Tunable Photonic Crystal Cavity with High Quality Factor and Small Mode Volume, Xinuo Yan1, Jingda Zhu1, Zhihao Wang2, Meng Lan3, Ketul Chokshi, 1University of the West of England, Bristol, UK; 2Shandong University, China; 3University of Delaware, USA. We design a mechanically tunable photonic crystal microcavity to be dynamically tunable while maintaining a quality factor of >1x109 and a mode volume ~0.3 (λn)3. Its optomechanical coefficient is ~15GHz/μm, at mid-IR wavelengths.

JTh2A.4 Sorting Laguerre-Gaussian modes by radial quantum number, Yiyu Zhou1, Mohammad Mirhosseini2, Dongbi Fu3, Jiapeng Zhao1, Seyed Mohammad Hashemi Rastgari1, Alan E. Willner1, Robert Boyd2, 1The Inst of Optics & Metrology, Univ of Rochester, USA; 2The Inst of Optics, Univ of Rochester, USA; 3Univ of British Columbia, Canada. For a radially planar photonic crystal microcavity, we design a micromachined mirror to radially sort Laguerre-Gaussian modes, which report the experiment can, in principle, have unit efficiency and no cross-talk.

JTh2A.5 Sub-Poissonian Twin-Beam Correlations at Blue and Red of Southern California, USA; 4Dept. of Physics, Univ. of Ottawa, Canada. We provide counter-evidence by theoretical analysis on the limits of manipulating conditional photon statistics of lasers via interference and post-selections.

JTh2A.7 Ghost Imaging with Paired X-Ray Photons, Aviad Schori1, Dena Borodin1, Keny Tamassaki2, Sharon Shwartz2, 1Bar-Ilan Univ., Ramat Gan, Israel; 2School of Physics, Tel-Aviv University, Israel. We observed ghost imaging with parametrically down-converted x-ray photons pairs. We reconstructed the image of silts with nominally zero background levels. Our procedure can lead to the observation of quantum phenomena at x-ray wavelengths.

JTh2A.8 Photon-Number Resolution in Conventional Superconducting Nanowire Single-Photon Detectors: Theoretical Predictions, Kathryn Nicolich1, Clinton T. Cahall2, Nurul T. Islam3, Gregory P. Lafayts4, Jungsang Kim5, 1Dept. of Electrical and Computer Engineering, Duke Univ., USA; 2IonQ Inc., USA. We demonstrate theoretically that a conventional single-pixel superconducting nanowire single-photon detector can resolve photon number by sensing changes in the rising edge of the electrical readout pulse.

JTh2A.9 Passive State Preparation in Continuous Variable Quantum Key Distribution, Bing Qi1, Phil Evans1, Warren Grice1, 1Oak Ridge National Lab, USA. We propose a passive continuous-variable quantum key distribution scheme, where Alice and Bob share a single-photon mode in one arm of the FWM process and transmit the other mode to Bob after attenuation.

JTh2A.10 Security verification for vacuum fluctuation based quantum random number generator, Arne Kords1, Cosmo Lupo2, Dino Solari2, Tobias Gehring1, Ulrik L. Andersen1, 1Danmarks Tekniske Universitet, Denmark; 2Univ of York, UK. We demonstrate a gigahertz source of verifiable quantum random numbers based on homodyne detection of the vacuum state. Using a whitening filter, we generate iid samples with a potential randomness rate of 20Gbit/s.

JTh2A.11 Multipartite Quantum Entanglement and Quantum Correlation from cascaded Four-wave Mixing Processes with spatial multiplexing, Jietao Jing1, Shuchao Lv1, Kai Zhang1, Wei Wang1, Hailong Wang1, Jun Xin2, Leiming Cao1, Sijin Li1, Lingxiao W2, Zhe Zhao1, 1Shanghai Jiao Tong University, China. We experimentally investigate multipartite quantum entanglement and theoretically study multipartite quantum element from cascaded FWM processes.

JTh2A.12 1.064-μm-band Up-conversion Single-photon Detector, Pei Ma1, Ming-Yang Zhang2, Quan Yao2, Xiu-Ping Xie2, Qing Zhang2, 1Jian-Wei Pan1, 2Hefei National Lab for Physical Sciences at Microscale and Dept of Modern Physics, Univ. of Science and Technology of China, China; 3Univ of Science and Technology of China Co., Ltd., China; 4Univ of Science and Technology of China, China. We demonstrate an up-conversion single-photon detector at 1.064-μm band using a PPLN waveguide. By employing two kinds of filtering schemes, we achieve the detection efficiency of 32.5% and 38% with noise count rate of 45 cps and 700 cps respectively.

JTh2A.13 Performance Improvement of Discrete-Modulation Continuous-Variable Quantum Key Distribution by Using the Machine-Learning-Based Detector, Jiawei Li1, Duan Huang1, Cailing Xie1, Ling Zhang1, Ying Guo1, 1School of Information Science and Engineering, Central South Univ, China. The discrete-modulation continuous-variable quantum key distribution is proposed using the machine-learning-based detector to preprocess the signal before the reconciliation process, which would mitigate the burden of error correction reconciliation and further improve the system performance.

JTh2A.14 Generation of Multi-mode NOON States with Arbitrary N, Lu Zhang1, Kam Wai C. Chan1, 1Univ. of Oklahoma, USA. We present three methods of generating NOON states with arbitrary photon number using either coherent states or Fock states along with single photons. Generation probabilities are calculated to show their efficiencies.

JTh2A.15 Experimental Demonstration of a 20-Mbit/s per Channel Free-Space Bi-directional Quantum Communication Link Using Orbital-Angular-Momentum Encoding and Multi-Port Mode Converters, Cong Liu1, Kai Pang2, Hao Song1, Guodong Xie1, Jiapeng Zhao1, Yongxiang Ren1, Haqian Song1, Zhe Xiao1, Rongzhou Zhang1, Li Jing1, Duy D. Duy2, Seyed Rastgari1, Guillaume Labrolle1, Pu Jian3, Robert Boyd4, Morie Tur1, Alan E. Willner5, 1Univ. of Southern California, USA; 2The Inst. of Optics, Univ. of Rochester, USA; 3CAI Labs, France; 4School of Electrical Engineering, Tel Aviv Univ., Israel. We experimentally demonstrate a free-space, bi-directional quantum communication link encoded by two OAM states using multi-port mode converters. We achieve a quantum- symbol-error-rate of ~0.058 for each channel at 20 Mbit/s/ channel when OAM mode-spacing is 4.

JTh2A.16 Spectral Resolution of Second-Order Coherence of Broad-Band Biphotons, Atsushi Ryo1, Sayaka Goto1, Hideki Inour1, Takeharu Goto1, Harumasa Inoue2, 1Bar-Ilan University, Israel; 2The Inst. of Optics, Univ. of Rochester, USA. We provide counter-evidence by theoretical analysis on the limits of manipulating conditional photon statistics of lasers via interference and post-selections.

JTh2A.17 One-Way Noise Measurement of Deployed Optical Fiber for Quantum Networks Using Mode-Locked Lasers, Hel- ena Zhang1, Matthew E. Greene2, Scott A. Hamilton1, Isacc Chuang3, 1Research Lab of Electronics, MIT, USA; 2Dept. of Physics, MIT, USA; 3Lincoln Lab, MIT, USA. One-way noise across a 42-km deployed optical fiber link is measured using two different techniques employing referenced mode-locked lasers. We compare the two techniques and assess their suitability for stabilizing the fiber for quantum networks.

JTh2A.18 Determining Full Parameters of U-Matrix for Reconfigurable Boson Sampling Circuits using Machine Learning, Longxiao Wang1, Hui Zhang2, Jiaxing Huo3, Gong Zhang2, Leong Chuan Kwek4, Joseph F. Fitzsimons3, Yidong Chong5, Glenn Tyler4, Robert Boyd2, 1Research Lab of Electronics, MIT, USA; 2Univ of Rochester, USA; 3Univ of Southern California, USA; 4Royal Institute of Technology and Design, Singapore; 5Sun Yat-sen Univ., China. We present two techniques employing referenced mode-locked lasers. We compare the two techniques and assess their suitability for stabilizing the fiber for quantum networks.

JTh2A.19 Performance analysis of d-dimensional quantum cryptography with mode-dependent detection, Jiapeng Zhao1, Mohammad Mirhosseini2, Yiyu Zhou1, Seyed Mohammad Hashemi Rastgari1, Yongxiang Ren1, Nicholas Steinhoff4, Glenn Tyler4, Robert Boyd2, 1Bar-Ilan University, Israel; 2Univ. of Rochester, USA; 3Univ. of Southern California, USA; 4The Optical Science Company, USA. We analyze the degraded performance of QKD that results from mode-dependent detection in spatial-mode-encoded QKD systems. A pre-compensation method is proposed to solve this problem without sacrificing the security.
JTh2A.20 Quantum temporal imaging and gravitational wave detection, Dmitri Horoshko1, Giuseppe Paterna1, Mikhail I. Kolobov1, B. I. Stepanov1, Inst. of Physics, NASB, Belarus; 2 CNRS, UMR 8523 - PH-LAM, Univ. of Lille, France. We study the quantum field evolution in a temporal imaging system, including the vacuum noise due to finite time aperture. We show how the gravitational wave detector signal can be transmitted to a higher frequency.

JTh2A.21 Purification of Photon Subtraction from Continuous Squeezed Light by Filtering, Jun-ichi Yoshikawa1, Warit Asavant1, Akira Furusawa2, Univ. of Tokyo, Japan. We show that Schrödinger cat states, generated by photon subtraction from squeezed states with conventional continuous-wave methods, have an inherent impurity. Furthermore, we show that the impurity is arbitrarily suppressed by optical filtering.

JTh2A.22 Quantum-Clasical Transmission on Single Wavelength, Rupesh Kumar1, Adrian Wonfor2, Richard V. Penty3, Ian White2, Quantum Communication Hub, UK; 2Univ. of Cambridge, UK. We demonstrate, for the first time, simultaneous generation, transmission and reception of quantum signals and classical signals on a single wavelength. 61.6kbps Quantum key and 590kbps classical data rates are estimated.

JTh2A.23 Quantum monitored long-distance secure optical network, Yupeng Gong1, Rupesh Kumar1, Adrian Wonfor2, Richard V. Penty3, Ian White2, Univ. of Cambridge, UK; 2Univ. of York, UK. We report a method for monitoring physical layer attacks in optical fiber communication using a modulated quantum signal. This system utilizes the quantum noise of the quadrature components of coherent states to monitor fiber links with quantum sensitivity.

JTh2A.24 High-Speed Quantum Key Distribution with Wavelength-Division Multiplexing on Integrated Photonic Devices, Alasdair Price1, Philip Sibson1, Chris Erven1, John Rarity1, Mark G. Thompson1, Centre for Quantum Photonics, Univ. of Bristol, UK. We experimentally implement a compact and practical solution for wavelength-division multiplexed quantum key distribution using integrated photonics. This increases secret key rates and allows for greater operational flexibility to meet network user requirements.

JTh2A.25 Quantum-Enhanced Optomechanical Magnetometry, Jan Bilek1, Berit Ly1, Ulrich B. Hoff2, Lars Madsen2, Stefan Okubo2, Hajime Inaba2, Kazumoto Hosaka2, Feng-Lei Hong1, Adam Leszczynski1, Michal Lipka1, Wojciech Wasilewski1, Univ. of Warsaw, Poland. We experimentally generate a spatially-entangled state using a Raman multimode quantum memory setup and characterize it with the entropic EPR-steering inequality. We obtain genuine violation of 1.06 ± 0.05 ebits and certify entanglement of formation of at least 0.70 ± 0.04 ebits.

JTh2A.26 Breaking up the Anapole: or How to Separate Toroidal and Electric Dipole Excitations in Matter, Vassili Savinov1, We-Yi Tsai2, Din Peng Tsai2, Nikolay I. Zheludev1, Univ. of Southampton, UK; 2Dept. of Physics, National Taiwan Univ., Taiwan. We theoretically calculate the magnetic field sensitivity of 20% using 2.2828 phase-squeezed states.

JTh2A.27 On-Chip Electro-Mechanical Routing of Single Photons from an Embedded Quantum Emitter, Zofia K. Bishop1, Andrew J. Foster1, Benjamin Royal1, Christopher Benthem1, Ed Clarke1, Maurice S. Skolnick1, Luke R. Wilson1, Physics and Astronomy, The Univ. of Sheffield, UK; 2Electronic and Electromechanical Engineering, The Univ. of Sheffield, UK. We demonstrate on-chip routing of single photons in a silicon-semiconductor-based electro-mechanical system with embedded quantum dots. Switching is achieved by electro-mechanical actuation of an integrated directional coupler.

JTh2A.28 Certification of high-dimensional entanglement and Einstein-Podolsky-Rosen steering with quantum memory, Mateusz Mazelanski1, Michal Dabrowski1, Michal Parniak1, Adam Leszczynski1, Michal Lipka1, Wojciech Wasilewski1, Inst. of Experimental Physics, Facul, Poland. We used a Zeeman-like ac-Stark shift to perform spatially-resolved rotations of spins in cold rubidium. Using SLM we extended coherent spins oscillations time and imprinted comb-like patterns on the atomic ensemble.

JTh2A.29 Ultrafast leakage suppression in weakly nonlinear atomic qubits, Hanjo Lee1, Yunheung Song1, Jaewook Ahn1, Korea Adv. Inst of Science and Tech, South Korea. We propose and experimentally demonstrate ultrafast coherent control for leakage transition suppression through inducing destructive interference of constituent two-photon pathways in a three-level system of atomic rubidium, without disturbing resonant two-level qubit subspace operations.

JTh2A.30 Fiber-Integrated Single Photon Devices with High Efficiency and Directional Emission, Changmin Lee1, Mustafa A. Buyukyakko1, Edo Waks1,2, Univ. of Maryland, USA; 2Joint Quantum Inst., Univ. of Maryland and National Inst. of Standards and Technology, USA. Fiber-integrated single photon device based on quantum dot nanobeams and fiber taper is proposed and calculated. Total collection efficiency of 88% is achieved into one arm of fiber taper. Broadband and robust operation of the system is also confirmed.

JTh2A.31 Improving Squeezing Vacuum Generation via Spatial Mode Shaping in Hot RB Vapor, Inna Novikova1, Mi Zhang1, Melissa Gunshor1, Eugeny Mikhailov1, R. N. Lanning1, Zhixiao Xiao2, Jonathan P. Dowling1, College of William & Mary, USA; 2Physics, Louisiana State Univ., USA. Achievable squeezed vacuum may be limited by contamination of the output fields with higher-order spatial modes. Squeezing can be improved by multipass interactions with a less optically-dense medium or by spatial tailoring of the input.

JTh2A.32 An 8-channel optical frequency comb for laser frequency and directional emission measurement, Chuan Li1,2,3, Longyuan Liu2,3,4, Xin Li1,3,4, Tianlong Wang1,3,4, Jiahe Liu1,3,4, 1State Key Lab of Quantum Optics and Quantum Optics Devices, East China Normal University, Shanghai, China; 2Fudan Center for Quantum Communication, Shanghai, China; 3Optical Science and Engineering, The Univ. of Sheffield, UK; 4Fudan University, Shanghai, China. We have developed an 8-channel frequency comb for laser frequency and directional emission measurement. The comb can be utilized to characterize atomic coherence and measurement of multiphotons. Seven lasers used in the Sr and Yb optical cavity laser clocks are frequency stabilized or measured using the developed comb.

JTh2A.33 Spatially-resolved spin manipulation using ac-Stark effect, Adam Leszczynski1, Mateusz Mazelanski1, Michal Parniak1, Michal Lipka1, Wojciech Wasilewski1, Inst. of Experimental Physics, Facul, Poland. We used a Zeeman-like ac-Stark shift to perform spatially-resolved rotations of spins in cold rubidium. Using SLM we extended coherent spins oscillations time and imprinted comb-like patterns on the atomic ensemble.

JTh2A.34 Charging Dynamics of Single InGaAs Quantum Dots under Resonant Excitation, Gary R. Landers1, Samantha D. Isaac1, Wyckoff H. H. Leung2, Glenn S. Solomon3, Edward Flagg3, West Virginia Univ., USA; 2Joint Quantum Inst., National Inst. of Standards and Technology, USA. We investigate the rates of charge fluctuation in single quantum dots under resonant excitation, with additional modulation of low-power above-band excitation. Time-resolved fluorescence is fit using stretched/ compressed exponentials, indicating a continuum of relaxation and charging rates.

JTh2A.35 Integrated Photonic Platform for Scalable Ion-Qubits towards Quantum Information Networking, Youngmin M. Kim1, Shahrar Aghaeemondibadi1, Edo Waks1, Univ. of Maryland, USA. We propose a Si photon platform where ion-qubits can be effectively coupled to polarization insensitive photonic circuits. Our approach aims to improve scalability of ion-qubit system via integration with photonic devices which could form a base architecture for realizing a quantum network.

JTh2A.36 Dissipation-enhanced optomechanically induced transparency, Yong-Chun Lu1, Cuicui Lu1, Li You1, Tsinghua Univ., China; 2Qian Xuesen Lab of Space Technology, China. We find that dissipation can be utilized as a resource to enhance optomechanical non-linearities. We theoretically induced transparency in the unresolved sideband regime. This positive effect of dissipation holds potential for applications including high precision measurements and slow light.

JTh2A.37 Highly Directional Single Photon Source Based on Nitrogen Vacancy Centers, Niko Nikola1, Boa Lubotzky1, Alexander Dohrn1, Hamza Abudayeh1, Nikolai Sadzik1, Florian M. Böhm1, Bernd Sonntheimer1, Ronen Rapaport1, Oliver Benson1, Humboldt-Universität zu Berlin, Germany; 2Hebrew Univ. of Jerusalem, Israel. A stable single photon device consisting of a nitrogen vacancy center coupled to a bulk seed growing will be presented. Beside the highly directional emission pattern, we will report on the functionalization technique using electrostatic forces.

JTh2A.38 Nitrogen-Vacancy-Based Spectroscopy and Control of the Local Paramagnetic Spin Bath in Nitrogen-15 Delta-Doped Diamond, Florian Guillot1, Fionn Gorman1, Eugeny Mikhailov1, R. N. Lanning1, Zhihao Xiao2, Jonathan P. Dowling1, College of William & Mary, USA; 2Physics, Louisiana State Univ., USA. We experimentally generate a spatially-localized single photon source in nitrogen-15 delta-doped diamond. We achieve into one arm of fiber taper. Broadband and robust operation of the system is also confirmed.

JTh2A.39 Towards Light Storage and Retrieval from a Solid-State Atomic Ensemble at the Single-Photon Level, Kuemel Kagawalal2,3,4,5,6,7,8,9, Elena Goldschmidt2, Sergey Polyakov1, Alan Migdall1, Joint Quantum Inst., UMC P, USA; 2US Army Research Labs, USA; 3National Inst. of Standards and Technology, USA. We report progress towards the implementation of a quantum memory in a rare-earth ion-doped crystal. Toward that goal, we demonstrate a narrowband spectral filter for our memory, and measure the optical correlations.

JTh2A.40 Observation of plasmmonic enhanced EIT and velocity selective optical pumping measurements with atomic vapor, Eran Talke1, P. Arora1, Yehonathan Livne1, Uriel Levy1, Dept. of Applied Physics, 91904, Israel, The Benin School of Engineering and Computer Science, The Center for Nanoscience and Nanotechnology, The Hebrew University of Jerusalem, Israel. We demonstrate theoretically and experimentally for the first time nanoscale plasmonic enhanced electromagnetically induced transparency and velocity selective optical pumping effects in miniaturized integrated quantum plasmonic device for D2 transitions in rubidium with V-type system.
JTh2A.41 Probing dipole-dipole interaction at cold-atom density range using optical two-dimensional coherent spectroscopy, Zeyang Yu1,2, Michael Titzer1, Xiaojun Liu1, Hebin Liu1,2
1Dept. of physics, Florida International Univ., USA; 2Wuhan Inst. of Physics and Mathematics, Chinese Academy of Sciences, China. We experimentally demonstrate that the dipole-dipole interaction in a potassium vapor at cold atom density can be observed using optical 2D coherent spectroscopy. This paves the way to implement 2D spectroscopy in cold atoms.

JTh2A.42 Coherent Population Trapping in Cs-filled Kagome Hollow Core Fibers, Marcelo A. Gouveia1,2, Thomas Bradley1, Mohsin Haji1, Natalie Wheeler1, Yong Chen1, Seyed Sandoghashi1, David Richardson1, Patrick Gill1, Marco Petrovich1
1Optoelectronics Research Centre, UK; 2Quantum Metrology Inst., National Physical Lab, UK. We report for the first time Coherent Population Trapping (CPT) in Cs-filled Kagome Hollow Core Fibers. Dark resonance contrasts of up to 90% and linewidths as narrow as 1.8 MHz were observed.

JTh2A.43 Novel nonlinear collective effects in hybrid quantum systems: relaxation to negative temperatures, William Munro1,2, Yusuhe Ham1, Kae Nemoto1,3, NTT Basic Research Labs, Japan; 1National Inst. of Informatics, Japan. Nonlinear systems are known to exhibit interesting and important phenomena that have profoundly changed our technological landscape. They can now be explored in quantum hybrid systems and here we discuss novel effects such as superadiabatic induced negative temperature relaxation in such systems.

JTh2A.44 Spontaneous and Stimulated Emission from Quantum Optical Systems, Rahul Tripathi1, Kevin Fischer1, Shanshan Xu1, Shanhui Fan1, Jelena Vuckovic1, Stanford Univ., USA; 1Electrical Engineering, Stanford, USA; 2Physics, Stanford, USA. We develop a method based on the input-output formalism to analyze stimulated emission of photons by a low-dimensional quantum optical system into 1D loss channels (e.g. waveguides) or a spatial continuum (e.g. free space, photonic crystal).

JTh2A.45 Channeling of Spontaneous Emission from an Atom into the Fundamental and Higher-Order Modes of a Vacuum-Clad Ultrathin Optical Waveguide Arrays, Kwan H. Chan1, Stefan Loffler1,3, Valentin Vlasov1,4, Shanesha Busch1, Viet Giang Truong1, Sile Nic Chormaic1, Olikinawa Inst of Sci and Tech Grad Univ, Japan. We study spontaneous emission from a multi-level atom into the fundamental and higher order modes of a vacuum-clad ultra-thin optical fiber. We examine the dependencies of the rate on the type of modes, the position of the atom, and the fiber radius.

JTh2A.46 Photostable Single-Photon Emission from Organic Nano-crystals, Sofia Pazzagli1,2, Pietro Lombardi1, Daniele Marrella1, Małgorzata Cudoba1, Bruno Trillini1, Francesca Catalotti1, Costanza Tonelli1,2,1,2, Dept. of Physics and Astrophysics, Univ. of Florence, Italy; 1National Inst. of Optics, INO-CNR, Italy; 2European Lab for Nonlinear Spectroscopy (LENS), Italy; 3Inst. of Complex Systems, ISC-CNR, Italy. We report on organic nanocrystals doped with tunable concentration of fluorescent molecules, grown with an easy and inexpensive method and performing as bright and photostable single-photon sources at both room and cryogenic temperatures.

JTh2A.47 Exceptional Points in Passive Plasmonic Nanostructure for Sensing, Jun-Hye Park1, Arshad Kogidala1, Abdoulaye Ndaw2, Boubaer Kante1, 1Univ. of California San Diego, USA. We propose a passive plasmonic nanocrystals sensor operated at an exceptional point (EP), that fundamentally shift more than conventional resonances and will pave the way to highly sensitive plasmonic devices.

JTh2A.48 Spin Hall Effect from Achiral Nanohole Arrays, Chao Liu1, Xiaoyu Guo1, H. C. Ong1,2, 1Chinese Univ. of Hong Kong, Hong Kong, China; 2Nanyang Technological University, Singapore. We continuously steer the propagation direction of the degenerate (-1,1) surface plasmon on circular nanohole arrays under an elliptical polarization. The directionality has been attributed to the coherent control of the dark and bright modes.

JTh2A.49 Angular sensitivity of PT-symmetric optical lattices, Konstantinos Makris1, Stylianos Miliaresis1, Ioannis Kavoulakis1, 1Univ. of Crete, Greece; 2Inst. for Theoretical Physics, Vienna Univ. of Technology, Austria. We investigate the sensitivity of the diffraction pattern in PT optical lattices near exceptional points. We examine the range of excitation angles in one and two-dimensional lattices, that leads to the maximum sensitivity.

JTh2A.50 Surface Emitting Plasmonic Laser with Distributed Feedback, Ekemba K. Tankyu1, Soheila Mashhadi1, Cansu Or12, M. Oktar Faruk1, Erin Harrison1,2, Mikhail A. Noginov1,2, 1Univ. of Delaware, USA; 2Summer Research Program, Center for Materials Research, NSU, USA; 3Center for Materials Research, NSU, USA. We have demonstrated the novel low-threshold surface-emitting plasmonic laser and explained its performance in terms of the distributed feedback mechanism, providing a new degree of freedom to the laser design.

JTh2A.51 Hybrid-plasmonic gold coated GaS nanowires, Faatemehsadeh Mohammad1, MyPhay Lyuychev1, Hoe Tan1, Chennupati Jagadish1, Martin Frasrd1, Hans Peter Wagner1, 1Dept. of Physics, Univ. of Cincinnati, USA; 2Dept. of Electrical Engineering, Stanford, USA; 3Physics, Stanford, USA. We develop a method based on the input-output formalism to analyze stimulated emission of photons by a low-dimensional quantum optical system into 1D loss channels (e.g. waveguides) or a spatial continuum (e.g. free space, photonic crystal).

JTh2A.52 Tunable Random Lasing Emissions by Manipulating Plasmonic Coupling Strengths on Flexible Substrates, TingWei Yeh1, ChunYang Chou1, ZuoPo Yang1, Nguyen Thi Bich Hanh1, YungCh Yoo2, Meng-Tsan Tsai2, Ye Jun Lee1, 1National Taiwan Normal Univ., Taiwan; 2National Chiao-Tung Univ., Taiwan. We experimentally demonstrated flexible random laser fabricated on the PET substrate with tunable emissions. Lasing wavelength is blue-shifted with the bending strains exerted on the PET, and the maximum shift of ~15 nm was achieved.

JTh2A.53 Optical properties of graphene flakes and organic molecules, Rodrigo A. Muniz1, Zaheen S. Sadeq1, John E. Sipe1, 1Univ. of Toronto, Canada. We compute the electronic states of graphene flakes and organic molecules including electron correlations beyond the mean field level. We analyze the linear and nonlinear optical properties of these systems and discuss their implications.

JTh2A.54 Highly Sensitive Refractive Index Sensing with Silicon-Based Dielectric Metasurfaces, Adam Ollanik1, Matthew D. Escarra1, Tanara Khan1,2, 1Chinese Univ. of Hong Kong, Hong Kong; 2Center for Materials Research, NSU, USA. We design and simulate angular momentum (OAM) spectrum with spiral polarization modulation, the diffracted light using a slit. We experimentally demonstrate that the dipole-multipole plasmonic lasing is achievable despite of a non-continuous metal surface.

JTh2A.55 Highly Sensitive Refractive Index Sensing with Silicon-Based Dielectric Metasurfaces, Adam Ollanik1, Matthew D. Escarra1, Tanara Khan1,2, 1Chinese Univ. of Hong Kong, Hong Kong; 2Center for Materials Research, NSU, USA. We design and simulate angular momentum (OAM) spectrum with spiral polarization modulation, the diffracted light using a slit. We experimentally demonstrate that the dipole-multipole plasmonic lasing is achievable despite of a non-continuous metal surface.

JTh2A.56 Tunable plasmonic subwavelength grating using electrically controlled conductive oxide, Erwin U., Gian Gao1, Alan X. Wang1, 1Oregon State Univ., USA. We design and experimentally demonstrate an electrically tunable plasmonic subwavelength grating at telecommunication wavelength based on a metallic subwavelength slit array coupled with a Si/SiO2/ITO semiconductor-oxide-metal (MOS) capacitor, achieving 32%-56% transmission-reflection modulation.

JTh2A.57 Generation of Surface Plasmon Polaritons in Graphene-Semiconductor Structure with Distributed Feedback, Igor O. Zolotovskii1, Yuliya S. Dadoenkova1, Aleksei S. Kadochkin1, Sergey G. Moiseev1, 1Ulyanovsk State Univ, Russia. We have shown the possibility of surface plasmon polaritons generation in a waveguiding system containing semiconductor film and graphene single-layer.

JTh2A.58 Scanning Light-Diffraction Microscopy, Hira Farooqi1, Saeed Skinner-Ramos1, Luis Grave de Peralta1, 1Physics and Astronomy, Texas Tech Univ., USA. We used and experimentally demonstrated a novel subwavelength resolution microscopy technique by illuminating the sample with the hollow-cone of light produced by a ring-shaped condenser and scanning the diffracted light using a slit.

JTh2A.59 Generation of Prescribed Optical Orbital Angular Mo-mentum Spectrum with Spiral Polarization Modulation, Chenshao Wan1, Xihua Tang1, YingXiong Qin1, Yu Xiao1, Qwen Zhan1, 1Huazhong Univ. of Science & Technology, China; 2Dept. of Electro-Optics and Photonics, Univ. of Dayton, USA. We report a method to generate prescribed orbital angular momentum (OAM) spectrum with spiral polarization modulation. The generated OAM spectrum contains 11 OAM states of equal intensity and various linear polarization angles.

JTh2A.60 High Q Si Slot Waveguide Ring Resonators for Gas Sensing Application, Yuki Tomono1, Hiromasa Shimizu1, 1Tokyo Univ. of Agr. and Tech., Japan. We fabricated Si slot waveguide ring resonators having Q-factor of 2.5x10^4. Based on the resonance characteristics, refractive index sensitivity Dn of 1x10^-5 was theoretically estimated by the difference of transmitted optical intensity at the resonance wavelength.

JTh2A.61 Determination of Complex Hermitian and Anti-Hermitian Interaction Constants from a Coupled System via Coher-ent Control, M. Saara Haimi1, Xianyu Guo1, Shaoqiong Cao2, H. C. Ong1, 1The Chinese Univ. of Hong Kong, Hong Kong. We devise a new method to determine the complex Hermitian and anti-Hermitian coupling constants from a coupled system via coherent control. The method is verified numerically and experimentally on various photonic and electronic systems.

JTh2A.62 Integrated Plasmonic Waveguide at the Mid-Infrared, Binggang Zhu1, Wen Zhou1, Hon Ki Tsang1, 1Chinese Univ. of Hong Kong, Hong Kong. We demonstrate an integrated plasmonic waveguide fabricated on the silicon-on-insulator platform at the mid-infrared range. Experimentally, the metal-insulator-metal made propagation loss is 1.16 dB/μm, and the Si-to-SiP2 mode converter loss is 4.1 dB/interface.

JTh2A.63 Excitation Light-Induced Anisotropies in LSP-Enhanced SHG from Au Nanoprisms, Atsuji Sugita1, Hirofumi Yogo2, Shohei Hamada1, Atsushi Ono1, Yoshimasa Kawata1, Shuzuka Uyama1, 1Shinshu Univ., Japan. We report excitation light-induced anisotropies in polarized SHG for Au nanoparticles at LSP resonances. The anisotropies were pronounced more in higher excitation powers. The phenomena were explained by taking account of 2nd and 4th-order nonlinearities.
Leahu1, Alessandro Belardini1, Emilija Petronijevic1, Roberto Grigore

Thermal Scan of Metal Based Metasurface and Evidence implying improved spatial resolution in optical measurements. Microscopy based on a multifrequency method. Using this novel excitation and detection scheme in near-field optical microscopy a high symmetry in the heat transport and its relation with the opto-metasurfaces. We experimentally evidence the role of the structures, which are consistent with the nonlinear photon-dielectric metasurfaces. We demonstrated at a quantum cascade laser used as both a light source and a detector. The experimental setup and preliminary results on gold/sapphire samples are presented.

JTh2A.65
Graded-Index Plasmonic Nanoparticles: Light Scattering Characteristics and Peculiarities, Dimitrios Tzarouchis1, An Sihvola1, ’Aalto Univ., Finland. Light scattering by sub-wavelength spheres exhibiting a radially inhomogeneous permittivity are presented. The theoretical model for power-law, exponential, and Drude-like inhomogeneous profiles are discussed, generalizing the concept of polarizability for graded-index nanoparticles.

JTh2A.66
Multifrequency Near Field Scanning Optical Microscopy (MF-SNOM), Hadar Greener1, Michael Meyen1, Uri Arieli1, Haim Suchowski1, ’Tel Aviv Univ., Israel. We introduce a novel excitation and detection scheme in near-field optical microscopy based on a multifrequency method. Using this method, we experimentally demonstrate enhanced sensitivity, implying improved spatial resolution in optical measurements.

JTh2A.67
Thermal Scan of Metal Based Metasurface and Evidence of Circular Dichroism and Optroscopic Anisotropy, Grigore Leahu1, Alessandro Belardini1, Emilia Petronijevic1, Roberto Li Voti1, Concita Sibilis1, Tiziana Cesca1, Giovanni Mattei1, ’Univ degli Studi di Roma La Sapienza, Italy; ’Università di Padova, Italy. Photothermal and photoacoustic techniques are utilized to explore the thermal properties of metal based metasurfaces. We experimentally evidence the role of the symmetry in the heat transport and its relation with the optical circular dichroism.

JTh2A.68
Electric Field Enhancement by Two-scale Structure, Mahsa Davishadeh Varche1, William John Thrift1, Mohammad Kamand1, Regina Ragan1, Filippo Capolino1, ’Univ of California Irvine, USA. We propose a novel multi-length-scale architecture for giant electric field enhancement. We investigated the capability of our structure to boost the electric field analytically and using full-wave simulations and verify our results with surface-enhanced Raman spectroscopy experiment.

JTh2A.69
Plasmonic enhancement and control of optical nonlinearity in monolayer WS2, Wei-Yun Liang1, Hyeyoung Ahn1, Youngang Sang1, Yenning Wang1, Jiwon Shu1, Sonya S. Bajaj1, Yi-Hsien Lee1, K. Birol Guven1, ’Tel Aviv Univ., Israel. We demonstrate reduced graphene resistance through h-BN integration hexagonal boron nitride h-BN)-encapsulated graphene on top of a compact silicon microdisk resonator for modulation applications. We demonstrated reduced graphene resistance through h-BN encapsulation and showed active tuning of the optical mode through voltage-legged graphene.

JTh2A.70
Integrated resonant units of metasurface for broadband efficiency and phase modulation, Ren Jie Lin1, Huai-Hsin Hsiao2, Yi-Chen Lai1, Bo Han Chen1, Pin Chieh Wu1, Yi-Chih Lai1, Shuming Wang1, Din Ping Tsai1,2, ’Dept. of Physics, National Taiwan Univ., Taiwan; ’Graduate Inst. of Biomedical Opto-chromatics, Taipei Medical Univ., Taiwan; ’Research Center for Applied Sciences, Academia Sinica, Taiwan; ’School of Physics, Nanjing Univ., China. Integrated-resonant units (IRUs) provide additional degree of freedom to control the phase compensation and enhance the conversion efficiency over a broad bandwidth of light. In this work, we demonstrated achromatic metalenses in visible range and broadband versatile polarization generator.

JTh2A.71
Enhanced Harmonic Generation in Metal-Insulator-Metal Nanostuctures, Malik Mohd Rahim Hassan1, Zhengning Gao1, Domenico de Ceglia1, Maria A. Vincenti1, Andrew Sarangan1, Imad Agha1, Michael Scalora2, Parag Banerjee2, Joseph Haus1, ’Dept. of Electro-Optics and Photonics, Univ. of Dayton, USA; ’Inst. of Materials Science and Engineering, Washington Univ., USA; ’Dept. of Information Engineering, Univ. of Padova, Italy; ’Dept. of Information Engineering, Univ. of Brescia, Italy; ’Charles M. Bowden Research Lab, US Army AMRDEC, USA; ’Dept. of Mechanical Engineering & Materials Science, Washington Univ., USA. We experimentally observed no change in second-harmonic signal and an enhancement of the third-harmonic signal from metal-insulator-metal nano-structures, which are consistent with the nonlinear photo-assisted electron tunneling current flowing through them.

JTh2A.72
Scattering near-field mid-infrared microscopy using self-mixing in quantum cascade lasers, Mingzhou Jin1, Mikhail A. Bekov1, ’Univ. of Texas at Austin, USA. We demonstrated scattering near-field mid-infrared imaging via the self-mixing in a quantum cascade laser used as both a light source and a detector. The experimental setup and preliminary results on gold/sapphire samples are presented.

JTh2A.73
Strong Mode Coupling and High-Q Supercavity Modes in Subwavelength Dielectric Resonators, Kirill Kashleev1, Andrey Bogdanov1, Sergey Gladyshev1, Zarina Sadrieva1, Mikhail Rybin2, Kirill Samusev2, Mikhail Limonov2, Yury S. Kivshar1, ’Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia; ’Ioffe Inst., Russia; ’Nonlinear Physics Centre, Australian National Univ., Australia. We reveal that isolated subwavelength dielectric resonators support states with giant Q-factors similar to bound states in the continuum formed via destructive interference between strongly coupled eigenmodes and characterized by singularities of the Fano parameters.

JTh2A.74
Hybrid Metal-Dielectric Metasurfaces For Refractive Index Sensing, Debidatta Ray1, TV Razaman1, Christian Santschi1, Andreas Tittl1, Dordaneh Etezadi1, Hatice Altug1, Olivier Martin1, ’EPFL, Switzerland. The utilization of a hybrid metal-dielectric metasurface for sensing is demonstrated experimentally. We show how the hybridization between the different modes supported by the structure determines the overall sensitivity of the system.

JTh2A.75
Optimization of Titanium Nitride Films using Plasma Enhanced Atomic Layer Deposition, Ray R. Secondo1, Vitaliy Avrutin1, Umit Ozturk1, Nathaniel Kinsey1, ’Virginia Commonwealth Univ., USA. We investigate the quality of atomic layer deposited Titanium nitride thin films and find metallicity close to high quality sputtered films on both Sapphire and silicon for a deposition temperature of 375°C.

JTh2A.76
InGaAs/InP Multi-quantum-well Nanowires Directly Grown on SOI Substrates and Optical Property Characterizations, Mengqi Wang1,2, Zhibo Li1, Xuliang Zhou1, Yue Li1, Pengfei Wang1, Hongyan Yu1, Wei Wang1,2, Jiaojing Pan1,2, ’Inst. of Semiconductors, Chinese Academy of Sciences, China; ’Colledge of Materials and Science and Opto-Electronic Technology, Univ. of Chinese Academy of Sciences, China. InGaAs/InP MQW nanowires were directly grown on SOI substrates by ART technique. Multiple characterizations which applied to reveal the material quality and optical properties, had proved that such MQW nanowire was capable of an active waveguide cavity for potential photonic applications.

JTh2A.77
Yb-doped Large-Made/Area AlP-Silicate Laser Fiber fabricated by MCVD, Anirudm Haldar1, Lin Di1, Andrey A. Unnikov1, N. J. Ramirez-Martinez1, Martín N. Núñez-Velázquez1, Pranabesh Banerj1, Shail-UL Alam1, Jayanta K. Sahu1, ’Univ. of Southampton, UK. We demonstrate an efficient ytterbium-doped aluminophos-silicate low-N.A. fiber fabricated by modified solution-doping process that shows continuous-wave laser efficiency of 81%. In ps-MOPA, the fiber provides 35kW peak power with repetition-rate 1.46MHz, and average power 9.1W.

JTh2A.78
Hybrid h-BN/Graphene/h-BN Silicon Device for Electro-optic Modulation, Tianran Fan1, Amir H. Hossainv1, ’Hamid Moradinejad1, Ali Asghar Eftekhari1, Ali Adibi1, ’Georgia Inst. of Technology, USA. We integrated hexagonal boron nitride h-BN)-encapsulated graphene on top of a compact silicon microdisk resonator for modulation applications. We demonstrated reduced graphene resistance through h-BN encapsulation and showed active tuning of the optical mode through voltage-legged graphene.

JTh2A.79
Investigation of High Temperature Photoluminescence Efficiency from InGaN/GaN MQWs, Abbas P. Sabbar1, Syam Madhusoodanan1, Sattar Al-Kabi1, Binzhong Dong1, Jiangbo Wang1, Shui-Qing Yu1, Zhong Chen1, ’1Dept. of Electrical Engineering, Univ. of Arkansas, Fayetteville, USA; ’2HC Semitek, China; ’HC Semitek, China Temperature and power dependent photoluminescence (PL) measurements from InGaAs/GaN MQWs, which was grown on a sapphire substrate were performed to extract the PL efficiency.

JTh2A.80
Numerical Characterization of Monolayer Ink-Jet Printed Poly styrene Lattice, Ray R. Secondo1, Karan Nashwan Al-Milaji1, Tse Ngai Ng1, Hong Zhao1, Nathaniel Kinsey1, ’Virginia Commonwealth Univ., USA; ’Univ. of California San Diego, USA. We investigate the color of polystyrene metasurfaces printed via a novel dual-droplet ink-jet technique resulting in a closely-packed hexagonal formation through self-assembly. Simulations, Mie Theory, and Bragg Diffraction calculations are utilized for spectra validation.

JTh2A.81
Highly Transparent Organic Microdisk Cavity in Visible Range by the Ink-Jet Printing Method, Taku Takagishi1, Hiroaki Yoshikawa1, Shinarto Mitsu1, Yuya Miki1, Naoya Nishimura1, Yoshi Okii1, Kyushu Univ., Japan; ’Nissan chemical industries, Ltd, Japan. We experimentally demonstrated the fabrication and the fundamental lasing evaluation of a printed microdisk cavity by focusing on a fluorinated spherical polymer F2-001 to achieve a microdisk with small absorption loss in the visible range.
JTh2A.82 Stable, inkjet printed temperature- and humidity-resistant black phosphorus for ultrafast lasers, Xinrin Jin, Guohua Hu, Na Zhang, Yuwei Hu, Ting Li, T Albrow-Owen, R Howe1, T Wu, Zheng Zheng, Tawfiqke Hasan1, Behang Univ., China; 2Cambridge Graphene Centre, UK. We demonstrate an inkjet-printed temperature- and humidity-resistant black phosphorus saturable absorber, enabling stable continuous mode-locking over 210 hours. Our work highlights the potential of BP-based devices for photonic applications operating under challenging environmental conditions.

JTh2A.83 Inkjet-printed optically uniform transition metal dichalcogenide nanosheets absorbers, Qing Wu1, Guohua Hu, Meng Zhang, Xinrin Jin, Yuwei Hu, Ting Li, T Albrow-Owen, R Howe1, T Wu, Zheng Zheng, Tawfiqke Hasan1, Behang Univ., China; 3Cambridge Graphene Centre, UK. We report self-starting mode-locking in all-fiber erbium-doped lasers utilizing inkjet-printed transition metal dichalcogenide saturable absorbers, exhibiting highly optical uniformity, with <5% standard deviations.

JTh2A.84 Single Crystal Growth of BaGa4S7 and BaGa4Se7 by the Horizontal Gradient Freeze Technique, Peter G. Schunemann1, Ertuğrul Karademir1, John F. Donegan1, Univ. of Dublin Trinity College, Ireland, 2Western Digital Corporation, USA. Focusing elements in integrated optics are required for localised high intensities and coupling between certain components. Here, a focused design element is used by applying analytical approximations, simulated using FDTD and characterised using far-field optical imaging. Focusing below 92% is predicted.

JTh2A.85 Planar Focusing Element Based on Scattering Structures in a Dielectric Waveguide, Brian D. Jennings1, David McCloskey1, Alexander Krichesky2, Christopher Wolff1, Frank Bello1, Ertuğrul Karademir1, John F. Donegan1, Univ. of Dublin Trinity College, Ireland, 2Western Digital Corporation, USA. We report on the design and fabrication of the first double-clad hypocycloid core-contour Kagome hollow-core photonic crystal fiber optimized for guidance in air-core at 1μm via Inhibited-Coupling and in a cladding silica ring via total-internal-reflection.

JTh2A.86 Novel spectrscopic transparent/scattering material for 260/280 nm ultraviolet optical detection, Kasuke Nakakubo1, Jun Feng Zhu1, Yuya Mikami1, Kinichi Morita2,1, Hiroaki Yoshioka1, Yuji Oki1, 2Dept. of Electrical and Computer Engineering, Univ. of Texas at Austin, USA. We study strain effects on Auger recombinations in GaInAs/GaAs multiple quantum well structures emitting ~3 μm, using differential reflection pump-probe and photoluminescence spectroscopy; results suggest increasing strain decreases Auger and increases radiative recombination strength.

JTh2A.87 Enhanced Spontaneous Emission of Quantum Emitters in the Vicinity of TiN Thin Films, Shaima I. Azzam1, Motoharu Saito2, Shunsuke Mura3, Satoshi Ishii1, Katsuhisa Tanaka3, Alexander Kildishev4, Purdue Univ, USA; 2Kyoto Univ., Japan; 3National Inst. for Materials Science, Japan. We report on the enhancement of spontaneous emission from organic dyes on top of TiN films. Up to 200-fold Purcell enhancement is achieved. The proposed structures are modeled in the time domain and validated experimentally.

JTh2A.88 Dissolvable and Recyclable Random Lasers, Shih-Yao Lin1, Yu-Ming Liao1, Hung-Ling1, Wei-Ju Lin1, Yang-Fang Chen1, Tyan-Yuan Lin1, Wei-Cheng Liao1, Yu-Fang Huang1, Ying-Chih Lai3, Zhaona Wang1, Xueyu Shi1, Cheng-Hang Chang1, National Taiwan Univ., Taiwan; 2National Taiwan Ocean Univ., Taiwan; 3National Chung Hsing Univ., Taiwan; 4Beijing Normal Univ., China. The dissolvable and recyclable random laser can be dissolve in water, accompanying the decay of emission intensity and the increment in lasing threshold. It can be reused after deionized treatment, exhibiting reproducibility with recycling processes.

JTh2A.89 All Inorganic Perovskite Quantum Dots Hybrid Green Light-Emitting Diode with Stable Performance, Chung-Ping Yu1, Shih-Yao Lin1, Tzu-Yu Chen1, Yu-Min Chiu1, Chung-Ping Huang1, Shu-Hsu Chang1, Shun-Chieh Hsu1, Teng-Ming Chen1, Hao-Chung Kuo1, Chen-Ching Lin2, Dept. of Applied Chemistry, National Chiao-Tung Univ., Taiwan; 3Inst. of Electro-Optical Engineering, National Chiao-Tung Univ., Taiwan; 4Inst. of Photonics System, National Chiao-Tung Univ., Taiwan, 5Inst. of Imaging and Biomedical Photonics, National Chiao-Tung Univ., Taiwan; 6Inst. of Lighting and Energy Photonics, National Chiao-Tung Univ., Taiwan. A silica-coated inorganic perovskite quantum dot hybrid light-emitting diodes is aged continuously in high and low light intensity conditions. Both blue and ultra-violet-pumped samples showed stable performances up to 104 hours.

JTh2A.90 Linear and Nonlinear Optical Response of Monolayer Two-dimensional Transition Metal Dichalcogenide Monolayer and WS2, fabricated by Chelate Precursor Doping Technique, Yuwei Hu1, Huan Zhan1, Kun Peng1, Shuang Liu1, Xiaolong Wang1, Li Ni1, Shihao Sun1, Jiai Jiang1, Lei Jiang1, Juan Yu1, Jianjun Wang1, Feng Jiang1, Aixiang Lin1, China Academy of Engineering Physics, Beijing. The chelate precursor doping technique, e.g. Yb:Ce-codoped alumino-silicate fiber was fabricated and reported. The fiber showed excellent laser stability at 1850 nm with minor 50% power degradation with <1.04%.

JTh2A.91 Optical Tapping of Living Bacteria in 2D Hollow Photonic Crystal Cavities, Rita Trenodos1, Manson Tardel2, Pierre Marcoux3, Emmanuel Picard1, Emmanuel Hadji2, David Peyrade2, Romuald Houdré1, Inst. de Physique, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland; 2CNRS - LTM - Micro and Nanotechnologies for Health, Univ. Grenoble Alpes, France; 3CEA/NAC-PHELOCOSINAPS Univ. Grenoble Alpes, France; 4CEA-LETI-DTBS-SBCS-LCM/LBAM, Univ. Grenoble Alpes, France. We report on the optical tapping of seven types of living bacteria in 2D hollow photonic crystal cavities. The possibility of distinction of bacteria via the interaction effects with the tapping field will be discussed.

JTh2A.92 Optical Trapping of Filiformis Phytoplankton, Andrey Chikishev2, John G. Wright1, Matthew Stott1, Jennifer A. Black2, Holger Schmidt2, Aaron Hawkins2, Brigham Young Univ., USA; 3Inst. of Modern Optics, Nankai Univ., China; 4Tianjin Key Lab of Op-toelectronic Sensor and Sensing Network Technology, China; 5Lomonosov Moscow State Univ., Russia; 6International Laser Center of Moscow State Univ., Russia. We apply the method of Raman spectroscopy to the study of enzyme kinetics. It is shown that Raman spectroscopy data can be used for calculation of chemical reaction rates and catalytic activity of α-chymotrypsin.

JTh2A.93 Optical Tapping of Filiformis Phytoplankton, Andrey Chikishev2, John G. Wright1, Matthew Stott1, Jennifer A. Black2, Holger Schmidt2, Aaron Hawkins2, Brigham Young Univ., USA; 3Inst. of Modern Optics, Nankai Univ., China; 4Tianjin Key Lab of Optoelectronic Sensor and Sensing Network Technology, China; 5Lomonosov Moscow State Univ., Russia; 6International Laser Center of Moscow State Univ., Russia. We apply the method of Raman spectroscopy to the study of enzyme kinetics. It is shown that Raman spectroscopy data can be used for calculation of chemical reaction rates and catalytic activity of α-chymotrypsin.
Effect of Viscosity on Fluorescence Lifetime Measuring Using Flow Cytometry, Faisal H. Alturkiastani, Kasip Nichani, Wenyen Li, Jessica P. Houston, New Mexico State Univ., USA. The effect of viscosity on Dronpa-3 fluorescence protein kinetics is studied using time resolved flow cytometry (TRFC). Phasor analysis and Förster-Hoffman relation analysis provide the basis of studying intracellular viscosity in high throughput manner.

Mode and sensing properties of the deformed microdroplet, Meng Zhang1, Jiansheng Liu1, Weifeng Cheng1, Jietao Cheng2, Hongwen Zhou2, Haitao Liu, Jie Chen1, Qing Wu1, Yuhang Wen2, Zheng Zheng1, Behang Wang, China; Virginia Tech, USA. The resonant mode along meridian of a deformed droplet on a hydrophilic substrate with different contact angle CA is investigated. A relatively large Q ~ 2000 and a quality factor of 500 nm RII can still be achieved even with CA down to 15000.

Hyper-spectral and multimodal CARS microscopy of structured endogenous biomolecules in Euglena gracilis, Joel T. Tabarangao1, Jeremy G. Porquez2, Aaron D. Siegkow3, Trent Univ., Canada. Using hyper-spectral CARS and SHG microscopies we image and fingerprint an intriguing biomolecule in phototrophic Euglena gracilis. The large CARS signal strength of this endogenous biomolecule opens new opportunities in label-free, live biological imaging.

Imaging of 3D Molecular Orientations by Polarization-Controlled Coherent Raman Microscopy, Young J. Lee1; 1Chi-lin Research Institute, Taiwan, China. Label-Free Biochemical Detection, Young J. Lee1; 1Chi-lin Research Institute, Taiwan, China. Imaging of 3D Molecular Orientations by Polarization-Controlled Coherent Raman Microscopy, Young J. Lee1; 1Chi-lin Research Institute, Taiwan, China. Label-Free Biochemical Detection, Young J. Lee1; 1Chi-lin Research Institute, Taiwan, China.

Spatially Gain-Tailored Fiber Raman Laser Cladding, Hajime Inaba1,2; 1The Univ. of Hong Kong, China. 2JST, ERATO, MINOSHIMA Intelligent Robotics, Japan. We demonstrate a vortex beams coupler which can superimpose FGBs, Yinhu Hou1, Qian Zhang1, Shuxian Qi1, Xiang Feng4, Pu Wang4, Beijing Univ. of Technology, China. We demonstrate a PM dual-wavelength single-frequency Er-doped fiber laser as a stable microwave generation source. The beat frequency of the dual-wavelength is 28.4474 GHz with the linewidth less than 0.3 kHz.

Spatial-Mode Switchable Ring Fiber Laser Based on Low Mode-Crosstalk Few-mode Fiber and Mode MUX/DEMUX, Yu Yang1, Juhao Lu1, Fang Ren1, Jinglong Zhu1, Yongqi He1, Zhou Li1, Qing Liu1, Peking Univ., China; 1Univ. of Science and Technology Beijing, China. A spatial-mode switchable ring fiber laser based on low mode-crosstalk few-mode fiber and mode multiplexer/demultiplexer (MUX/DEMUX) is proposed. We experimentally demonstrate that output lasing mode can be switched among the three lowest-order LP modes.

Efficient Frequency Doubling of an Ytterbium-Doped Fiber Ring Laser Using an Internal Enhancement Cavity, Stanislav K. Vassilev1, William A. Clarkson1, 1Optoelectronics Research Centre, UK. A novel fiber laser geometry incorporating an internal resonant enhancement cavity to generate visible output via second harmonic generation is presented. Preliminary experiments using system fiber gain medium yielded 17W of single-mode output at 540nm.

Generation and Amplification of First Order OAM with Fused Taper Coupler, Jianxiang Wen1; 1Shanghai Univ., China. We demonstrated a vortex beams coupler which can generate at range of 1480 ~ 1640 nm and built up an all-fiber vortex amplification system, which is of the higher gain and better flatness of OAM.

All-fiber Laser Source at 1.7 µm for Photoacoustic Microscopy in Lipid Detection, Nan Chen1, Can Li2, Bowen Li1, Kenneth Xin-Yip Wong1; 1The Univ. of Hong Kong, China. Multi-wavelength all-fiber laser source in 1.7-µm regime combining parametric oscillation and thulium-doped fiber amplification is reported. Its high flexibility facilitates itself of high performance in high-speed OAP-PAM for lipid detection in the first overtone wavelength.

Distribution of Bending-Induced Birefringence in Single-Mode Fibers with PA-CDFR, Yanling Shang1, Zhi Zhou1, Yufeng Zhai1, Kent D. Sevick1, Feng Qi1, Jennifer Wang1, Anton Khamene2, James Chen1, Xiaohua Yang1, Xiaolan S. Yao1; 1Hebei Univ., China; 2General Photonics Corporation, USA. We demonstrate the distributed bending-induced birefringence measurement in single-mode fibers with high spatial resolution using a polarization-analyzing optical frequency domain reflectometry. The bending-induced birefringence coefficient of 5.499×10⁻¹⁰ m⁻¹ is accurately obtained.

Implementation of linearly-polarized LP01 modes to any azimuthally-oriented LP01 mode conversion, Lipeng feng1, Yan Li2, Shian Wu1, Xingmin Zeng3, Wei Li4, Rongsheng Chen5, Jifang Qiu1, Xiaobin Hong1, Ian P. Giles6, Jian Wu1, Beijing Univ. of Posts and telecom, China; 2Phoenix Photonics, UK. We propose a scheme that converts fundamental modes of different polarization to asymmetrical spatial modes of different orientation, of utility in exchange data between preceding PDM and rising MOD optical networks.

Multiplexed mode-locked fiber laser emitting dissipative and conventional solitons, Bowen Liu1, Yiyang Luo1, Yang Xiang1, Zhijun Fan1, Yinxiong Gai1, Qihun Sun1, Xiahui Tang1, Huazhong Univ. of Science and Technology, China. We report a bidirectional passively mode-locked fiber laser supporting both dissipative and conventional soliton emission in different propagating directions. Moreover, broadband wavelength-tunable solitons, dual-wavelength solitons and wavelength-tunable noise-like pulses are respectively obtained.

High Peak Power Single-Frequency Amplifier Based on Er-Yb Doped Polarization Maintaining LMA Fiber, Anne Durécu1, Pierre Boudron1, François Gavuste1, Hermance Jaccmin1, Julien Le Gouët1, Laurent Lombard1; 1ONERA, France. We report on single-frequency fiber amplifiers based on PM Er:Yb doped P2O5-Al2O3-SiO2 fibers. Peak power up to 700W at 1545nm for 730ns pulse duration was obtained with a good beam quality and a 17dB PER.

Bidirectional, Er-doped, Dual-comb Fiber Laser with Carbon Nanotube Polyimide Film, Shuto Sato1, Lei Jin1, Yoichi Saitakibara1, Emiko Omoda1, Hiromichi Kataura1, Norihiko Nishizawa1; 1Nagoya Univ., Japan; 2AIST, Japan. A dual-directional, Er-doped dual comb fiber laser was demonstrated using polyimide film dispersed with single wall carbon nanotube. Difference of repetition frequency was temporally stable and it could be tuned continuously by pump power control.

Directly modified single mode fiber as an intermodal interferometer based on single femtosecond-laser induced line, Pengcheng Chen1, Shu Xuewen1; 1Huazhong Univ. of Sci. & Tech., China. We demonstrate a novel Mach-Zehnder interferometer based on a single femtosecond-laser induced positive refractive index-modified line created in the core of a single-mode fiber. The device is extremely simple in structure and very efficient in manufacturing.

Dispersion Engineering Analysis of Er-Fiber Based Comb Amplification in All-Fiber Configuration, Ken Kashivagi1; 1National Inst. of Advanced Industrial Science and Technology, Japan; 2JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan. We experimentally and numerically investigated dispersion engineering of amplification of erbium-fiber based comb. Spectral narrowing in a fiber amplifier increased the effective gain and enhanced the peak power at fiber-based dispersion compensator output.
We demonstrate an electro-optic JTh2A.125

dual-comb spectroscopy, Wang Shuai1, Xinyu Fan1, Bingxin Xu1, Zuyuan He1; Shanghai Jiao Tong Univ., China. We demonstrate an electro-optic dual-comb spectroscopy with 1-MHz spectral resolution. By using quasi-integra-ratio multiheterodyne approach, 36000 electro-optic comb lines were well resolved with an increased measurement speed of 3000.

JTh2A.126

Design of a Dual-Channel Mode-locked Fiber Laser that Avoids Multi-Pulsing, Xianting Zhang1, Shaokang Wang2, Meng Liu1, Can Li1, Cihang Kong1, Kenneth Kin-Yip Wong2; 1Univ. of Hong Kong, Hong Kong; 2South China Normal Univ., China. We report on the observation of optical rogue waves (RWs) in a normal-dispersion fiber laser during the chaotic dissipative soliton build-up process. These findings indicate a promising approach for optical RW generation.

JTh2A.127

Optical Computing Based on Recirculating Frequency Shifter, Zhiqiang Qin1, Qiaohua Cen1, Yitang Dai1, Feifei Yin1, Kun Xu1; Beijing Univ. of Posts and Telecommunications, China. Optical computing is an effective technique to accelerate the computing process. Here, an optical computing scheme based on recirculating frequency shifter is proposed and experimentally demonstrated. Matrix multiplication can be realized based on our scheme.

JTh2A.128

High Damage Threshold Semiconductor Saturable Absorber Mirror for Fiber Lasers, Yan Wang1, Nan Liu1, Wanki Gao1, Huanyu Song1, Mingjie Hu1, Haming Lin1, Wenxia Bao1, Xiaoyu Ma1, Zhigang Zhang1; Peking Univ., China; Inst. of semiconductors, Chinese Academy of Sciences, China; 1Tianjin Univ., China; 2Z Lasers, China. We demonstrate a high damage threshold semiconductor saturable absorber mirror for mode-doped fiber lasers, with a damage threshold of 9.5 mJ/cm², a modulation depth of 11.5%, a saturation fluence of 39.3 J/cm², an S parameter of 3±10 J/cm².

JTh2A.129

Fabrication of Low Loss Low-NA Highly Yb-doped Aluminophosphosilicate Fiber for High Power Fiber Lasers, Raghuvaran Sidharthan1, Serene Hueting Lim1, Kang Jie Lim1, Daryl Ho1, Chun Ho Tee1, Junhua Ji1, Huizi Li1, Yue Men Seng1, Song Liang Chua1, Seongwao Yoo1; Nanyang Technological Univ, Singapore; 2DSO National Labs, Singapore. We report fabri-
cation and characterization of photodarkening-suppressed highly Yb-doped step-index fibers. The fiber contains 2.9wt% of Yb and has background loss of ~100 dB/km. The fiber gener-
ates >100 W laser output power with 75% slope efficiency.

JTh2A.130

An Er Fiber Laser Generating Multi-Milliwatt Picosecond Pulses with Nearly Shot-Noise-Limited Intensity Noise, Hironobu Yoshimi1, Kazuhiko Sumimura2, Yasuyuki Ozeki1; 1Tohoku University, Japan; 2Tokyo University of Agriculture and Technology, Japan. We demonstrate a polarization-maintaining fiber laser generating 8-40 ps pulses at 40 MHz with an average power of ~5 mW. Its intensity noise is measured to be only 2.4-dB higher than the shot noise limit.

JTh2A.131

Localization of light and transport of infrared optical image in a tellurite optical fiber with transversely-disordered refractive index profile, Hoang Tuan Tong1, Shune Kuroyo1,4, Kenshiro Nagashita1, Takenobu Suzuki1, Yasutake Ohishi1; Toyota Technological Inst., Japan. By numerical calculations and experiments, we demonstrate that tellurite optical fibers with transversely-disordered refractive index profile can be used to obtain the localization of light and to transport infrared optical images at 1.55 nm.

JTh2A.132

All-Polarization-Maintaining One- and Two-Stage Holmium-doped Fiber Amplifiers at 2051 nm, Robert E.rench1, Clement Romano1,2, Benoit Cadier3,4; 3Institut Telecom/Paris Telecom Tech, France; 4Blue Photonics, France. We report the performance of one- and two-stage single clad polarization-maintaining (PM) Ho-doped fiber amplifiers (HDFAs) at λ = 2051 nm, pumped at λ = 1550 nm. We show that the Ho-doped fiber has a slope efficiency η = 70 %, and demonstrate an output power of 3.5 W and a gain G = 43 dB.

JTh2A.133

Cladding Pumped EDFA with Annular Erbium Doping, Charles Matte-Breton1, Haoshuo Chen1, Nicolas K. Fontaine1, Roland Ryf1, René-Jean Essiambre2; 2Université Laval, Canada; 2Nokia Bell Labs, USA. We present simulation, fiber design and experimental characterization of a cladding pumped EDFA with erbium doping in the cladding for future all-core EDFA development of multi-core EDFA with increased saturation output power.

JTh2A.134

Gain-Switched Thulium-Doped Fiber Laser with Electrically Tuning at 1690-1765 nm, Can Li1, Nan Chen1, Zhichao Luo1,2; 1Univ. of Hong Kong, Hong Kong; 2Hisense (Guangzhou) Laser Tech Co., Ltd., China. We demonstrate a gain-switched thulium-doped fiber laser with electrically tuning at 1690-1765 nm. Stable laser pulse with duration of 190 ns, average power of 654 mW, and pulse energy of 2.2 μJ is achieved.

JTh2A.135

Dual Pumping Scheme for Efficient 4 μm Operation of a Ho:InGaAs Glass Fiber Laser, Richard S. Qumby1; Worchester Polytechnic Inst., USA. Numerical modeling shows that pumping a Ho-doped fluoride fiber laser at both 910 and 2100 nm will give a cw output at 4100 nm with a slope efficiency of ~17%.

JTh2A.136

Fiber-based Picosecond Source with Variable Transform Limited Linewidth and Flexible Repetition Rate, Daniel Kieler1, Thomas Walther1; TU Darmstadt, Laser and Quantum Optics, Germany. We present a 1028-nm master oscillator power amplifier system generating transform limited pulses with adjustable duration (250 and 735 ps) and repetition rate (10 and 1 MHz).

JTh2A.137

Off-resonance long-period fiber gratings and spin-optics response, Moti Friedman1; Bar-Ilan Univ., Israel. We investi-
gated the spectral response of strong long-period fiber gratings (LPFGs) and found an off-resonance spectral response including a spin-optics coupling between polarization and modes for asymmetric LPFGs.

JTh2A.138

Probabilistic Phase Control for Coherent Beam Combing, Henrik Tuenemann1, Akira Shikawa1; 1Univ. of Electro-Communications, Japan. Using probabilistic phase control, we realize coherent beam combining without using explicit modula-
tion or polarization for error signal generation. Furthermore, the technique allows fusioning multiple types of sensor data.

JTh2A.139

Polarization-maintaining, dual-wavelength, dual-comb mode-locked fiber laser, Ruiyu Wang1, Xin Zhao1, Weiran Li1, Zheng Zheng1,2; 1School of Electronic and Information Engineering, Beihang Univ., China; 2Collaborative Innovation Center of Geospatial Technology, China. A self-starting, dual-wavelength, dual-comb mode-locked fiber laser based on all polarization-maintaining parts and a carbon nanostructure modelock is demonstrated, and dual-wavelength operation is realized through spatial filtering facilitated by waveplates in the cavity.

JTh2A.140

Timing Stabilization of Solid-State Yb-Based Laser System, Stefano Valiente1,2, Anne-Laure Calendoni1, Joachim Meier1, Emma Kueny1,2, Huseyin Cankaya1,2, Nicholas H. Matlis1, Giovanni Carri1,2, Franz X. Kätner2,1; 1Center for Free Electron Laser Science,Deutsches Elektronen Synchrotron (DESY), Germany; 2Dept. of Physics, Univ. of Hamburg, Germany; 3The Hamburg Centre for Ultrafast Imaging, Univ. of Hamburg, Germany. We present a tight optical timing stabilization to 10 fs RMS jitter between two compressed branches of a sub-picosecond Yb based laser system operating at 1 kHz.

JTh2A.141

Extension of the Stable Operation of an All-Polarization Maintaining Mode-Locked Fiber Laser, Hanlie Afkhami-Rad1, Mehran Tehrani2, Jean-Claude M. Diels1; 1Univ. of New Mexico, USA. We present an all-polarization maintaining mode-locked fiber laser at 1532 nm with en-
hanced stability by cooling of the carbon nanotube saturable absorber. The laser output power ranges from 50 μW to 200 μW depending on the cooling.

JTh2A.142

Pulse-Chirp Instability and Its Influence for Its Measurement, Rana Jafan1, Rick Trebino2; 1Georgia Inst. of Technology, USA. Pulses often possess random amounts of linear chirp. We find that SPIDER cannot detect this variation, yielding instead a shorter, flat-phase, coherent artifact. SHF-FROG can and provides a better estimate of the average pulse.

JTh2A.143

Ultrafast Broadband Photodetectors Based on Three-Dimensional Dirac Semimetal Cd3As2, Jiawei Lai1, Qinsheng Wang1, Cai-Zhen Li1, Shaofeng Ge1, Jin-Guang Li1, Wei Li1, Xuefeng Lu1, Junchao Ma1, Da-Peng Yu1, Zh-Min Liao2; 1Shanghai Jiao Tong University; 2International Center for Quantum Materials, School of Physics, Peking Univ., China; 3State Key Lab for Mesoscopic Physics, School of Physics, Peking Univ., China. We present a tight optical timing stabilization to 10 fs RMS jitter between two compressed branches of a sub-picosecond Yb based laser system operating at 1 kHz.

JTh2A.144

Ultralow-Noise and Agile Microwave Synthesizer Based on a Femtosecond Mode-Locked Fiber Laser, Juan Wei1,2, Dohyeon Kwon1, Shilong Pan1, Jungwon Kim1; Korea Ad-
anced Inst of Science & Tech, South Korea; 2Nanjing Univ. of Aeronautics and Astronautics, China. We demonstrate a microwave synthesizer based on a mode-locked fiber laser and all-fiber photonic chips, which outputs 9-11 GHz signals with integrated timing jitter of 7-6 fs to 9.1 fs [integration bandwidth: 10 Hz-10 MHz] and frequency switching time of 135 ms.

JTh2A.145

Simplified Pre-Characterization of Chirped Pulses in Single- shot Supercontinuum Spectral Interferometry, Dinhuy Vu1,2, Do-Hyeon Kwon1, Shilong Pan1, Jungwon Kim1; Korea Advanced Inst of Science & Tech, South Korea; 2Nanjing Univ. of Aeronautics and Astronautics, China. We demonstrate a mode-locked fiber laser and all-fiber photonic chips, which outputs 9-11 GHz signals with integrated timing jitter of 7-6 fs to 9.1 fs [integration bandwidth: 10 Hz-10 MHz] and frequency switching time of 135 ms.
Dual-comb spectrally encoded confocal microscopy, Ping-ultrafast pulse delivery and power coupling are demonstrated. The applications of DHAFs in fiber laser and core anti-resonant fibers (DHAFs) that function as air core hollow-fang Li2, Xiaoyong Wang1, Min Xiao1,3; Singapore. We design, fabricate and characterize dual hollow-core anti-resonant fiber (DHAFs) that as function core fiber couplers. The applications of DHAFs in fiber laser and ultrafast pulse delivery and power coupling are demonstrated.

Femtosecond laser delivery and coupling via dual hollow-core anti-resonant fiber, Xiaosheng Huang1, Seongwao Yoo1, Dingyuan Tang1, Tie Ma1, Nanyang Technological Univ., Singapore. We design, fabricate and characterize dual hollow-core anti-resonant fibers (DHAFs) that as function core fiber couplers. The applications of DHAFs in fiber laser and ultrafast pulse delivery and power coupling are demonstrated.

Dual-comb spectrally encoded confocal microscopy, Jing-ping Feng1, Jiqiang Kang1, Sisi Tian1, Xi Zhou1, Chi Zhang1, Kenneth Kin-Yip Wong1; ‘The Univ. of Hong Kong, Hong Kong, China; ‘Huazhong Univ. of Science and Technology, China. We report a dual-comb spectrally encoded confocal microscopy (DC-SECM) at 3-MHz frame rate and 8.8-μm resolution. Comparing with mode-locked laser based SEC, DC-SECM features with lower detection bandwidth and higher power efficiency.

An aberration-free ultrafast optical oscilloscope with large temporal window, Xiao Chen1, Yuhua Duan1, Xi Zhou1, Chi Zhang1, Xingfan Zhang1; ‘Huazhong Univ. of Science and Technology, Wuhan National Lab for Optoelectronics & School of Optical and Electronic Information, China. We report an aberration-free ultrafast optical oscilloscope based on the time-to-frequency conversion. It achieves 430-fs temporal resolution over 14 ns temporal window, which represents the largest record-length-to-resolution ratio (3.2×10⁵) of any single-shot-capable ultrafast oscilloscope.

An ultrafast holographic optical element (HOE), Riki Trebino1; Georgia Inst. of Technology, USA. We improved the FROG-algorithm convergence speed for complex pulses using a “multi-grid” technique. We achieved a factor of ~7 improvement for cross-correlation FROG for pulses with time-bandwidth products from 40 to 90.

Ultrafast Coherent Holographic Transfer in Non-Fullerene OPV Blends, Rui Wang1, Chunfeng Zhang1, Zhiqiu Zhang1, Ying-fang Li1, Xiaoyang Wang1, Min Xiao1; ‘National Lab of Solid State Microstructures, School of Physics, and Collaborative Innovation Center of Advanced Microstructures, Nanjing Univ., China; ‘Beijing National Lab for Molecular Science, CAS Key Lab of Organic Solids, Inst. of Chemistry, Chinese Academy of Science, China; ‘Dept. of Physics, Univ. of Arkansas, USA. We study the ultrafast hole transfer process in the OPV blends of J1/ITIC utilizing two-dimensional electronic spectroscopy. The results show coherent vibronic coupling plays a critical role in ultrafast hole transfer process.

Mode-Locked all-fiber laser using Two-Dimensional Perovskite in C and L band, Seongjin Hong1, ferdinand delee2, Jaedoek Park3, Sanghoon Song1, Yota Ueda1, Emmanuelle Deleporte1, Kwong2, Chee-Wei Wong1; ‘Mesoscopic Optics and Quantum Electronics Lab, Univ. of California, Los Angeles, USA; ‘Technology and Research (ASTAR), Inst. of Microelectronics, Singapore. We observed chaotic state, breather comb, and dissipative Kerr soliton (DKS) with repetition rate of 19 GHz in dispersion-managed SiN microresonator. The DKS pulse train is characterized by SHG noncollinear autocorrelator and frequency-resolved optical gating.

Femtosecond laser delivery and coupling via dual hollow-core anti-resonant fiber, Xiaosheng Huang1, Seongwao Yoo1, Dingyuan Tang1, Tie Ma1, Nanyang Technological Univ., Singapore. We design, fabricate and characterize dual hollow-core anti-resonant fibers (DHAFs) that as function core fiber couplers. The applications of DHAFs in fiber laser and ultrafast pulse delivery and power coupling are demonstrated.

Femtosecond laser delivery and coupling via dual hollow-core anti-resonant fiber, Xiaosheng Huang1, Seongwao Yoo1, Dingyuan Tang1, Tie Ma1, Nanyang Technological Univ., Singapore. We design, fabricate and characterize dual hollow-core anti-resonant fibers (DHAFs) that as function core fiber couplers. The applications of DHAFs in fiber laser and ultrafast pulse delivery and power coupling are demonstrated.

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**JTh2A.167**

**Harmonic Injection Locking for a Direct Optical to RF Link**, Ricardo Bustos Ramirez, Michael E. Plascak, Ashish Bhardwaj, Gloria Hoeffer, Fred Kish, Peter Delfyett, 

*Finisera Corporation, USA; *CREOL, The College of Optics and Photonics, USA. We demonstrate a chip-scale direct optical to RF link, that down-converts 600 GHz frequency comb to 10GHz, using harmonic multi-tone injection locking. A minimum injection power of 10W and locking bandwidth of 4.3MHz is observed.

**JTh2A.168**

**Photonic Measurement of Broadband Microwave Bursts**, Yihan Li, Naoya Kuse, Martin E. Fermann; 

*IMRA America, Inc., BRL, USA; *IMRA America, Inc., USA. We report a photonic-assisted system for broadband microwave burst measurements. By deploying a dual coherent electro-optical comb and optical storage, wavelength and time-division multiplexings are enabled simultaneously to offer broad bandwidth and fast acquisition speed.

**JTh2A.169**

**4D Pulse Shaping of Discretized Beam Arrays**, Wei Liu, Joseph Robinson, Alan Fry, Sergio Carbajo, 

*Stanford Univ. SLAC National Accelerator, USA.* We report on a novel ultrafast laser architecture capable of generating 4D arbitrarily distributed beams based on an array of coherently combined fibers, each containing femtosecond pulses with controlled intensity, wavefront, and polarization vector distribution.

**JTh2A.170**

**Spectrally sampled second-harmonic interferometric autocorrelation for 3.5 fs pulse measurement**, Heng-Jia Liu, An-Chia Hsu, Chun-Lu Chen, Shang-Da Yang; 

*National Tsing Hua Univ., Taiwan.* We demonstrate that two interferometric autocorrelation traces obtained by sampling two second-harmonic tones around the carrier would be sufficient to algebraically retrieve the spectral phase of a 3.5 fs pulse.

**JTh2A.171**

**Directly Determining the Coefficient of Thermal Expansion of High-power Light-emitting Diodes by Optical Coherence Tomography**, TingWei Yeh, Chun-Yang Chou, Chun-Ying Huang, YungChih Yao, YiKa Huang, Meng-Tsian Tsai, Yi-Ju Lee; 

*National Taiwan Normal Univ., Taiwan;* 

*Univ. of Washington, USA;* 

*National Chi Nan Univ., Taiwan;* 

*Chang Gung Univ., Taiwan;* 

*Chang Gung Memorial Hospital, Taiwan.* We used optical coherence tomography to measure CTE of high-power LEDs encapsulated in polystyrene resin. This work validates OCT can provide an alternative way to directly and nondestructively determine spatially resolved CTE of packaged LEDs.

**JTh2A.172**

**A Fast, Accurate and Widely Applicable Computer Algorithm for Estimating Layer Number of Two-Dimensional Materials**, Seungwan Cho, Jekwun Lee, Soohyun Park, Hyemin Bae, MinJi Nah, Beom Kim, Chihun In, SeungHoon Yang, Sooun Lee, Seung Young Seo, JeHyun Kim, Chul-Ho Lee, Woyoung Shim, Moon-Ho Jo, Dohun Kim, Hyoung-Choi; 

*Electrical and Electronic Engineering, Yonsei Univ., South Korea;* 

*KU-KIST Graduate School of Converging Science and Technology, Korea Univ., South Korea;* 

*Dept. of Materials Science and Engineering, Yonsei Univ., South Korea;* 

*Dept. of Materials Science and Engineering, Pohang Univ. of Science and Technology, South Korea;* 

*Dept. of Physics and Astronomy, Seoul National Univ., South Korea;* 

*Center for Artificial Low Dimensional Electronic Systems, Inst. for Basic Science, South Korea.* We present a computer algorithm for layer number estimation of few-layered two-dimensional materials. Based on the optical contrast method, this algorithm analyzes an optical microscope image in a few seconds with high accuracy over 90%.

**JTh2A.173**

**Characterizing Chromatic Dispersion of Multiple Few-Mode Fibers Using Bidirectional OTDR Technique**, Huyuan Liu, 

*Taiyuan Univ., China.* A dual-off-axis-pumping scheme is presented to generate orbital-angular-momentum (OAM) beam in Yb:CALGO laser. The wavelength-tunable width about 10 nm and the OAM-tunable range from ±1h to ±15h, controlled by the off-axis-displacements and pump power.

**JTh2A.174**

**The Reliability Assessment of Interferometric Fiber Optical Gyrosopes Based on Bayesian Estimation**, Kun Ma, Jing Jin, Jing Ma, Ningsong Song, Beihang Univ., China. With the combination of prior distribution and likelihood function, the joint posterior distribution of interferometric fiber optical gyroscopes (FOGs) is obtained based on Bayesian estimation and the reliability of FOGs is assessed.

**JTh2A.175**


*Naval Research Lab, USA;* 

*Sotera Defense Solutions, USA;* 

*European Space Agency, Netherlands.* By accurately characterizing and simulating the charge deposited in a device, two-photon absorption laser-based approach is used for quantitatively predicting radiation effects induced by heavy-ion excitation.

**JTh2A.176**

**Study on Improved Object Identification by Using a Fused Image from Hyper-Spectral IR Images, Do-Hwi Kim, Chang-won Kim, Kuk-Han Lim, Jun-Hyuk Choi, Tae-Kuk Kim;** 

*Chung Ang Univ., South Korea.* We report a highly coherent octave spanning visible optical comb from a doubled Er fiber laser. The fractional residual instability is lower than 10^{-18} at 1s and reaches 3x10^{-20} after 1000 s of averaging time.

**JTh2A.178**

**Analysis of Broadband terahertz metamaterial filter based on multiplexed metallic bar resonators**; 

*Naval Research Lab, USA;* 

*Sotera Defense Solutions, USA;* 

*European Space Agency, Netherlands.* By deploying a dual coherent electro-optical comb and optical storage, wavelength and time-division multiplexings are enabled simultaneously to offer broad bandwidth and fast acquisition speed.

**JTh2A.179**

**Broadband Wavelength Tunable Mode-Locked Tm-Doped Fiber Laser Based on Carbon Nanotubes, Bo Fu, Syed Hussain, Giancarlo Soavi, Biaicheng Yao, Daniel Popa, Andrea Ferraro;** 

*Cambridge Graphene Centre, UK.* We report a broadband tunable Tm-doped fiber laser mode-locked by carbon nanotubes. The wavelength tunability is enhanced by introducing a polarization-maintaining isolator and two polarization controllers and the tunable range is up to 60 nm.

**JTh2A.180**

**A Raman Spectroscopy and Optical Microscopy System for Studies at Low Temperatures and High Magnetic Fields**, Todd Sayles; 

*Quantum Design, USA.* We present an optical probe for the PPMs of temperatures from 1.8 to 350 K and magnetic fields up to 16 T with XYZ motion control and integrated camera for fluorescence, Raman spectroscopy, and microscopy.
Efficient semiconductor source of multicycle terahertz pulses using intensity-modulated pump, Gyorgy Toth1, 2, József A. Fülöp1, 3, János Hebling2; PTE High-Field THz Research Group, Hungary; 2Inst. of Physics, Univ. of Pécs, Hungary; 3ELI-ALPS, ELI-Hu Nkft., Hungary.

Detection of O18 and D Isotopes in Water Vapor using a Fiber-Coupled Tunable Diode Laser Absorption Spectroscopy Multi-Pass Cell, Allan S. Chang1, 2, Ate Visser1, 2, Erik Oerter1, 2, Tiitana Bond1, 2, Lawrence Livermore National Lab, USA. We have demonstrated detection of water isotope- logues (H16O, H18O and HDO) by a compact fiber- coupled tunable laser absorption spectroscopy setup. The measured results agree well with HITRAN simulation.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
STh3A.1 • 14:00
CMOS-Compatible High-Q Photonic Crystal Cavities, Delphin Dodane1, Jérôme Bourdieronne1, Sylvain Combré1, Alfredo De Rossi1; 1Thales Research & Technology, France. All-Solid Cladding Photonic Crystal Cavities have been fabricated in CMOS foundry. A recent design concept resulted into a measured Q-factor of 0.6 million (4.1x10^5 in average). Statistical analysis leads to an estimate of the fabrication disorder of 1.2 nm.

STh3A.2 • 14:15
High-Contrast Resonance Excitation in Photonic Crystal Nanobeams via Side-Coupling and Wave-Vector Matching, Francis Afzal1, Sami Halimi1, Sharon M. Weiss1; 1Vanderbilt Univ., USA. Photonic crystal nanobeams engender exceptional high-Q devices but suffer broadband signal off-resonance and low on-resonance transmission. We demonstrate drastically improved transmission metrics without compromising Q-factor using side-coupled excitation with optical momentum matching.

STh3A.3 • 14:30 Invited
InP Membrane Photonic Crystal Fano Devices, Kresten Iwrd1, Yi Yu1, Dagmawi Bekele1, Thorsten S. Rasmussen1, Aurimas Sakana1, Andrei Marchevsky1, Kristoffer S. Mathiessen1, Hitesh K. Sahoo1, Luisa Ottaviano1, Elizaveta Semenova1, Jesper Mork1; 1DTU Fotonik, Technical Univ. of Denmark, Denmark. Membrane photonic crystals offer many possibilities for designing small energy efficient devices like switches and lasers. We will present theoretical and experimental results on devices based on Fano resonances in photonic crystals.

STh3A.4 • 15:00
Lasing in a topological photonic crystal nanocavity, Yusutomo Ota1, Ryota Katsumi1, Katsuuyuki Watanabe1, Satoshi Iwamoto1, Yasuhiro Arakawa1; 1Univ of Tokyo, Japan. We report lasing oscillation in a zero-dimensional edge state formed at the boundary of two photonic crystal nanobeams with distinct band topologies. The topological origin of the nanocavity mode ensures a single mode operation.

STh3B.1 • 14:00 Invited
Microring Weight Banks for Neumorphic Silicon Photonics, Alexander Taf1, Thomas Ferreria de Lima1, Mitchell Nahmias1, Bhavin Shastri1, Paul R. Prucnal1; 1Princeton Univ., USA. Research in photonic information processing has experienced a recent resurgence. Microring weight banks enable reconfigurable neural network approaches on silicon photonics. We discuss the latest results in neuromorphic silicon photonic networks and microring weight banks.

STh3B.2 • 14:30
Thermally Tunable III-V Photonics Architecture for Coherent Nonlinear Optical Circuits, Marina Radulaski1, Ranjoy Bose1, Tho Tran1, Thomas Van Vaerenbergh2, David Kelpinski1, Raymond Beausoleil1; 1Stanford Univ., USA; 2Hewlett Packard Enterprise, USA. We develop a thermally tunable hybrid photonics architecture integrating GaAs photonic crystal cavities, SiN, grating couplers and waveguides, and chromium microheaters. We demonstrate external signal coupling to frequency-synchronized microcavities connected by a bus waveguide.

STh3B.3 • 14:45
Design, Fabrication and Demonstration of a Chip-Scale Reconfigurable Photonic Signal Processor, Xiaoping Cao1, Shuang Zheng1, Yun Long1, Yan Luo1, Li Shen1, Jian Wang1; 1WNU, China. Inspired by electronic Field Programmable Gate Arrays, we experimentally demonstrate a reconfigurable hexagonal mesh processor based on silicon platform. Assisted by tunable Mach–Zehnder couplers, numerous topologies and functions can be implemented with favorable performances.

STh3B.4 • 15:00
Reconfigurable Silicon Photonic Signal Processor Based on the SCOW Resonant Structure, Liangjun Lu1, Lin Shen1, Linjie Zhu1, Jianping Chen1; 1Shanghai Jiao Tong Univ., China. We propose a reconfigurable silicon photonic signal processor composed of three stages of self-coupled optical waveguide (SCOW) resonators. The processor can be configured to ring resonator and MZI-based optical filters.

JTh3C.1 • 14:00 Invited
Photon-Pair Generation and Quantum-classical Correspondence in Nonlinear Photonic Devices, Andrey A. Sukhorukov1, 1Nonlinear Physics Centre, RSPE, The Australian National Univ., Australia. We present theoretical and experimental advances towards efficient photon-pair generation through spontaneous parametric down-conversion in nonlinear nanostructures and metamaterials, enabling quantum entanglement engineering at sub-wavelength scale for photon generation with tailored polarization and spatial correlations.

JTh3C.2 • 14:30
Photon Pair Generation on a Silicon Chip Using Nanophotonic Periodically-Poled Lithium Niobate Waveguides, Ashutosh Rao1, Nima Nader1, Martin J. Stevens1, Thomas Gerrits2, Omar S. Magana Loaiza2, Guillermo Camacho-Gonzalez1, Jeffrey Chiles1, Amirmahdi Honandoost1, Martin Malinowski1, Richard Mini1, Sasan Fathpour1; 1CREOL, Univ Central Florida, USA; 2NIST, USA. We present a new class of photon pair sources on a silicon chip. The source is based on nanophtonic periodically poled lithium niobate waveguides and presents MHz rate pair generation.

JTh3C.3 • 14:45
A Nanophotonic Platform Integrating Quantum Memories and Single Rare-earth Ions, Tian Zhang1,2, Jonathan Kinden1, Jake Rochman1, John G. Bartholomew1, Andrei Farzana1; 1California Inst. of Technology, USA; 2Univ of Chicago, USA. We demonstrate a quantum nanophotonic platform integrating on-chip quantum memories and optically addressable single rare-earth ions. We show near-transform-limited, high-purity single photon emissions from individual rare-earth ions.

JTh3C.4 • 15:00 Invited
Tailoring radiative emission in integrated quantum light sources, Andrea Fore1, Daniele Pellegrino1, Michele Cotrufo1, Ewold Verhagen1,2, Robert Johnne1, Maurangelo Petruzella1, Francesco Pagliano1, Frank van Otten1,2; 1Dep. Applied Physics, Eindhoven Univ. of Technology, Netherlands; 2AMOLF, Netherlands. ‘Max Planck Inst. for the Physics of Complex Systems, Germany. An approach to the real-time control of the exciton-photon interaction rate in solid-state systems will be discussed. It enables the temporal shaping of single photons and the coherent coupling of excitons and photons.
**Executive Ballroom 210D**

**JTh3D.1 • 14:00**

Advanced Microwave Photonics Applications and Routes to Hybrid Integration, Richard DeSalvo1, Anthony Klee1, Charles Middleton1, Kristina Bagnell1, Elliott Grafer1, Alex Cramer1; "Harris Corporation, USA. We review recent advances in microwave photonic systems for wideband spectral awareness and down-conversion. Progress is shown toward hybrid integration of these systems with the latest chip-scale technologies to reduce SWAP and improve performance.

**JTh3D.2 • 14:30**

Integrated Microwave Photonics for 5G, Chris Roeloffzen1, Jörn Epping1, Roelof Timens1, Paul van Dijk1, René Heideman1, Marcel Hoekman1, Robert Grootjans1, Laurens Bliek1, Sander Wahls1, Michel Verhaegen1; "LioniX Internationale, Netherlands; Delft Center for Systems and Control, Delft Univ. of Technology, Netherlands. This paper describes the design, fabrication, packaging, testing and automated tuning of an integrated 1x1 optical beamforming network. It consists of hybirdly integrated InP and TriPleX chips, where end-facet coupling is used for optical interfacing.

**JTh3D.3 • 15:00**

Fast and Broadband SOI Photonic Integrated Microwave Phase Shifter, Giovanni Serafino1, Claudio Porzi1, Marc Sans2, Fabio Falconi1, Sergio Pimia1, Vito Soraniello1, John Mitchell1, Marco Romagnoli1, Antonella Bogoni1, Paolo Ghelfi1; "TeCUP, Scuola Superiore Sant’Anna, Italy; "Dept. of Electronic and Electrical Engineering, Univ. College London, UK; "National Photonics Labs, CNIT, Italy. An integrated silicon-on-insulator microwave photonic phase shifter based on an optical deinterlever and a reverse-based pn-junction waveguide providing broadband phase shift up to more than 400° with fast reconfiguration time of 1 ns is demonstrated.

**JTh3D.4 • 14:45**

Demonstration of pseudospin-to-orbital angular momentum conversion in photonic graphene, Kaiyong Lu1, Dao-Hong Song1, Shig Xia1, Zhihuan Dai1, Lijin Tang1, Jingjun Xu1, Zhigang Chen1,3; "The MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China; "Collaborative Innovation Center of Extreme Optics, Shaxi Univ., China; "Dept. of Physics and Astronomy, Stanford State Univ., USA. Momentum-matched selective excitation of two sublattices with vortex beams leads to direct observation of pseudospin-dependent conical diffraction and topological charge transformation, including spin-orbital angular momentum conversion arising from inherent degree-of-freedom in photonic graphene.

**JTh3D.5 • 15:00**

Tunable Vortex Beam, Single-Resonant Ultrafast Optical Parametric Oscillator, Varun Sharma1, S. C. Kumar1, G. K. Samanta1, M. Ebrahim-Zadeh1; "Photonic Sciences Lab., Physical Research Lab, India; "ICFO-Institut de Ciencies Fotoniques, Spain; "Instituto Catalán de Recerca i Educació Avançada (ICREA), Spain. We demonstrate the direct transfer of pump vortex mode to the idler beam in a single-resonant optical parametric oscillator, generating ultrafast vortex beam of order as high as l=3, tunable across 1109-1209 nm.

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**Executive Ballroom 210E**

**FTh3E.1 • 14:15**

Observation of a Bessel beam soliton, Mariano Flammini1, Giuseppe Di Domenico1, Davide Pierangeli1, Fabrizio Di Mei1, Aharon Agrawat1, Eugenio DelRe1,2; "Dept. of Physics, Univ. of Rome “La Sapienza”, Italy; "Center for Life Nano Science&Sapienza, Istituto Italiano di Tecnologia, Italy. "Collaborative Innovation Center for Optoelectronic Science & Technology, College of Optoelectronic Engineering-Shenzhen Univ., China; "Dept. of Applied Physics, Hebrew Univ. of Jerusalem, Israel; "ISC-CNRS, Universita di Roma “La Sapienza”, Italy. We have demonstrated experimentally and numerically that a Bessel-Beam propagating in a strongly self-focusing medium undergoes relevant dynamics along the propagation axis that ultimately cause it to self-trap in a periodic breather.

**FTh3E.2 • 14:30**

Nonlinear Optical Conversion of Photon Spin to Orbital Angular Momentum, Alex M. Wilhelm1, David Schmidt1, Charles Martin Rochette1; "Optoelectronics Research Centre at McGill Univ. towards the fabrication of chalcogenide-based mid-infrared optical fiber components such as nonlinear gain media, optical fiber couplers and optical filters.

**FTh3E.3 • 15:00**

Tunable Vortex Beam, Single-Resonant Ultrafast Optical Parametric Oscillator, Varun Sharma1, S. C. Kumar1, G. K. Samanta1, M. Ebrahim-Zadeh1; "Photonic Sciences Lab., Physical Research Lab, India; "ICFO-Institut de Ciencies Fotoniques, Spain; "Instituto Catalán de Recerca i Educació Avançada (ICREA), Spain. We demonstrate the direct transfer of pump vortex mode to the idler beam in a single-resonant optical parametric oscillator, generating ultrafast vortex beam of order as high as l=3, tunable across 1109-1209 nm.

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**Executive Ballroom 210F**

**STh3F.1 • 14:15**

Suspended Si waveguides for spectral engineering of mid-IR frequency combs, Nima Nader1, Jeff Chiles1, Abijith Kowligy2, Henry Timmers1, Sae Woo Nam1, Scott Diddams1; "Invited"; "Optoelectronics Research Centre at McGill Univ. towards the fabrication of chalcogenide-based mid-infrared optical fiber components such as nonlinear gain media, optical fiber couplers and optical filters.

**STh3F.2 • 14:30**

Picoscosecond fiber-laser-pumped widely tunable, narrow-linewidth, high-peak-power, mid-infrared OP-GaAs OPA, Qiang Fu1, Lin Xu1, Sijing Liang1, David Shepherd1, David Richardson1; "Invited"; "Optoelectronics Research Centre at McGill Univ. towards the fabrication of chalcogenide-based mid-infrared optical fiber components such as nonlinear gain media, optical fiber couplers and optical filters.
14:00–16:00  
STh3G • Quantum Information Processing on Photonic Nanostructures  
Presider: Mark Thompson; University of Bristol, UK

Recent Advances in Quantum Information Science Using Photonic Systems, Mikhail Lukin1,2; Harvard Univ., USA. We will discuss a new scientific interface between quantum optics, many-body physics, nanophotonics, and quantum information science. Examples include manipulating arrays of individually trapped cold neutral atoms and atom-like emitters in diamond.

Mikhail Lukin received the Ph.D. degree from Texas A&M University in 1998. He has been a Professor of Physics at Harvard since 2004, where he is currently a co-Director of Harvard-MIT Center for Ultracold Atoms. His research interests include quantum optics, quantum metrology, nanophotonics, and quantum information science.

14:00  
ATh3H.1 • Spin-Photon Interface Controlled Optical Switching in a Nanobeam Waveguide, Tim Schroeder1, Alissa Jawad1, Depeng Ding2, Martin Hayhurst Appet1, Sahand Mahmoodian1, Mathias Lobli2, Immo Sollier1, Rudiger Schott1, Camille Papon1, Tommaso Pregnolato1, Saren Stobbe1, Leonardo Midolo1, Andreas Weck1, Arne Ludwig2, Richard Warburton1, Peter Lodahl1,2; Niels Bohr Inst., Denmark. We demonstrate a single InGaAs quantum dot electron spin controlled photon switch in a nanobeam waveguide with 4-fold switching ratio, a spin-state preparation fidelity of 96%, and a lifetime T1 approaching 5 μs.

Electromechanically Tunable Diamond Color Centers Coupled to Nanophotonic Waveguides, Bartholomeus J. Machielse1, Michael J. Burek1, Sjurun Meesaal2, Clevon Chia2, Young-Ik Sohn2, Haig Atikian2, Linbo Shao2, Smarak Maity1, Mikhail Lukin1, Marko Loncar1; Dept. of Physics, Harvard Univ., USA; John A Paulson School of Engineering and Applied Sciences, Harvard Univ., USA. We present a platform for the generation and high-efficiency collection of indistinguishable photons from spatially separated silicon-quantum-dot (SQD) color centers by use of waveguide-coupled nanoelectromechanical systems (NEMS).

Spectral Tuning of Multiple Germanium Vacancy Centers in Diamond with Mechanical Strain, Smarak Maity1, Linbo Shao2, Young-Ik Sohn2, Sjurun Meesaal2, Bartholomeus J. Machielse1, Edward Bielejec1, Marko Loncar1; Harvard Univ., USA; Sandia National Labs, USA. We experimentally demonstrate spectral tuning of the optical transitions of the germanium vacancy (GeV) center using strain in a diamond microcantilever. The GeV shows a large strain susceptibility on the order of PHz/strain. Spectral alignment of two initially spectrally separated GeVs is achieved.

Quantum Measurement of Membrane’s Vibration, JITENG SHENG1, XINWEI WEI1, SHUHU WU1, HAIBIN WU1; East China Normal Univ., China. We demonstrate that the sub-shot-noise measurement of membrane’s displacement can be realized with the cooperation of membrane-based interferometer and quantum correlated light. This provides a new strategy to study cavity optomechanics with squeezed light.

Quantum Optomechanics with Ultra-coherent Soft-Clamped Resonators, JUXIN CHEN1, MASSIMILIANO ROTTI1, DAVID MASON1, YEGHISHE TARTSUANIAN1, YANNICK SEAS1, ALBERT SCHLOSSER1; Niels Bohr Inst., Denmark. Soft-clamped mechanical resonators realise quality factors Q>106 and parametric frequency conversion in Al2O3. We demonstrate Q factors of >107 and parametric frequency conversion in Al2O3 micro-trench resonators co-integrated with SiN/SiN waveguides on silicon. Under 1550-nm pumping we show oscillation at wavelengths ranging from 1135 to 2445 nm.
the effect of radiation on cancer cells by Raman scattering. We will also demonstrate an optical trap to study the diffusion of nanoparticles in cancer tissues. We will describe a microfluidic chip designed to study the diffusion of nanoparticles in cancer tissues. We will also demonstrate an optical trap to study the effect of radiation on cancer cells by Raman scattering.

Dr. Siddharth Ramachandran started his scientific career as a Member of Technical Staff at Bell Laboratories in 1998, followed by continuing, in 2002, with its fiber-optics-related spin-off, OFS Laboratories. In 2010, he moved back to academia and is now a Professor in the Department of Electrical Engineering at Boston University.

We introduce a new wavefront shaping technique guided by optically detectable magnetic resonance (ODMR). We present subwavelength light focusing in scattering media with our ODMR-guided wavefront shaping, which paves the way for subwavelength quantum sensing in deep-tissue.
FTH3M.1 • 14:00
Disorder Topological Defects Induce Photonic Phase Transition, Bo Wang1, Elhaman Maguid2, Arkady Faerman1, Vladimir Kleiner1, Erez. Hasman1; 1Technion-Israel Inst. of Technology, Israel. We report on the observation of photonic phase transition emerging from disorder topological defects in geometrical phase metasurfaces. Low defect concentration induces isolated vortices, whereas high disorder leads to a random vortex interaction.

FTH3M.2 • 14:15
Topological photonic crystals in the visible: design and angle-resolved characterization of the bulk and edge states, Siying Peng1, Nick Schilder2, Xiang Ni2, Sophie Meuret2, Hugo Doelman3, Toon Coenens4, Femius Koenderink5, Alexander Khankiev6, Andrea Alù7, Harry Atwater8, Albert Polman9; 1Applied physics, California Inst. of Technology, USA; 2Center for Nanophotonics, AMOLF, Netherlands; 3Dept. of Electrical Engineering, City Univ. of New York, USA; 4Dept. of Electrical and Computer Engineering, Univ. of Texas at Austin, USA. We fabricated and characterized photonic crystals with topological bulk states and pseudo-time-reversal-symmetry protected helical edge states in the visible regime. With a 30kV electron beam, we excite cathodoluminescence in the nanostructured material and derive photonic band structures.

STh3N.2 • 14:15
Spatio-temporal Characterization and Optimization of a 200-kHz OPCPA Laser System, Sara Mikaelsson1, Miguel Miranda1, Anne Harth2,3, Chen Guo1, Thomas Brinhammer1, Yu-Chen Cheng1, Arthur Losquin4, Christoph Heyl1,5, Alexander Pape1, Jan Ahmed1, Oliver Prochnow1, Uwe Morgner1, Anne L’huillier1, Card Arnold1; 1Dept. of Physics, Lund Univ., Sweden; 2Max-Planck Inst. for Kemptphysics, Germany; 3Spatio-temporal phase transition emerging from disorder topological defects in geometrical phase metasurfaces. Low defect concentration induces isolated vortices, whereas high disorder leads to a random vortex interaction.

STh3N.3 • 14:30
Characterization of Spatiotemporal Coupling with a Hyper-spectral Hartmann Wavefront Sensor, Christophe Dorrer1, Seung-Whan Bahk1, Univ. of Rochester, USA. A broadband optical source is directly characterized using a Hartmann wavefront sensor implemented with a custom hyperspectral camera, yielding the accurate experimental characterization of radial group delay and pulse-front tilt.

STh3N.4 • 14:45
Spatially-Resolved, Single-Shot Wavefront Sensing of Broadband High-Harmonic Sources, Matthias Jansen1, Lars Freisem1, Denis Rudolph1, Kjetil S. Eikema2, Stefan Witte1, 1Physics and Astronomy, Vrije Universiteit Amsterdam, Netherlands; 2Advanced Research Center for Nanolithography, Netherlands. A novel grating-based Hartmann-type wavefront sensor is developed and used to measure wavefronts of nine high-harmonics at 25-49 nm wavelength simultaneously. Pulse front tilts of the high-harmonic beam are measured in a single exposure.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

Marriott
Salon VI

CLEO: Applications & Technology

Thursday, 14:00–16:00

ATh3P • Sensing in Extreme Environments & Organic Optical Materials

President: David Bomse; Mesa Photonics, LLC, USA

ATh3P.1 • 14:00

HO2 Detection in a Photolysis Reactor Using Faraday Rotation Spectroscopy, Chu Teng1, Chao Yan1, Aric Roussos1, Timothy Chen1, Yiguang Ju1, Gerard Wysocki1; 1Princeton Univ., USA. We perform Faraday rotation spectroscopy at 7.2 μm to quantify HO2 formation from the reaction between excited singlet O(1D) atoms and C2H2. A digitally balanced detection scheme is employed to suppress spectral interferences from diamagnetic C2H2.

ATh3P.2 • 14:15

Criegee Intermediates Dynamic Analysis Based on Dual Optical Frequency Comb Spectrometer, Haoyuan Lu1, Dave Li1, Jy Zhao1, Peng Zuo1; 1School of Electronics Engineering and Computer Science, Peking Univ., China; 2Biomedical engineering Dept., Johns Hopkins Univ., USA; 3College of environment sciences and engineering, Peking Univ., China. We propose a Fourier transform spectrometer based on dual optical frequency comb structure. The spectrum resolution can reach 0.001 nm with 71.5 microseconds time resolution. It can be used for precisely analyzing the spectrum dynamic process of Criegee intermediates.

ATh3P.3 • 14:30

Invited

Single-particle fluorescence detection of biological particles in the atmosphere, Anne Pering1; 1Chemical Sciences Division, NOAA Earth System Research Lab, USA; 2Cooperative Inst. for Research in Environmental Sciences, Univ. of Colorado, Boulder, USA. Single-particle fluorescence sensors, such as the Wide-Band Integrated Bioaerosol Sensor (WIBS), allow real-time detection of atmospheric primary biological particles. In this talk I discuss instrumental and methodological developments and present key findings from ambient studies.

ATh3P.4 • 15:00

Ultrafast Laser Enhanced Rayleigh Backscattering on Silica Fiber for Distributed Sensing under Harsh Environment, Mohan Wang1, Dhom Meophisath1, Sheng Huang1, Aidong Yan1, Shuo Li1, Ran Zou1, Paul Ohodnicki1, Michael Buric2, Ming-Jun Liu1; 1David Carpenter1, Joshua Daw1, Kevin P. Chen1; 1Univ. of Pittsburgh, USA; 2National Energy Technology Lab, USA; 3Corning Research and Development Corporation, USA; 4National Taiwan Univ., Taiwan; 5Pathology, National Taiwan Univ. Hospital, Taiwan. Third harmonic generation microscopy (THG) was used for high-resolution label-free human brain imaging. The THG images of human brain tissues show neuronal soma, dendrites, and lipofuscin in gray matter while myelinated axons in white matter.

ATh3Q • A&T Topical Review on Neurophotonics II

President: TBD

ATh3Q.1 • 14:00

An Active Visible Nanophotonics Platform for Sub-Millisecond Deep Brain Neural Stimulation, Aseema Mohanty1, Qian Li2, Mohammad Amin Tadayon1, Gaurang R. Bhatt1, Euijae Shim1, Xingchen Ji1, Jaime Cardenas1, Steven A. Miller1, Adam Kepecs3, Michal Lipson1; 1Columbia Univ., USA; 2Cornell Univ., USA; 3Cold Spring Harbor Lab, USA; 4Univ. of Rochester, USA. We demonstrate the first visible-range nanophotonics switch network and create an implantable probe for in-vivo deep-brain stimulation. The probe enables stimulation patterns of single neurons with the timing and spatial precision to decode animal behavior.

ATh3Q.2 • 14:30

Energy-Efficient and High-Throughput Nanophotonic Neuromorphic Computing, Mohammadamin Nazirizadeh1, Mohammad-Sadegh Shamsabardeh1, S. J. Ben Yoo1; 1Univ. of California Davis, USA. High-efficient bio-inspired nanophotonic neuromorphic computing is discussed. Using reconfigurable photonic interconnects combined by optical 2D and 3D integrated circuits, more than 500× improvement in energy consumption is predicted compared to the state-of-the-art implementations of SNNs.

ATh3Q.3 • 14:45

Liquid-level Sensor Using Optical Microfiber Probe, Jurjie Wang1, Yanpeng Li1, Lingduo Li1, Wei Zhang1, Zhijun Yan1, Qizhen Sun1, Deming Liu1; 1School of Optical and Electronic Information, National Engineering Lab for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China. A liquid-level sensor using reflective optical microfiber probe as the sensing element is proposed and experimentally demonstrated. By monitoring the reflection wavelength shift, an ultra-high liquid-level sensitivity of ~153.5 nm/mm is achieved.

ATh3Q.4 • 15:00

Third Harmonic Generation Microscopy for Label-free Human Brain Imaging, Sandeep Chakraborty1, Hao-Cheng Gao1, Chen-Tung Yen1, Hsin-Yi Huang1, Chi-Kuang Sun1; 1National Taiwan Univ., Taiwan; 2Pathology, National Taiwan Univ. Hospital, Taiwan. Third harmonic generation microscopy (THG) was used for high-resolution label-free human brain imaging. The THG images of human brain tissues show neuronal soma, dendrites, and lipofuscin in gray matter while myelinated axons in white matter.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
JTh3C • Symposium on Integrated Sources of Non-Classical Light: Perspectives and Challenges I—Continued

JTh3C.5 • 15:30
Diamond Color Center Integration with a Silicon Carbide Photonics Platform, Marina Radulaski1, Yan-Kai Tzeng1, Jingyu Li1, Xiaoyan Zhou1, Kasper E. Lund2, Søren Stobbe1; 1Stanford Univ., USA; 2Univ. of Lyon, France. We develop hybrid microresonators composed of the color center-rich nanodiamonds and silicon carbide microdisks fabricated on a silicon wafer. We demonstrate up to five-fold resonant enhancement of diamond silicon-vacancy and chromium-related color center emission.

JTh3C.6 • 15:45
Covalent Defects of Carbon Nanotubes: Room Temperature, 1.5 µm Single Photon Emitters for Integrated Photonics, Han Htoon1; 1Center for Integrated Nanotechnologies, Los Alamos National Lab, USA. We demonstrate room-T single photon emission at 1.55 µm telecommunication wavelength with 99% single-photon purity and the shot-noise limited emission stability from covalently-introduced aryl sp3 defect sites of single-wall carbon nanotubes.

16:00–16:30 Coffee Break, Concourse Lobby
JTh3D • Symposium on Advances in Integrated Microwave Photonics I—Continued

JTh3D.4 • 15:15
Automated Initialization of Reconfigurable Silicon-Nitride (SiN) Filters, Siva Yegnanarayanan1, Ryan Maxson1, Cheryl Sorace-Agaskar1, Dave Kharas1, Gregory Stienbrecher1, Paul W. Juodawlkis1, 1Massachusetts Insit of Tech Lincoln Lab, USA. We demonstrate automated initialization of tunable optical filters consisting of an initial feed-forward step followed by iterative feedback. Rapid convergence is demonstrated on high-order all-pass-filter (APF) structures in a silicon-nitride photonic integrated circuit (PIC).

JTh3D.5 • 15:30  Invited
Integrated Microwave Photonic Component Technologies, Jonathan Klamkin1, Yuan Liu1, Bowen Song1, Fengqiao Sang1, Brandon Isaac1, 1Univ. of California Santa Barbara, USA. Key integrated microwave photonic component technologies are presented including low-loss waveguide true time delays for optical signal processing functions and high-performance hybrid integrated active devices.

FTh3E • Non-diffracting and Vortex Beams—Continued

FTh3E.6 • 15:15
Landau-Zener-Bloch oscillations and valley-dependent vortex generation in photonic graphene, Yong Sun1,2, Daniel Leykam3, Stephen Nenni1, Daosheng Song1, Hong Chen1, Y. D. Chong4, Zhigang Chen5,6; 1Dept. of Physics and Astronomy, San Francisco State Univ., USA; 2MOE Key Lab of Advanced Micro-Structured Materials, School of Physics Science and Engineering, Tongji Univ., China; 3Center for Theoretical Physics of Complex Systems, Inst. for Basic Science, South Korea; 4Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological Univ., Singapore; 5MOE Key Lab of Weak-Light Nonlinear Photonics, TÉDA Applied Physics Inst. and School of Physics, Nankai Univ., China; 6Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore. We observe Bloch oscillations and Landau-Zener-tunneling at Dirac points in photonic graphene. The non-adiabatic wave dynamics depend anisotropically on the direction of an applied index gradient, resulting in imperfect Landau-Zener-tunneling and valley-dependent vortex generation.

FTh3E.7 • 15:30
Launching Electromagnetic Donuts: Non-transverse electromagnetic pulses, Apostolos Zdagkas1, Parik Moitra1, Oleksander Buchnev1, Nikitas Papasimakis1, Nikolai I. Zheludev1,2; 1Univ. of Southampton, UK; 2Nanyang Technological Univ., Singapore. We demonstrate experimentally for the first time the generation of electromagnetic “Flying Donuts”, few-cycle pulses of toroidal topology with non-separable spatial and temporal structure, and discuss applications in the study of anapole excitations in matter.

FTh3F • Mid-IR Nonlinear Devices—Continued

FTh3F.6 • 15:30
Generation of high power, higher order, continuous-wave optical vortices tunable in the mid-IR wavelength ranges, A. Aadhi1, Varun Sharma1, G. K. Samanta2; 1Physical Research Lab, India. We report on direct transfer of vortices at near-IR to the mid-IR wavelengths using a dual-crystal singly-resonant optical parametric oscillator producing vortices of order up to l=6 and power of 6 W across 2270-3560 nm.

FTh3F.8 • 15:45
Generation of Vector Vortex Beam From Doubly-Resonant Nanosecond Optical Parametric Oscillator, Varun Sharma1, S. C. Kumar1, A. Aadhi1, H. Ye1, G. K. Samanta1, M. Ebrahim-Zadeh1; 1ICFO-Institut de Ciencies Fotoniques, Spain; 2Instituto Catalana de Recerca i Estudis Avancats (ICREA), Spain; 3Photonic Sciences Lab, Physical Research Lab, India. We demonstrate a novel experimental scheme to generate tunable vector vortex beam directly from an optical parametric oscillator (OPO). Using a nanosecond doubly-resonant OPO, we produce vector vortex beam tunable across 964-990 nm.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Thursday, 14:00–16:00

**STh3G • Quantum Information Processing on Photonic Nanostructures—Continued**

**STh3G.3 • 15:15**
Single-Photon Detection by Cavity-Assisted All-Optical Gain, Christopher L. Parisi1, Mihir Pant1, Mikkel Heuck1, Dirk Englund1; 1Dept. of Electrical Engineering and Computer Science, MIT, USA; 2Dept. of Photonics Engineering, Techni

**STh3G.4 • 15:30**
Switching radiative processes via mode field modulation, Daniele Pellegrino1, Francesca Pagliano1, Armando Genco1, Maurangelo Petruzzella1, Frank van Otten1, Andrea Fiore1; 1Eindhoven Univ. of Technology, Netherlands; 2nanoPHAB, Netherlands. We experimentally demonstrate the control over the emission of quantum dots embedded in photonic molecules via mode field modulation. By locally changing the cavity frequencies we control, and even suppress, spontaneous emission.

**STh3G.5 • 15:45**
Chiral quantum optics in hot vapor cladded waveguide, Roy T. Zektzer1, Eiran Talker1, Yefim Barash1, Noa Mazurski1, Uriel Levy1; 1The Hebrew Univ. of Jerusalem, Israel. We demonstrate a strong magneto optic effect in chip scale integrated atomic cladded waveguides. Chiral effects and non-reciprocity of the integrated waveguide-atomic vapor system is observed. Possible applications such as isolators are discussed.

**STh3G.6 • 15:15**
Elastic Strain Engineering for Exceptional Mechanical Coherence, Nils Johan Engelsen1, Amir Ghadimi1, Sergey A. Fedorov1, Mohammad J. Beryeyi1, Ryan Schilling1, Dalziel Wilson1,2, Tobias J. Kippenberg1; 1Physics, Ecole polytechnique fédérale de Lausanne, Switzerland; 2IBM Research, Switzerland. We utilized strain engineering combined with soft-clamping to realize exceptionally high Q SiN nanomechanical oscillators. The quality factors (>400 million) and Q×f products (approaching 10⁹ Hz) are both unprecedented for any room temperature mechanical oscillator.

**STh3G.7 • 15:30**
Frequency Conversion of a Quantum Dot Single-Photon Source on a Nanophotonic Chip, Anshuman Singh1,2, Qing Li1,2, Jin Liu3, Xiyuan Lu1,2, Christian Schneider4,5, Simon Hönl1, Katharina Schneider1, Pol Welter1, Yannick Baumgartner1, Herwig Hahn1, Lukas Czornomaz1, Dalziel Wilson1, Paul Seidler1; 1IBM Research — Zurich, Switzerland. We present a complete process flow for fabrication of integrated GaP-on-insulator photonic devices via direct wafer bonding of epitaxial films. High-fidelity patterning enables a range of applications, such as waveguide resonators and photonic crystal cavities.

**STh3G.8 • 15:45**
Single-Photon-Level Interface for Linking Sr + Transition at 422nm with The Telecommunications C-band, A. Wright1, Robert J. Francis-Jones1, Corin Gawith3, Jonas N. Becker1, Patrick Ledingham1, Ian Walsmsley1, Benjamin Brecht1, Joshua Nunn1, Peter J. Mosley1; 1Univ. of Oxford, UK; 2Univ. of Southampton, UK. We present a single-stage bi-directional interface capable of linking Sr+ trapped ion qubits emitting single photons at 422 nm with the telecoms C-band. We achieve external (up/down) conversion efficiencies of 9.4%(1.1%).

**STh3G.9 • 16:00**
Silicon nitride metalenses for unpolarized high-NA visible imaging, Zhi-Bin Fan1, Zeng-Kai Shao1, Ming-Yuan Xie1, Xia-Ning Pang1, Wen-Sheng Ruan1, Fu-Li Zhao1, Yu-Jie Chen1, Si-Yuan Yu1, Jianwen Dong1; 1Sun Yat-Sen Univ., China. We experimentally demonstrate the high-NA silicon nitride metalenses with centimeter aperture and micro size in visible region, fabricated by 695-nm-thick hexagonal silicon nitride arrays. The potential application of wide-viewing-angle functionality has also been shown.

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**16:00–16:30 Coffee Break, Concourse Lobby**
STh3J • Optofluidics & High Throughput Biosensing—Continued

STh3J.4 • 15:15
A Novel Cell and Particle Sorting Approach Based on Fluorescence Dynamics, Jianzhi Li1, Jessica P. Houston2, New Mexico State Univ., USA. Fluorescence activated cell sorting (FACS) is an approach that is based solely on detection of the amount of fluorescence emitted. We advance FACS with a unique phase mixing approach to enable separation based on fluorescence dynamics.

STh3J.5 • 15:30
Microfluidic Diatomite Analytical Devices for Ultra-Sensitive Detection of Hazardous Chemicals, Xianming Kong1, Kenny Squire1, Alan X. Wang1, Oregon State Univ., USA. We report microfluidic diatomite analytical devices (μDADs), which consist of highly porous photonic crystal biosilica microchannels, as an innovative lab-on-a-chip platform to detect hazardous chemicals with the sensitivity down to ppb level.

STh3J.6 • 15:45
Optical Lattice-Based Cell Guiding and Stretching Using Integrated Vertical Multimode-Interference Waveguides, Zhanshi Yao1, Andrew W. Poon1, Hong Kong Univ. of Sci. and Tech., Hong Kong. We report our recent progress in optical lattice-based cell guiding and stretching using integrated SU8-filled vertically embedded multimode-interference waveguides. We obtain a throughput of ~6 cells/s for the deformability characterization of rabbit red blood cells.

STh3K • Multimode Fiber Optics—Continued

STh3K.3 • 15:15
Imaging Beyond a Multimode Fibre with Time of Flight Depth Information, Dean Stellings1, David Phillips1, Matthew Edgar1, Sergey Turtashev1, Tomáš Čamánek1, Miles Padgett1, Univ. of Glasgow, UK; Univ. of Exeter, UK; Univ. of Dundee, UK; Leibniz Inst. of Photonic Technology, Germany. Imaging through a multimode fibre can be achieved using a DMD. Using a Q-switched laser we extend this to include the time of flight as a first step towards 3D imaging though a fibre.

STh3K.4 • 15:30
Time-Domain Interference of Nonlinearly Interacting Spatial Modes in a Multimode Fiber, Sai Kanth Dacha1, Thomas E. Murphy1, Univ. of Maryland at College Park, USA. The study of nonlinear optics in multimode fibers has gathered considerable interest recently. We report experimental observation of time-domain interference between nonlinearly interacting co-polarized spatial modes of a graded-index multimode fiber at 1550nm.

STh3K.5 • 15:45
Mode Scrambler Using CO2-laser Inscribed Long-period Gratings, Yanhe Zhao1, Haoshuo Chen1, Nicolas K. Fontaine1, Jiaxiong Li2, Roland Ryf1, Megumi Uchida2, Yurina Tanaka3, Kaoru Minoshima4,5, The Univ. of Electro-Communications, Japan; JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan. We demonstrate a mode scrambler using CO2-laser inscribed long-period gratings for mixing 3 spatial modes. The mode-dependent loss and modal transfer matrices versus wavelength are characterized using a swept-wavelength interferometer.

STh3K.6 • 16:00
One-shot three-dimensional imaging with a paired filter and chirped-frequency comb, Takashi Kato1,2, Megumi Uchida1,2, Yurina Tanaka1,2, Kaoru Minoshima1,2, The Univ. of Electro-Communications, Japan; JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan. One-shot three-dimensional imaging with chirped-frequency comb interferometry was demonstrated using 2D spectral imaging technique with a paired spectral filter. Non-scanning image measurement of a target 3D surface profile with 120-pixels square area was demonstrated.

STh3L • Imaging and Ranging—Continued

STh3L.5 • 15:15
Controlled Transmission Through Highly Scattering Media Using Semi-Definite Programming as a Phase Retrieval Computation Method, Moussa N’Gom1, Univ. of Michigan, USA. An SLM in a simple optical setup allows computation of the complex transmission matrix of the system. Arbitrary intensity profiles can then be generated.

STh3L.6 • 15:30
Overcoming the Coherence Distance Barrier in Long-Range FMCW LIDAR, Taehwan Kim1, Pavan Bhargava1, Vladimir Stojanovic1, UC Berkeley, USA. Coherence distance has been considered as a hard limit for FMCW LIDAR range. We show laser characterization and a detection algorithm tailored to laser properties can significantly improve the accuracy, extending the range beyond coherence distance.

STh3L.7 • 15:45
One-shot three-dimensional imaging with a paired filter and chirped-frequency comb, Takashi Kato1,2, Megumi Uchida1,2, Yurina Tanaka1,2, Kaoru Minoshima1,2, The Univ. of Electro-Communications, Japan; JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan. One-shot three-dimensional imaging with chirped-frequency comb interferometry was demonstrated using 2D spectral imaging technique with a paired spectral filter. Non-scanning image measurement of a target 3D surface profile with 120-pixels square area was demonstrated.

16:00–16:30 Coffee Break, Concourse Lobby
Thursday, 14:00–16:00

FTh3M • Chirality Vortices and Topological Effects—Continued

FTh3M.5 • 15:15
Giant intrinsic chiro-optical activity in planar nanostructures, Alexander Y Zhu1, Wei-Ting Chen1, Aun Zaidi1, Yao-Wei Huang1, Mohammadreza Khorasaninejad1, Vyshakh Sanjeev1, Cheng-Wei Qiu1, Federico Capasso1; 1Harvard Univ., USA; 2National Univ. of Singapore, Singapore; 3Univ. of Waterloo, Singapore. We demonstrate near-unity circular dichroism in planar dielectric nanostructures, with approximately 90% of the incident light of the chosen helicity being transmitted at normal incidence at 540nm. Such strong intrinsic chiral behavior exists due to the excitation of giant higher-order multipoles.

FTh3M.6 • 15:30
Microscopic Origin of the Chiroptical Response of Plasmonic Media, Matthew Davis1,2, Jay Lee1, Henri Lezec1, Amit K. Agrawal1,2; 1Syracuse Univ., USA; 2Center for Nanoscale Science and Technology, USA. Plasmonic systems hold potential for amplifying chiroptical signals of molecular systems, however a comprehensive understanding of this effect does not exist. We discuss the common origin of chiroptical response in two-dimensional and three-dimensional plasmonic systems.

FTh3M.7 • 15:45
A chiral waveguide directional coupler using transition metal dichalcogenide monolayers, Zhili Yang1, Edo Waks1; 1Univ. of Maryland, College Park, USA. We demonstrated an on-chip broadband input-polarization-dependent directional coupler with a directionality of 0.3 based on coupling between a glide-plane photonic crystal waveguide and WSe2 monolayers.

STh3N • Ultrafast Metrology I—Continued

STh3N.5 • 15:30
Spatio-temporally wideband ultrafast imaging, Cihang Kong1, Xiaoming Wei1,2, Kevin K. Tsia1, Kenneth Kin-Yip Wong1; 1Univ. of Hong Kong, Hong Kong; 2Dept. of Medical Engineering, California Inst. of Technology, USA. We present a 10’s-MHz imaging system through a simple spatio-temporally sweeping unit which is constructed with incremental optical fibers. It is demonstrated that this imaging modality can be performed over an ultrawide wavelength range, i.e., 500-2000 nm.

STh3N.6 • 15:30
Microscopic Origin of the Chiroptical Response of Plasmonic Media, Matthew Davis1,2, Jay Lee1, Henri Lezec1, Amit K. Agrawal1,2; 1Syracuse Univ., USA; 2Center for Nanoscale Science and Technology, USA. Plasmonic systems hold potential for amplifying chiroptical signals of molecular systems, however a comprehensive understanding of this effect does not exist. We discuss the common origin of chiroptical response in two-dimensional and three-dimensional plasmonic systems.

STh3N.7 • 15:45
Cascading Nonlinearity Inside a Spectrometer (CaNIS) for Ultrashort Pulse Diagnostics, Ning Hsu1, Luke Horstman1, Jean-Claude M. Diels1; 1Univ. of New Mexico, USA. An ultrashort pulse is characterized by using spectra only. Second harmonic and cascading spectra are manipulated with a grating spectrometers to determine the original pulse’s spectral phase, and hence achieve complete field reconstruction.

ATH3O • Novel Spectroscopic Approaches I—Continued

ATH3O.6 • 15:15
Wavelength calibration of high-performance spectrometers with a stabilized optical comb from an ultrafast semiconductor disk laser, Antoine Jallageas1, Jacob Nuernberg2, Cesare Alliari1, Dominik Waldburger1, Sandro M. Link1, Florian Emuery1, Jacques Morel1, Ursula Keller1; 1Federal Institut of Metrology METAS, Switzerland; 2Inst. of Quantum Electronics, ETH Zurich, Switzerland. We demonstrate for the first time that a fully stabilized ultrafast semiconductor disk laser is a suitable tool to perform wavelength calibration of high-performance spectrometers, opening new possibilities for wider and more accurate instruments calibrations.

ATH3O.7 • 15:30
Noise Correlation Spectroscopy for spectroscopic measurements of low energy modes, Giorgia Sparapassi1, Jonathan O. Tollerud1, Filippo Glicenstein1, Daniele Faust1,2; 1Università degli Studi di Trieste, Italy; 2Elettra Sincrotrone Trieste S.C.p.A., Italy. Noise Correlation Spectroscopy (NCS) is a technique exploiting statistical correlations imprinted onto spectral components of shaped ultrashort light pulses by a light-matter inelastic scattering process, in order to measure low energy eigenmodes of a material.

16:00–16:30 Coffee Break, Concourse Lobby
ATH3P • Sensing in Extreme Environments & Organic Optical Materials—Continued

ATH3P.5 • 15:15
Passive radiative cooling structure with vivid colors, Gil Ju Lee1, Hyun Myung Kim1, Yeong Jae Kim1, Young Min Song1; 1GIST, South Korea. A colored passive radiative cooler can widen the applicability of passive cooling strategy. This photonic structure is based on 1D structure/thermal emitter polymer and can be easily fabricated by metal/dielectric deposition and polymer coating.

ATH3P.6 • 15:30
Observation of Coherent Perfect Absorption in Resonant Organic Materials, Ali Kazemi Jahromi1, Lorelle N. Pye1, Soroush Shabahang1, Massimo Villsinger1, Joshua Perlstein1, Ayman Abouraddy1; 1Univ. of Central Florida, CREOL, USA. By judiciously devising mirror reflectivities of a cavity containing an absorber, we experimentally demonstrate coherent perfect absorption in a resonant organic dye, even though the material’s intrinsic absorption significantly varies across the dye absorption bandwidth.

ATH3P.7 • 15:45
Silk is a natural metamaterial for self-cooling: An oxymoron?, Seung Ho Choi1, Zahyun Ku1, Seong-Ryul Kim1, Kwang-Ho Choi2, Augustine Urbas3, Young L. Kim1; 1Purdue Univ., USA; 2Air Force Research Lab, USA; 3National Inst. of Agricultural Sciences, South Korea. As light transmittance in silk is suppressed by Anderson localization, its reflectance is drastically enhanced. A further combination with the high emissivity from the biomolecules of silk in infrared radiation results in passive radiative cooling.

ATH3Q • A&T Topical Review on Neurophotonics II—Continued

ATH3Q.5 • 15:30
Identification of Biomarker (L-2HG) in Real Human Brain Glioma by Terahertz Spectroscopy, Yan Peng1, Wanqing Chen1, Yiming Zhu; 1Univ of Shanghai for Science & Tech, China. L-2-Hydroxyglutaric acid disodium salt (L-2HG), a unique biomarker in glioma, has been detected effectively in real human brain glioma by THz time-domain spectroscopy (THz-TDS), which is especially meaningful for the diagnose and treatments of glioma.

ATH3Q.6 • 15:45
Neurite Outgrowth and Retraction Caused by Combined Optical and Chemical Stimulations, Yu-Chiu Kao1, Yu-Cing Liao1,2, Chau-Hwang Lee1; 1Research Center for Applied Sciences, Academia Sinica, Taiwan; 2Inst. of Biophotonics, National Yang-Ming Univ., Taiwan. We demonstrated that a 473 nm light spot caused neurite retraction of a neuroblastoma cell, while a 650 nm light spot on soma plus a myosin II inhibitor stimulated the neurite re-growth effectively.
Fast adiabatic mode evolution based on geometry-induced suppression of nearest-mode crosstalk, Josep Fargas Caballeras, Milos Popovic,
1Dept. of Electrical and Computer Engineering, Boston Univ., USA. A new degree of freedom in the design of adiabatic mode-evolution structures allows dramatic length reduction while maintaining the characteristic large bandwidth and insensitivity, leading to a 10x shorter ultrabroadband, low-loss 2x2 3dB coupler design.

Curvature Control in a Segmented Beam Expander: Emergence of a Semi-lens, Sama Khabab, Robert Gastula, Ming Lu, Aron Stein, Wei Jiang, Rutgers Univ., USA; 2Brookhaven National Lab, USA. We introduce direct curvature control in optimizing a segmented beam expander that maintains width continuity. Unexpectedly, the optimization algorithm yields a structure with abrupt width discontinuity. Spatial phase analysis reveals the emergence of a semi-lens.

Double-Inverse Tapers for Efficient Light Coupling with Arbitrary Polarization, Junqu Liu, Arsalan Raja, Martin Pfeiffer, Clemens Henniker, Harun Guo, Michael Zervas, Michael Geiselman, Tobias J. Kippenberg, EPFL, Switzerland; 3LIGENTEC SA, Switzerland. Efficient light coupling to integrated photonic devices is vital. We present novel, double-inverse tapers, which can achieve optimum coupling with arbitrary polarization. Reduced lithography requirement makes the double-inverse tapers promising for operation at near-IR and visible wavelengths.

On-Chip Polarization Control Using Augmented Low Index Guiding Platform, Xiao Sun, J. Stewart Atchison, Mo Mogehld, 1Univ. of Toronto, Canada. The Augmented Low-index Guiding Waveguide can confine the two orthogonal polarization modes in different layers. We present our recent theoretical and experimental results on several polarization manipulation devices enabled by such a platform.

Optical Equalization Using Spatial Phase Manipulation for VCSEL-MMF Based Links, Chenyu Liang, Wenjie Zhang, Shun Yao, Qing Wang, Zuyuan He, Shanghai Jiaotong Univ., China; 3Inst. of Laser Engineering, Beijing Univ. of Technology, China; 4Sino-semiconductor Photonics Integrated Circuit Co., Ltd., China. We propose an optical equalization scheme for VCSEL and MMF based link by using spatial phase manipulation. Over 2-dB power penalty improvement is achieved by experiment for 25-Gb/s 30km transmission.

Fabrication Constrained Inverse Design of a 3-channel Wavelength Demultiplexer, Alexander Y. Piggott, Logan Su, Nevin S. Sampat, Jan Petykiewicz, Jelena Vuckovic, Stanford Univ., USA. We have implemented an automated nanophotonic design algorithm with fabrication constraints. This was used to demonstrate a compact 3-channel wavelength demultiplexer with a channel spacing of 40nm, insertion loss <2.92dB, and under 10.7 dB crosstalk.

Ultra-broadband Compact Adiabatic Coupler in Silicon-on-Insulator for Joint Operation in the C- and O-Bands, Heba Tamaaz, Eslam Effiey, Yun Wang, Ian D’Mello, McGill Univ., Canada. An ultra-broadband, compact adiabatic coupler in silicon-on-insulator platform is presented. It has 70 µm coupling length and a splitting ratio of 3±0.8 dB over bandwidth >160 nm measured jointly in the C- and O-bands.

Direct coupling between 2D-PDA and triangular/square shape aligned MCF for universal SDM photoreceiver, Tomishima Urzawa, Takahide Sakamoto, Atsushi Kanno, Naokatsu Yamamoto, Tetsuya Kawanishi, National Inst. of Information & Comm Tech, Japan; 2Waseda Univ., Japan. We successfully achieved the high coupling efficiencies and alignment tolerances between a newly developed 10-GHz 32-pixel two dimensional photodetector array (2D-PDA) and triangular- and square-shape-aligned multi-core fiber (MCF) for universal SDM photoreceivers.

Non-Linear Light Sources for Silicon Photonics, Matteo Galli, Universita degli Studi di Pavia, Italy silicon photonics has rapidly become the platform of choice for on-chip integration of high performing photonic devices, now extending their functionalities to quantum-based applications. We review recent progress in this growing field and highlight the challenges that need to be overcome to make quantum photonics a reliable and widespread technology.

Scalable On-Chip Generation and Coherent Control of Complex Optical Quantum States, Piotr Rostocki, Michael Kues, Christian Reimer, Luis Romera Cortés, Stefania Sciara, Benjamín Wetzel, Young Zhang, Alfonso Cino, Sai T. Chu, Brent E. Little, David J. Moss, Luca Caspani, Jose Azana, Roberto Morandi, INRS-Energie Mat & Tele Site Varennes, Canada; 4National Research Univ. of Information Technologies, Mechanics and Optics, Russia; 5Univ. of Glasgow, UK; 6Univ. of Palermo, Italy; 7Univ. of Sussex, UK; 8City Univ. of Hong Kong, China; 9Univ. Inst. of Optics and Precision Mechanics, Chinese Academy of Science, China; 10Swanburne Univ. of Technology, Australia; 11Univ. of Strathclyde, UK. Integrated quantum frequency combs provide access to multi-photon and high-dimensional entangled states, and their control via standard telecommunications components, and can thus open paths for reaching the state complexities required for meaningful quantum information science.
### Microcomb Engine for Microwave Photonics

- **Presider:** Maurizio Burla; ETH Zurich, Switzerland and David Marpaung; University of Twente, Netherlands
- **Amplitude modulation of pump laser for suppressing fluctuations**
- **We** experimentally demonstrate nonlinear wave collapse at mW-power levels in a genuine 1D system formed by coupled optical fibers.
- **Based on time-multiplexing we realize an effective two-dimensional lattice and observe strong nonlinearly driven field compression.**

### Photonic Integrated Circuits for Microwave Signal Generation and Processing

- **Presider:** Jianping Yao; Univ. of Ottawa, Canada.
- **Silicon photonic integrated circuits (PICs) for the implementation of microwave photonic systems to perform functions including microwave signal processing based on a reconfigurable grating, and microwave signal generation based on an optoelectronic oscillator are discussed.**

### Spatiotemporal Phenomena in Multimode Fibers

- **Frank W. Wise;** Cornell Univ., USA. New phenomena observed recently in multimode optical fibers will be reviewed, and their relevance to applications will be discussed.

### Universal Entropic Response of Nonlinear Multimode Optical Systems

- **Fan Wu;** Univ. of Central Florida, USA. We study numerically and experimentally the competition between intramodal and intermodal Raman scattering of ultrashort pulses in multimode fibers.
- **Aku J. Antikainen;** Univ. of Rochester, USA; **Giovanni A. Agrawal;** Univ. of Central Florida, USA. We show that the mode occupancies in nonlinear multimode optical systems follow a universal behavior that tends to maximize the system's entropy at steady-state. This thermodynamic response occurs irrespective of the type of nonlinearities involved.

### Intermodal Raman Scattering of Ultrashort Pulses in Multimode Fibers

- **Aki J. Antikainen;** Univ. of Rochester, USA; **Lars Rishøj;** Université Libre de Bruxelles, Belgium. We study numerically the competition between intramodal and intermodal Raman scattering of ultrashort pulses in a multimode fiber. Considerable pulse energy can be transferred between different modes depending on the extent of group velocity matching.

### Injection Locking of Dissipative Kerr Solitons

- **Presider:** Demetrios N. Christodoulides; Univ. of Central Florida, CREOL, USA; **Mike Mirov;** Univ. of Central Florida, CREOL, USA; **Konstantin L. Vodopyanov;** IPG Photonics, USA.
- **We report a radio frequency injection locking technique with amplitude modulation of pump laser for suppressing fluctuations of the repetition rate of a microresonator-based dissipative Kerr soliton frequency comb.**

### Half-watt average power compact femtosecond source with a bandwidth of 3-8 µm based on subharmonic GaAs OPO

- **Viktor O. Smolski;** Sergei Vasilyev; Igor Moskalev; Mike Mirov; Qitian Ru; Andrey Muravev; Peter G. Schunemann; Konstantin L. Vodopyanov; IPG Photonics, USA. High-power (0.5 W) mid-IR output suitable for ultra-broadband frequency comb generation was produced in a subharmonic GaAs optical parametric oscillator that was synchronously pumped by a compact 0.9 GHz, 6 W femtosecond Cr:ZnS (2.35 μm) MOPA.
FTh4G.1 • 16:30
Experimental Test of Bell’s Inequality for Temporal Orders, Giulia Rubino1, Lee Rozena1, Francesco Massa1, Mateus Araújo1, Magdalena Zych1, Caslav Brukner2, Philip Walther1; 1Univ. of Vienna, Austria; 2Univ. of Queensland, Australia. Bell’s inequality has been violated using different physical systems, but never for the temporal order between events. Here we present such a Bell inequality and experimentally violate it by entangling the temporal order between events.

FTh4G.2 • 16:45
A Four-Photon Graph State Generator in Silicon, Jeremy C. Alcock1, Catarina Vigili1, Raffaele Santagati1, Joshua W. Silverstone1, Mark G. Thompson1; 1Univ. of Bristol, UK. We present a four-photon, four-qubit graph state generator in silicon quantum photonics, achieving, for the two and four qubit cases respectively, fidelities of 0.931 ± 0.004 and 0.62 ± 0.04, and a visibility of 0.85 ± 0.03.

FTh4G.3 • 17:00
A Broadband All-Fiber SU(1,1) Interferometer, Joseph M. Lukens1, Raphael C. Pooser2,3, Nicholas A. Peters2,3; 1Oak Ridge National Lab, USA; 2Dept. of Physics, Univ. of Tennessee, USA. We describe an SU(1,1) interferometer based on highly nonlinear optical fiber, attaining >97% peak interference visibility and >90% visibility over a 554 GHz optical band.

FTh4G.4 • 17:15
Rabi-like Oscillations in Photon Pair Correlations, Steven Rogers1, Austin Graf1, Eman Javid1, Qiang Lin1; 1Univ. of Rochester, USA. We have produced a new quantum coherence phenomenon via photon generation within ultra-high-Q silicon microdisks. The Rayleigh-scattering-induced strong coupling of counterpropagating modes leads to Rabi-like oscillations in the biphone second-order coherence.

FTh4G.5 • 17:30
Schrödinger Cats for Quantum Internet, Alexander I. Lvovsky1, Alexander Ulanov2, Demid Sychev2, Anastasia A. Pushkina1, Egor Turunov1, Valery Novikov1; 1Univ. of Calgary, Canada; 2Russian Quantum Center, Russia. We generate and characterize an entangled state between qubits encoded in single-photon polarizations and superpositions of opposite-amplitude coherent states. We demonstrate its application for exchanging quantum information between discrete- and continuous-variable encodings of quantum information.

FTh4H.1 • 16:30
Bypassing Loss in Plasmonic Modulators, Christian Haffner1, Daniel Orelladauri1, Yuriy Fedoryshyn1, Arne Josten1, Benedikt Bauerle1, Wolfgang Heni1, Tatsuhiko Watanabe1, Tong Cui1, Bojun Cheng1, Soham Saha1, Delwin Elder1, Larry D. Dalton1, Alexandra Bittolosaeva1, Vladimir M. Shalaev2, Nathaniel Kinsey1, Juerg Leuthold1; 1ETH Zurich, Switzerland; 2School of Electrical & Computer Engineering and Brick Nanotechnology Center, Purdue Univ, USA; 3Dept. of Chemistry, Univ. of Washington, USA; 4Electrical and Computer Engineering, Virginia Commonwealth Univ, USA. We show that Ohmic losses in plasmonic modulators can be bypassed by using a resonant scheme. This enables the first modulator that unites low-loss, high-speed, compact footprint and low-electrical energy consumption.

FTh4H.2 • 17:00
Electro-Absorption Waveguide Modulator Performance, Ruban Amin1, Jacob Khurgin1, Volker J. Sorger1; 1The George Washington Univ, USA; 2Johns Hopkins Univ, USA. A holistic analysis for waveguide-based electro-absorption modulators demonstrates that all materials with direct interband absorption show comparable performance from the fundamental point of view. Only reducing the effective waveguide area can lead to reduced switching energy and wide bandwidth.

FTh4H.3 • 17:15
High responsivity and bias-free graphene photodetector with nano-grating contact electrodes, Mina Jarrahi1, Senthil Cakmakyapan1; 1Univ. of California Los Angeles, USA. We present a high responsivity and bias-free graphene photodetector with responsivity levels as high as 225 mA/W at 800 nm wavelength, which uses nano-grating contact electrodes to enhance optical absorption and photocarrier extraction.

FTh4H.4 • 17:30
Integrated Quantum Optics: From Emitters to Detectors, Val Zwillich1; 1Technische Universiteit Delft, Netherlands. We develop quantum devices to generate quantum states of light with semiconductor quantum dots, superconducting single photon detectors and on-chip circuits to filter and route light.

FTh4H.5 • 17:45
Schrodinger Cats for Quantum Internet, Alexander I. Lvovsky1, Alexander Ulanov2, Demid Sychev2, Anastasia A. Pushkina1, Egor Turunov1, Valery Novikov1; 1Univ. of Calgary, Canada; 2Russian Quantum Center, Russia. We generate and characterize an entangled state between qubits encoded in single-photon polarizations and superpositions of opposite-amplitude coherent states. We demonstrate its application for exchanging quantum information between discrete- and continuous-variable encodings of quantum information.

FTh4H.6 • 18:00
Direct Bandgap Type-I GeSn Quantum Well toward Si-Integrable Lasers, Scott D. Stirkerman1, Marco Matyioka2, Andrew F. Briggs1, Kenneth J. Underwood2, Kyle M. McNicholas1, Robert Kudrawiec1, Juliet Gopinath1, Seth Bank1; 1Microelectronics Research Center, Univ. of Texas at Austin, USA; 2Wroclaw Univ. of Technology, Poland; 3Dept. of Physics, Univ. of Colorado Boulder, USA; 4Dept. of Electrical, Computer and Energy Engineering, Univ. of Colorado Boulder, USA. Incorporation of bismuth into III-V emitters typically results in dramatically reduced luminescence efficiency. We present type-I dilute-bismide III-V quantum wells exhibiting enhanced photoluminescence near 4 µm, suggesting a viable route to extend diode laser emission.

FTh4I.1 • 16:30
Epitaxy-free Direct Bandgap GeSn Materials and Devices for Facile 3D Photonic Integration, Jinfeng Liu1, Xiaoxin Wang1, Dartmouth College, USA. We present direct bandgap GeSn crystallized on dielectric layers at <450 °C with room-temperature photoluminescence, ~0.1 ns transient optical gain >4000/cm at λ=2100-2350 nm, and a photocurrent responsivity of ~10 mA/W @1V at λ=2180 nm.

FTh4I.2 • 17:00
Systematic Study of Ge0.89Sn0.11 Photodiodes for Low-Cost Shortwave Infrared Imaging, Huong Tran1, Thach Pham1, Wei Du1, Yang Zhang1, Seyed Ghetman2, Perry Grant1,2, Joseph Grant1, Greg Sun1, Richard Soref1, Joe Margelts1, John Tolle1, Baohua Li1, Mansour Mortazavi1, Shui-Qing Yu1; 1Univ. of Arkansas, USA; 2Wilkes Univ, USA; 3Univ. of Arkansas Pine Bluff, USA; 4Univ. of Massachusetts Boston, USA; 5ASM, USA; 6Arktonics, USA. The characteristics Ge0.89Sn0.11 photodiodes were systematically investigated. A cutoff wavelength of 2.65 µm at 300 K and the peak detectivity of 4.3*10^10 Jones at 77 K were achieved. An infrared imaging of an object was demonstrated using the single Ge0.89Sn0.11 photodiode.

FTh4I.3 • 17:15
Dilute-Bismide Alloys for GaSb-based Mid-Infrared Semiconductor Lasers, Scott D. Stirkerman1, Marco Matyioka2, Andrew F. Briggs1, Kenneth J. Underwood2, Kyle M. McNicholas1, Robert Kudrawiec1, Juliet Gopinath1, Seth Bank1; 1Microelectronics Research Center, Univ. of Texas at Austin, USA; 2Wroclaw Univ. of Technology, Poland; 3Dept. of Physics, Univ. of Colorado Boulder, USA; 4Dept. of Electrical, Computer and Energy Engineering, Univ. of Colorado Boulder, USA. Incorporation of bismuth into III-V emitters typically results in dramatically reduced luminescence efficiency. We present type-I dilute-bismide III-V quantum wells exhibiting enhanced photoluminescence near 4 µm, suggesting a viable route to extend diode laser emission.

FTh4I.4 • 17:30
Direct Bandgap Type-I GeSn Quantum Well toward Si-Based Photonic Devices, Perry C. Grant1, Joe Margelts1, Yimin Zhan1, Wei Dou1, Gray Abemethy1, Andrian Kuchuk1, Wei Du1, Seyed Ghetman2, Baohua Li1, John Tolle1, Jinfeng Liu1, Greg Sun1, Richard Soref1, Mansour Mortazavi1, Shui-Qing Yu1; 1Univ. of Arkansas, USA; 2Arktonics LLC., USA; 3ASM, USA; 4Wilkes Univ, USA; 5Univ. of Arkansas-Pine Bluff, USA; 6Dartmouth College, USA; 7Univ. of Massachusetts-Boston, USA. GeSn single quantum well on relaxed GeSn and Ge buffered Si substrate was investigated. The direct bandgap well and type-I band alignment were achieved, which were confirmed by calculation and photoluminescence studies.
Univ., Turkey. Epitaxial GaN on sapphire is a promising material platform for low-loss, nonlinear and active metasurfaces with spectra spanning from the UV to the near-IR. 

Four-wave mixing and six-wave mixing processes in III-V semiconductors, demonstrate simultaneous occurrence of second-, third-, and fourth-harmonic generation, sum-frequency generation, and frequency doubling using meta-surface based on III-V semiconductors (InGaAs/GaAs). We experimentally demonstrate high efficiency and low-loss dielectric metasurfaces incorporating III-V semiconductors and show that by integrating transparent conducting oxides with a photonic waveguide array it is possible to realize ultrafast control over topology of photonic systems. This precise control is highly important for optically controlled memory devices and quantum communication applications.

Gain tunable all-dielectric metasurfaces incorporating III-V semiconductors, InGaAs/GaAs fiber laser, which has been demonstrated through both numerical simulation and experiment. 

We experimentally explore the spatial and spectral response of a chip-scale hybrid atomic-dielectric grating. Spectral control of the diffraction orders mediated by the atomic vapor paves the path to a variety of novel atomic-controlled diffractive-optical elements. 

III-V semiconductor metasurface as the optical mixer, InGaAs/GaAs fiber laser, which has been demonstrated through both numerical simulation and experiment. 

Emission Beyond 4μm and Mid-Infrared Lasing from a Dy3+:InF3 Fiber, Yale University, New Haven, CT. A passively cooled 2825 nm splice-less erbium-doped fluoride fiber laser delivering 20 W output power in continuous wave operation was reported. This result represents the highest mid-IR output power obtained from a splice-less laser cavity.

Yb-doped Fiber Laser Based Coherent Mid-Infrared Frequency Comb at λ = 4.5 μm for CRDS application, University of Southampton, UK. An offset free mid-infrared optical frequency comb was generated based on an Yb-doped fiber laser system with tunability of 3.9-4.7 μm. Cavity ring down spectroscopy measurement was demonstrated with QCL and MIR comb-reference. 

CO2 Measurement in Laminar Premixed Flames Using Heterodyne Phase-Sensitive Dispersion Spectroscopy, Stanford University, CA. We present a diodyson-doped InF3 fiber exhibiting laser emission beyond 4 microns, the longest wavelength to date from a fluoride-based fiber. Laser emission around 3 μm is also demonstrated.

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High-ef

High-efficiency and low-loss dielectric metasurfaces on a gallium nitride platform, University of Southampton, UK. The present talk will present some advancement in laser diagnostics in combustion environments. Several techniques will be described and the talk will also include new developments addressing some of the challenges in the field.

Co2 Measurement in Laminar Premixed Flames Using Heterodyne Phase-Sensitive Dispersion Spectroscopy, Stanford University, CA.

Development and Application of Laser Diagnostic Techniques for Combustion Studies, University of Southampton, UK.
Broadband Hot Electron Creation in Nanoscale Gap Plasmons for Active Color Display and Highly Secure Encryption, FTh4M.2 • 16:45

Hybrid Structures, Raktim Sarma1, Salvatore Campione1, Michael goldflam1,2, Joshua Shank1,2, Michael Smith1,3, Jinhui Noh1,3, Peide Ye1,3, Michael Sinclair2, Igal Brener1,2, Sandia National Labs, USA; 2Purdue Univ., USA. We experimentally demonstrate spectral tuning and amplitude modulation of reflectance at long infrared wavelengths using a complementary metasurface strongly coupled to an epsilon-near-zero (ENZ) mode in an ultrathin InGaAs layer with a reflecting backplane.

FTh4M.2 • 16:45
Wavelength-dependent Optical-rotation Manipulation for Active Color Display and Highly Secure Encryption, Masowen Song1,2, Alexander Kildishev1,3, Di Wang1,3, Zhuofeng Fei1,2, Vladimir M. Shalaev1,2, Alexandra Boltasseva1,3, Honglin Yu1,2, Vladimir M. Shalaev1,3; 1Brick Nanotechnology Center, Purdue Univ., USA; 2Key Lab of Optoelectronic Technology and Systems of Education Ministry of China, Chongqing Univ., China; 3School of Electrical and Computer Engineering, Purdue Univ., USA. We present a silica coated aluminum metamirror with extremely sharp, high-contrast, and polarization-independent optical rotation of infrared light. Excitation of localized surface plasmons maps discrete polarizations into distinct optical rotation angles, resilient to noise, and can reliably compensate for spectral efficiency variations.

FTh4M.3 • 17:00
Broadband Hot Electron Creation in Nanoscale Gap Plasmons, Gary Wiederrecht1,2, Argonne National Lab, USA. We report experimental and theoretical results on the use of broadband plasmonic nanochip metasurfaces to produce large concentrations of hot electrons. Transient absorption spectroscopy enables the detection of hot electron populations and their decay pathways.

FTh4M.4 • 17:30
Ultrafast Tunable Metasurface with Transparent Conducting Oxide Antenna Array, Soham Saha1,2,3,4, Awek Dutta1,2,3,4, Clayton DeVault1,2,3,4, Vladimir M. Shalaev1,2,3,4, Alexandra Boltasseva1,2,3,4; 1Brick Nanotechnology Center, USA; 2Purdue Univ., USA. We demonstrate large reflection and transmission modulation and femtosecond relaxation times in undoped zinc oxide films. Using these experimental results, we designed an optically tunable, terahertz-speed metasurface with a 1.4 dB extinction ratio at 1.3 µm.

FTh4N.1 • 16:30
Deep Learning Reconstruction of Ultrashort Pulses, Tom Zahavy1,2, Alexander Kildishev1,3, Max Born Inst., Germany. We demonstrate pulse retrieval from dispersion-scan and FROG traces using a genetic algorithm. The algorithm is extremely robust even for complex pulse shapes, resilient to noise, and can reliably compensate for spectral efficiency variations.

FTh4N.2 • 16:45
Differential Evolution for Robust Phase Retrieval in Ultrafast Pulse Characterization, Gunter Steinmeyer1, Max Born Inst., Germany. We demonstrate pulse retrieval from dispersion-scan and FROG traces using a genetic algorithm. The algorithm is extremely robust even for complex pulse shapes, resilient to noise, and can reliably compensate for spectral efficiency variations.

FTh4N.3 • 17:00
Ultra-short Optical Pulses for Coherent Ultra-wide Band RF Signal Sampling, Daniel Onori1, Filippo Scotti1, Giovanni Serafini1, Paolo Ghezzi1, Antonella Boggia1,2, CNIT, Italy; 2Sant’Anna School of Advanced Studies, Italy. The importance of ultra-short and stable optical pulses for ultra-wideband RF signal sampling is demonstrated through the implementation and comparison of different solutions of RF scanning receiver based on photonics.

FTh4N.4 • 17:30
All-linear Phase Retrieval of a Single-soliton Kerr Comb, Ziyou Kong1,2, Chengting Bao1,2, Oscar Sandoval1,2, Bohao Liu1,2, Minghao Qi1, Andrew M. Weiner1,2, Purdue Univ., USA. We demonstrate all-linear phase retrieval of a single-soliton Kerr comb via dual-comb electric field cross-correlation (EFXC). This approach greatly lowers the power needed for ultrafast waveform reconstruction of optical frequency combs.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

**Marriott Salon VI**

**Marriott Willow Glen**

**CLEO: Applications & Technology**

**ATh4P • Environmental Greenhouse Gas Sensing**

*Presider: Mark Zondlo; Princeton Univ., USA*

- **ATh4P.1 • 16:30** Invited
  - **Bringing Laser Spectroscopy to the Deep Sea, Anna P. Michal**
  - *WHOI, USA.* By coupling laser-based techniques to gas extraction techniques, gases critical for understanding ocean processes such as methane and carbon dioxide can be measured. Recent advances in oceanographic chemical sensing using laser-based techniques will be presented.

- **ATh4P.2 • 17:00**
  - **Compact Amplitude-Modulated, Phase-Analyzed Spectroscopy (CAMPAS) for Gas Analysis, David Bomse**
  - *Mesa Photonics, LLC, USA.* Optical absorption in gases within an integrating sphere is determined by phase shifts of amplitude modulated laser light. This technique could achieve performance advantages similar to those of FM radio over AM radio.

- **ATh4P.3 • 17:15**
  - **Quantifying methane emissions among simulated gas wells with a dual-frequency comb spectrometer, Sean C. Coburn**
  - *Caroline Alden; Robert Wright; Esther Baumann; Kevin Cossel; Nathan R. Newbury; Kuldeep Prasad; Ian R. Coddington; Gregory B. Reiker; Univ. of Colorado at Boulder, USA; CIRES, USA; NIST, USA; NIST, USA.* We present the results of a single-blind field test assessing the capability of a dual-frequency comb spectrometer coupled with atmospheric inversion methods for detecting and quantifying methane emissions from natural gas production infrastructure.

- **ATh4P.4 • 17:30** Invited
  - **Recent Advancement in Cavity Ringdown Spectroscopy in Measuring Effects of Natural Gas Industry, Tracy Tsai**
  - *Picarro, USA.* Natural gas is a growing energy source, but to minimize environmental impact and safety risks, the natural gas infrastructure must be monitored for methane emissions. I will present field results collected with a cavity ring-down based spectrometer.

**ATh4Q • A&T Topical Review on Scientific and Commercial Progress in Semiconductor Laser Technology I**

*Presider: Bojan Resan; Univ. of Applied Sciences FHNW, Switzerland*

- **ATh4Q.1 • 16:30** Invited
  - **Progress in VECELs: from Gain Mirror Technology to New Applications, Mircea D. Guina**
  - *Tampere Univ. of Technology, Finland; VEXLUM Ltd, Finland.* We review recent progress in VECEL technology in connection to new milestones that continue to pave the way for practical use in emerging applications. We focus on wavelength extension and applications in quantum technology, dermatology, or spectroscopy.

- **ATh4Q.2 • 17:00** Invited
  - **Commercial Semiconductor Disk Lasers, Nils Hempler**
  - *David Paboeuf, Tiago Ortega, Robin Head, Walter Lubeigt; M Squared Lasers, UK.* This paper will present the development of commercial semiconductor disk lasers undertaken at M Squared Lasers mainly for microscopy and quantum applications.

- **ATh4Q.3 • 17:30** Invited
  - **First demonstration of O-band grating-assisted microcylinder surface-emitting laser, Xiang Ma**
  - *Quanan Chen, Wei Sun, Ye Liu, Gongyan Zhao, Gonghui Liu, Qiaoyin Lu, Weihua Guo; Wuhan National Lab for Optoelectronics, Huazhong Univ. of S & T, China.* Grating-assisted microcylinder surface-emitting laser (GAMSEL) in the O-band was demonstrated. Continuous-wave working with side-mode suppression-ratio >40dB has been realized and the output beam is radially polarized.
STh4A • Waveguide Structures—Continued

STh4A.6 • 17:45
Large Bandwidth Waveguide Spectral Splitters Using Higher-Order Mode Evolution, Jean-Etienne Tremblay1, Marcin Malinowski1, Guillermo Camacho-Gonzalez2, Susan Fathpour3, Ming C. Wu1; ’Univ. of California, Berkeley, USA; ’CREOL, Univ. of Central Florida, USA. Broadband spectral filters separating 1µm/Qµm wavelengths of octave-spanning frequency combs have been realized using mode evolution to high-order modes. The splitters are fabricated in chalcogenide glass (Ge23Sb7S70) and can be readily integrated with supercontinuum sources.

STh4A.7 • 18:00
Ultra-Broadband and Compact Asymmetrical Beam Splitter Enabled by Angled Sub-Wavelength Grating MMI, Eslam Ellki1, Yannick D’Mello1, Yun Li1, David Patel1, David V. Plant1; ’McGill Univ., Canada. We present an ultra-broadband and compact asymmetrical beam splitter using sub-wavelength grating based multi-mode interference coupler. We experimentally demonstrate splitting ratios from 50:50 to 90:10 over 100 nm bandwidth using a 2µm x 3µm design.

STh4A.8 • 18:15
Arbitrary Ratio, Wavelength-insensitive 2x2 MMI Coupler in SOI with Enhanced Fabrication Tolerance, Jin Zhang1, Liangshun Han1, Bilip Kuo1, Stojan Radic1; ’Univ. of California, San Diego, USA. We present a new arbitrary-ratio 2x2 MMI coupler design. The design demonstrated 2.6 times lower coupling ratio variation across extended C-band, and 2.2 times ratio error reduction when subjected to ±10 nm thickness and width deviations.

STh4B • On-chip and Offchip Coupling Schemes—Continued

STh4B.6 • 17:45
Efficient coupling of ultra-high Q crystalline microresonators to integrated photonic waveguides, Miles H. Anderson1, Nikolay Pavlov1, John Jost1, Gregory Lihachev3, Junqiu Liu1, Tiago Morais1, Michael Zervas1; ’Columbia Univ., USA. We present a new integrated photonic chip solution for coupling light to ultra-high quality factor (Q) crystalline microresonators, which is in the form of an index-matching suspended silica beam-waveguide. The scheme enables coupled Q-factors exceeding 100 million near critical coupling.

STh4B.7 • 18:00
3D Photonic Structure for Plug-and-Play Fiber to Waveguide Coupling, Oscar Jimenez1, Mohammad Amin Tadayon1, You-Chia Chang1, Michal Lipson1; ’Columbia Univ., USA. We show a 3D photonic structure for passive high alignment tolerance fiber to waveguide coupling. We measured a coupling efficiency of 2.5dB±0.4dB from fiber to a polymeric waveguide for fiber misalignments within a 17µm diameter.

STh4B.8 • 18:15
Automated Assembly of Duplex Fiber Connectors to Photonic Chips in Standard Microelectronic Tools, Ted Lichoulas1, Eddie Kimbrell1, Alexander Janta-Polczynski1, Elaine Cyp1, Paul Butler1, Nicolas Boyer2, Tymon Barwicz3; ’AFL Telecommunications, USA; ’IBM, Canada; ’IBM, USA. We demonstrate self-aligned assembly of LC-terminated fibers to chips in a manner compatible with standard microelectronics assembly lines. We show -1.5dB peak transmission to chip with 0.9dB penalty over a 100nm bandwidth and all polarization.

18:30–20:00 Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, Room 230A

18:30–20:00 Dinner Break (on your own)

20:00–22:00 Postdeadline Paper Sessions, Location TBD
JTh4D • Symposium on Advances in Integrated Microwave Photonics II—Continued

JTh4D.4 • 17:45
Ultra-Compact Optical True Time Delay Lines Featuring Fishbone-Like One-Dimensional Photonic Crystal Waveguide, Chi-Jui Chung1, Xiaochuan Xu1, Gencheng Wang2, Zeyu Pan1, Ray Chen1,2; 1Dept. of Electrical and Computer Engineering, Univ. of Texas at Austin, USA; 2Omega Optics, Inc, USA; 3College of Information Science and Electronic Engineering and the Cyrus Tang Center for Sensor Materials and Applications, Zhejiang Univ., China. An ultra-compact on-chip optical true-time-delay line features the slow light enhanced fishbone-like one-dimensional photonic crystal waveguide is proposed. A delay time of 65 ps/mm which corresponds to group index of 19.47 is observed experimentally.

JTh4D.5 • 18:00
Plasmonics for RF Photonics, Juerg Leuthold1, Yannick Sa-Plasmonics for RF Photonics, Juerg Leuthold1, Yannick Sa-

FTh4E • Multimode Nonlinear Fiber Optics—Continued

FTh4E.5 • 17:45
Optical Trapping and Manipulation of Multiple Microparticles Using SDM Fibers, Joel A. Hernández-García1, Amado M. Velazquez-Benitez1, Yarin Guerra-Santillán2, Raul Caullillo-Virueza3, Jose Enrique Antonio-Lopez2, Rodrigo Amezcua-Correa4, Juan-Hernandez-Cordero2; 1CCADET-UNAM, Mexico; 2Facultad de Ciencias, UNAM, Mexico; 3CREOL, UCF, USA; 4IM, UNAM, Mexico. We demonstrate optical trapping and dynamic manipulation of microparticles using multi-core and few-mode fibers. Tuning of the input state of polarization of the trapping beam allows for particle rotation and adjustable trapping distances.

FTh4E.6 • 18:00
Analysis of Parametric Instabilities in Parabolic Multimode Fibers under High Intensity Conditions, Helena L. Lopez Aviles1, Fan Wu1, Zeinab Sanjabi Eznaveh1, Mohammad Amin Eftekhari1, Frank W. Wise2, 1Univ. of Washington, USA; 2Univ. of Central Florida, USA. We systematically study geometric parametric instabilities in parabolic multimode fibers. We show, both analytically and experimentally, that global dispersion processes and self-focusing effects can substantially affect the spectral positions and widths of the generated sidebands.

FTh4E.7 • 18:15
Mode-Resolved Control and Measurement of Nonlinear Pulse Propagation in Multimode Fibers, Zimu Zhu1, Logan Wright1, Joel Carpenter2, Dan Nolan1, Ming-Jun Li1, Demetrios N. Christodoulides1, Frank W. Wise2; 1Cornell Univ., USA; 2The Univ. of Queensland, Australia. We demonstrate use of spatial light modulators to control modal excitation and make mode-resolved measurements of nonlinear pulse propagation in multimode fiber; and present a representative experiment wherein we observe discrete Raman beam clean-up.

FTh4F.5 • 17:45
Femtosecond mid-IR difference-frequency generation in BaGa3Ge5Se12 from a 40 MHz optical parametric oscillator pumped at 1035 nm, Gero Stibenz1, Marcus Beutler2, Ingo Rimke3, Valeriy Badikov3, Dmitrii Badikov3, Valentin Petrov1, ‘Max Born Inst., Germany; 2APE, Germany; 3Kuban State Univ., Russia. Mixing the signal and idler pulses near 2 µm from a femtosecond synchronously-pumped optical parametric oscillator in a BaGa3Ge5Se12 crystal we generate mid-IR pulses tunable up to 10 µm with 45% maximum internal quantum efficiency.

FTh4F.6 • 18:00
Pulsed Optical Parametric Generation and Oscillation in Orientation-Patterned Gallium Phosphide, Han Yu1,2, Chaitanya Kumar Suddappalli2, Junxiong Wei1, Peter G. Schunemann1, Majid Ebrahim-Zadeh1,4; 1ICFO-Institut de Ciencies Fotoniques, Spain; 2Radiantis, Spain; 3BAE Systems, Incorporated, USA; 4Instituto Catalán de Recerca i Estudis Avancats (ICREA), Spain. We report a Nd:YAG-laser-pumped pulsed OPG/OPO based on OPO-GaP. The OPG and singly-resonant OPO spanning 2.8 µm-3.1 µm provide up to ~2 mW and ~20 mW idler power, respectively. Crystal thermal effects are also investigated.

FTh4F.7 • 18:15
Critically Phase-Matched Deep-Infrared Femtosecond Optical Parametric Oscillator Based on CdSiP2, Callum F. O’Donnell1,2, Chaitanya Kumar Suddappalli2, Kevin Zawislak2, Peter G. Schunemann1, Majid Ebrahim-Zadeh1,4; 1ICFO-Institut de Ciencies Fotoniques, Spain; 2BAE Systems, USA. We report a femtosecond optical parametric oscillator across 6654–8329 nm based on critically phase-matched CdSiP2. Directly pumping with a Ti:sapphire laser, we generate 19 mW of average power in ~300 fs pulses at 80 kHz.

18:30–20:00 Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, Room 230A

18:30–20:00 Dinner Break (on your own)

20:00–22:00 Postdeadline Paper Sessions, Location TBD
FTh4G.6 • 18:00
Generation of Schrodinger’s cat state in an optical double sideband mode, Takahiro Serikawa1, Jun-ichi Yoshikawa1, Hidehiro Yonezawa2, Timothy Ralph3, Elanor Huntington4; 1Univ. of Tokyo, Japan, 2The Univ. of New South Wales, Australia; 3Univ. of Queensland, Australia, 4Australian National Univ., Australia. An optical Schrodinger’s cat state is generated in 500.6MHz double sideband mode of continuous wave light. We used phase modulation to selectively subtract a photon from sideband. The reconstructed Wigner function exhibits a significant negativity of -0.088 without any correction.

FTh4G.7 • 18:15
Amplifying Schrödinger cat state with an optical parametric amplifier, Meihong Wang1, Zhongzhong Qin1, Miao Zhang1, Li Zeng1, Xiaolong Su1, Changde Xie1, Kunrui Peng1; 1Shanxi Univ., China. We experimentally demonstrate the deterministic amplification of an optical Schrödinger cat state by an optical parametric amplifier. The results provide an efficient way to amplify the amplitude of an optical cat state.

FTh4H.5 • 18:00
Circulary Polarized Light Detection Based on Efficient Chip-Integrated Metasurface, Ali Basiri1,2, Xiaohui Chen1,2, Pouya Amrollahi3, Jiafan Bai1,2, Chao Wang1,2, Yu Yao1,2; 1School of Electrical, Computer and Energy Engineering, Arizona State Univ., USA, 2School for Engineering of Matter, Transport & Energy, Arizona State Univ., USA, 3Biodesign Center for Molecular Design & Biomimetics, Arizona State Univ., USA. We report on-chip detection of circularly polarized light at telecommunication wavelengths. Preliminary experimental results show extinction ratios close to 10 dB and efficiencies up to 90% at designed wavelengths.

FTh4H.6 • 18:15
Extraordinary Properties of Epsilon-Near-Zero and Low-Index Chalcogenide Metamaterials, Davide Piccinotti1, Behrad Gholipour1, Jin Yao1, Kevin F. MacDonald1, Brian E. Hayden1, Nikolay I. Zheludev1,2; 1Univ. of Southampton, UK, 2Nanyang Technological Univ., Singapore. ‘Laminar flow’ transmission, suppression of plasmonic powerflow vortices, and absorption decreasing with increasing Joule losses can be observed in metamaterials combining plasmonic nanostructures with chalcogenide inclusions exhibiting epsilon-near-zero and sub-unitary refractive index behaviors.
FTh4J • Random and Alternative Materials Metasurfaces—Continued

FTh4J.6 • 17:45
Mid-infrared Magnetic Mirror Based on a Hybrid Metal/Dielectric Metasurface, Ming Ye1, Shiqiang Li1, Yang Gao4, Vivek R. Shrestha1, Kenneth B. Crosier1;1'The Univ. of Melbourne, Australia. We propose a hybrid metal/dielectric metasurface that functions as a mid-infrared magnetic mirror. It consists of amorphous silicon cuboids on gold. The physical mechanism is explained by image theory. Measured reflection spectra agree with simulations.

FTh4J.7 • 18:00
Towards Random Metasurface based Devices, Mathieu Dupre1, Junhee Park1, Liyi Hsu1, Abdoulaye Ndao1, Boubacar Kante1;1UCSD, USA. Using full wave simulations and a transmission matrix approach, we design and then realize random metasurface lenses with anisotropic nanorods, and show that we can obtain a diffraction limited focal spot for all polarizations.

FTh4J.8 • 18:15
Disordered Geometric Phase: Photonic Transition from Spin Hall to Random Rashba Effect, Elhanan Maguid1, Michael Yannai1, Arkady Faerman1, Igor Yulevich1, Vladimir Kleiner1, Erez. Hasman1;1Technion-Israel Inst. of Technology, Israel. We report on photonic spin-symmetry breaking and unexpected optical transport phenomena arising from disordered geometric phase structures. Weak disorder induces a photonic spin Hall effect, whereas strong disorder leads to a random Rashba effect.

STh4K • Long Wavelength Fiber Sources—Continued

STh4K.5 • 17:45
Generation of sub-100 fs pulses tunable from 1.8 to 2.0 μm from an All-fiber, All-PM Source Pumped at 1560 nm, Grzegorz J. Sabo1, Tadeusz Martynkien1, Karol Tarnowski1, Pawel Mergo1, Janoslaw Sutor1;1Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland; ‘Manfa Cune-Skłodowska Univ., Poland; ‘Faculty of Fundamental Problems of Technology, Wrocław Univ. of Science and Technology, Poland. An all-fiber, all-PM source of widely tunable (1800 – 2000 nm) ultrashort pulses seeded by an Er-doped fiber laser is presented. The system delivers sub-100 fs pulses with 400 mW average power and >8 nJ energy.

STh4K.6 • 18:00
Dual Comb Spectroscopy with a Free-Running Bi-Directional Mode-Locked Thulium Fiber Laser, Joshua Olson1, Yi-Hsin Ou1, Ali Azarm1, Khanh Q. Kieu1;1Univ. of Arizona, USA. We present a Thulium fiber laser mode-locked in bi-directionally with a carbon nanotube saturable absorber and demonstrate single-shot dual-comb spectroscopy of H2O in the short-wave infrared (SWIR) with the laser.

STh4K.7 • 18:15
15 GHz actively mode-locked fiber laser at 2 micron, Jian-Xiong Qin1, Ruhong Dai1, YeFei Meng1, Wenbin Gao1, Yongbing Xu1, Yao Li1, Shining Zhu1, Frank (Fengqiu) Wang1;1Nanjing Univ., China. We demonstrate a 15-GHz actively-mode-locked thulium fiber laser. The repetition-rate is improved by one order of magnitude compared with existing results and such a source can be used for 2 µm optical data-communication and processing.

Emerging Trends in Nonlinear Optics – A Review of CLEO: 2018, Room 230A

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
FTh4M.5 • 17:45
Magnetic Plasmon Hybridization in Vertically Stacked Double-gap Nanocavities, Seyed Ali Safabadi Tah1, Wei Zhou1; Virginia Tech, USA. In vertically stacked double-gap nanocavities, the strong magnetic-optical interaction between magnetic plasmon modes in individual gap nanocavities can lead to new hybridized bonding and anti-bonding modes with a tunable splitting energy.

FTh4M.6 • 18:00
Perovskite Nanostructures and Metasurfaces Enhanced by Mie Resonances, Sergey Makarov1, Ekaterina Tiguntseva1, Anvar Zahidov1,2; ITMO Univ., Russia; 1ITMO Univ., Russia; 2Univ. of Texas at Dallas, USA. We study resonant properties of nanoantennas and nanostructured metasurfaces made of halide perovskites and demonstrate experimentally the photoluminescence enhancement near the dipolar and multipolar Mie resonances for both visible and near-infrared frequency ranges.

FTh4M.7 • 18:15
Bifunctional Gap-Plasmon Metasurfaces for Visible Light, Fei Ding1, Rucha Deshpande1, Sergey I. Bozhevolnyi1; 1Univ. of Southern Denmark, Denmark. We design, fabricate and experimentally demonstrate bifunctional gap-plasmon metasurfaces for visible light, allowing simultaneous polarization-controlled unidirectional surface plasmon polariton (SPP) excitation and beam steering at normal incidence.

STh4N.5 • 17:45
Cross-spectrum approach for absolute timing jitter measurement of mode-locked lasers, Alexis Casanov1,2; Benoît Trophème1; Antoine Courjaud1; Giorgio Santarelli1; 1Amplitude Systems, France; 2Université de Bordeaux, France. A combination of cross-spectral analysis and balanced optical cross-correlation techniques is proposed to access the absolute timing jitter of one laser mode-locked solid-state laser. This method gives a record jitter detection floor.

STh4N.6 • 18:00
Waveform characterization of optical pulses by plasma luminescence of gas, Nariyuki Saito1, Nobuhisa Ishii1, Teruto Kanai1, Jiro Itatani1; 1Univ. of Tokyo, Japan. We propose and demonstrate a new all-optical method to characterize an optical waveform using plasma luminescence of gas. Our technique is based on simple physics, and applicable to compact pulse diagnostics and petahertz time-domain spectroscopy.

STh4N.7 • 18:15
Intrapulse Coherence for Gauging the Quality of Passive Carrier-Envelope Phase Stabilization, Gunter Steinmeyer1; Max Born Inst., Germany. The intrapulse coherence is introduced as a measure for judging a fixed phase relation between different spectral components within a laser pulse. This new criterion plays an important role for passive CEP stabilization of OPA systems.

ATH4O.6 • 17:45
Identification of white powder samples using broadband coherent light in the molecular fingerprint region, Luke Maidment1; Richard A. McCracken1; Ougahan Kara1; Peter G. Schunemann1; Derryck T. Reid1; 1Heriot-Watt Univ., UK; 2BAE Systems, USA. Stand-off Fourier-transform spectroscopy of eleven white powder samples illuminated by a broadband femtosecond source was used to construct a library of spectra, which are demonstrated to enable automated chemical detection using a simple correlation algorithm.

ATH4O.7 • 18:00
Edible Oils Sensing Setup Based on a Core-Offset Mach-Zehnder Interferometer With Single Mode Fiber, Ledy J. Cuchimaque Lugo1, Rafael Castro-López2, Maria E. Sosa Morales3, Juan M. Sierra Hernandez1; 1Departamento de Ingeniería Electrónica, División de Ingenierías, Campus Irapuato-Salamanca, Universidad de Guanajuato, Comunidad de Palo Blanco, Salamanca, Gto., C.P. 36885, México., Mexico; 2Departamento de Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, Carretera Irapuato-Silo km 9, Irapuato, Gto. 36500 México., Mexico. Peroxides are compounds related to rancidity in oils. A peroxides index sensing setup based on a Mach-Zehnder interferometer is presented. The output power spectral shift occurs from 1490 to 1580 [nm] with sensitivity of 0.88 [nm/meq/kg].

ATH4O.8 • 18:15
Alpha Radiation Induced Luminescence in Solar Blind Spectral Region, Thomas H. Kerst1,2; Juha Toivonen1; 1Tamperé Univ. of Technology, Finland; 2Helsinki Inst. of Physics, Finland. Intense luminescence in the solar blind spectral region is produced by modifying the gas atmosphere around an alpha emitter. This enables standoff detection of alpha radiation under daylight conditions.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
### SF1A • Si Photonics

**President: Qiang Lin; Univ. of Rochester, USA**

**SF1A.1 • 08:00**
High-resolution on-chip digital Fourier transform spectroscopy, Derek Kita, Brando Miranda, David Favela, David Bono, Jérôme Michon, Hongtao Lin, Tian Gui, Juejun Hu; IMT, USA. We experimentally demonstrate a high-resolution, on-chip digital Fourier transform (dFT) spectrometer using a reconfigurable Mach-Zehnder interferometer. The dFT architecture claims the multiplex advantage for signal enhancement, with a resolution that scales exponentially with device footprint.

**SF1A.2 • 08:15**
Silicon Linear Optical Logic Gates for Low-Latency Computing, Shota Kita, Kenji Nozaki, Kenta Takata, Akihiko Shinya, 1,2, Kenta Takata, 1,2, Akihiko Shinya 1,2, Masaya Notomi 1; The Univ. of Texas at Austin, USA; 2Univ. of Glasgow, UK. The resolution of optical systems is limited by diffraction. We exploit the spatial properties of correlated photon-pairs to reconstruct a super-resolved image made of bisectant pixel-coordinates, achieving 40% of the theoretical 2D optical resolution enhancement.

**SF1A.3 • 08:30**
Microdisk-Based Full Adders for Optical Computing in Silicon Photonics, Zhaoying Ying, Zheng Wang, Zheng Zhao, Shounak Dhar, David Pan, Richard Sorel, Ray Chen; 1The Univ. of Texas at Austin, USA; 2Univ. of Massachusetts Boston, USA. We experimentally demonstrate a two-bit thermal-optic ripple-carry full adder based on microdisk resonators in silicon photonics with the advantages of large bandwidth, low power consumption, and high scalability, paving the way to future optical computing.

### FF1B • Quantum Enhanced Measurements

**President: Raphael Pooser; Oak Ridge National Lab, USA**

**FF1B.1 • 08:00**
Quantum-enhanced imaging with quantum correlations, Ernes Toninelli, Paul-Antoine Moreau, Adam Mihalyi, Thomas Gregory, Matthew Edgar, Miles Padgett; 1The Univ. of Glasgow, UK. The resolution of optical systems is limited by diffraction. We demonstrate a photons-based particle accelerator is the goal of the "Accelerator on a Chip International Collaboration" (ACHIP). Half way into the program, the current status is discussed.

**FF1B.2 • 08:15**
Imaging incoherent point sources with quantum-inspired measurements, Kent Fisher, Hugo Ferretti, Edwin (Weng-Kun) Tham; Aephraim M. Steinberg 1,2, Thomas J. Kippenberg 1; 1The Univ. of California Irvine, USA; 2Univ. of California Berkeley, USA. We present multidimensional coherent spectroscopic signatures with a nearly diffraction-limited spot size. Encapsulation by boron nitride narrows both the homogeneous and inhomogeneous linewidths of MoSe₂.

**FF1B.3 • 08:30**
Super-Resolution Localization and Readout of Individual Solid State Qubits, Eric A. Bersin, Michael Walsh, Sara L. Mouradian, Matthew Trusheim, Tim Schröder, DirkEnglund; 1MIT, USA; 2Niels Bohr Inst., Denmark. We demonstrate super-resolution imaging and readout of solid state defect centers. Multiple nitrogen vacancy centers within 130 nm are resolved. Simultaneous control sequences are performed to demonstrate protection of nearby NV states during readout.

### JF1C • Symposium on Lasers in Accelerator Science and Technology I

**President: Sergio Carbajo; Stanford University and SLAC National Accelerator Laboratory, US**

**JF1C.1 • 08:00**
Invited Photonics-based Laser-driven Particle Acceleration: from proof-of-concept structures to the accelerator on a chip, Peter Hommelhoff, 1Physics Dept., Friedrich Alexander Univ. Erlangen-Nurnberg, Germany. Demonstrating a photons-based particle accelerator is the goal of the "Accelerator on a Chip International Collaboration" (ACHIP). Halway into the program, the current status is discussed.

**JF1C.2 • 08:30**
Invited X-ray laser based on Inverse Compton Scattering, William Graves, 1Arizona State Univ., USA. A compact XFEL based on inverse Compton scattering is described. A novel method allows coherent control of the phase, bandwidth, and pulse length of the x-ray pulses, and enables multi-color experiments with precisely tunable femtosecond delays.

**JF1C.3 • 08:30**
Intrinsic Homogeneous Linewidth of Trions in Monolayer MoSe₂, Michael Titze, Bo Li,1 Pulikel Ajayan2,3, Hebin Li 1,2 Monolayer Revealed using Multi-dimensional Coherent Spectroscopy, Eric Martin, Jason Horng, Hanna G. Ruth, Eunice Paik, Michael-Herr Wentzel, Hui Deng, Steven T. Cundiff, 1Dept. of Physics, Univ. of Michigan, USA. We use a collinear multidimensional coherent spectroscopic technique to measure van der Waals structures with a nearly diffraction-limited spot size. Encapsulation by boron nitride narrows both the homogeneous and inhomogeneous linewidths of MoSe₂.
Silicon-based deep sub-wavelength slit for ultra-broadband THz coherent detection, Alessandro Tommasino 1,2, Riccardo Piccol 1, Yo-an Jestin 1, Alessandro Busacca 1, Sebastien Delprat 1, Mohamed Chaar 3, Marco Peccianti 4, Matteo Clerici 5, Luca Razzari 1, Roberto Morandotti 1,2, 3, INRS-EMT, Canada; 4, DEIM, Univ. of Palermo, Italy; 5, School of Engineering, Univ. of Glasgow, UK; 6, National Research Univ. of Information Technologies, Russia. We report on the characterization of a new type of CMOS-compatible device for terahertz solid-state biased coherent detection, which relies on a 1-µm-wide metallic slit embedded in a thin film of PECVD-grown silicon nitride.

Observation of Strong THz Fields from Mid-Infrared Two-Color Laser Filaments, Anastasios D. Koulouklidis 1,2, Claudia Gollner 3, Matteo Clerici 4, Luca Razzari 1, Roberto Morandotti 1,2, 3, INRS-EMT, Canada; 4, DEIM, Univ. of Palermo, Italy; 5, School of Engineering, Univ. of Glasgow, UK; 6, National Research Univ. of Information Technologies, Russia. We report on the characterization of a new type of CMOS-compatible device for terahertz solid-state biased coherent detection, which relies on a 1-µm-wide metallic slit embedded in a thin film of PECVD-grown silicon nitride.

Towards Millijoule Narrowband Terahertz Laser Pulses Using the Chip-and-Delay Technique, Spencer W. Jolly 1, Frederike Ahl 2, Nicholas H. Matlis 1, Vincent Leroux 1, Timo Eichner 1, Koustuban Ravi 5, Hideki Ishizuki 6, A Photonic Crystal Slab Laplace Differentiator, Cheng Guo 1, Meng Xiao 2, Marc-Christ Kinkov 1, Yu Shi 1, Shanhui Fan 1, Stanford Univ., USA. We propose an implementation of a Laplace differentiator based on a photonic crystal slab that operates at transmission mode. Such a device may facilitate nanophotonics-based optical analog computing for image processing. A Photonic Crystal Slab Laplace Differentiator, Cheng Guo 1, Meng Xiao 2, Marc-Christ Kinkov 1, Yu Shi 1, Shanhui Fan 1, Stanford Univ., USA. We propose an implementation of a Laplace differentiator based on a photonic crystal slab that operates at transmission mode. Such a device may facilitate nanophotonics-based optical analog computing for image processing.
SF1I.1 • 08:00
Toward Hybrid Organic-Inorganic Perovskite Diode Lasers, Noel C. Giebink1,2; 1Pennsylvania State Univ., USA. Hybrid organic-inorganic perovskites represent a promising, wavelength-tunable materials platform for a future diode laser. This talk will present progress toward this goal, including continuous-wave lasing and high-brightness perovskite light emitting diodes.

SF1I.2 • 08:15
MEMS-tunable dielectric metasurface lens, Ehsan Arabi1, Amir Arabi2, Seyedeh Mahsa Kamali3, Yu Hori2, MohammadSadegh Faraji-Dana4, Andrea Faraon1; 1California Inst. of Technology, USA; 2Electrical Engineering, Univ. of Massachusetts Amherst, USA. We report a micro-electromechanically tunable metasurface doublet composed of a moving metasurface on a membrane and a stationary one. The doublet provides more than 180 diopters change in the optical power.

SF1I.3 • 08:30
Lasing from high-quality lead halide perovskite single crystal microparticles, Sangyeon Cho1,2; Kyeong-Hoon Park3,4; 1Harvard-MIT Health Sciences and Technology, MIT, USA; 2Welfman Center for Photomedicine, Massachusetts General Hospital and Harvard Medical School, USA. We have synthesized CsPbBr3 and CH3NH3PbBr3 single-crystal microparticles with improved surface quality and obtained whispering-gallery mode lasing from a size of 2 μm. The method can produce high-quality perovskite microlasers in large quantity within minutes.

SF1J.1 • 08:00
Dynamic Dielectric Metasurfaces Incorporating Phase-Change Material, Sajjad Abdollahi-Ramezani1, Hossein Taghinejad2, Yashar Kiarashi Nejad1, Ali Asghar Eftekhar1, Ali. Adibi1; 1Georgia Inst. of Technology, USA. We present a highly-reconfigurable metasurface with unprecedented efficiency for spatial and spectral manipulation of optical wavefronts, leveraging control over the overlapped Mie-dipolar-modes of dielectric nanorings and large refractive index tunability granted by GeSbTe phase-change material.

SF1J.2 • 08:15
MEMS-tunable dielectric metasurface lens, Ehsan Arabi1, Amir Arabi2, Seyedeh Mahsa Kamali3, Yu Hori2, MohammadSadegh Faraji-Dana4, Andrea Faraon1; 1California Inst. of Technology, USA; 2Electrical Engineering, Univ. of Massachusetts Amherst, USA. We report a micro-electromechanically tunable metasurface doublet composed of a moving metasurface on a membrane and a stationary one. The doublet provides more than 180 diopters change in the optical power.

SF1J.3 • 08:30
Continuous Gradient Dielectric Metasurfaces for Non-discrete Spatial Light Manipulation, Masashi Miyata1, Mitsumasa Nakajima1, Toshikazu Hashimoto2; 1NTT Device Technology Labs., Japan. We demonstrate continuous gradient metasurfaces that can form a non-discrete one-dimensional phase pattern on a surface. The capability of our approach for wavefront shaping is demonstrated in efficient and versatile optical multi-beam splitters.

SF1K.1 • 08:00
45W 2 μm Nanosecond Pulse Delivery Using Antiresonant Hollow-core Fiber, Elizabeth M. Lee1,2, Jiaqi Luo1,2, Biao Sun2, Vincent Larry Ramalingam1,2, Xiu Yu1, Qijie Wang1, Fei Yu3, Jonathan C. Knight3; 1School of Electrical & Electronic Engineering, Nanyang Technological Univ., Singapore; 2Precision Measurements Group, Singapore Inst. of Manufacturing Technology, Singapore; 3Centre for Photonics and Photonic Materials, Dept. of Physics, Univ. of Bath, UK. We demonstrated the highest reported transmission of 44.9W average power from a 1900nm 1.2ns source using an antiresonant hollow-core delivery fiber with good output beam quality.

SF1K.2 • 08:15
2-3 μm wavelength-range low-loss inhibited-coupling hollow-core fiber, Martin Maure1,2, Frédéric Delahaye1, Foued Amrani1, Benoit Debord1,2, Frédéric Grémont1,2, Fetah Benabid1,2; 1GPPMM, Xlim, CNRS UMR 7252, Limoges Univ, France; 2GLOphotonics SAS, France. We report on ultra-broad transmission of 44.9W average power from a 1980nm 1.2ns source using an antiresonant hollow-core delivery fiber with good output beam quality.

AF1M.1 • 08:00
Optical Sensing Systems for Industrial and Medical Process Monitoring, Guido Perrone1; 1Politecnico di Torino, Italy. The paper reviews how photonic sensors, and those based on fiber optics in particular, can enable new applications in the framework of the so-called “industry 4.0” and in the biomedical field.

AF1M.2 • 08:30
A Family of Interferometric Fiber Optic Gyroscopes for Miniaturized Satellites, Jing Jin1, Kun Ma2, Cai Wei1, Lingshe Kong2, 1Beihang Univ., China. The compact interferometric fiber optical gyroscope configurations and components, efficient and reliable parameters monitoring and fault diagnosis, performances and in-orbit tests of miniaturized products for space use are presented in this paper.
SF1N.1 • 08:30
Generation of 1 mJ, 85 fs, 2.5 μm Pulses from a Cr3+:ZnSe Chirped Pulse Oscillator, Lam H. Mach1, Xiaoming Ren1, Yanchun Yin1, Yang Wang1, Zenghu Chang1; CREOL and Dept. of Physics, Univ. of Central Florida, USA. We demonstrate the generation of 1 mJ, 85 fs, 2.5 μm pulses with 300 nm of available bandwidth at 1 kHz of repetition rate from a Chirped Pulse Amplifier based on the Cr3+:ZnSe gain medium.

SF1N.2 • 08:15
8.6 MHz Extended Cavity Cr:ZnS Chirped-pulse Oscillator, Nikolai Tolski1,2, Cherrie S. Lee1, Evgeni Sorokin1, Irina Sorokina1,2; ‘Norges Teknisk Naturvitenskapelige Univ, Norway; ‘Atla Lasers AS, Norway; ‘Vienna Univ. of Technology, Austria. We report the first extended cavity Cr:ZnS chirped-pulse oscillator mode-locked by graphene. We demonstrate 415 mW average power at 8.6 MHz repetition rate which results in 48 nJ pulse energy.

SF1N.3 • 08:30
High Energy, Few-Cycle Parametric Source Tunable in the 5-11 μm Window, Driven by an Yb Bulk CPA System, Giedrius M. Ardonovas1,2, Guangyu Fan1, Pavel Malevich1, Tan Li1, Stéphane Petit1, Jean-Christophe Delagnes1, Eric Cormier1, Giedrius Andriukaitis1, Edgar Sakis1, Andrius Baltuska1, Tadas Balciunas1; ‘CELI A, France; ‘Vienna Univ. of Technology, Austria; ‘DSO National Labs, Singapore. We demonstrate an efficient difference frequency generation in the 5-11 μm spectral range. A KTA-AOGS based parametric source is driven by 14 mJ Yb:CPA and provides 150 μJ pulses with up to 3 μm bandwidth.

FF1P.1 • 08:00
Invited
Femtosecond Response of Atoms and Molecules to Ultra-Intense X-rays, Rebecca Boll1, ‘European XFEL, Germany. The interaction of heavy atoms and small molecules with very intense soft and hard X-ray FEL pulses is discussed, and comprehensive results from several recent experiments at the LCLS are presented.

FF1P.2 • 08:30
Attosecond Transient Absorption and Four-Wave Mixing with Tunable IR Pulses, Nathan Hakerna1, Jens E. Bækhøj1, Kenneth J. Schafer2, Mette B. Gaarde2, Arvinder S. Sandhu1, ‘Univ. of Arizona, USA; ‘Louisiana State Univ., USA. We extend the technique of attosecond transient absorption spectroscopy by incorporating tunable IR pulses from an OPA. This technique is used to control Autler-Townes splitting and drive XUV four-wave mixing processes in Helium.

AF1Q.1 • 08:00
Invited
New Platform for High Power IR and Visible Diode Laser Modules: Towards Yellow Wavelengths., Peter Skovgaard1, Danny Noordegraaf1, Mathias Christensen1,2, Mariafemundila Silvia Suarez1, Thomas Buss1, Peter E. Andersen1, Ole B. Jensen1,2; Norlase ApS, Denmark; ‘Fotonik, DTU, Denmark. A new platform of Watt-class, visible lasers is presented. Enabled by tapered diodes and highly efficient frequency conversion, visible laser modules are realized. Such lasers are inherently robust and can be made in unusual wavelengths, such as 577 nm.

AF1Q.2 • 08:30
A Widely-Tunable High-SMSR Narrow-Line-width Laser Heterogeneously Integrated on Silicon, Minh Tran1, Tin Komljenovic1, Duanni Huang1, Linjun Liang1, MJ Kennedy1, John E. Bowers1, ‘Univ. of California Santa Barbara, USA. A heterogeneously-integrated widely-tunable semiconductor laser utilizing unbalanced MZI filter assisted Vernier ring resonators is demonstrated. A wavelength tuning range of 55 nm, SMSR greater than 50 dB and spectral linewidth of 50-85 kHz over this range was achieved.
SF1A.4 • 08:45
128x128 Silicon Photonic MEMS Switch with Scalable Row/Column Addressing, Kyungmok Kwon1, Tae Joon Seok2, Johannes Hennekson1, Jianheng Luo1, Lane Ochiokubo1, John Jacobs1, Richard Muller1, Ming C. Wu1, UC Berkeley, USA; 2Gwangju Inst. of Science and Technology, South Korea; 1TSC Semi-conductors, USA. 128x128 silicon photonic switch with 16,384 MEMS-actuated switching elements and row/column addressing scheme have been successfully integrated on a 16x17mm2 chip. The maximum (minimum) on-chip loss is 22.7 dB (4.8 dB).

SF1A.5 • 09:00
Invited
Monolithically Integrated Photonics with Silicon Nanoelectronics in Advanced Bulk CMOS Process Nodes for Next-Generation Systems-on-Chip, Milos Popovic1, Fabio Pavanello1, Amir H. Atabaki1, Sajjad Moazeni2, Hayk Gevorgyan3, Jalena Notaros4,5, Luca Alloatti6, Mark T. Wade7, Chen Sun1, Seth Kruger1, Kenaith Al Qubaisi1, Inbert Warg1, Bohan Zhang1, Anatal Khilo1, Christopher Baiocco1, Vladimir Stojarovic1, Rajeev Jaggia Ram2, Boston Univ., USA; 2MIT, USA; 3Univ. of California Berkeley, USA; 4Univ. of Colorado Boulder, USA; 5SUNY Polytechnic inst., USA. We demonstrate microring-based, 10Gbps single-chip electronic-photonic transceivers for dense WDM links that are monolithically integrated in a new 65nm bulk-CMOS microelectronics-derivative process on 300mm wafers. The polysilicon platform includes waveguides/resonators, modulators, and sensitive avalanche photodetectors.

SF1A.6 • 09:15
Quantum Measurements in weak coupling regime: from Sequential weak values to Protective measurements, Marco Genovese1, Fabrizio Piacentini1, Alessio Avella1, Enrico Rebulpello1, Salvatore Virzi1, Ivo Degiovanni1, Marco Gramenga1, Giorgio Brida2, INRIM, Italy Quantum measurements in weak coupling regime represent a new interesting paradigm with significant applications both conceptual and practical. Here we present several experimental achievements exploiting weak values, and the first realization of protective measurements.

FF1B • Quantum Enhanced Measurements—Continued
We present a robust reconstruction algorithm for isolated attosecond pulses, which exploits the phase-dependent energy modulation of a photoelectron ionized in the presence of a circularly polarized laser field.

FF1C • Symposium on Lasers and Technology I—Continued
SF1A.4 • 08:45
Super-Resolution Quantum Imaging at the Heisenberg Limit, Manuel Unternehm1, Bänz Bessire1, Leonardo Gasparini2, Matteo Pereroni2, André Stefanov2, IAP, Univ. of Bern, Switzerland; 2Fondazione Bruno Kessler, FBK, Italy. The theory of optical centroid measurement, having shown N-fold spatial resolution using entangled N-photon states, is formulated in the framework of an imaging formalism. An exemplary experiment using photon pairs demonstrates double resolution and uses a newly developed integrated detector array.

FF1D • Ultrafast Spectroscopy of 2D Materials—Continued
We study the transient optical response of monolayer MoS2 with an unprecedented temporal resolution. From the build-up dynamics of the transient signal around A/B excitonic peaks we directly extract the characteristic time-scale for excitation formation process, which ranges between 15 and 35 fs.

FF1D.5 • 09:00
Direct time-domain observation of ultrafast excitation formation in monolayer MoS2, Chiara Trovatiello1, Stefano Dal Corso1, Giulio Cerullo1, Kaysun Yao2, Nick Borys1, Francesco Scotognella3, Ilka Kneisel1, P. James Schuck2. Dipartimento di Fisica, Politecnico di Milano, Italy; 1Molecular Foundry Division, Lawrence Berkeley National Lab, USA; 1Stanford Pulse Inst., USA; 2SLAC National Accelerator Lab, USA. We present a robust reconstruction algorithm for isolated attosecond pulses, which exploits the phase-dependent energy modulation of a photoelectron ionized in the presence of a circularly polarized laser field.

FF1D.6 • 09:15
Tuning Exciton-polaritons in Monolayer WSe2 Using Electrical Field Gating, Biswath Chakraborty1, Jie Gu1, Mandeep Khand- torian1, Zheng Sun1, Vinod M. Menon1, 1The City College of New York, USA; 2Dept. of Physics and Astronomy, Univ. of Pittsburgh, USA. We demonstrate the tuning of the exciton-polaritons in monolayer WSe2 embedded in a microcavity via electrostatic gating at room temperature. Under high electro-doping the formation of polaritons with the charged excitons is observed.
eralizes to multifrequency fields, producing a
nance excitation. This technique provides

Dragomir N. Neshev 1, Martti Kauranen 2; Aristeidis Lamprianidis 1, Mohsen Rahmani 1, Godofredo S. Bautista 2, Xiaorun Zang 2, Lei Susumu Noda 2, Yasushi Takahashi 1; 1Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia; 2Sydney Institute, The University of Sydney, Australia. We find that electrons in strong electromagnetic fields exhibit Bloch oscillations, in analogy to light propagation in index-gradient waveguide arrays. Our relativistic non-perturbative approach generalizes to multifrequency fields, producing rich variety of oscillations.

Excitation Wavelength Dependence of a High-Q Nanocavity-based Raman Silicon Laser, Daiki Yamasita 1, Takashi Asano 2, Susumu Noda 3, Yasushi Takahashi 1, Osaka Prefecture Univ., Japan; 2Kyoto Univ., Japan. We investigate the excitation wavelength dependence of the laser emission from a nanocavity-based Raman silicon laser with a technique called Raman-scattering-luminescence excitation. This technique provides an overview of the Raman gain including nonlinear optical losses.

Broadband Achromatic Metalenses, Yu Han Chen 1, Pin Chieh Wu 1, Shuming Wang 1, Ren Jie Lin 1, Jia Wern Chen 1, Yi-Chieh Lai 1, Cheng Hung Chu 1, Bo Han Chen 1, Shining Zhu 2, Tao Li 2, Zhenlin Wang 2, Ding Ping Tai 1; 1National Taiwan Univ., Taiwan; 2Research Center for Applied Sciences, Academia Sinica, Taiwan. We propose a design principle to realize achromatic meta-surfaces devices which successfully eliminate the chromatic aberration over a continuous wavelength range from 400 to 660 nm and 1200 to 1680 nm in a transmission and reflection scheme, respectively.

Bias Dependance of a nanocavity-based Raman silicon laser with a technique called Raman-scattering-luminescence excitation. This technique provides an overview of the Raman gain including nonlinear optical losses.

Bloch oscillations of a free electron in a strong field, Adi Pik 1,2, On Reinhardt 1, Liang Jie Wang 1, Yonatan Plotnik 1, Ido Kaminer 1,2; 1Electrical Engineering, Technion-Israel Inst. of Technology, Israel; 2Chemistry, Technion-Israel Inst. of Technology, Israel. We find that electrons in strong electromagnetic fields exhibit Bloch oscillations, in analogy to light propagation in index-gradient waveguide arrays. Our relativistic non-perturbative approach generalizes to multifrequency fields, producing rich variety of oscillations.

Aberration Corrected Metalenses for Imaging, Sajan Shrestha 1, Adam Overvig 1, Nantang Yu 1; Columbia Univ., USA. We experimentally demonstrated chromatic aberration correction in converging and diverging metalenses up to wavelength range of ~450 nm in the near-infrared by utilizing dispersion engineering of meta-units.

Asymmetric beam generation in an on-chip 2D-pattern-projecting lasers, Kazuyoshi Hirose 1, Yoshiaki Kurosaka 1, Yu Takiguchi 1, Kazuki Sugiyama 1, Yoshio Nomoto 1, So Ueno 1, Yoav Blau 1, Hiroshi Kurosaka 1, 1Hamamatsu Photonics K.K., Japan. We successfully generate an asymmetric beam pattern in integrable phase-modulating surface-emitting lasers, which showed static, arbitrary, two-dimensional beam pattern from on-chip size, while symmetric beam patterns are obtained in the conventional device.

Coherent Control of Light-matter Interactions in Standing Waves, Kevin F. MacDonald 1, Eric Plum 1, Daniele Facio 2, Nikolay I. Zheludev 1,3; 1Univ. of Southampton, UK; 2Univ. of Glasgow, UK; 3Nanyang Technological Univ., Singapore. In standing wave light fields, ‘coherent control’ of energy exchange, in ultrafast films and metasurfaces, between incident and scattered waves leads to new technological opportunities relevant to optical data processing, spectroscopy, and nonlinear/quantum optics applications.

Direct generation of Laguerre-Gaussian beam with holographical phase-modulated surface-emitting lasers, Yu Takiguchi 1, Kazuyoshi Hirose 1, Takahiro Sugiyama 1, So Ueno 1, Yoav Blau 1, Hiroshi Kurosaka 1, 1Hamamatsu Photonics K.K., Japan. Holographically-designed Laguerre-Gaussian beam generation with surface emitting semiconductor lasers are demonstrated. Holographic information was inserted as resonator between the cladding layers. The Laguerre-Gaussian holograms was calculated in the form of complex-amplitude phase hologram.
 Highly Sensitive UV-Vis-NIR Inorganic Perovskite Quantum Dot Phototransistors Based on Layered Heterojunctions, Chen Zou\textsuperscript{1}, Yu Xin Xu\textsuperscript{2}, Lilo D. Pozzo\textsuperscript{1}, Li Y. Lin\textsuperscript{1}; \textsuperscript{1}Electrical Engineering, Univ. of Washington, USA; \textsuperscript{2}Chemical Engineering, Univ. of Washington, USA. We report a high-performance phototransistor based on a layered heterojunction composed of all-inorganic perovskite quantum dots (iPQDs) and a narrow bandgap conjugated polymer (PFP-DTT). The device exhibits stable and excellent optoelectronic properties with broadband photodetection range.

 Low Coherence Illumination of Flexible Perovskite Random Lasers, Yu-Chi Wang\textsuperscript{1}, Yu-Heng Hong\textsuperscript{1}, Kuo-Bin Hong\textsuperscript{1}, Tsung-Sheng Kao\textsuperscript{1}, Tien-Chang Lu\textsuperscript{1}; \textsuperscript{1}National Chiao Tung Univ., Taiwan. We demonstrated that the methylammonium metal-halide perovskites can be exploited as a random laser source for the advanced speckle-free imaging. Furthermore, the lasing performance can be actively controlled via the mechanical modulation of supporting substrates.

 Directional Plasmonic Image Sensors for Lens-Free Compound-Eye Vision, Leonard Kogos\textsuperscript{1}, Lei Tan\textsuperscript{1}, Roberto Paella\textsuperscript{1}; \textsuperscript{1}Boston Univ., USA. We describe a novel lens-free camera technology inspired by the compound-eye vision modality that combines ultrathin plasmonic metasurfaces to enable angle-resolved photodetection with computational imaging for wide-field-of-view image reconstruction.

 Hollow Core Negative-Curvature Fiber for High Energy Pulse Delivery at UV Wavelength, Shoufei Gao\textsuperscript{1}, Ying Ying Wang\textsuperscript{1}, Pu Wang\textsuperscript{1}, Wei Ding\textsuperscript{1}; \textsuperscript{1}Beijing Univ. of Technology, China; \textsuperscript{2}Lab of Optical Physics, Inst. of Physics, Chinese Academy of Sciences, China. We report a UV guiding hollow-core negative-curvature fiber with loss of 0.2 dB/m at 355 nm. This fiber enables, for the first time, picosecond pulse delivery up to 160 μJ at 355 nm with no damage observed.

 Highly Efficient Energy Transfer Between TMDCs and Organic Materials, Cheshuan Cheng\textsuperscript{1}, Zidong Li\textsuperscript{1}, Parag Deotare\textsuperscript{1}; \textsuperscript{1}Univ. of Michigan, USA. We demonstrate MoS\textsubscript{2} photodetectors sensitized with highly absorbent organic j-aggregate thin films. Förster resonance energy transfer (FRET) radius of 1.649 nm was estimated across the hybrid organic-inorganic interface.

 Intra-cavity metasurfaces for topologically spin-controlled laser modes, Elhanan Maguid\textsuperscript{1}, Ronen Chriki\textsuperscript{2}, Michael Yannai\textsuperscript{1}, Chene Tradonsky\textsuperscript{1}, Vladimir Kleiner\textsuperscript{1}, Anka Schwuchow\textsuperscript{1}, Joerg Bierlich\textsuperscript{2}, Jens Kobelke\textsuperscript{1}, Markus Schmidt\textsuperscript{3}, Christian Spielmann\textsuperscript{1}; \textsuperscript{1}Friedrich Schiller Univ. Jena, Germany; \textsuperscript{2}Helmholtz Inst. Jena, Germany; \textsuperscript{3}Otto Schott Inst. of Material Research, Germany. We experimentally demonstrate that the ellipticity of light exiting antiresonant hollow core fibers is a function of the input polarization which manifests as ellipticity varying with the azimuthal periodicity of the cornered core.

 Highly Sensitive UV-Vis-NIR Inorganic Perovskite Quantum Dot Phototransistors Based on Layered Heterojunctions, Chen Zou\textsuperscript{1}, Yu Xin Xu\textsuperscript{2}, Lilo D. Pozzo\textsuperscript{1}, Li Y. Lin\textsuperscript{1}; \textsuperscript{1}Electrical Engineering, Univ. of Washington, USA; \textsuperscript{2}Chemical Engineering, Univ. of Washington, USA. We report a high-performance phototransistor based on a layered heterojunction composed of all-inorganic perovskite quantum dots (iPQDs) and a narrow bandgap conjugated polymer (PFP-DTT). The device exhibits stable and excellent optoelectronic properties with broadband photodetection range.

 Low Coherence Illumination of Flexible Perovskite Random Lasers, Yu-Chi Wang\textsuperscript{1}, Yu-Heng Hong\textsuperscript{1}, Kuo-Bin Hong\textsuperscript{1}, Tsung-Sheng Kao\textsuperscript{1}, Tien-Chang Lu\textsuperscript{1}; \textsuperscript{1}National Chiao Tung Univ., Taiwan. We demonstrated that the methylammonium metal-halide perovskites can be exploited as a random laser source for the advanced speckle-free imaging. Furthermore, the lasing performance can be actively controlled via the mechanical modulation of supporting substrates.

 Directional Plasmonic Image Sensors for Lens-Free Compound-Eye Vision, Leonard Kogos\textsuperscript{1}, Lei Tan\textsuperscript{1}, Roberto Paella\textsuperscript{1}; \textsuperscript{1}Boston Univ., USA. We describe a novel lens-free camera technology inspired by the compound-eye vision modality that combines ultrathin plasmonic metasurfaces to enable angle-resolved photodetection with computational imaging for wide-field-of-view image reconstruction.

 Hollow Core Negative-Curvature Fiber for High Energy Pulse Delivery at UV Wavelength, Shoufei Gao\textsuperscript{1}, Ying Ying Wang\textsuperscript{1}, Pu Wang\textsuperscript{1}, Wei Ding\textsuperscript{1}; \textsuperscript{1}Beijing Univ. of Technology, China; \textsuperscript{2}Lab of Optical Physics, Inst. of Physics, Chinese Academy of Sciences, China. We report a UV guiding hollow-core negative-curvature fiber with loss of 0.2 dB/m at 355 nm. This fiber enables, for the first time, picosecond pulse delivery up to 160 μJ at 355 nm with no damage observed.

 Highly Efficient Energy Transfer Between TMDCs and Organic Materials, Cheshuan Cheng\textsuperscript{1}, Zidong Li\textsuperscript{1}, Parag Deotare\textsuperscript{1}; \textsuperscript{1}Univ. of Michigan, USA. We demonstrate MoS\textsubscript{2} photodetectors sensitized with highly absorbent organic j-aggregate thin films. Förster resonance energy transfer (FRET) radius of 1.649 nm was estimated across the hybrid organic-inorganic interface.

 Intra-cavity metasurfaces for topologically spin-controlled laser modes, Elhanan Maguid\textsuperscript{1}, Ronen Chriki\textsuperscript{2}, Michael Yannai\textsuperscript{1}, Chene Tradonsky\textsuperscript{1}, Vladimir Kleiner\textsuperscript{1}, Anka Schwuchow\textsuperscript{1}, Joerg Bierlich\textsuperscript{2}, Jens Kobelke\textsuperscript{1}, Markus Schmidt\textsuperscript{3}, Christian Spielmann\textsuperscript{1}; \textsuperscript{1}Friedrich Schiller Univ. Jena, Germany; \textsuperscript{2}Helmholtz Inst. Jena, Germany; \textsuperscript{3}Otto Schott Inst. of Material Research, Germany. We experimentally demonstrate that the ellipticity of light exiting antiresonant hollow core fibers is a function of the input polarization which manifests as ellipticity varying with the azimuthal periodicity of the cornered core.
An all-fiber mid-infrared (6 – 9 µm) source based on difference frequency generation in OP-GaP crystal, Jaroslav Z. Soto, Tadeusz Martynek, Peter G. Schunemann, Pawel Mergo, Grzegorz J. Sobon, Tadeusz Martynkien, Peter G. Schunemann, 1Politech, Poland; 2BAE Systems, Inc., USA; 3Lab of Optical Fiber Technology, Maria Curie-Skłodowska Univ., Poland. We present an all-fiber source generating laser pulses in the 6 – 9 µm spectral range. The developed setup is based on difference frequency generation in the OP-GaP crystal and delivers 7.4 mW at 7600 nm.

Electron dynamics in transition metal dichalcogenides utilizing attosecond transient absorption spectroscopy, Alexander Guggenmos1, Hung-Tzu Chang2, Michael Zurch3, Diana Y. Qiu4, Yaron Geva5, Xin-Liang Jiang6, Yufeng Liang6, Felipe H. da Jornadas7, Adam Schwartzberg4, Vincent C. Tung5, Steven G. Louie2,3, Stephen R. Leone1,2. 1Dept. of Chemistry, Univ. of California, Berkeley, USA; 2Dept. of Physics, Univ. of California, Berkeley, USA; 3Materi- als Sciences Division, Lawrence Berkeley National Lab, USA; 4Molecular Foundry, Lawrence Berkeley National Lab, USA; 5School of Engineering, Univ. of California, Merced, USA; 6Chemical Sciences Division, Lawrence Berkeley National Lab, USA; 7Joint Center of Artificial Photosynthesis, Lawrence Berkeley National Lab, USA. Strong enhancement of exciton binding has been observed in valence-excitons in the optical regime of 2D materials. We report direct observation of long-lived core-exciton states in transition metal dichalcogenides by attosecond transient absorption spectroscopy in the XUV.

Optical Chirality for High Harmonic Generation, Ofir Neufeld1, Oren Cohen1,2. 1Physics, Technion, Israel; 2Solid State Inst., Technion, Israel. We link the chirality of attosecond pulses with the chirality of the pump that drives them by extending the theory of optical chirality. We propose a chiral tri-circular pump that generates tunable highly helical attopulses.

Mid-infrared saturable absorber mirror (MIR-SAM) based on Dirac semimetal thin films, Lei Huang1,2, Jiarong Qi1, Yafei Meng1, Chunhua Zhu1, Yao Li3, Yongbing Xu4, Yi Shi4, Frank Fengqiao Wang4, Yanming Univ., China. We have for the first time fabricated a Dirac semimetal saturable absorber with a mirror structure. The centimeter-scale, SESAM-like device can operate across 3-5 µm, and mid-infrared pump-probe spectroscopy is used to study the nonlinear absorption characteristics.
SF1A • Si Photonics—Continued

SF1A.6 • 09:30
Monolithically Integrated Holmium Lasers on Silicon Chips, Nansu Li1,2, Emin Magden1, Zhan Su1, Neetesh Singh1, Alfonso Ruocco1, Ming Xin1, Matthew Byrd1,3, Michael Watts1, 2Research Lab of Electronics, MIT, USA; 3John A. Paulson School of Engineering and Applied Science, Harvard Univ., USA; 4Analog Photonics, USA; 5Dept. of Engineering Physics, McMaster Univ., Canada. We demonstrate holmium-doped DFB lasers monolithically integrated on silicon. Single mode lasing at wavelength from 2.02 to 2.10 µm with 15 mW maximum output power are reported. This work extends silicon-photonics microsystems beyond 2 µm.

SF1A.7 • 09:45
Quantum-dot nanolasers on Si photonic circuits, Alto Osada1, Yasutomo Ota1, Ryota Katsumi2, Katsumi Watanabe2, Satoshi Iwamoto2, Tatsuhisa Arakawa2; 1Inst. for Nano Quantum Information Electronics, The Univ. of Tokyo, Japan; 2Inst. of Industrial Science, The Univ. of Tokyo, Japan. We report the hybrid integration of quantum dot nanolasers on silicon photonic circuits using transfer printing. The pick-and-place assembly method facilitates the integration of two nanolasers on a single CMOS-processed waveguide that supports two-wavelength output.

SF1B • Quantum Enhanced Measurements—Continued

SF1B.7 • 09:30
Distorted Quantum Sensing Using Continuous-Variable Multiparticle Entanglement, Quntao Zhuang1, Zhenheng Zhang2,3,4, Jeffrey H. Shapiro5, 6MIT, USA; 7Dept. of Materials Science and Engineering, Univ. of Arizona, USA. Continuous-variable multiparticle entanglement, obtained from dividing a squeezed state between multiple nodes, is shown to enhance distributed field-quadrature displacement sensing. In the lossless case, its performance has Heisenberg scaling in the number of nodes.

SF1B.8 • 09:45
Manipulation of Two-Photon Interference by Entanglement, Polina Sharapova1, Kai Hong Luo1, Harald Herrmann1, Matthias Reinehr2, Torsten Meier1, Christine Silberhorn3; 1Univ. of Paderborn, Germany. We demonstrate that entangled states are able to significantly extend the functionality of integrated Hong-Ou-Mandel interferometers and give rise an antibunching peak and rapid oscillation fringes with twice the optical frequency in the coincidence probability.

FF1B • Quantum Enhanced Science

FF1C • Symposium on Lasers in Accelerator Science and Technology I—Continued

JF1C.5 • 09:30
Invited: Linear-Field Particle Acceleration in Free Space by Spatiotemporally Structured Laser Pulses, Liang Jie Wong1,2, Kyung-Hong Hong1,2, Sergio Carballo1,2, Ana Fallah1,2, Philippe Piot1,2, Marin Soljacic1,2, John Joanopoulos1,2, Franz X. Kaertner4, Ido Kaminer6; 1SIMTech, Singapore; 2MIT, USA; 3Stanford SLAC, USA; 4MIT, USA; 5Stanford, USA; 6Technion, Israel. We show that net energy transfer via linear-field forces, between a laser pulse and a bunch of multiple interacting electrons, can be realized in unbounded free space by engineering the spatiotemporal structure of light.

JF1C.6 • 09:45
Continuous-Variable Multipartite Entanglement, Chenglong Wang1,2,3,4, Yang Zhou1,2, Zheshen Zhang1,2, Jiawei Lai1,2, Shaofeng Ge1,2, M. Chandra Sekhar1,2, Shuang Jia1,2, Kai Chang1, Dong Sun2,3,4; 1International Center for Quantum Materials, School of Physics, Peking Univ., China; 2Collaborative Innovation Center of Quantum Matter, China; 3SKLSM, Inst. of Semiconductors, Chinese Academy of Sciences, China; 4Dept. of Physics, Hunan Normal Univ., China. The dynamical evolution of anisotropy properties of black phosphorus (BP) under magnetic field is studied by polarization resolved mid-IR ultrafast transient reflection spectroscopy. We found magnetic field can efficiently adjust the anisotropy response of BP.

FF1D • Ultrafast Spectroscopy of 2D Materials—Continued

FF1D.7 • 09:30
Ultrafast Dynamical Evolution of Anisotropic Response of Black Phosphorus under Magnetic Field, Wei Lu1,2, Xuefeng Liu1,2, Xiaoying Zhou1,2, Yang Zhou1,2, Chenguang Zhang1,2, Jiawei Lai1,2, Shaofeng Ge1,2, M. Chandra Sekhar1,2, Shuang Jia1,2, Kai Chang1, Dong Sun2,3,4; 1International Center for Quantum Materials, School of Physics, Peking Univ., China; 2Collaborative Innovation Center of Quantum Matter, China; 3SKLSM, Inst. of Semiconductors, Chinese Academy of Sciences, China; 4Dept. of Physics, Hunan Normal Univ., China. The dynamical evolution of anisotropy properties of black phosphorus (BP) under magnetic field is studied by polarization resolved mid-IR ultrafast transient reflection spectroscopy. We found magnetic field can efficiently adjust the anisotropy response of BP.

FF1D.8 • 09:45
Ultrafast quantum beats of linearly polarized excitons in two-dimensional ReS2, Sangwan Sim1,2, Doonee Lee1, Artur Trifonov2, Taeyoung Kim3, Soonyoung Cha1, Ji Ho Sung3, Sungjun Choi3, Wooyoung Shim3, Moon-Ho Jo1, Hyunyong Choi1, Yonsei Univ., South Korea; 2Spin Optics Lab, Russia; 3Center for Artificial Low Dimensional Electronics Systems, IBR, South Korea. We observe quantum beats of excitons in atomically thin ReS2. Our observation directly confirms the quantum coherence between anisotropic excitations which are linearly polarized with different orientations.
Optimizing the Nonlinear Optical Response of Plasmonic Metasurfaces, Yoel Blechman1, Euclides C. Almeida1, Basudeb Sain1, Yehiam Prior1, 1Weizmann Inst. of Science, Israel. We demonstrate that the enhancement of the decay. 800ps at the beginning to 300ns at the end with a time-dependent lifetime ranging from revealing a highly nonlinear decay dynamics of photo-generated carriers in strip silicon nanowaveguides, revealing a highly nonlinear decay dynamics with a time-dependent lifetime ranging from 800ps at the beginning to 300ns at the end of the decay.

FF1E.7 - 09:30

Probing free-carrier recombination in silicon strip nano-waveguides, Ivan A. Aldaya1,2, Andres Gil-Molina1,3, Julian Pita3, Lucas Gabrielli3, Hugo Fraginoti3, Paulo C. DaIese3, 1Inst. of Physics, Univ. of Campinas, Brazil; 2State Univ. of Sao Paulo, Brazil; 3School of Electrical Engineering, Univ. of Campinas, Brazil; 4Mack graphe, Mackenzie Presbyterian Univ. , Brazil. We analyze recombination dynamics of photo-generated free-carriers in strip silicon nanowaveguides, revealing a highly nonlinear decay dynamics with a time-dependent lifetime ranging from 800ps at the beginning to 300ns at the end of the decay.

FF1E.8 - 09:45

Large-scale Metasurface Design using the Adjoint Sensitivity Technique, Mahdad Mansourae, Amir Arbabi1, 1Univ. of Massachusetts at Amherst, USA. We introduce a general technique for the design of metasurfaces composed of a large number of meta- atoms that enables efficient multifunctional metasurfaces. As a proof-of-concept, we demonstrate a metalens with 0.78NA and 74% focusing efficiency.

FF1F.7 - 09:45

A violet III-nitride vertical-cavity surface-emitting laser with a MOCVD-grown tunnel junction contact, Seunggeun Lee1, Charles Forman1, Changmin Lee1, Jared Kearns1, John T Leonard2, Daniel Cohen2, James Speck2, Shuji Nakamura1, Steven DenBaars1, 1Dept. of Electrical and Computer Engineering, Univ. of California, Santa Barbara, USA; 2Materials Dept., Univ. of California, Santa Barbara, USA. We demonstrated a violet III-nitride vertical-cavity surface-emitting laser (VCSEL) with GaN tunnel junction (TJ) contact grown by a metal-organic chemical vapor deposition (MOCVD) technique. A peak output power of 319 μW was achieved.

FF1F.8 - 09:45

Nonphotonic light sails for relativistic spaceflight by high-power laser beams, Ogjnn Ilic1, Cora Went1, Harry Atwater1, 1California Inst. of Technology, USA. We show that designed nanophotonic structures could become multiband building-block elements of a relativistic light sail, due to their ability to achieve substantial reflectivity and low ab- sorption in the near-IR, significant emissivity in the mid-IR, and a very low mass.
AF1M.6 • 09:30
Inherent Signal Distortion in Dynamic Fiber-Optic Interrogators Employing Frequency Scanning, Hari D. Bhatta1, Roy Davidi1, Moshe Tur1; 1Tel Aviv Univ., Israel, Israel. It is shown, theoretically and experimentally, that signal distortion is inherently present in dynamic fiber-optic strain sensing techniques, which use frequency scanning to determine the value of the measurand.

AF1M.7 • 09:45
Temperature-sensitivity enhancement in a tapered dual-core As$_2$Se$_3$-PMMA fiber with an antisymmetric long-period grating, Song Gao1, Chams Baker1, Liang Chen1, Xiaoyi Bao1; 1Univ. of Ottawa, Canada. We report sensitivity enhancement of temperature measurement by a factor of 4.0 based on effective group-velocity matching between the even and odd modes of a dual-core chalcogenide-PMMA taper that is inscribed with an antisymmetric long-period grating.

AF1M • Fiber-Optic Based Sensing—Continued

AF1K • Hollow Core Fibers—Continued

SF1K.6 • 09:30
Mode transformation in an inhibited-coupling guiding asymmetric tubular hollow fiber, Jonas R. Ośorio1, Matthieu Chafer1,2, Benoît Debord1,2, Fabio Giovanardi1, Martin Cordier1, Frédéric Delahaye1, Luca Vincetti1, Frédéric Gérôme1,2, Fetah Benabid1,2; 1GPPMM Group, XLIM Research Inst., Univ. of Limoges, France; 2OLO Photonics, France; 3Univ. of Modena and Reggio Emilia, Italy; 4Télécom ParisTech, Université Paris-Saclay, France. We report on mode transformation in an asymmetric tubular hollow fiber. We theoretically and experimentally show that LP$_e$ and LP$_o$ modes superposition entails an output profile with unusual spatially-separated orthogonal polarization sites.

SF1K.7 • 09:45
Low-Frequency Suppression of Classical Laser Fluctuations Using Hollow-Core Fibre, Euan Allen1, Giacomo Ferranti1, Dylan H. Mahler1, Kristina Rusinova1, Peter J. Mosley1, Jonathan Matthews1; 1Univ. of Bristol, UK; 2Univ. of Bath, UK. We demonstrate classical laser amplitude noise suppression at 4.5 MHz using hollow-core free-boundary fibre. We attain suppression of 2.0 dB and get to within 0.2 dB of the shot-noise limit.

AF1J.7 • 09:30
Bianisotropic All-dielectric Metasurfaces for Efficient Diffraction of Mid-infrared Electromagnetic Waves, Zhiyuan Fan1, Maxim R. Shcherbakov1, Gennady Shvets1; 1Cornell Univ., USA. We design and experimentally demonstrate a bianisotropic all-silicon metasurface with a near unity diffraction efficiency by implementing a 4-mode interference in the far field. Resonant and non-resonant properties of the modes and interactions can be mediated by sculpting meta-atoms of the metasurface.

AF1J.8 • 09:45
Self-Aligned Nano-Transfer of Metasurface Polarimeter to an Optical Fiber Tip using UV-Curable Hybrid Polymer, Michael Juhl1, Carlos Mendez1, J. P. Ballinas-Mueller1, Frederico Capasso1, Kristian Leoson1,2, Innovation Center Iceland, Iceland; 1Univ. of Iceland, Iceland; 2Harvard John A. Paulson School of Engineering and Applied Sciences, USA. We present a novel method of patterning an optical fiber facet using self-aligned nano-transfer of a gold pattern to a UV-curable hybrid polymer. We experimentally demonstrate a metasurface polarimeter on a 1550 nm single-mode fiber.

SF1I.6 • 09:30
Invited Patterning of Organic Micro-/Nano-crystals for High-Performance Optoelectronic Devices, Jianhong Jia1; 1Inst. of Functional Nano and Soft Materials Lab (FUNSOM), Soochow Univ., China. Organic micro-/nanocrystals (OMNCs) are promising systems to construct new-generation optoelectronic devices. However, the scale-up of OMNCs for technological applications is difficult. We developed a series of simple methods to produce patterned OMNCs for device applications.

10:00–10:30 Coffee Break, Concourse Level
AF1Q.6 • 09:30
Room Temperature Operation of Directly Patterned Perovskite Distributed Feedback Light Source under Continuous-Wave Optical Pumping, Abouzar Gharajeh1, Ross Haroldson1, Zhitong Li1, Jiyoung Moon1, Balasubramaniam Balachandran1, Walter Hu1, Anvar Zakhidov1, Qing Gu1; 1The Univ. of Texas at Dallas, USA; 2Microelectronics Dept., Fudan Univ., China; 3ITMO Univ., Russia. We report the first directly patterned perovskite distributed feedback (DFB) resonator with a narrow amplified spontaneous emission (ASE) at pump powers as low as 0.1W/cm², under continuous-wave (CW) optical pumping condition at room temperature.

SF1N.6 • 09:30
High Power Offset-free Ultrafast Mid-IR Source Harnessing SPM-enabled Spectral Selection, Gengji Zhou1,2, Franz X. Kaertner1,2, Guang Cheng3,4, CFEL, DESY, Germany. We demonstrate a novel fiber approach for power scaling difference-frequency-generation based ultrafast mid-IR laser sources that are tunable from 7.4 μm to 16.8 μm with up to 5.3-mW average power at 9.3 μm.

SF1N.7 • 09:45
High-Power Harmonic Frequency Comb Covering the Mid-Infrared Molecular Fingerprint Region, Christian Gaida1, Tobias Heuermann1,2, Martin Gebhardt1,2, Thomas Butler1, Daniel Gerd1, Lenard Vamos1, Ferenc Krausz1, Jens Limpert1,2, Ioachim Pupeza3,4, Inst. of Applied Physics, Germany; 3Max Planck Inst. of Quantum Optics, Germany; 4Ludwig Maximilians Univ. Munich, Germany; 5Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. We present a multi-channel, 0.1 mW/THz-level, 50 MHz-repetition-rate harmonic frequency comb covering the spectral range 18.5 – 85 THz (or 3.5 – 15 μm, or 625 – 2860 cm⁻¹), based on intrapulse difference-frequency mixing within few-cycle, high-power 1.96 μm pulses.

SF1N.7 • 09:45
Unusual Scaling Laws for Plasmonic Nanolasers, Suo Wang, Xing-Yuan Wang, Huazhou Chen, Yilin Wang, Lun Dai, Rupert Oulton, Renmin Ma; 1Peking Univ., China; 2Imperial College London, UK. We report unusual scaling laws allowing plasmonic lasers with superior performances over photonic lasers at the nanoscale, which clarifies the long-standing debate over the viability of metal confinement and feedback strategies in laser technology.

10:00–10:30 Coffee Break, Concourse Level
SF2A.1 • 10:30
Quantum frequency conversion using nanophotonics, Qings Li1,2, Anshuman Singh1,2, Xiuyan Liu1,2, Varun Verma1, Richard Minn2, Sae Woo Nam1, Kartik Srinivasan1,2, CNST, NIST, USA, 1Univ. of Maryland, USA, 2PML, NIST, USA. We demonstrate quantum frequency conversion of photon pairs with both pair generation and frequency conversion implemented in Si3N4 microrings. Quantum correlations between the signal and idler are preserved, with an on-chip conversion efficiency around 25%.

SF2A.2 • 11:00
Observation of second harmonic and sum frequency in an optically poled Si3N4 waveguide, Davide Grassani1, Adrien Billet1, Martin Pfeiffer2, Tobias J. Kippenberg2, Camille-Sophie Bres1, Photonic System Lab (PHOSL), Ecole Polytechnique Federale de Lausanne, Switzerland, 1Lab for Photonics and Quantum Measurements (LPQM), Ecole Polytechnique Federale de Lausanne, Switzerland. Enhanced second order nonlinear processes in a Si3N4 waveguide following optically induced $\chi^{(2)}$ is demonstrated, enabling the detection of a frequency doubled pulsed train and SFG with $>$37 dB conversion efficiency for 18 W pump peak power.

JF2B.1 • 10:30 Invited
Quantum Sensing and Imaging with Diamond Spins, Ania Bleszynski Jayich1, Alec Jenkins1, Susanne Baumann1, Dolev Bluvstein1, Simon Meynell1, Amila Anyaratne1, 1Univ. of California Santa Barbara, USA. The diamond nitrogen-vacancy (NV) center quantum sensor features excellent spatial resolution, sensitivity, and versatility. I discuss recent developments in NV-based imaging of condensed matter systems and ongoing developments in improving the NV center’s functionality.

JF2C.1 • 10:30 Invited
Laser-shaping of Electron Beams for X-ray Free-electron Laser Applications, Agostino Marinelli1, 1SLAC National Accelerator Lab, USA. From seeding to laser-based electron bunch compression, to the generation of attosecond X-ray pulses, conventional lasers are ubiquitous in X-ray free-electron laser facilities. In my talk I will give an overview of advanced XFELs schemes involving the use of high-power lasers.

JF2C.2 • 11:00
Multi-kW Average Power Thin Disk - Slab Ti:Sa Amplifiers, Vladimir V. Chvykov1, Roland Nagymihály1, Huabao Cao1, 1ELI-HU Non-Profit Ltd., Hungary, 2Univ. of Michigan, USA. We demonstrate quantum frequency conversion using nano-structures in a Ti:Sapphire thin disc. Multi-kW output power is obtained, which can be used to generate multi-kW average power from 100 kW peak power Ti:Sa lasers.

JF2C.3 • 11:00 Invited
Quantum Manipulation of Competing Phases by Terahertz Pulses, Jingang Wang1, 1Iowa State Univ., USA. We reveal a hidden quantum phase of prethermalized, gapless electron fluid, which evolves following single-cycle, resonant terahertz quench of the SC gap above a critical fluence and implies novel organization principles beneath superconductivity.
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Friday, 10:30–12:30
SF2I  •  Electrooptic and Nanophotonic Materials
Presider: Tian Gu; MIT, USA
SF2I.1  •  10:30
A Breakthrough leading to A New Type of E-O Materials Electro-Elasto-Optical Properties of EEO Crystals (PMN-PT Based Relax Ferroelectric Crystals) by Special Modifications, Pengfei Han1; EEOptics Corp., USA. Important findings from a systematic investigation on Electro-Elasto-Optical characterization for PMN-PT based ferroelectric crystals. The new E-O material is biaxial EEO crystal with N_p=2.545, N_m=2.558, N_s=2.564, 2V=109° and effective EO-coefficient g over 300–600pm/V and V_p less than 100V.

SF2I.2  •  10:45
Periodic Poling of Ion-Sliced X-Cut Magnesium Oxide Doped Lithium Niobate Thin Films, Jonathan T. Nagy1, Ronald M. Reano2; 1The Ohio State Univ., USA. We fabricate and periodically pole 700 nm thick ion-sliced x-cut magnesium oxide doped lithium niobate thin films. Uniform domains with 50% duty cycle are imaged by piezo-response force microscopy.

SF2I.3  •  11:00
Ultralow-Q Lithium Niobate Microring Resonator, Mian Zhang1, Cheng Wang2, Rebecca Cheng3, Amr Hassan Shams-Ansari1,3, Marko Loncar1; 1John A. Paulson School of Applied and Engineering Sciences, Harvard Univ., USA; 2Dept. of Physics, Brown Univ., USA; 3Dept. of Electrical Engineering and Computer Science, Harvard Univ., USA. We demonstrate ultralow loss monolithic integrated lithium niobate photonic platform consisting of dry-etched subwavelength waveguides. We show microring resonators with a quality factor of 10^7 and waveguides with propagation loss as low as 2.7 dB/m.

SF2J  •  Cavity Optomechanics
Presider: Karen Gutter; Univ. of Maryland at College Park, USA
SF2J.1  •  10:30
Optomechanically Mediated Wavelength Conversion in Diamond Microdisks, Matthew Mitchell1,2; David P. Lake1,2, Paul E. Barclay1,2; 1Inst. for Quantum Science & Technology, Canada; 2NRC - National Inst. for Nanotechnology, Canada. Optomechanically mediated wavelength conversion in a single-crystal diamond microdisk operating in the resolved sideband regime is demonstrated. Frequency down-conversion is demonstrated with an expected internal conversion efficiency of ~ 45%.

SF2J.2  •  11:00
Diamond Optomechanical Crystals at Cryogenic Temperatures, Cleaven Chia1, Srujan Meesala1, Gabriella Gardosi1, Sajid Naeem1,2, Meir Orenstein1, Marin Soljacic2; 1Aston Univ., UK; 2Dept. of Physics, Cornell Univ., USA. We propose a electrically tunable plasmonic microresonator fabricated in single-crystal diamond with its chemical potential controlled by a periodically structured metasurface. We demonstrate fabrication of SNAP microresonators with parabolic profiles via fiber tapering with a laser-heated microfurnace. The developed method enables simple and convenient fabrication of prospective frequency comb generators and miniature dispersionless SNAP delay lines.

SF2J.3  •  11:00
Topological Valley Transport of Infrared Plasmons on a Nanoscale in Metagated-Tuned Graphene, Minwoo Jung1,2, Zhiyuan Fan1, Gennady Shvets1; 1School of Applied and Engineering Physics, Cornell Univ., USA; 2Dept. of Physics, Cornell Univ., USA. We propose a topologically tunable plasmonic platform for valleytronics—a monolayer graphene with its chemical potential controlled by a periodically structured metagratings. Topologically protected edge states show reflection-free propagation around sharp corners.

SF2K  •  Novel Fiber Technology
Presider: Sze Set; Univ. of Tokyo, Japan
SF2K.1  •  10:30
SNAP: Subangstrom Precise and Ultralow Loss Nanophotonic Platform, Misha Sumetsky1,2; 1Aston Univ., UK; 2AMOLF, Netherlands. We demonstrate the fabrication of prospective frequency comb generators and miniature dispersionless SNAP delay lines.

SF2K.2  •  11:00
Harmonic SNAP Bottle Microresonators Produced via Tapering of Optical Fibers, Dashiell L. Vitullo1, Gabriella Gardosi1, Sajid Naeem2, Meir Orenstein3, Michael Brodsky4, Misha Sumetsky1,2; 1Aston Univ., UK; 2U.S. Army Research Lab, USA. We demonstrate fundamental valley(spin)-dependent directional emission of transition metal chalcogenides (TMDs) into plasmonic eigenstates of a silver nanowire through spin-orbit coupling of light.

SF2K.3  •  11:00
Inducing Indirect Optical Transitions Using Graphene Plasmonas, Yariv Kurman1,2, Nicholas Rivera1, Thomas Christensen1, Shai Tsesses1, Meir Orenstein2, Marin Soljacic2, John Joannopoulos1, Ido Kaminer1,2; 1Electrical Engineering, Israel Inst. of Technology, Israel; 2Physics, MIT, USA. We show that graphene plasmons placed near a quantum-well induces a pronounced shift in the emission/absorption frequency. The high momenta of graphene plasmons reaches the electron’s momenta, enabling indirect optical transitions and inducing structural nonlocal properties.
AF2M.1 • 10:30
Broadband spectral-focusing CARS of pharmaceutical drugs, Jeremy G. Porquez1, Aaron D. Slepove1, Trent Univ., Canada. We apply supercontinuum-Stokes-based spectral-focusing CARS hyperscans for chemical identification and 3D imaging of pharmaceutical powder samples. A wide spectral scan range, combined with facile epi-detection, allows for strong progress toward quantitative drug assaying with CARS.

AF2M.2 • 10:45
Distribution Pulsation Waveform Inspection to Radial Artery with Shadow Moiré fringe, Chun-Hsiung Wang1, Yu-Hsiang Hsu1, Shu-Sheng Lee1, Wen-Jung Wu1, Chih-Kung Lee1, National Taiwan Univ., Taiwan; 2National Taiwan Ocean Univ., Taiwan. A non-invasive full-field arterial-induced skin vibration inspection system is developed based on Shadow Moiré, 2D Continuous Wavelet Transform and Region of Interest techniques. Pulsation profiles obtained can be used for potential diagnostic use.

AF2M.3 • 11:00
Deep tissue, wide-field multiphoton imaging using TEMPIX, Adria Escobet-Montalban1, Roman Semytshev2, Minghui Chen1, Wardyia Alfash3, Melissa Andrews4, Simon Herrington5, Michael Mazilu6, Kishan Dhokia7, School of Physics and astronomy, Univ. of St Andrews, Univ. of St Andrews, UK; 2School of Medicine, Univ. of St Andrews, UK; 3Biological Sciences, Univ. of Southampton, UK; 4Inst. of Genetics and Molecular Medicine, Univ. of Edinburgh, UK. We demonstrate a new approach, temporal focusing microscopy with single-pixel detection (TEMPIX), for wide-field multiphoton imaging through scattering media without any a priori knowledge or requirement to determine the properties of the media.

AF2M.1 • 10:30
Sub-100 fs pulse generation from a Tm:Ho:CALYO laser mode-locked by a GaSb-based SESAM at ~2043 nm, Yong-guang Zhao1, Yicheng Wang1, Xuzhao Zhang1, Xavier Matos2, Zhangben Pan3, Pavel Loko1, Wei Zhou1, Xiaodong Xu1, Xu Jun1, Deyuan Shen1, Soile Suomalainen1, Antti Harkonen1, Mircea D. Guina1, Uwe Griebner1, Valentin Petrov2, Jangsu Normal Univ., Germany; 3Max-Born-Inst. for Nonlinear Optics and Ultrafast Spectroscopy, Germany; 4Universitat Rovira i Virgili (URV), Spain; 5China Academy of Engineering Physics, China; 6ITMO Univ., Russia; 7Tongji Univ., China; 8Tampere Univ. of Technology, Finland. We report on the first sub-100 fs mode-locked Ho+-laser in the 2-µm spectral range. The disordered co-doped Tm:Ho:CALYO crystal produced pulses as short as 87 fs with 27-mW average output power at 80.45-MHz repetition rate.

AF2M.2 • 10:45
Sub-120 fs Kerr-lens Mode-locked Tm:Sc2O3 Laser In-band pumped by an Er:Yb fiber MOPA, Masaki Tokurakawa1, Masaki Fujita1, Christian Kraenkel2, Univ. of Electro-communications, ILS, Japan; 2Zentrum für Lasermaterialien, Leibniz-Institut für Kristallzüchtung, Germany; 3Max-Born-Inst. for Laser-Physik, Universitit Hamburg, Germany. We demonstrate a Kerr-lens mode-locked Tm:Sc2O3 laser in-band pumped by a 1611 nm Er:Yb fiber laser. 115 fs pulses with 42.6 nm spectral bandwidth are obtained. The output power and repetition rate are 420 mW and 95 MHz, respectively.

AF2M.3 • 11:00
Frontiers in Ultrafast Thin-Disk Laser Oscillators, Clément Paradis1, Norbert Madsching2, Maxim Gaponenko3, François Labaye1, Valentin J. Wittwer1, Thomas Sedlmeier2, Laboratoire Temps-Fréquence, Université de Neuchâtel, Switzerland. Ultrafast thin-disk lasers continue achieving higher average powers and pulse energies than other oscillator technologies. We discuss performance instabilities in nonlinear fiber optics systems. In particular, we show how these techniques can provide novel insight into the dynamics of ultrafast complex optical systems.

Corkum holds a Canada Research Chair at the University of Ottawa and directs the Joint NRC/University of Ottawa Attosecond Science Laboratory. He is a member of the Royal Societies of London and of Canada, also a foreign member of the US National Academy of Science and of the Austrian Academy of Science.

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FF2P1 • 10:30
Tutorial
High Harmonics from Solids and Gases, Paul B. Corkum1; 2Univ. of Ottawa, Canada; 3National Research Council of Canada, Canada. Experiments and models show that intense light ionizing transparent solids or gases creates a sequence of harmonics extending to photon energies >1 keV in gases and >H29 in solids. The same process creates attosecond pulses.

FF2P2 • 10:30
High-order Harmonic Generation in Solids, Presider: Alexis Chacon; Los Alamos National Lab., USA

FF2P3 • 10:30
Invited
Real-time Measurements of Nonlinear Instabilities in Optical Fibers, Piotr Ryczkowski1, Mikko Nåth2, Cyril Billet3, Jean-Marc Merolla4, John M. Dudley5, Goergy Genty6, Tampereen Teknillinen Yliopisto, Finland; 2Max-Born-Inst. for Nonlinear Optics and Ultrafast Spectroscopy, Germany; 3Laboratoire d’Optique de l’Ecole Polytechnique, France. We review recent advances in the real-time characterization of instabilities in nonlinear fiber optics systems. In particular, we show how these techniques can provide novel insight into the dynamics of ultrafast complex optical systems.

FF2P4 • 10:30
Invited
Demonstration of GHz-band RF receiver and spectrometer using random speckle patterns, Adam Scalefield1, The Aerospace Corporation, USA. We report experimental demonstrations of compressive sensing with photonic systems in which the measurement matrices are implemented using speckle in multimode waveguides. We calibrate by measuring a dictionary of single frequency RF sinusoids.

FF2N2 • 10:45
Invited
Sub-120 fs Kerr-lens Mode-locked Tm:Sc2O3 Laser In-band pumped by an Er:Yb fiber MOPA, Masaki Tokurakawa1, Masaki Fujita1, Christian Kraenkel2, Univ. of Electro-communications, ILS, Japan; 2Zentrum für Lasermaterialien, Leibniz-Institut für Kristallzüchtung, Germany; 3Max-Born-Inst. for Laser-Physik, Universitit Hamburg, Germany. We demonstrate a Kerr-lens mode-locked Tm:Sc2O3 laser in-band pumped by a 1611 nm Er:Yb fiber laser. 115 fs pulses with 42.6 nm spectral bandwidth are obtained. The output power and repetition rate are 420 mW and 95 MHz, respectively.

FF2N3 • 11:00
Invited
Frontiers in Ultrafast Thin-Disk Laser Oscillators, Clément Paradis1, Norbert Madsching2, Maxim Gaponenko3, François Labaye1, Valentin J. Wittwer1, Thomas Sedlmeier2, Laboratoire Temps-Fréquence, Université de Neuchâtel, Switzerland. Ultrafast thin-disk lasers continue achieving higher average powers and pulse energies than other oscillator technologies. We discuss performance instabilities in nonlinear fiber optics systems. In particular, we show how these techniques can provide novel insight into the dynamics of ultrafast complex optical systems.

Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.
Broadband parametric down-conversion in an X-cut lithium niobate microresonator, Rui Luo1, Haowei Jiang1,2, Steven Rogers1, Harunsoh Liang1, Yang He1, Qiang Lin1; 1Univ. of Rochester, USA; 2Shanghai Jiao Tong Univ., China. We report spontaneous parametric down-conversion with a bandwidth of about 400 nm in a high-Q lithium niobate microdisk resonator. The broadband feature is enabled by cyclic phase matching in an X-cut microresonator.

Four-wave mixing at 1550 nm is enabled by cyclic phase matching in an an X-cut lithium niobate microresonator. The nonlinear parameter of GaN is estimated as 3.4±1e-18 [m²/W].

Atomic Force Microscopy Beyond the Standard Quantum Limit, Benjamin Lawrie1, Raphael C. Poozer1; 1Quantum Information Science Group, Oak Ridge National Lab, USA. We explore the impact of quantum noise reduction on force microscopy for broadband off-resonant materials characterization by integrating a multi-spatial-mode squeezed state as the readout field in a commercially available microscope.

We demonstrate plasma-deposited (temperature < 300°C), deuterated silicon nitride waveguides with 0.22 dB/cm propagation loss at λ = 1552 nm. Pumping at λ = 1560 nm, we obtain a 550 nm-bandwidth Kerr-microcombs and octave-spanning supercontinuum.

Quantum Enhanced Joint Multi-Parameter Measurement, Jiamin Li1,2, Nan Huo1,2, Xiaoying Li1,2, Z.Y. Ou1,2,1; 1School of Electrical Measurement, National Lab, USA; 2Stanford Univ., USA. We present two laser heater shaping solutions based on Laguerre-Gaussian and discrete beamlet array distributions that significantly outperform current microbunching instability suppression approaches in free-electron lasers.
We report extremely strong cavity tuning by photorefraction in LiNbO3 photonic crystal nanocavities. The waveguide geometry enables phase-matching of harmonic generation to higher-order modes. Simulations reveal how periodic poling enables harmonic generation through a cascaded mechanism.

Photorefraction quenching in high quality LiNbO3 photonics crystal nanocavities, Hanxiao Liang1, Rui Luo1, Mingxiao Li1, Yang He1, Housen Jiang1; 1Univ. of Rochester, USA. We report extremely strong cavity tuning by photorefraction in LiNbO3, photonics crystal nanocavities, with a tuning rate up to ~84 MHz/photon. In particular, we report for the first time intriguing quenching of photorefraction in these devices.

Sub-wavelength field enhancement in mid-IR: Photonics vs Plasmonics vs Phononics, Tengfei Li1, Vivek Nagal2, David Gracias2, Jacob Khurgin1, 1Electrical and Computer Engineering, Johns Hopkins Univ., USA; 2Chemical and Biomolecular Engineering, Johns Hopkins Univ., USA. We compare different means for the mid-infrared light enhancement on sub-wavelength scale. Depending on whether the magnitude of the bandwidth of enhancement is important, metallic or phononic structures are preferable.

Broadband mid-infrared frequency combs in quasi-phase-matched lithium niobate waveguides, Abijith Kowligy1, Alex Lind1; 1Time and Frequency Division, NIST, USA; 2KM-Labs, USA; 3Ecole Polytechnique Federale de Lausanne, Switzerland; 4JILA - Univ. of Colorado and NIST, USA; 5Physics, Univ. of Colorado, USA. We demonstrate nanophotonic waveguides for mid-infrared supercontinuum generation and high-harmonic generation. The waveguide geometry enables phase-matching of harmonic generation to higher-order modes. Simulations reveal how periodic poling enables harmonic generation through a cascaded mechanism.

Metal-insulator-metal Metamaterial Absorbers with Optical Absorption Tailored by Embedded Phonons, Junyu Li1, Rui Li1, Rui Li1; 1School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China; 2Shenzhen R & D Center of Huazhong Univ. of Science and Technology, China. We proposed using narrowband absorption filter integrated lithium tantalite (LT) based pyroelectric detector array as spectroscopic sensor for NDIR gas sensing. Measured absorption spectra of the narrowband absorber and calculated thermal responses are provided.

Monolithic integration of mid-infrared quantum cascade lasers coupled with passive InGaAs waveguides, Seungyong Jung1,2, 3; 1School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China; 2Shenzhen R & D Center of Huazhong Univ. of Science and Technology, China. We demonstrated lasing and mode coupling of mid-infrared quantum cascade lasers monolithically integrated with passive InGaAs waveguides. We experimentally demonstrate lasing and mode coupling of mid-infrared quantum cascade lasers monolithically integrated with passive InGaAs waveguides for integrated-photonic applications. A waveguide-coupled device produced 30 mW peak power with $J_0=3.5 \text{ kW/cm}^2$ at room-temperature.
SF2J • Cavity Optomechanics—Continued

SF2J.3 • 11:15
High Harmonic Generation Via an Electro-Optomechanical Oscillator, Turker Beyazo-glu1, Clark T. Nguyen1, UC Berkeley, USA. We present an Electro-Opto-Mechanical Oscillator achieving 270 harmonics from a 37-MHz mechanical oscillation, more than 2x larger in harmonic number and 1000x higher in frequency compared to the previous mark. This is achieved by producing large oscillation amplitude with a unique device design.

SF2J.4 • 11:15
Foundry-compatible Hybrid Silicon / Lithium Niobate Electro-Optic Modulator, Peter Weigel1, Jie Zhao2, Douglas Trotter2, Dana Hood2, John Mudrick2, Christina Dallo2, Andrew Panerene1, Andrew Starbuck1, Christopher DeRose2, Anthony Lentine1, Shayan Mookhtjeria1, Univ. of California San Diego, USA; 2Applied Microphotonic Systems, Sandia National Labs, USA. A foundry-compatible hybrid silicon-lithium niobate electro-optic modulator with an optical bandwidth greater than 6 GHz is presented. Wafer-scale photolithography processing is used to fabricate silicon features before bonding to a 600 nm lithium niobate film.

SF2J.5 • 11:30
Measurement of Nonlinear Refractive Index of Solids in the Mid-Infrared, Gauri Patwardhan1,2, Jared Ginsberg1, M. Mehdi Jadidi1, Xiaohe Gao4, Alexander L. Gaeta2, 1Applied and Engineering Physics, Cornell Univ., USA; 2Applied Physics and Applied Mathematics, Columbia Univ., USA. We report experimental measurements of nonlinear refractive index of solids in the mid-infrared. Here we present our results for fused silica at wavelengths of 2.3 and 3.5 um, and for silicon at 2.3 um.

SF2J.6 • 11:45
Super Absorbing Nano-gap Metasurface With Sub-5-nm Gaps for Extreme Light Confinement, Dengxin Ji1, Alec R. Cheney1, Nan Zhang1, Haomin Song1, Jun Gao2, Xie Shen1, Alec R. Cheney1, Nan Zhang1, Haomin Song1, Jun Gao2, Xie Shen1, Nan Zhang1, Haomin Song1, Jun Gao2, Xie Shen1, Nan Zhang1, Haomin Song1, Jun Gao2, Xie Shen1.

SF2K • Novel Fiber Technology—Continued

SF2K.3 • 11:15
Invited talk Ultra-low Loss Silica Core Fiber for Long Haul Transmission, Yoshiaki Tamura1, Hirotaka Sakuma1, Yoshinori Yamamoto1, Takemi Hasegawa1, Sumitomo Electric Industries Ltd., Japan. We review recent advances in optical fiber technologies that realize ultra-low losses as low as 0.142 dB/km including pure-silica core and reduction of microscopic density fluctuation.

SF2K.4 • 11:30
Integration of high-performance Optoelectronic Nanowire-based Devices at Optical Fiber Tips, Wei Yan1, Tapayoty Das Gupta2, Inês Richard1, Fabien Sorin3, 1Ecole Polytechnique Federale de Lausanne, Switzerland; 2Dept. of Electrical Engineering, Israel Inst. of Technology, Israel. We present an Electro-Opto-Mechanical Stabilized Oscillator based on deep-subwavelength graphene-loaded plasmonic waveguides, Masaaki Ono1,2, Masanori Hata3, Masato Tsunekawa4, Kenso Nozaki5, Hisashi Sumi-kura6, Masaya Notomi4,5, 1Nanophotonics Center, NTT Corporation, Japan; 2NICT, Japan; 3Dept. of Physics, Tokyo Inst. of Technology, Japan; we have demonstrated ultracompact all-optical modulators by deep-subwavelength graphene-loaded plasmonic waveguides ($60 \times 40 \, \text{nm}^2$), and achieved an ultrafast response time ($2.2 \, \text{ps}$) with a substantially small consumption energy ($155 \, \text{nJ}$) for the first time.

SF2K.5 • 11:45
Reconfigurable Optical Circularizer In An Optomechanical Microresonator, Zhen Shen1, Yan-Lei Zhang1, Yuan Chen1, Fang-Wen Sun1, Xu-Bo Zou1, Guang-Can Guo1, Chang-Ling Zou1, Chun-Hua Dong1, 1Univ. of Science and Technology of China, China. We experimentally demonstrate a reconfigurable non-reciprocal device with alternative functions as either a circulator or a directional amplifier via optomechanically induced coherent photon-phonon conversion or gain.

SF2K.6 • 11:45
Broadband Negative Refraction of Hyperbolic Highly Squeezed Graphene Plasmons, Jing Liang1, Xiao Lin1, Yi Yang1, Ido Kaminer1,2, 1Weizmann Institute of Science, Israel; 2Dept. of Electrical Engineering and Computer Science, MIT, USA. We show that highly tunable atomic energy levels can be achieved by exploiting plasmonic Lamb shifts. The shifts can be larger than fine-structure shifts and potentially larger than the Coulomb interactions at certain Fermi energies.

Marriott Salon I & II
Microseconds delay. The acquisition-time in optical sensing, Nebras Alattar, Rusul M. Al-Shammary, Michele Manzo, Katia Gallo, Brian Rodriguez, James Rice, School of Physics, Univ. College Dublin, Ireland; 2School of biosystems & food engineering, Univ. College Dublin, Ireland; 3Laser and Optoelectronics Engineering Dept., Univ. of Technology, Iraq; 4Royal Inst. of Technology, Sweden. The acquisition-time in optical sensors using SERS is vital value. Wide-field SERS is used to perform high-density measurements of GNP photodeposition on a periodically-proton-exchanged-LiNbO₃, which leads to increased sensitivity at ultralow probe concentrations <10⁻⁸ M.

A hyperspectral camera based on ghost imaging via sparsity constraints with a flat-field grating, Liu S. Ying, 1Shanghai Inst of Optics and Fine Mech, China; 2Univ. of Chinese Academy of Sciences, China. We propose a hyperspectral camera based on ghost imaging via sparsity constraints with a flat-field grating, which can greatly improve spectral resolution and optimize the measurement matrix according to optical fields with different wavelengths.
SF2A.6 • 12:00
Stability of cnoidal wave frequency combs in microresonators, Zhen Qi1, Shaokang Wang2, Jose Jaramillo-Willegaz2, Minghao Qi3, Andrew M. Weiner2, Giuseppe D’Aguanno3, Curtis R. Menyuk1; 1Univ. of Maryland Baltimore County, USA; 2Purdue Univ., USA; 3Univ. of Texas at Austin, USA. We determine the regions in the parameter space of microresonators where cnoidal waves (Turing rolls) are stable; solitons are included as a special limit. Conditions to obtain broadband frequency combs are identified.

SF2A.7 • 12:15
Non-Hermiticity in Weakly Coupled Semiconductor Laser Arrays, Zhe Gao1, Matthew T. Johnson2, Harshil Dave3, Bradley J. Thompson1, Kent D. Choquette1; 1Univ of Illinois at Urbana-Champaign, USA; 2USA Air Force Academy, USA. Coupled semiconductor laser arrays are naturally non-Hermitian optical systems. We show that in a weakly coupled semiconductor laser array, the control for gain/loss is dominated by the nonlinearities, rather than simply following the pump profile.

JF2B.5 • 12:00
Optomechanical Quantum Thermometry, Thomas Purdy1, Robinjeet Singh1,2, Nikolai Klimov1,2, Zeeshan Ahmed1, Karen Grutter1,2, Kartik Srinivasan1, Jacob Taylor1,2,3,4, NIST, USA; 2Joint Quantum Inst., USA; 3JQI and QuICS, University of Maryland, USA; 4Lab for Physical Sciences, USA. We demonstrate quantum-backaction-noise-calibrated Brownian motion thermometry as a metrological application of quantum optomechanics. We present recent work as well as on-going efforts to enhance the bandwidth, sensitivity, and range of these devices.

FF2D.6 • 12:00
Vacuum Bloch-Siegert Shift in Landau Polaron with Ultrahigh Cooperativity, Xinwei Li1, Motoaki Bamba2, Qi Zhang2,3,4, Saeed Fallahi1, Geoff Gardner1, Weili Gao1,2, Minhan Lou1, Katsumasa Yoshioka1, Michael J. Manfra1, Junichiro Konoshiba1; 1Dept. of Electrical and Computer Engineering, Rice Univ., USA; 2Dept. of Material Engineering Science, Osaka Univ., Japan; 3Argonne National Labs, USA; 4Dept. of Physics and Astronomy, Purdue Univ., USA. Terahertz spectroscopy of Landau polaritons reveals a shift induced by the ultrastrong coupling of cyclotron-orbiting electrons with the counter-rotating component of the vacuum fluctuation field, evidencing the breakdown of the rotating wave approximation.
magnetic transitions. Her lar librations/rotations, via torque-enhanced Optical Magnetic Force Induces Molecular Rotations, Tuan M. Trinh1, Krishnadu Malhotra1, Elizabeth Dreyer2, Stephen Rand1; 1Univ. of Michigan, USA. Optical interactions involving both electric and magnetic fields in two-photon scattering can stimulate molecular librations/rotations, via torque-enhanced magnetic transitions. Here we report ultrafast observations of magneto-electrically-induced vibrations and rotations.

FF2F.7 • 12:00 Surface-Enhanced Infrared Absorption Spectroscopy via Coaxial Zero-Mode Resonators with Sub-10 nm Gaps, Daehan Yoo1, Daniel A. Mohr1, Ferran Vidal-Codina2, Aurelian John-Herpin2, Minsk Jo3, Sung-Ivan Kim3, Joseph Matson4, Joshua D. Caldwell5, Ngoc-Cuong Nguyen6, Luis Martin-Moreno4, Jaime Perera7, Hatice Altug8, Sang-Hyun Oh1; 1Dept. of Electrical and Computer Engineering, Univ. of Minnesota, USA; 2Inst. of Aeronautical Science, MIT, USA; 3Inst. of BioEngineering, École Polytechnique Fédérale de Lausanne, Switzerland; 4Dept. of Physics, Ajou Univ., South Korea; 5Dept. of Energy Systems Research, Ajou Univ., South Korea; 6Dept. of Mechanical Engineering, Vanderbilt Univ., USA; 7Instituto de Ciencia de Materiales de Aragón, Spain; 8Departamento de Física de la Materia Condensada, CSIC-Universidad de Zaragoza, Spain. We demonstrate high-contrast infrared absorption spectroscopy on ultrathin protein films enabled by coaxial nanogap resonators, where light can be efficiently coupled with vibrational modes of proteins at the zeroth-order Fabry-Perot resonance condition.

FF2F.8 • 12:15 Generating Spin Current from Mid infrared Plasmonic Metamaterial Absorbers, Satoshi Ishii1, Ken-ichi Uchida1, Thang Dao2, Yoshiki Wada3, Eiji Saitoh1, Tadashi Nagao4; 1National Inst. for Materials Science, Japan; 2Tohoku Univ., Japan. Wavelength selective spin current is generated in the mid infrared range by combining plasmonic metamaterial absorbers with platinum/yttrium-iron-garnet spintronic devices. The wavelength selectivity is attributed to the plasmonic resonance of the metamaterial absorber.

FF2G.6 • 12:00 External cavity GaSb-based cascade diode lasers with tuning range of 280 nm centered near 3.13 μm., Meng Wang1, Tao Feng1, Takashi Hosoda1, Gela Kipished2, Jiang Jiang1, Leon Shiterengas3, Gregory Belenky4, Stony Brook Univ., USA. Cascade type-I quantum well GaSb-based laser heterostructures with broad optical gain demonstrated tuning from 2.99 to 3.27 μm (above 35 meV) in Littrow external cavity configuration. The devices generated up to 5 mW of the narrow spectrum output power in continuous wave regime at room temperature.

FF2G.7 • 12:15 Pure Amplitude or Frequency Modulation of a Quantum Cascade Laser by Use of an Integrated Heater, Atif Shehzad1, Pierre Brochard1, Renaud Matthey1, Alfredo Biamatto2, Stephane Blaser2, Tobias Gresch3, Richard Maulin3, Antoine Muller3, Thomas Südmeier3, Stephane Schilt1, 1Univ. of Neuchatel, Switzerland; 2Alpes Lasers, Switzerland. We present pure amplitude and frequency modulation realized electrically in a quantum cascade laser (QCL) equipped with an integrated heater (IH), achieved by simultaneously modulating the QCL and IH currents with proper amplitudes and phases.

FF2H.4 • 12:00 Diffusion in Translucent Media, Azriel Z. Genack1, Zhou Shi1,2, Queens College of the City Univ. of New York, USA; 3Physics, The Graduate Center of the City Univ. of New York, USA; 4Chiral Photonics, USA. We show in optical measurements and simulations that the scaling of transmission, intensity profiles of transmission eigenchannels, and the statistics of transmission eigenvalues are the same in translucent and opaque media.
SF2I.7 • 12:00  
**Engineering the Coupling Between the Berreman Mode and Nanobar Antennas in Epsilon-near-zero Materials**, Owen Domínguez1, Daniel Wasserman1, Anthony Hoffman1; 1Electrical and Computer Engineering, Univ. of Texas at Austin, USA; 2Electrical Engineering, Univ. of Notre Dame, USA. We design, fabricate and characterize the coupling between nanobar antennas and optical modes on epsilon-near-zero thin AlN films. Reflection measurements and simulations indicate that the interaction can be controlled via incident angle and antenna length.

SF2I.8 • 12:15  
**Memetic Algorithm Optimization of Thin-film Photonic Structures for Thermal and Energy Applications**, Yu Shi1, Wei Li1, Aaswath Raman1, Shanhui Fan1; 1Electrical Engineering, Stanford Univ., USA. We present an effective thin-film optimization method using the memetic algorithm for thermal and energy applications. This method rigorously treats broadband material dispersion and produces structures with superior performances than their counterparts in the literature.

SF2J.6 • 12:00  
**Integrated Brillouin microcavity laser with sub-milliwatt threshold**, Yi Yang1, Baojiang Shen1, Haining Wang1, Qifan Yang1, Xu Yi1, Seung Hoon Lee1, Dong Yoon Oh1, Kerry Vahala1; 1California Inst. of Technology, USA. A Brillouin laser featuring an ultra-high-Q silica cavity monolithically integrated with a silicon-nitride waveguide is demonstrated. The device features a sub-milliwatt threshold pump power and provides high-coherence output for on-chip sources, gyroscopes, and microwave generation.

SF2J.7 • 12:15  
**Electromechanically Induced Brillouin Scattering in AlN Optomechanical Waveguides**, Qiuyu Liu1, Huan Li1, Shuo Li1; 1Univ. of Minnesota, USA. We experimentally demonstrate electromechanically induced Brillouin scattering in a photonic waveguide fabricated on aluminum nitride thin film, and show single sideband modulation due to the non-reciprocal acousto-optic phase matching conditions.

SF2J.8 • 12:15  
**Coupling Single Defect Emissions From 2-Dimensional Semiconductors into Long-Range Propagating Gap Plasmons in Metal-Insulator-Metal Waveguides**, Subhajit Dutta1, Tao Cai1, Edo Waks1; 1Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, College Park, USA. We demonstrate coupling of single defect emissions from the 2-D transition metal dichalcogenide (TMD), Tungsten diselenide (WSe2) into propagating surface plasmon modes in lithographically fabricated silver-air-silver, metal-insulator-metal (MIM) waveguides.
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<td><strong>CLEO: Applications &amp; Technology</strong></td>
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<td><strong>AF2M • Imaging &amp; Microscopy—Continued</strong></td>
<td><strong>SF2N • Ultrafast Oscillators—Continued</strong></td>
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<td><strong>AF2Q • A&amp;T Topical Review on Time-Stretch Technology: Principles and Applications I—Continued</strong></td>
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<td><strong>AF2M.7 • 12:00</strong> Increasing the Speed of CCD-based Thermoreflectance Imaging: An Experimental and Theoretical Demonstration, Mark Hallman¹, Kyle Allison¹, Johanna Hardin², Ami Ratsunskaya¹, Janice A. Hudgings¹; ¹Physics and Astronomy Dept., Pomona College, USA; ²Mathematics Dept., Pomona College, USA. To increase the speed of thermoreflectance imaging, we derive detailed statistical models of both the conventional imaging algorithm and our proposed higher speed technique, and we experimentally confirm both the models and resulting speed enhancement.</td>
<td><strong>SF2N.6 • 12:00</strong> Nonlinear-Mirror Modelocked 323-fs Thin-Disk Oscillator, Francesco Saltarelli¹, Andreas Diebold¹, Ivan J. Graumann¹, Christopher R. Phillips¹, Ursula Keller¹; ETH Zurich, Switzerland. We present the first nonlinear-mirror modelocked thin-disk laser, delivering 21 W at 323 fs pulse duration. This opens a new chapter for the nonlinear-mirror technique which, until now, only modelocked few-ps bulk oscillators.</td>
<td><strong>FF2P.4 • 12:00</strong> Observation of selection rules for circularly polarized high harmonics from a solid, Nan-yuki Saito¹, Peyyu Xia¹, Faming Lu¹, Nobuhisa Ishii¹, Tenuto Kanai¹, Jiro Itatani¹; 'Univ. of Tokyo, Japan. We report on the observation of selection rules for circularly polarized high harmonics from solids driven by single-color circularly polarized mid-infrared pulses. Our result offers a novel way to produce circularly polarized short wavelength light.</td>
<td><strong>AF2Q.4 • 12:00</strong> Ultrafast Optical Sampling Spectroscopy Based on Dispersive Fourier Transform, Srikamal Soundararajan¹, Lin Yang¹, Lingze Duan¹; 'Univ. of Alabama in Huntsville, USA. Time-wavelength optical sampling combines ultrafast optical sampling and dispersive Fourier transform and has been demonstrated for real-time absorption spectroscopy with a low-pressure C₃H₄ sample.</td>
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<td><strong>AF2M.8 • 12:15</strong> High-Resolution and Real-Time W-Band Imaging Radar Based on Photonics for Security Check, Shaowen Peng¹, Shangquan Li¹, Xuedi Xiao¹, Dexin Wu¹, Xiaoxiao Xue¹, Xiaoping Zheng¹; 'Tsinghua National Lab for Information Science and Technology, Dept. of Electronic Engineering, Tsinghua Univ., China. We present a photonics-based W-band imaging radar for non-cooperative and non-contact security check with a two-dimension imaging resolution of ~1.9cm × ~1.6cm and an image frame rate of 200 fps.</td>
<td><strong>SF2N.7 • 12:15</strong> Repetition-Rate Stabilized 10-GHz Straight-Cavity SESAM-Modelocked Yb:CALGO Laser, Leonard M. Krüger¹, Aline S. Mayer¹, Christopher R. Phillips¹, Valentin J. Wittwer¹, Olga Razskazovskaya², Thomas Sudmeyer², Ursula Keller¹; ETH Zurich, Switzerland; 'Univ. of Neuchatel, Switzerland. We present a repetition-rate stabilized SESAM-modelocked 10-GHz Yb:CALGO laser using a self-defocussing straight-cavity that suppresses Q-switching and delivered 171 fs pulses at 1.44 W, and even 104 fs at 0.81 W with a dispersion-compensating output coupler.</td>
<td><strong>FF2P.5 • 12:15</strong> A real space perspective of high harmonic generation in crystalline solids, Harshit Lakhota¹, Minjie Zhan¹, Hae-Yong Kim¹, Eleftherios Goulielmakis¹; 'Max Planck Inst. of Quantum Optics, Hans-Kopfermann-Str. 1 D-85748, Garching, Germany. We present a real space picture for high harmonic generation in solids. We studied the crystal orientation dependence of extreme ultraviolet high harmonics in MgF₂.</td>
<td><strong>AF2Q.5 • 12:15</strong> Dynamic Dispersion via Acousto-Optic Angular Excitation of Multimode Waveguides, Jacky Chan¹, Sebastian Karpf¹, Bahram Jalali¹; 'Univ. of California, Los Angeles, USA. To enable tunable temporal engineering in optical communications and processing systems, we integrate RF and wavelength control of mode excitation angle in a multimode waveguide. Dynamic tunability of dispersion is demonstrated over 1.27 ns and 40 nm of optical bandwidth.</td>
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**12:30–14:00 Lunch Break (on your own)**

Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.
Graphene nano-optomechanical resonators on an integrated photonic platform, Xiang X1, Zefeng Chen1, Jingwen Ma1, Jian-Bin Xu1, Xiankai Sun1; 1The Chinese Univ. of Hong Kong, Hong Kong. Graphene nanophotonic resonators are demonstrated for the first time on an integrated photonic platform. A resonator made with effective mass 4.5 fg and frequency 8.1 MHz was measured in air with mechanical Q of ~28.

The LIGO Squeezed Light Upgrade, Lee McCuller1, 1MIT Kavli Inst. for Astrophysics and Space Research, USA. Squeezed light sources are being commissioned for operation during the third observing run of advanced LIGO. I overview the implementation and optomechanical tradeoffs of continuously squeezed states for interferometers as gravitational wave observatories.

High Efficiency Aperiodic Metasurfaces Based on Variable Phase Shifting Element Spacing, Qiajia Jiang1, Zhihao Fan1, Jonathan Fan1; 1Stanford Univ., USA. We report new method for designing high efficiency aperiodic metasurfaces by approximating the desired phase profile with linear sections and optimizing the spacing between subwavelength-scale phase shifter elements within each section.

Multifunctional Silicon Metagratings, David Sill1, Jianyi Yang1, Sage Doshay1, Evan W. Wang1, Thaibao Phan1, Jonathan Fan1; 1Stanford Univ., USA. We design highly efficient multi-functional silicon metagratings based on adjacent-based optimization and experimentally demonstrate devices exhibiting negative refraction and wavelength sorting capabilities.

Solving Equations with Waves in Collections of Mach-Zehnder Interferometers, Mario Juran-Mencaglia1, Nasim Mahmoodi Estakhri1, Brian Edwards1, Nader Engheta1; 1Univ of Pennsylvania, USA. We present how waves in ensembles of Mach-Zehnder interferometers (MzIs) can be utilized to perform mathematical operations and solve integral equations with kernels that can be reconfigured by adjusting phases in such MzIs.

Optically Levitated Torque Sensor and Ultrastiff Nanomechanical Rotor, Tongcang Li1, Jonghoon Ahn1, Zhijun Xu1, Jaehee Bang1; 1Purdue Univ., USA. We propose to optically levitate a nonspherical nanoparticle in vacuum to detect the quantum vacuum torque (Casimir torque). We have levitated nonspherical nanoparticles in vacuum and driven them to mechanically rotate at several hundred MHz.

FF3C.1 • 14:00
High Efficiency Aperiodic Metasurfaces Based on Variable Phase Shifting Element Spacing, Qiajia Jiang1, Zhihao Fan1, Jonathan Fan1; 1Stanford Univ., USA. We report new method for designing high efficiency aperiodic metasurfaces by approximating the desired phase profile with linear sections and optimizing the spacing between subwavelength-scale phase shifter elements within each section.

FF3C.2 • 14:15
Multifunctional Silicon Metagratings, David Sill1, Jianyi Yang1, Sage Doshay1, Evan W. Wang1, Thaibao Phan1, Jonathan Fan1; 1Stanford Univ., USA. We design highly efficient multi-functional silicon metagratings based on adjacent-based optimization and experimentally demonstrate devices exhibiting negative refraction and wavelength sorting capabilities.

FF3C.3 • 14:30
Solving Equations with Waves in Collections of Mach-Zehnder Interferometers, Mario Juran-Mencaglia1, Nasim Mahmoodi Estakhri1, Brian Edwards1, Nader Engheta1; 1Univ of Pennsylvania, USA. We present how waves in ensembles of Mach-Zehnder interferometers (MzIs) can be utilized to perform mathematical operations and solve integral equations with kernels that can be reconfigured by adjusting phases in such MzIs.

FF3D.1 • 14:00
Selective Observation of Nonradiative Electronic States in Silicon-Vacancy Centers in Diamond, Christopher L. Smallwood1, Matthew W. Day1, Travis Autry1, Geoffrey M. Diederich1, Ronald Ulbricht1, Tim Schröder1, Edward Bielevator1, Mark E. Siemens1, Steven T. Cundill1, 1Physics, Univ. of Michigan, USA; 2JILA, Univ of Colorado / NIST, USA; 3Physics, Univ. of Colorado, USA; 4Physics and Astronomy, Univ. of Denver, USA; 5Electrical and Computer Science, MIT, USA; 6Sandia National Labs, USA. Multidimensional coherent spectroscopy measurements of SiV centers in diamond reveal a previously unexamined population of silicon-based defect states, which are not detected in photoluminescence and which exhibit a substantial degree of inhomogeneous broadening.

FF3D.2 • 14:15
Exploring the State Structure of Quantum Dot/Quantum Well Systems by Two-Dimensional Coherent Spectroscopy with White Pulses, Mirza Kolarzik1, Sophia Helzef1, Kevin Thommes1, Bastian Herzog1, Nina Oswichimkow1, Ulrike K. Woggon1, 1LOAP, Technical Univ. Berlin, Germany. Coulomb-bound states of mixed dimensionality (Crossed Excitons) are directly observed in InGaAs quantum dot/quantum well systems by coherent two-dimensional spectroscopy. The setup incorporates collinear geometry, inversion control by electrical carrier injection, and white supercontinuum pulses.

FF3D.3 • 14:30
Vibrational Interferometry Enables Single-Scan Acquisition of all a 3x3 Multi-Dimensional Coherent Spectral Maps, Travis Autry1, Galen Moody1, Corey McDonald1, James W. Fraser1, Richard Mirin1, Kevin L. Silverman1, 1NIST, USA; 2Queen’s Univ., Canada; 3Physics, Univ. of Colorado, USA. We demonstrate a new method for multidimensional coherent spectroscopy of nanostructures. We use a heterodyne technique implemented with a confocal microscope to record the amplitude and phase of all degenerate third-order wave-mixing processes.

FF3D.4 • 14:45
Sub-Cycle Effects in Carrier-Envelope-Phase-Sensitive Photoemission from Plasmonic Nanoparticles, William Putnam1,2, Phillip D. Keatley1, Richard Hobbs1,3, Praful Vasireddy1; 1MIT Kavli Inst. for Astrophysics and Space Research, USA; 2JILA, Univ of Colorado / NIST, USA; 3Physics, Trinity College Dublin, Ireland; 4Physics, Univ. Of Hamburg, Germany. We study carrier-envelope-phase-sensitive (CEP-sensitive) photoemission from plasmonic nanoparticles illuminated with few-cycle laser pulses of varying intensity. The CEP-sensitive photocurrent exhibits antiresonant-like behavior due to competing emission from different optical half-cycles.
FF3E • 14:00
Optical Refrigeration Advances: Solid-State Cryocoolers and Athermal Disk Laser
Mansoor Sheik-Bahae1, Junwei Meng1, Zhou Yang1, Alexander Albrecht1, Eric Lee1, Richard Epstein1, Markus Hehlen1,2, Univ. of New Mexico, USA; 3Los Alamos National Lab, USA. Having reached record temperatures <90K in Yb:YLF, cryogenic optical refrigeration of an arbitrary load has been demonstrated for the first time. In parallel, research on radiation-balanced-lasers has led to demonstration of athermal rare-earth-doped thin-disk lasers.

FF3F • 14:00
Optomechanical Interactions and Single Particle Tracking
Presider: Luca Sapienza; Univ. of Southampton, UK

FF3F1 • 14:00
Experimental realization of Feynman’s ratchet with an optically trapped microsphere
Jaehoon Bang1, Rui Pan1, Thai M. Hoang2, Jonghoon Ahn3, Christopher Jarzynski1, Hai Tao Quan4, Tongcang Li5, Purdue Univ., USA; 2Peking Univ., China; 3Univ. of Maryland, USA. Feynman’s ratchet is a microscopic heat engine that was proposed by Richard Feynman. Here we experimentally realize Feynman’s ratchet for the first time with a colloidal particle in a feedback controlled one dimensional optical trap.

FF3F2 • 14:15
Opto-Thermophoretic Trapping in Simple Polar Liquids
Xiaolei Peng1, Linhan Lin1,2, Yuebing Zheng1,2, Materials Science & Engineering Program and Texas Materials Inst., The Univ. of Texas at Austin, USA; 2Dept. of Mechanical Engineering, The Univ. of Texas at Austin, USA. We experimentally demonstrate opto-thermophoretic trapping of particles in several simple polar liquids with a dominant interfacial entropy-driven force, which is determined by the surface chemistry of the particles and physical properties of the solvents.

FF3F3 • 14:30
Interaction of light with thin liquid membranes
Anatoly Patsyk1, Miguel Bandres1, Mordechai Segev1, 2Technion-Israel Inst. of Technology, Israel. We study the interaction of light with liquid thin soap membranes experimentally. We observe optical beams form liquid waveguides, bulges, and trigger nucleation of crystals in the membrane due to absorption and surface tension effects.

FF3F3 • 14:30
Single Particle Tracking: Recent Advances in Methods and Applications, Christie Landes1, Rice Univ., USA. The temporal resolution of single-molecule spectroscopy is limited by the frame rate of scientific cameras. We have developed a novel imaging technique to improve the temporal resolution by 20 times and to image subframe events.

FF3G • 14:00
High-Power, High-Efficiency Mid-Infrared Quantum Cascade Lasers
Presider: Seungyong Jung; Univ. of Texas at Austin, USA

FF3G1 • 14:00
Phase Measurement of a QCL Comb in the Mid-IR
Matthew Singleton1, Pierre Jouy1, Matthias Beck1, Jerome Fast1, ETH Zuerich, Switzerland. QCL combs arise through cascaded four-wave mixing, with simulations suggesting a strongly frequency modulated field. Experimentally, we show that QCL combs can possess a linear chirp, and demonstrate that the comb states are reproducible.

FF3G2 • 14:30
Brillouin cooling in a linear waveguide through dispersive symmetry breaking
Nils T. Otterstrom1, Eric Kittlaus1, Ryan O. Behunin1, Peter T. Rakich1, Applied Physics, Yale Univ., USA. We experimentally demonstrate Brillouin cooling in a linear waveguide for the first time. Leveraging the dispersive symmetry-breaking of inter-modal Brillouin scattering, we achieve Brillouin cooling with an optical cavity or discrete acoustic modes.

FF3G3 • 14:45
Tailoring Spatial Intensity-Correlations of Speckle Patterns
Nicholas Bender1, Hasan Yilmaz1, Yaron Bromberg2, Hui Cao1, Yale Univ., USA. We demonstrate the temporal focusing of optical pulses through multimode fibers with strong mode mixing. The focusing efficiency varies strongly with the focus time, which can be explained by the time-dependent correlations between output channels.

FF3H • 14:00
Wavefront Shaping with the Generalized Wigner-Smith Operator
Presider: Viktoria Babicheva; Georgia State University, USA

FF3H1 • 14:00
Wavefront Shaping with the Generalized Wigner-Smith Operator, Philipp Ambichl1, Andre Brandstötter1, Matthias Kühmayer1, Michael Horndycki1, Julian Böhm1, Ulrich Kuhl1, Stefan Rotter1, 2Technische Universität Wien, Austria; 3Université Côte d’Azur, France. We introduce a wave front shaping protocol based on a generalization of the Wigner-Smith time-delay operator. This tool is used to create light fields with desired properties at a predetermined target embedded inside a medium.

FF3H2 • 14:15
Temporal Focusing of Total Transmission through Multimode Fibers with Random Mode Mixing, Wen Xiong1, Cha Wei Hsu1, Hui Cao1, Yale Univ., USA. We demonstrate the temporal focusing of optical pulses through multimode fibers with strong mode mixing. The focusing efficiency varies strongly with the focus time, which can be explained by the time-dependent correlations between output channels.

FF3H3 • 14:30
Constant Pressure Sound Waves in Non-Hermitian Disordered Media, Etienne Rivet1, Andre Brandstötter1, Konstantinos Makris1, Herve Lissek2, Stefan Rotter1, Romain Fleury1, Technische Universität Wien, Austria; 2EPL, Switzerland; 3Univ. of Crete, Greece. Theory shows that waves with constant intensity can perfectly transmit through a disordered medium with a tailored distribution of gain and loss. We present the first experimental realization of this concept using an acoustic waveguide.

FF3H4 • 14:45
Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.
**SF3.1 • 14:00**
5 kW 30/600Yb-doped Aluminumophosphosilicate Laser Fiber, Cong Gao1, Chengyu Li1, Yuying Wang1, Huan Zhan1, Kun Peng1, Lilhua Zhang1, Li Ni1, Xiaolong Wang1, Lei Jiang1, Yuwei Li1, Shuang Liu1, Jianjun Wang1, Feng Jing1, Aoxiang Lin1, 1Laser Fusion Research Center, China Academy of Engineering Physics, China. A 30/600 Yb-doped aluminumophosphosilicate fiber was fabricated and presented 5.17 kW laser output at 1064 nm with slope efficiency of 85.69%. Stable operation at 5 kW was demonstrated for 10 hours.

**SF3.2 • 14:15**
Novel Fabrication Technique for Highly Efficient Tm-doped Fibers, Norberto J. Ramirez-Martinez1, Martin M. Nuñez-Velazquez1, Andrey A. Uminkov1, Jayanta K. Sahu1, 1Optoelectronics Research Centre, Univ. of Southampton, UK. Thulium-doped aluminosilicate fiber fabricated by MCVD process combining both solution doping and gas phase. Laser characterization report a slope efficiency of ~72% with respect to launched pump power at 2068nm emission wavelength.

**SF3.3 • 14:30**
Cladded Single Crystal Fibers for All-Grating Fiber Lasers, Brandon Shaw1, Shyam Bayya1, Wooshong Kim1, Jason Myers1, Dan Rhonehouse1, Noor Qadri1, Charles Askins1, John Polee1, Rajesh Thapa1, Dan Gibson1, Rafael Gattass1, Joseph Kolis1, Brad Stadler1, Jas Sanghara1, 1US Naval Research Laboratory, VX-Naval aluminosilicate fiber fabricated by MCVD process combining both solution doping and gas phase. Laser characterization report a slope efficiency of ~72% with respect to launched pump power at 2068nm emission wavelength.

**SF3.4 • 14:45**
Hybrid mode-locked erbium-doped fiber laser with black phosphorus saturable absorber, Yuwei Hu1, Xinjin Jin1, Guohua Hu1, Meng Zhang1, Qiong Wu1, Zheng Zheng1, Tawfique Hasan2, 1Beihang Univ., China; 2Cambridge Graphene Centre, UK. We demonstrate a self-starting erbium-doped fiber laser mode-locked by an inkjet-printed black phosphorus saturable absorber, delivering 102 fs pulses with 40 nm spectral width. Our work highlights the potential of BP-based devices for future photonic technologies.

**SF3.5 • 14:45**
Waveguide Polariometry using Belinfante Forces, Vincent Gims1, J-Liu Liu1, Alan She1, Federico Capasso1, 1Harvard SEAS, USA; 2Applied Physics, Vrije Universiteit Brussel, Belgium; 3MIT Lincoln Lab, USA. We reveal the surprising polarization dependence of lateral forces acting on resonant Mie particles in evanescent fields. This effect can be utilized to retrieve the polarization state of light inside birefringent waveguides.

**SF3.6 • 14:15**
Optomechanically coupled glass nanospike array on the endface of a multicore fiber, Zhe Wang1, Shangrui Xie1, Xin Jiang1, Ricardo Perennou1, Johannes R. Koehler1, 1School of Engineering, Georgia Institute of Technology, USA. We report the fabrication and characterization of an optomechanically coupled array of glass nanospikes on the endface of a germanate multicore fiber. Strong optical gradient forces drive the mechanical motion of the free-standing nanospikes.

**SF3.7 • 14:15**
Soft Optical Contact Sensing based on On-Demand Drawn, High Aspect Ratio Elastomeric Micropillars, Jiang Li1, Jiaying Kim1, 1Iowa State Univ., USA. We demonstrate on-demand fabrication of high aspect-ratio, microsphere-tipped elastomeric micropillars on various structures with uncommon geometries. A fiber optic contact sensor is realized by integrating a micropillar onto the end facet of an optical fiber.

**SF3.8 • 14:15**
Spectral dynamics of dual-color-soliton intracavity collision, Yuan Wei1, Bowen Li1, Xiaoming Wei2, Ying Yu1, Kenneth Kin-Yip Wong1, 1Univ. of Hong Kong, Hong Kong; 2California Inst. of Technology, USA. By using the dispersive Fourier transform (DFT), we unveil the collision-induced soliton spectral dynamics, which features evolving spectral fringes over the soliton main lobe, and the rebuilding of Kelly sidebands with wavelength drifting.

**SF3.9 • 14:15**
Spectroscopic efficiency of mid-infrared absorption spectroscopy with a Plasmonic Filter Array, Benjamin J. Craig1, Vivek R. Shrestha1, Jaquin Meng1, Kenneth B. Crozier1, 1Univ. of Melbourne, Australia. We demonstrate mid-infrared plasmonic filters. We experimentally determine the spectrum of a mid-infrared light source using an algorithm whose inputs are the total power transmitted by each filter and the transmission spectrum of each filter.

**SF3.10 • 14:15**
Phase-type zigzag grating for suppression high order diffraction, Zhen Liu1,2, Tanhash Pu3,4, Lina Shi1, Changxing Xie1, 1Inst. of Microelectronics of CAS, China; 2Univ. of Chinese Academy of Sciences, China. We present a novel design of phase-type diffraction grating for spectrum measurement from soft x-ray to far infrared. The 0, 2n, 3n order diffractions can be suppressed and the absolute diffraction efficiency is 27.72%.

**AF3M.1 • 14:00**
Experimental Demonstration of Mid-Infrared Computational Spectroscopy with a Plasmonic Filter Array, Benjamin J. Craig1, Vivek R. Shrestha1, Jaquin Meng1, Kenneth B. Crozier1, 1Univ. of Melbourne, Australia. We demonstrate mid-infrared plasmonic filters. We experimentally determine the spectrum of a mid-infrared light source using an algorithm whose inputs are the total power transmitted by each filter and the transmission spectrum of each filter.

**AF3M.2 • 14:15**
Folded planar metasurface spectrometer, MohammadSadeegh Faraji-Dana1, Ehsan Arbab1, Amir Arbab1, Seyyedeh Mahsa Kamali1, Hyongunh Kwon1, Andre Parson1, 1T. J. Watson Lab of Applied Physics, California Inst. of Technology, USA; 2Electrical and Computer Engineering, Univ. of Massachusetts Amherst, USA. We present a folded planar spectrometer based on dielectric metasurfaces operating in the near-IR range(760nm- 860nm) and achieving ~12nm spectral resolution. The planar and compact shape makes the demonstrated spectrometer well-suited for applications requiring integrated and portable spectrometers.
SF3N.1 • 14:00
6 GHz Repetition Rate Photocathode Laser for Multi-Bunch Operation of a Relativistic Electron Gun, Chen Li1, Lutz Winkelmann1, Ingrid Hart1, 1Deutsches Elektronen-Synchrotron, Germany. We report a new photocathode laser with 6 GHz repetition rate, generated by an electro-optic modulator comb. The laser is amplified by an Yb fiber amplifier to 10 W and will be converted to UV for photoelectron generation.

SF3N.2 • 14:15
Space-Time Control of Broadband Light in a Multimode Fiber, Bohao Liu1, Andrew M. Weiner1, 1Purdue Univ., USA. Strong modal dispersion of a highly multimode fiber causes a space-time scrambled output field. Using pulse shaping, impulse responses at specific output spots can be characterized and spatial-temporal focusing can be achieved.

SF3N.3 • 14:30
Generation of 1.4-fs Ultrashort Single-Cycle Pulses with a Repetition Rate Exceeding 100 THz by Arbitrarily Manipulating Amplitude and Phase, Chuan Zhang1, Kazumichi Yoshii1,2, Dmitry Tregubov1, Chiaki Ohs1, Masaru Suzuki1, Kaoru Minoshima1,2, Masayuki Katsuragawa1,2, Kazumichi Yoshii1,2, Daniel Gubbins1,2, 1The Univ. of Electro-Communications, Japan; 2JST, ERATO MINOSHIMA Intelligent Optical Synthesizer Project (IOS), Japan. We report a new optical technology which enables arbitrarily manipulating amplitudes and phases of a highly-discrete optical spectrum and its application to generating a train of 1.4-fs ultrashort pulses with a repetition-rate exceeding 100 THz.

SF3N.4 • 14:45
Carrier-Envelope Phase Control and Single-Cycle Autocorrelation in Attosecond Coherent Nanotransport, Markus Ludwig1, Tobias Rybka1, Felix Ritzkowski1, Alfred Leitenstorfer1, Daniele Binda1, 1Univ. of Konstanz, Germany. We employ a pair of single-cycle near-infrared pulses to control coherent transfer of single electrons between the contacts of a plasmonic nanocircuit. As a result, attosecond highly nonlinear phenomena manifest themselves at pulse energies.

SF3N.5 • 14:00
HHG in Solids: Influence of Band Structure on Harmonic Spectral and Temporal Properties, Mette B. Gaarde1, 1Louisiana State Univ., USA. I will discuss how the spectral and temporal properties of harmonic radiation from solids are closely connected to their band structure. I will compare predictions for yields, cutoff energies and orientation-dependence to recent experimental results.

SF3N.6 • 14:15
Disentangling surface and bulk contributions to high-harmonic generation from solids, Giulio Vampa1, Hanhe Liu1, Tony F. Heinz1, David Reis1, 1Stanford PULSE Inst., USA; 2Dept. of Applied Physics and Photon Science, Stanford Univ., USA. We demonstrate that surface space-charges alter the large amplitude oscillations of electron-hole pairs during high-harmonic generation from silicon, resulting in the emission of weak even-order harmonics. Our results extend surface non-linear optics to the non-perturbative regime.

SF3N.7 • 14:30
Enhanced Solid-State High-Harmonic Generation from a Silicon Metasurface, Hanhe Liu1,2, Cheng Guo1,2, Giulio Vampa1, Jingyuan Linda Zhang1,2, Tomas Sarmiento1,2, Meng Xiao1, Philip Bucksbaum1,2, Jelena Vuckovic1,2, Shanhui Fan1,2, 1Stanford PULSE Inst., USA; 2Physics, Stanford Univ., USA; 3UVL, USA. We report resonantly enhanced non-perturbative high-harmonic emission by more than two orders of magnitude from a Si metasurface that possesses a Fano-like resonance resulting from a classical analog of electromagnetically induced transparency.
We demonstrate a wide-range tunability of microring resonators in a GST-on-Silicon platform, which allows for low-loss integrated photonics in the ultraviolet and visible spectrum.

We describe the fabrication and testing of photonic circuits using a III-V LED light source coupled to waveguide-integrated WSI single photon detectors for use in advanced computing and on-chip quantum optics experiments.

We present evidence of non-Markovian dynamics of CdSe colloidal quantum dots is determined by purely optical means. This capability allows maximizing the Zeeman interaction in a magnetic field which is vital e.g. for efficient and ultrafast single-photon amplification.

We develop a new technique combining wavelength-scale diffractive elements with robust metasurfaces. We implement robustness control in topology-optimized metasurfaces and show that robust metasurfaces are relatively insensitive to geometric erosion and dilation. We also explore the physical mechanisms enabling robustness through a coupled mode analysis.

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Investigation of solid state laser cooling in Ytterbium-doped silica fibers, Esmaeil Mobini¹, Mostafa Pyskohan², Behnam Aboi³, Arash Mafi¹; ¹Univ. of New Mexico, USA. The possibility of solid-state laser cooling (SSL) in a single mode Yb-doped silica fiber is investigated. The results show that the material is a viable candidate for SSL and radiation-balanced lasers.

The possibility of solid-state laser cooling (SSL) in a single mode Yb-doped silica fiber is investigated. The results show that the material is a viable candidate for SSL and radiation-balanced lasers.
SF3J.5 • 15:00
Crystal growth, spectroscopy and femtosecond laser performance of Tm:Na2CNGG disordered garnet crystal, Zhongben Pan1, Yicheng Wang2, Yongguang Zhao3,4, Huaqin Dai5, Xianjun Dai5, Huaqiang Cai6, Ji Eun Baek7, Sun Young Choi7, Fabian Rotermund8, Xavier Mataos9, Josep Maria Serres9, Pavel Loiko8, Ursula J. Gibson1,2; Pavel Loiko6, Uwe Griebner1, Valentin Petrov1,10; Mihran Abajian10; Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany; 1Inst. of Chemical Materials, China Academy of Engineering Physics, China; 2Jiangsu Key Lab of Advanced Laser Materials and Devices, Jiangsu Normal Univ., China; 3Dept. of Physics, Korea Advanced Inst. of Science and Technology (KAIST), South Korea; 4Física i Cristallografia de Materials i Nanomaterials (FCM-FCNAI)-EMaS, Dept. Química Física i Inorgànica, Universitat Rovira i Virgili (URV), Campus Sesclades, Spain, 11ITMO Univ., Russia. We report on the crystal growth, spectral properties, and mode-locked laser operation of Tm:Na2CNGG, generating pulses as short as 84 fs at ~2018 nm using single-walled carbon nanotubes as a saturable absorber.

SF3J.6 • 15:15
Reduced loss in SiGe-core optical fibers, Truyen Sargard1, Korbinian Mühlerberger, Wu Wei1, Xiong Yang1, Thomas Hawkins1, John Ballato1, Frederik Laurell1, Michael Fokine1, Jr., Ursula J. Gibson1; 1Norges Teknisk Naturvitenskapelige Univ, Norway; 2Applied Physics, KTH, Sweden. We investigate CO2 laser processing of SiGe-core glass fibers, and show that homogeneous, low optical loss cores can be made. Coaxial Ge-rich centers within the semiconductor cores can also be fabricated.

SF3J.7 • 15:30
Efficient High Power Yellow Tb3+-LiLuF4 Laser, Elena Castellano-Hernandez1, Maksim Dzemesh1, Hiroki Tanaka2, Christian Kränkel1,3; 1Leibniz Inst. for Crystal Growth, Germany; 2Dept. of Electronics and Electrical Engineering, Koenig Univ., Japan; 3Inst. of Laser Physics, Univ. of Hamburg, Germany. We experimentally demonstrate mid-infrared polarization rotators in silicon-on-sapphire at wavelength ~4.55 μm to enable integration of quantum cascade lasers and detectors with slotted photonic crystal waveguide gas sensors. Polarization selective grating couplers are also demonstrated.

SF3K.4 • 15:00
Figure-9 Fiber Laser with Phase Bias by Frequency Shifter, Yuki Shirakura1, Koji Takiguchi1, Shinji Yamashita1; 1The Univ. of Tokyo, Japan. We propose a novel figure-9 fiber laser using a frequency shifter to produce phase bias. Mode-locking operation is successfully archived, and arbitrary phase bias can be produced by changing the frequency shift.

SF3K.5 • 15:15
Reduction of Intensity Noise in Mode-Locked Er-Fiber Oscillators and Amplifiers by Optical Bandpass Filtering, Dohyun Kim1, Shin-shuang Zhang1, Jungwoo Kim1; 1Korea Advanced Inst. of Science & Tech, South Korea. We report an all-fiber mid-infrared Er-fiber oscillator and amplifier with a high figure-of-merit of ~15 GHz – 1 MHz) of mode-locked Er-fiber oscillator output is demonstrated by optical bandpass filtering. Optical filtering also reduces the Er-doped fiber amplifier output RIN by ~10 dB.

AF3M.4 • 15:15
Wavefront Aberration Compensation Method to Fabricate Large Gratings with Low Spacing Error Using Broad-beam Scanning Exposure, Yuxuan Zhao1, Liyang Zeng1, Yabin Wu1, Xinghang Yang2, Tianyu Yang3, Jie Qiu3; 1Tsinghua Univ., China. A wavefront aberration compensation method is proposed to reduce the spacing error accumulation in broad-beam scanning exposure. A 200 mm × 100 mm grating with a spacing error of 0.07 λ was fabricated.
Flexible Width Nyquist Pulse based on a Single Mach-Zehnder Modulator, Jianqi Hu, Simon J. Fabbri, Camille-Sophie Bres, EPFL, Switzerland. We present a Nyquist pulse generation technique based on a single Mach-Zehnder modulator driven by a multi-harmonic electrical signal. The direct control of the RF components yields a range of 10 GHz sinc-shaped pulse train.

We demonstrate recovery of broadband optical waveforms from in-band noise by linear coherent spectral energy re-distribution, Benjamin G. Crockett, Luis Romero Cortés, Jose Azana, INRS, Canada. We introduce a novel concept for in-band noise mitigation applicable to non-repetitive events, through linear spectral and temporal phase control. We demonstrate recovery of broadband optical waveforms, with unknown characteristics, buried under noise.

We present a Nyquist pulse generation technique based on a single Mach-Zehnder modulator driven by a multi-harmonic electrical signal. The direct control of the RF components yields a range of 10 GHz sinc-shaped pulse train.

Strong-Field Polarization-State Control of Higher Harmonics Generated in Crystalline Solids, Nicola Klenke1,2, Nicolas Tancogne-Dejean1, Giulio M. Rossi1,2, Yudong Yang1,2, Roland E. Mainz1,2, Giuseppe Di Sciacca1, Eliza Casandruc1, Angel Rubio3,4, Franz X. Kaertner1,2, Oliver Muecke1,2, ‘Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Germany; ‘Univ. of Hamburg, Physics Dept. and The Hamburg Centre for Ultrafast Imaging, Germany. We present a three-octave-wide phase-stable seeding scheme using separate supercontinua in bulk driven by a CEP-stable laser and its second harmonic to provide optimized seeds for each spectral channel of a parallel parametric waveform synthesizer.

Anisotropic Polarization Dependent High Harmonic Generation in the Ferroelectric Crystal BaTiO3, Shima Gholam Mirzaei, Erin Crites, John E. Britar, Aiping Chen1, Michael Chini1,2, ‘Physics, Univ. of Central Florida, USA; ‘CREOL, the College of Optics and Photonics, Univ. of Central Florida, USA; ‘Center for Integrated Nanotechnologies, Los Alamos National Lab, USA. We generate high-order harmonics from femtosecond mid-IR pulses in ferroelectric BaTiO3 crystals. We find that odd and even harmonics’ intensity and polarization behave differently when rotating the input polarization with respect to the crystal axes.

We demonstrate recovery of broadband optical waveforms from in-band noise by linear coherent spectral energy re-distribution, Benjamin G. Crockett, Luis Romero Cortés, Jose Azana, INRS, Canada. We introduce a novel concept for in-band noise mitigation applicable to non-repetitive events, through linear spectral and temporal phase control. We demonstrate recovery of broadband optical waveforms, with unknown characteristics, buried under noise.

Strong-Field Polarization-State Control of Higher Harmonics Generated in Crystalline Solids, Nicola Klenke1,2, Nicolas Tancogne-Dejean1, Giulio M. Rossi1,2, Yudong Yang1,2, Roland E. Mainz1,2, Giuseppe Di Sciacca1, Eliza Casandruc1, Angel Rubio3,4, Franz X. Kaertner1,2, Oliver Muecke1,2, ‘Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Germany; ‘Univ. of Hamburg, Physics Dept. and The Hamburg Centre for Ultrafast Imaging, Germany. We present a three-octave-wide phase-stable seeding scheme using separate supercontinua in bulk driven by a CEP-stable laser and its second harmonic to provide optimized seeds for each spectral channel of a parallel parametric waveform synthesizer.
A multifunctional micro-electro-opto-mechanical (MEOM) platform based on phase-transition materials, Xi Wang¹, Kaichen Dong¹, Wai Sung Choe¹, Hui Liu¹, Shuai Lou¹, Kyle Tom¹,², Hans Bechtel¹, Zheng You¹, Junqiao Wu¹,², Jie Yao¹,²;¹Univ. of California, Berkeley, USA; ²Materials Sciences Division, Lawrence Berkeley National Lab, USA; ³Dept. of Precision Instrument, Tsinghua Univ., China; ⁴Advanced Light Source Division, Lawrence Berkeley National Lab, USA. We demonstrate a new MEOM multifunctional platform activated by the structural phase transition of an embedded vanadium dioxide layer. Its diverse stimuli and > 50% optical modulation depth over a broad wavelength range promise versatile applications.

A Near Deterministic Plasmonic Quantum Zeno Gate using Graphene Nanoribbons, Irati Alonso Calafell¹, Joel Cox², Milan Radonjic¹, José Ramón Martínez Saavedra², Javier García de Abajo², Lee Rozema¹, Philip Walther¹;¹Univ. of Vienna, Austria; ²ICFO, Spain. The scalability of photonic quantum-computation is limited by the low success probability of two-qubit logic gates. We propose a root-SWAP gate based on graphene nanoribbons, where the strong two-plasmon absorption boosts its success above 90%.
| Concurrent sessions are grouped across four pages. Please review all four pages for complete session information. |

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**FF3E • Photon-Phonon Interactions and Cooling—Continued**

**FF3E.7 • 15:45**
Observation of stimulated Brillouin scattering and Brillouin frequency comb generation in diamond, Zhenxu Bai1,2, Robert J. Williams1, Ondrej Kitzler1, Soumya Sarang1, Richard P. Mildren1; 1Macquarie Univ., Australia; 2Harbin Inst. of Technology, China. We report evidence for stimulated Brillouin scattering in diamond using an intense Raman-generated intracavity pump. Configurations are described for producing a single Stokes line and a Brillouin frequency comb containing up to the 22 orders spaced over 1.55 THz.

**FF3F • Optomechanical Interactions and Single Particle Tracking—Continued**

**FF3F.7 • 15:45**
All-optical Light Control in Dielectric Bilayer Optical Surfaces via Optomechanical Interaction, Carol Bibiana Rojas Hurtado1, Johannes Dickmann1, Walter Dickmann2, Thomas Siefke1, Stefanie Kroeker1,2; 1Physikalisch-Technische Bundesanstalt, Germany; 2Technische Universität Braunschweig, Germany; 3Friedrich-Schiller-Universität Jena, Germany. We propose a bilayer Gamma-shape grating structure as a novel nano-optomechanical system promising for all-optical modulation in a frequency range of a few MHz up to a few 100 MHz.

**SF3G • Quantum Cascade Lasers—Continued**

**SF3G.7 • 15:45**
Difference-Frequency Generation Terahertz Quantum Cascade Lasers with Surface Grating Outcouplers, Jae Hyun Kim1, Seungyong Jung1, Yifan Jiang1, Kazuue Fujita2, Masahiro Hitaka1, Akio Ito2, Tadatoshi Edamura1, Mihail A. Belkin1; 1Univ. of Texas at Austin, USA; 2Hamamatsu Photonics K.K., Japan. We report terahertz quantum cascade laser sources based on intra-cavity difference-frequency generation processed into double-metal waveguides with surface-grating outcouplers. Over 112 μW of peak power output is produced at room temperature at 1.9 THz.

**FF3H • Wavefront Shaping in Complex Media—Continued**

**FF3H.7 • 15:45**
Broadband perfect transmission through non-Hermitian disordered media, Konstantinos Makris1, Andre Brandstötter2, Stefan Ritter2, 1Univ. of Crete, Greece; 2Inst. for Theoretical Physics, Vienna Univ. of Technology, Austria. We examine the resonance properties of a novel type of waves, the constant-intensity (CI) waves in one-dimensional non-Hermitian disordered media. Such CI waves propagate perfectly through a scattering landscape without any reflection.

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**FF3E • Photon-Phonon Interactions and Cooling—Continued**

**FF3F • Optomechanical Interactions and Single Particle Tracking—Continued**

**SF3G • Quantum Cascade Lasers—Continued**

**FF3H • Wavefront Shaping in Complex Media—Continued**
SF3I.8 • 15:45
Direct generation of a ‘bottle beam’ from an end-pumped Nd:YVO₄ laser with second-harmonic generation, Jung-Chen Tung¹, Yuan-Yuan Ma¹, Yung-Fu Chen², Kai-Feng Huang², Takashige Omatsu³; ‘Chiba Univ., Taiwan’; ‘National Chiao Tung Univ., Taiwan’. We have demonstrated, for the first time, the generation of an optical ‘bottle beam’ with a ‘zero-intensity’ region surrounded by three-dimensional bright regions from an intra-cavity frequency-doubled Nd:YVO₄ laser with a nearly hemispherical cavity configuration.

SF3J.8 • 15:45
Long-Wave Infrared Germanium-on-Silicon Waveguides Beyond 10 μm, Dmitry Kozak¹, Todd H. Stievater¹, Rita Mahon¹, Marcel W. Priesnner¹, William S. Rabinovich¹; ‘US Naval Research Lab, USA’. We show low-loss propagation in germanium-on-silicon (GOS) waveguides from 6.85 μm to 11.25 μm. The loss is as low as a few dB/cm at a wavelength of 10 μm for both the quasi-TE₀₀ and quasi-TM₀₀ modes.

AF3M.7 • 15:45
Peculiarities of near-room-temperature thermal-emission measurements using FTIR spectroscopy, Yuzhe Xiao¹, Alireza Shahsafi¹, Patrick Roney¹, Chenghao Wan¹, Graham Joe¹, Zhaoning Yu¹, Jad Salman¹, Mikhail Katz¹; ‘Univ. of Wisconsin-Madison, USA’. We investigated the impact of multi-source background emission on thermal-emission measurements using FTIR spectroscopy. We found that a backward-emitting background in the interferometer can lead to partial or total cancellation of the measured thermal emission.
FF3P.7 • 15:45
Wannier-Stark Localization in Bulk Gallium Arsenide Induced by Extreme Mid-Infrared Fields, Johannes Bühler1, Christian Schmidt1, Alexander-Cornelius Heinrich1, Jonas Allerbeck1, Reinold Podzimski1, Daniel Berghoff2, Tonsten Meier1, Wolf G. Schmidt3, Christian Reich1, Werner Wegscheider3, Daniele Brida1, Alfred Leitenstorfer1; 1Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany; 2Dept. of Physics and Center for Optoelectronics and Photonics Paderborn, Univ. of Paderborn, Germany; 3Solid State Physics Lab, ETH Zurich, Switzerland. Sub-cycle transmission measurements of bulk gallium arsenide biased by intense mid-infrared transients reveal a strong blue-shift of the optical absorption when the peak electric field reaches 10 MV/cm, indicating 2D-localization of electronic wave functions.

AF3Q.5 • 15:45
High-resolution time-stretch microscopy based on asynchronous optical sampling, Xi Zhou1, Xin Dong1, Jiqiang Kang2, Liao Chen1, Chi Zhang1, Kenneth Kin-Yip Wong2, Xinxiang Zhang1; 1Wuhan National Lab for Optoelectronics, China; 2Dept. of Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong. We propose and demonstrate an ultrafast time-stretch microscopy based on asynchronous optical sampling (ASOPS) with 92-MHz sampling rate and 10-kHz frame rate, and this microscopy achieves 2.3-µm lateral resolution leveraging 1.9-MHz acquisition bandwidth.
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