OSA Laser Congress

*Advanced Solid State Lasers (ASSL)*

*Laser Applications Conference (LAC)*

4 November - 8 November 2018

The Westin Boston Waterfront

Boston, Massachusetts, USA

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Advanced Solid State Lasers Conference (ASSL)

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Michal Koselja; Inst. of Physics, Czech Academy of Sciences, Czech Republic
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Katrin Paschke; Ferdinand Braun Inst., Germany

Laser Applications Conference (LAC)

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Gerald Uyeno; Raytheon, USA
Rudolf Weber; Univ. of Stuttgart, Germany

OIDA Executive Forum Committee
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Berthold Schmidt, Trumpf, Germany
Martin Seifert, USA

Thank you to all the Committee Members for contributing many hours to maintain the high technical quality standards of OSA meetings.
General Information

Registration
Harbor Wing Lobby

Please note: registration desk will be closed during lunch breaks.

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Access to the Wireless Internet
Activate your computer’s wifi by selecting the available network and enter password listed below. Click connect.

- Network: OSA Laser Congress
- Password: Laser2018

OSA Laser Congress Press Room
Lewis Room

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About OSA Publishing’s Digital Library
Registrants and current subscribers can access all of the meeting papers, posters and Postdeadline Papers on OSA Publishing’s Digital Library. The OSA Publishing’s Digital Library is a cutting-edge repository that contains OSA Publishing’s content, including 16 flagship, partnered and co-published peer reviewed journals and one magazine. With more than 304,000 articles including papers from over 640 conferences, OSA Publishing’s Digital Library is the largest peer-reviewed collection of optics and photonics.

OSA Laser Congress 2018
4 November - 8 November 2018

Online Access to Technical Digest
Full Technical Attendees have both EARLY and FREE continuous online access to the Congress Technical Digest and Postdeadline Papers through OSA Publishing’s Digital Library. The presented papers can be downloaded individually or by downloading .zip files (.zip files are available for 60 days).

1. Visit the conference website at osa.org/LasersOPC.
2. Select the “Access digest papers” link on the right hand navigation.
3. Log in using your email address and password used for registration. You will be directed to the conference page where you will see the .zip file link at the top of this page.

[Note: if you are logged in successfully, you will see your name in the upper right-hand corner.]

Access is limited to Full Technical Attendees only. If you need assistance with your login information, please use the “forgot password” utility or “Contact Help” link.

Poster Presentation 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. Submit your poster PDF no later than 27 November 2018 to myishak@osa.org. Your PDF should be named using your presentation number with “-1” added at the end (###final_id###-1.pdf). If submitted, poster PDFs will be available about three weeks after the meeting. While accessing the papers in OSA Publishing’s Digital Library look for the multimedia symbol shown above.

Update Sheet
All technical program changes will be communicated in the on-site Congress Program Update Sheet. All attendees receive this information with registration materials and we encourage you to review it carefully to stay informed of changes in the program.
Special Events and Sessions

Events

Congress Networking Reception
Sunday, 4 November, 17:30-18:30
Harbor Ballroom Foyer, Harbor Wing

The event is open to all OSA Laser Congress registered participants.

Complimentary Lunch
Monday-Wednesday, 5-7 November
12:30-14:00 (Mon-Tues); 12:00-13:30 (Wed)
Galleria Hall

Complimentary lunch will be served in the Galleria Hall from Monday - Wednesday. The event is open to all OSA Laser Congress registered participants.

Tuesday’s lunch is sponsored by:

Congress Banquet
Wednesday, 7 November, 18:00-21:00
Spirit Cruise

Boarding: 18:00-18:50
Departure: 19:00

One (1) banquet ticket is included in the Full Technical Congress Registration. There is a mandatory RSVP fee of $10.00 to attend.

Guest Tickets: $95 (onsite purchase only)

Spirit Cruises are fun and engaging. Designed for comfort and incredible harbor views, the Spirit of Boston is ready to show you the city of Boston. There’ll be great food, drinks, DJ entertainment and casino games to choose from onboard.

You’ll love Spirit’s panoramic skyline views, climate-controlled interior decks, delicious buffet-style meals, dance floor, DJ, and bar games.

Walking Directions:
From the Westin Boston Waterfront Hotel follow World Trade Center Avenue 2 blocks to the World Trade Center Pier. Go down one level to Seaport Boulevard. The Spirit of Boston is anchored on the north side of the pier. Entry clearly marked. Shuttle will be available; check Program Update Sheet for more information.

Sponsored By:

Sessions

Student & Early Career Professional Development & Networking Lunch and Learn
Monday, 5 November, 12:00-13:00
Marina I

Join us for an interactive lunch and learn program focused on professional development within the field. This program will engage students and early career professionals with the key leaders in the field who will share their professional development journey and provide useful tips to those who attend. Lunch will be provided.

Programs are open to OSA Members. There is limited space and we ask that you RSVP to attend. Please email Curtis Burrill at cburrill@osa.org to RSVP.

Sponsored by:

Student Poster Session
Monday, 5 November, 18:30-20:00
Galleria Hall, Harbor Wing

Selected student presenters will be presenting their research during this poster session. All attendees are welcome to network with students and learn about their work. Beverages and snacks served.

Sponsored by:

Poster Sessions
Tuesday, 6 November, 10:00-11:30
Thursday, 8 November, 10:00-11:30
Galleria Hall, Harbor Wing, Concourse Level

Poster presentations offer an effective way to communicate new research findings and provide a venue for lively and detailed discussion between presenters and interested viewers. Don’t miss this opportunity to discuss current research one-on-one with the presenters. Each author is provided with a board to display the summary and results of his or her paper.

Poster Set Up and Removal
All posters must be set by the start of the poster session, and placed in their assigned spots. Posters set in the incorrect spots may be marked as “No Shows” and will not be indexed. The presenter must remain in the vicinity of their poster for the duration of the session. All presenters must remove their posters at the conclusion of the session. Management will remove and discard any remaining posters after the time listed below.
Special Events and Sessions

Sessions (continued)

**ASSL Postdeadline Papers Session**
*Tuesday, 6 November, 19:00-20:00*  
*Harbor Ballroom I & II*

The ASSL Technical Program Committee has accepted a limited number of Postdeadline Papers for oral presentations. The purpose of Postdeadline Papers is to give participants the opportunity to hear new and significant material in rapidly advancing areas. See the Update Sheet for the list of Postdeadline Papers. The Postdeadline Papers can be found in OSA Publishing's Digital Library by visiting www.osa.org/LaserOPC and selecting “Access Digest Papers” link on the right hand navigation.

**Directed Energy Defense Special Session**
*(Restricted Access)*
*Tuesday, 6 November, 08:00-10:00*  
*Harbor Ballroom III*

OSA, in conjunction with the Directed Energy Professional Society, will host a panel session that will explore the U.S. Dept. of Defense programs using High Energy Laser solutions to counter emerging threats to U.S. military operations, both domestically and abroad. The panel will discuss individual Service programs that address their respective mission sets, as well as the state-of-the-science that underlies High Energy Laser applications, from the Directed Energy Joint Transition Office.

Session is open to Laser Congress attendees from USA, NATO allies, EOP partners, Japan, South Korea, and Switzerland.

Speakers:
- Adam Aberle, *US Army Space & Missile Defense Command, USA*
- Larry Grimes, *DE Joint Transition Office, USA*
- David Kiel, *US Navy Directed Energy Weapons Office, USA*
- Nic Morley, *US Air Force Research Lab, USA*

**Reaching for the Brightest Light: High-Intensity Ultrafast Lasers**
*Tuesday, 6 November, 20:15-21:15*  
*Harbor Ballroom I & II*

Momentum is building behind U.S. efforts to advance petawatt laser science and technology following the 2018 National Academy of Sciences report, “Opportunities in Intense Ultrafast Lasers: Reaching for the Brightest Light.” This session will describe existing U.S. and international capabilities and facilities and explore the scientific motivations and challenges for developing petawatt laser science and technology in the U.S. We will also discuss community efforts to organize and set out a strategic path for this field, emphasizing particular technical areas that need organizational attention. The session, held under the auspices of the National Photonics Initiative, will be conducted by Peter Moulton, MIT Lincoln Laboratory, and will feature short, invited presentations and time for audience participation.

**OIDA Executive Forum**
*Thursday, 8 November, 08:00-13:30*  
*Harbor Ballroom III*

OIDA Executive Forum is a half-day program that focuses on the business aspects of the laser market, spanning finance to new product development, and complements the more technical nature of the collocated conferences on advanced solid-state lasers and laser applications. This executive-level event is a highly-interactive and intensive program focused on peer learning and information exchange that will help leaders in the industry plan for disruptors, capitalize on opportunities, and remain relevant to their audiences. A networking lunch will be provided at the conclusion of the program.
Short Courses

Short Courses cover a broad range of topic areas at a variety of educational levels. They are an excellent opportunity to learn about new products, cutting-edge technology and vital information at the forefront of your field. They are designed to increase your knowledge of a specific subject while offering you the experience of knowledgeable teachers.

Short Courses are complimentary for technical congress attendees, but a separate registration is required to attend, and space is limited.

SC467: Quadratic Nonlinear Optics
Sunday, 4 November
09:00-12:00
Instructor: Ady Arie; Tel Aviv Univ., Israel
Short Course Level: Advanced Beginner
Course Description
The course will focus on three wave mixing processes, which represent the strongest and most pronounced manifestation of nonlinearity in optics. It starts with the description of the material properties that govern nonlinear optical processes, followed by the analysis of the interaction of light waves in these materials, that enables to generate light at new frequencies through different up-conversion and down-conversion processes. The crucial role of phase matching and the two main methods to satisfy it are then discussed in detail. Finally, two advanced topics-nonlinear optical holography and adiabatic frequency conversion—are reviewed.

- Electrical susceptibility and induced polarization, Centrosymmetric and non-centro-symmetric materials, symmetry properties of the second order nonlinear susceptibility tensor.
- Coupled-wave equations in quadratic nonlinear media. The cases of sum frequency generation, difference frequency generation and second harmonic generation. Optical parametric amplification and oscillation.
- Nonlinear diffraction and nonlinear optical holography: Cerenkov and Raman-Nath nonlinear diffraction, Spatial and spectral shaping of light waves in nonlinear processes.
- Adiabatic frequency conversion-analogy with two-level systems, Bloch sphere representation, broadband frequency conversion.

Benefits and Learning Objectives
Participants of this course will learn:

- Understand the underlying concepts of nonlinear optical interactions.
- Evaluate the advantages and limitations of different nonlinear devices, crystals and phase matching options for nonlinear generation at a chosen wavelength.
- Calculate propagation angles, polarizations and/or quasi-phase matched periods for satisfying phase matching conditions.
- Learn about the recent developments in the field.

SC471: Physics of Guided-Wave Light Propagation: Applications to Fiber Lasers and Nonlinear Optics
Sunday, 4 November
14:00-16:45
Instructor: Siddharth Ramachandran; Boston Univ., USA
Short Course Level: Intermediate
Course Description
A fiber may be characterised by the number of discrete spatial modes it carries, their effective modal areas, and the phase accumulated when they propagate, all of which control interactions between different modes or colours, due to the linear (via interference) or nonlinear (via, primarily, the \(\chi^{(3)}\) nonlinearity in silica) coupling. These interactions are not unlike those encountered in bulk optical media, but with a fundamental distinction — owing to the revolutionarily low loss of optical fibers, interaction lengths can be several orders of magnitude greater than that feasible with bulk media, and hence no other mediums facilitates, with such ease, remote delivery of light. This course will:

- Describe the physics of light propagation in optical fibers, which may guide light due to total internal reflection (as is the case with a majority of fibers, including most photonic crystal fibers) or due to band-gap effects (such as hollow-core bandgap fibers).
- Elucidate the key design parameters that allow achieving desired mode areas, nonlinear coefficients, phase and dispersion matching, and show how these can be connected with simple ray-optic and wave-optic theories.
- Explore the regimes in which single-mode, mono-mode, few-mode, and vastly multimode fibers, including their vector effects, are applied and exploited.
- Provide illustrative examples of applications in which specially designed fibers have been used, focusing on recent advances in nonlinear fiber optics, high-power lasers and imaging applications.

Benefits and Learning Objectives
Participants of this course will learn:

- The physics of guided wave light propagation in the linear as well as nonlinear regime.
- The ability to design fibers and waveguides for specific high-power lasers, nonlinear and imaging applications.
- An overview of emerging trends in the use of novel fiber designs and spatial modes for future applications.
Joint Plenary Session
Monday, 5 November, 08:15-10:30
Harbor Ballroom I & II

08:30-09:30

Margaret Murnane
JILA, Univ. of Colorado at Boulder and NIST, USA

Harnessing Quantum Light Science for Tabletop X-Ray Lasers, with Applications in Nanoscience and Nanotechnology

High harmonic generation (HHG) is a unique quantum light source with fundamentally new capabilities – producing fully spatially and temporally coherent beams with linear or circular polarization throughout the extreme ultraviolet (EUV) and soft X-ray region, all on a tabletop. This talk will introduce and review recent developments in HHG sources, as well as exciting advances in spectroscopy of materials. A host of applications in nanoscience and nanotechnology have now been demonstrated, including quantifying how nanoscale energy flow differs from bulk, measuring how fast a material can change its electronic or magnetic state, probing how spin currents can control and enhance magnetization in ultra thin films, and visualizing the dynamic band structure of material and electron-electron interactions on sub-femtosecond timescales. In particular, a new technique called attosecond-ARPES (angle resolved photoemission) harnesses HHG pulse trains to measure the fastest care and spin dynamics intrinsic to materials, making it possible to distinguish sub-femtosecond electron scattering and screening for the first time, or to identify new phases that traditional spectroscopies are blind to.

09:30-10:30

Norman Hodgson
Coherent Inc., USA

Industrial Femtosecond Lasers for Material Processing

Over the last decade, modelocked Yb-based laser architectures have matured to a point where they can reliably generate output powers in excess of 100 W with pulse energies of greater than 100 µJoules. This evolution has led to the development of femtosecond laser products which are now being deployed in various industrial applications that require material removal using sub-picosecond pulses.

This talk will provide an overview of the different femtosecond laser architectures, their state-of-the-art performance, and future developments. In addition, the current understanding of laser material interaction with ultrashort pulses is reviewed to find guidelines for the optimization of ultrafast processing in regards to pulse duration and laser wavelength. The talk will conclude with a presentation of the main industrial ultrafast laser applications.

Light the Future Talk (Joint Keynote Session)
Tuesday, 6 November, 11:30-12:30
Harbor Ballroom I & II

Philip Lubin
Univ. of California at Santa Barbara, USA

Directed Energy Propulsion - Enabling the First Interstellar Missions

Recent advances in photonics and directed energy systems allow us to begin the path to both extremely rapid solar system travel as well as relativistic flight for the first interstellar missions. From wafer-scale spacecraft capable of speeds greater than c/4 that could reach the nearest star in 20 years to 10 kg spacecraft travelling at c/50 to large missions capable of supporting human life for rapid interplanetary transit-all can be enabled by the same system. Photonics, like electronics, and unlike chemical propulsion is an exponential technology with a current double time of about 20 months. The same system can be used for many other purposes including kilometer scale telescopes for specialized applications including exoplanet searches and imaging, planetary defense, space debris mitigation among many others. This would be a profound change in human capability. We will discuss the results of our NASA Starlight and Breakthrough Starshot programs, the many technical challenges ahead, current laboratory prototypes and our recent data on kilometer baseline arrays as well as the many transformative implications of this program.
Awards

IPG Student Presentation Contest

IPG, the Laser Congress’s Premier Corporate Sponsor, provides funding for various paper presentation awards, which are determined by the ASSL General and Program Chairs. All current students presenting a paper during an ASSL session are eligible for these awards. ASSL will present several awards for outstanding poster and oral presentations by students.

A total of six awards winners will be selected during Laser Congress 2018: best contributed oral presentation and up to two runners ups, and best poster presentation and up to two runners ups.

*OSA thanks the following corporate sponsor who has supported student awards for this conference for many years!*

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Manage Your Laser Congress Experience in a Sn-App

Use the conference app to plan your day by searching presentations, exploring the exposition by viewing a list of exhibitors and daily activities, and networking with attendees.

Download the app in one of three ways:

1. Visit assl.osa.org/app
2. Search for ‘OSA Events’ in the app store
3. Scan the QR code

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OSA Laser Congress 2018       4 November - 8 November 2018
Exhibits / Buyers’ Guide

The Exhibits are located in Galleria Hall and open to all registered attendees. Visit a diverse group of companies, representing all aspects of solid-state laser system design and implementation. Coffee breaks, lunches and poster sessions will all be held in conjunction with the exhibition.

| Monday, 5 November | 10:00-10:30 | Exhibits & Coffee Break |
| 12:30-14:00 | Exhibits & Complimentary Lunch |
| 16:00-16:30 | Exhibits & Coffee Break |
| 18:30-20:00 | Exhibits & Student Posters |

| Tuesday, 6 November | 10:00-11:30 | Exhibits, Posters & Coffee Break |
| 12:30-14:00 | Exhibits & Complimentary Lunch |
| 16:00-16:30 | Exhibits & Coffee Break |

| Wednesday, 7 November | 10:00-11:00 | Exhibits & Coffee Break |
| 12:00-13:30 | Exhibits & Complimentary Lunch |
| 15:30-16:00 | Exhibits & Coffee Break |

| Thursday, 8 November | 10:00-11:30 | Exhibits, Posters & Coffee Break |

AdOptica GmbH
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URL: www.adloptica.com
AdOptica GmbH from Berlin, Germany develops and manufactures high efficient multifocal and laser beam shaping optics: product families foXXus and piShaper are applied in various industrial and scientific techniques. Other expertise includes laser techniques in printing industries, holography, interferometry, laser based measuring instruments, optical system designing.

AdValue Photonics, Inc.
Tabletop 203
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URL: www.advaluephotonics.com
AdValue Photonics is a leading manufacturer of innovative fiber lasers and amplifiers, located in Arizona, USA. The company’s products range from 0.5 µm and 1.0 µm, to 1.5 µm and 2.0 µm in wavelengths; picoseconds to nanoseconds in pulse width; and single frequency narrow linewidth to broadband sources.

Altechna
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URL: www.altechna.com
Altechna is a producer and supplier of custom laser optics and laser accessories. It provides innovative technological solutions and custom designs of laser optics for academic and industrial customers worldwide. Its highly competent professionals have accumulated all the necessary know-how to evaluate and execute every order with attention to the finest detail.

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URL: www.amplitude-laser.com
Amplitude Laser Group is a leading manufacturer of ultrafast and nanosecond lasers for scientific, medical and industrial applications. The group consists of three manufacturing locations in Bordeaux and Paris, France, and San Jose, USA. ranging from Yb High Energy & High Rep rate, OPA, Ti:sapphire, Nd:YAG, OPO and Dye lasers.

APE Angewandte Physik & Elektronik GmbH
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APE GmbH is a worldwide operating developer and manufacturer of instruments for the generation of ultrashort laser pulses with widely tunable wavelength as well as devices for pulse measurement and manipulation. APE’s product portfolio ranges from autocorrelators to harmonic generators, from acoustooptics to optical parametric oscillators (OPOs) and optical parametric Amplifiers (OPAs).

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As an independent and recognized specialist, asphericon is among the technological leaders in the field of asphere manufacture. asphericon assists its customers from the initial optical design, via manufacturing and coating, full-surface interferometric measuring and documentation, through to the assembly of optical modules and their optical characterization.
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Class 5 Photonics offers the most powerful femtosecond lasers on the market. Accelerate your research and ultrafast applications by a factor of 10-100. Discover new frontiers in 3D bio-imaging, multi-photon processing, extreme ultraviolet high harmonic generation or time-resolved atomic and molecular spectroscopy benefiting from unmatched resolution.

Cristal Laser S.A.
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URL: www.cristal-laser.com

Cristal Laser is a French-based privately owned SME specialized in the growth and manufacturing of crystal materials used in laser optics. We were established in 1990 and are boasting a 2,400 square meter plant with top level crystal growth, optical fabrication and testing equipment. Our success has been made possible by a staff of highly trained personnel dedicated to meet the expectations of our customers - industrial laser manufacturers or research facilities. Our top products are LBO harmonics generators, RTP electro-optic modulators, KTP frequency-doubling or parametric crystals. We sell worldwide.

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Cryslaser is one of the most professional and largest Laser Crystal manufacturers in China. Based on cooperation with Research Centers and Universities and more than 45 years experience in crystal growth, our main products include Laser Crystals (NdYAG, Cr4+YAG etc.), NLO Crystals (KBBF, LBO, BBO, etc.) and Diffusion-Bonded Crystals, Laser Components.

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URL: www.deps.org

The Directed Energy Professional Society (DEPS) was founded in 1999 to foster research, development and transition of Directed Energy (DE) technology for national defense and civil applications through professional communication and education. We intend to be recognized as the premier organization for exchanging information about and advocating research, development and application of Directed Energy, which includes both high energy lasers (HEL) and high power microwaves (HPM). The DEPS is incorporated as a nonprofit corporation in New Mexico, organized and operated exclusively for charitable, scientific, and educational purposes.

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E: sales@ekspla.com
URL: www.ekspla.com

We are an innovative manufacturer of solid-state, fiber lasers and components from unique custom systems to small OEM series. The in-house R&D team is able to tailor products for specific applications and according to specific requirements. Main products are: femtosecond, picosecond and nanosecond lasers, tunable wavelength systems, ultrafast fiber lasers, spectroscopy systems and laser electronics.
## Exhibits / Buyers’ Guide

### Electro-Optics Technology, Inc.
**Tabletop 109**
3340 Parkland Court
Traverse City, MI 49686, USA
E: sales@eotech.com
URL: www.eotech.com

EOT has been supplying enabling components and diagnostic equipment to manufacturers and users of high power laser systems since 1987. Current products include: Faraday rotators and optical isolators for use with laser diodes, fiber lasers, and solid-state lasers. EOT also stocks a complete line of photodetectors.

### Forward Photonics, LLC
**Booth 315**
500 West Cummings Park, Suite 1900
Woburn, MA 01801, USA
E: info@forwardphotonics.com
URL: www.forwardphotonics.com

Forward Photonics employs wavelength beam combining (WBC) technology patented from MIT Lincoln Laboratory, which allows for brightness scaling with any semiconductor laser material. FP has experience building lasers at many wavelengths, from UV to LWIR, and up to kilowatts of power. FP has had particular success in using WBC with quantum cascade lasers.

### Gentec-EO Inc.
**Tabletop 506**
445 St-Jean-Baptiste, Suite 160
Québec, G2E 5N7, Canada
E: info@gentec-eo.com
URL: www.gentec-eo.com

With a 45-years track record of providing quality solutions for laser measurement applications, Gentec-EO stands ready to serve you now and in the future! Laser power & energy meters, photo detectors, THz detectors, OEM solutions and beam diagnostics, we also have calibration centers on 3 continents for fast turn-around times.

### Gooch & Housego, PLC
**Booth 318**
Head Office, Dowlish Ford
Ilminster, Somerset, TA19 0PF, UK
E: info@goochandhousego.com
URL: www.goochandhousego.com

Gooch & Housego, or G&H, is a key supplier of complete optical system design, engineering and manufacturing services to the aerospace, defense & space; biomedical; industrial and scientific sectors. Manufacturing complex assemblies and components in Europe and the USA, the Group’s technologies are based on acousto, electro, fiber and precision optics.

### Inrad Optics Inc.
**Tabletop 214**
181 Legrand Ave.
Northvale, NJ 07647, USA
E: sales@inradoptics.com
URL: www.inradoptics.com

Inrad Optics grows nonlinear crystals including BBO, DKDP, LiNbO3, and ZGP; Q-switches and Pockels Cell, and other custom optics for laser beam delivery applications. Other products include Transmission Flats, Waveplates, electro-opto-mechanical assemblies, UV Filter crystals; and Scintinel™ stilbene, a scintillation crystal for fast neutron detection.

### IPG Photonics Corp.
**Booth 310, Premier Corporate Sponsor**
50 Old Webster Road
Oxford, MA 01540, USA
URL: www.ipgphotonics.com

IPG Photonics is the leading developer/ manufacturer of high-performance fiber lasers & amplifiers for diverse applications in numerous markets. Diverse lines of low, medium & high power lasers & amplifiers are used in materials processing, communications, medical & advanced applications. IPG’s products are displacing traditional applications while enabling new applications.

### LAYERTEC GmbH
**Tabletop 504**
Ernst-Abbe-Weg 1
Mellingen, 99441, Germany
E: info@layertec.de
URL: www.layertec.de

German one stop shop for optical high-end laser components. Coatings ranges from high power applications, polarization control, broadband and ultrafast optics to complicated custom designs, using sputtering and evaporation technologies. In-house facility for precision optics. Large stock and customized production. More than 40 coating chambers and 270 employees.

### Light Conversion, Ltd.
**Tabletop 304**
Keramiku 2B
Vilnius, 10233, Lithuania
E: sales@altosphotonics.com
URL: www.lightcon.com

Light Conversion delivers solid state femtosecond laser and OPA systems, enabling innovation and discovery across industrial and scientific applications. TOPAS and ORPHEUS series of OPA’s are well known throughout ultrafast science. Our product portfolio forms a best-in-class set of devices for femtosecond applications in industry, medicine, and fundamental research.

### Lumibird
**Tabletop 201**
49 Willow Peak Dr.
Bozeman, MT 59718, USA
E: sales@quantelusa.com
URL: www.quantel-laser.com

Lumibird is one of the world’s leading specialists in lasers. With 50 years of experience and expertise in solid-state lasers, laser diodes and fiber laser technologies, the group (formerly Keopsys-Quantel) designs, manufactures and markets high performance lasers ranging from spectroscopy to atom cooling; LIBS to combustion research. Uniquely, Lumibird offers customers very flexible scientific lasers with user configurable wavelengths and performance parameters as well as “designed for purpose” ruggedized lasers for industrial applications.
MegaWatt Lasers
**Tabletop 111**
P.O. Box 24190
Hilton Head Island, SC 29925, USA
E: sales@megawattlasers.com
URL: www.megawattlasers.com

MegaWatt Lasers manufactures application specific solid-state lasers and components for medical, industrial, and defense applications. Standard products include a complete line of high-quality diffuse-reflector pump chambers for solid-state laser applications. MegaWatt Lasers is known for its line of Eyesafe Er:Glass microlasers for various remote sensing applications.

Nikon Corporation Glass Business Unit
**Tabletop 216**
Shinagawa Intercity Tower C, 2-15-3
Konan, Minato-ku
Tokyo, 108-6290, Japan
E: Glass.Sales@nikon.com
URL: www.nikon.com/products/glass/index.htm

Nikon began research, development and production of optical glass materials in 1918, the year after the establishment of Nippon Kogaku K.K. (Nikon Corporation). By leveraging this vast history of technology, Nikon produces industry-leading synthetic silica glass and calcium fluoride materials. As well as the most advanced photomask substrates for FPD applications, lenses for semiconductor lithography systems and optical components for many other demanding applications, Nikon’s analysis and measurement services are also contributing to our customers’ quality assurance needs in a variety of applications.

Northrop Grumman Aerospace Systems
**Silver Corporate Sponsor**
One Space Park
ST71LK R11/2706
Redondo Beach, CA 90278, USA
URL: www.ngc.com

Northrop Grumman Synoptics
**Tabletop 113**
1201 Continental Blvd.
Charlotte, NC 28273, USA
E: stsyn opticssales@ngc.com
URL: www.as.northropgrumman.com/synoptics

The world’s leading manufacturer of crystals for use in solid-state lasers. Products are used in applications in the military, medical, industrial and scientific markets. Materials include Nd:YAG, CTH:YAG, Er:YAG, Ruby, Undoped YAG, Nd:YLF, Alexandrite, TGG, KTF, Ti:Sapphire, KTP, Cr4+:YAG, Co:Spinel, Yb:LuAG and Yb: YAG. Diffusion bonding and contract crystal growth is also available.

NYFORS
**Booth 312, Gold Sponsor**
Solkraftsvägen 12
Stockholm, 13570, Sweden
E: info@nyfors.com
URL: www.nyfors.com

Established in 1987, NYFORS has accumulated experience in all areas of fiber processing. Our portfolio currently includes: CO2 laser splicing and glass shaping equipment, automatic systems for fiber preparation, fiber-end and window stripping, high precision cleavers and optical fiber recoaters as well as proof testers and cleave check interferometers.

OptiGrate Corporation, an IPG Photonics Company
**Booth 413**
562 South Econ Circle
Oviedo, FL 32765, USA
E: info@optigrate.com
URL: www.optigrate.com

OptiGrate is a pioneer of commercial Volume Bragg GRATings and supplies VBGs to more than 500 customers on 6 continents for laser line narrowing, spectroscopy, laser pulse stretching and compression, etc. Nowadays, OptiGrate is a leading manufacturer of VBG-based filters and components. Since May 2017, OptiGrate is a part of the IPG Photonics Family.

Orientir, Inc.
**Booth 412**
B2, 199 Western Rd. High-Tech Dist. Western Zone
Sichuan, 611700, China
E: sales@orient-ir.com
URL: www.orient-ir.com

Orientir, Inc. is a high-tech company specializing in infrared optical components research, producing, and marketing. Our main products include Co2 laser optical components and infrared imaging components with materials: ZnSe, ZnS, CaF2, BaF2, Ge, Si and chalcogenide glasses.

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Washington, DC 20036, USA
E: info@osa.org
URL: www.osa.org

OPN is the award-winning monthly news and member magazine/website from The Optical Society (OSA). Its print version reaches an audience of more than 20,000 OSA members and others, and its readers have a high degree of purchasing power. The OPN website has enjoyed steadily growing traffic, with an online readership of more than 158,000 unique visitors and with more than 412,000 page views per year.

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Washington, DC 20036, USA
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OXIDE Corporation
**Tabletop 210**
1747-1 Makihara Mukawa
Hokuto, Yamanashi, 408-0302, Japan
E: sales@opt-oxide.com
URL: www.opt-oxide.com

The OXIDE team of experienced experts assure superior quality. At OXIDE, we cut and polish our own crystals and our skilled engineers evaluate their properties. Through the critical evaluation by engineers with extensive knowledge and vast technical experience, we are able to offer stable and high quality crystals which best suit your requirements.
Exhibits / Buyers’ Guide

Raicol Crystals Ltd.  
**Booth 409**  
22 Hamelacha St.  
Rosh Ha'Ayan, 4809162, Israel  
E: info@raicol.com  
URL: www.raicol.com

NONLINEAR CRYSTAL PIONEERS with 50 years of experience and expertise in the field of crystal growth. A one-stop-shop from crystal growth to coating and EO cell assembly. Global pioneers of RTP, HGTR KTP and PPKTP crystals. Flexible solution, with capabilities for mass-production and small R&D quantities.

RESOLUTION Spectra Systems  
**Tabletop 115**  
13 chemin du Vieux Chêne  
Meylan, 38240, France  
E: info@resolutionspectra.com  
URL: www.resolutionspectra.com

RESOLUTION Spectra Systems offers high resolution laser spectrum analyzers and wavelength meters in the VIS-NIR range (630-1100 nm). Those are ideal tools for characterizing pulsed and CW lasers and for sensing applications. Based on SWIFTSTM technology, these innovative instruments have unique features: compactness, high accuracy, speed and robust calibration.

Scientific Materials Corp.  
**Tabletop 220**  
31948 East Frontage Road  
Bozeman, MT 59715, USA  
E: sales@scientificmaterials.com  
URL: www.scientificmaterials.com

Manufacturer of high speed Michelson interferometers with single, double and triple beam ports in a compact fiber-coupled head. Also manufactures microscope vibrometers, gage-block calibration systems and frequency stabilized HeNe lasers. These devices are ideal types of precision instruments for measuring lengths, angles, vibration motion as well as derived quantities like weights, forces, and pressures.

TelAztec  
**Tabletop 218**  
15 A Street  
Burlington, MA 01803, USA  
E: jpnole@telaztec.com  
URL: www.telaztec.com

TelAztec anti-reflection nano-textures eliminate the need for traditional thin-film antireflection coatings by using a designed nanotexture etched directly into the bulk optic. With no added absorption, TelAztec’s Random AR nano-textures provide unsurpassed laser damage threshold levels over thin-film type coatings with surpassed operational stability. Available for laser optics including lenses, windows, fiber facets and in a variety of UV, visible, and IR materials.

Thorlabs  
**Booth 209**  
56 Sparta Ave.  
Newton, NJ 07860, USA  
E: sales@thorlabs.com  
URL: www.thorlabs.com

Thorlabs has a broad range of fiber processing technologies to an extensive portfolio of fiber, optics, optomechanics, semiconductor, and optoelectronics equipment. Our acquisition of the Vytran team brought us innovative fiber fusion splicing and glass processing solutions for the fiber laser, sensing, medical, telecom, aerospace, and specialty fiber products markets.

TRUMPF Scientific Lasers GmbH + Co. KG  
**Booth 317**  
Feringastraße 10a  
Unterföhring, 85774, Germany  
E: info@trumpf-scientific-lasers.com  
URL: www.trumpf-scientific-lasers.com

TRUMPF Scientific Lasers focuses on high-energy picosecond lasers based on the thin-disk technology. The lasers of the Dira series deliver pulses with up to 200 millijoule pulse energy. The product portfolio covers the repetition rate range from 1 kilohertz to a few hundred kilohertz.

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URL: www.workinoptics.com

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71 Bradley Road  
Madison, CT 06443, USA  
E: sales@xsoptix.com  
URL: www.xsoptix.com

XSoptix is a North American distributor for optical components and test equipment. Product Highlights: eagleyard lasers covering 630nm-1150nm, monocom Solid State Lasers and BARS, Arroyo laser drivers and mounts, Finisar Waveshaper @ 1um, Sercalo MEMS mirrors and switches, ID Photonics Tunable Lasers and Yokogawa Optical Spectrum Analyzers.

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Explanation of Session Codes

The first letter of the code designates the meeting. The second letter denotes the day of the week. The third element indicates the session series in that day (for instance, 1 would denote the first sessions in that day). Each day begins with the letter A in the fourth element and continues alphabetically through the parallel session. The lettering then restarts with each new series. For example, a presentation coded AM2B.4 indicates that this paper is being presented as part of the ASSL meeting on Monday(M) in the second series of sessions (2), and is the second parallel session (B) in that series and the fourth paper (4) presented in that session.

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## Agenda of Sessions

### Sunday, 4 November

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<td>Registration, Harbor Wing Lobby (closed during lunch)</td>
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<tr>
<td>09:00-16:15</td>
<td>Short Courses, Marina I&lt;br&gt;SC467 - Quadratic Nonlinear Optics (09:00—12:00)&lt;br&gt;SC471 - Physics of Guided-Wave Light Propagation: Applications to Fiber Lasers and Nonlinear Optics (14:00—16:15)</td>
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<tr>
<td>17:30-18:30</td>
<td>Congress Networking Reception, Harbor Ballroom Foyer</td>
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### Monday, 5 November

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<th>Event</th>
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<tbody>
<tr>
<td>07:00-18:00</td>
<td>Registration, Harbor Wing Lobby (closed during plenary sessions and lunch)</td>
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<tr>
<td>08:15-08:30</td>
<td>Welcome Remarks, Harbor Ballroom I &amp; II</td>
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<tr>
<td>08:30-10:00</td>
<td>JM1A • Joint Plenary Session, Harbor Ballroom I &amp; II</td>
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<tr>
<td>10:00-10:30</td>
<td>Exhibits and Coffee Break, Galleria Hall</td>
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<tr>
<td>10:30-11:30</td>
<td>AM2A • High Power and Beam Combination</td>
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<tr>
<td>11:30-12:30</td>
<td>LM2B • Brittle Materials&lt;br&gt;LM3B • Laser Surface Modification For Technology Frontiers</td>
</tr>
<tr>
<td>12:30-14:00</td>
<td>Complimentary Lunch in Galleria Hall</td>
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<tr>
<td>14:00-16:00</td>
<td>AM4A • Laser Materials I (Crystals)&lt;br&gt;LM4B • Laser Processing for Microelectronic Devices</td>
</tr>
<tr>
<td>16:00-16:30</td>
<td>Exhibits and Coffee Break, Galleria Hall</td>
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<tr>
<td>16:30-18:30</td>
<td>AM5A • Er and Tm lasers&lt;br&gt;LM5B • 16kW+ Laser Materials Processing</td>
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<tr>
<td>18:30-20:00</td>
<td>AM6A • Student Poster Session, Galleria Hall</td>
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## Agenda of Sessions

**Tuesday, 6 November**

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<tr>
<th>Time</th>
<th>Session</th>
<th>Location</th>
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<td>07:00-18:00</td>
<td>Registration, Harbor Wing Lobby&lt;br&gt;(closed during lunch)</td>
<td>Harbor Ballroom I &amp; II</td>
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<tr>
<td>08:00-10:00</td>
<td>ATu1A • Unconventional Techniques, Harbor Ballroom I &amp; II</td>
<td>Harbor Ballroom I &amp; II</td>
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<tr>
<td>08:00-10:00</td>
<td>Directed Energy Defense Special Session (Restricted Access), Harbor Ballroom III</td>
<td>Harbor Ballroom III</td>
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<tr>
<td>10:00-11:30</td>
<td>ATu2A • ASSL Poster Session with Exhibits and Coffee Break, Galleria Hall</td>
<td>Galleria Hall</td>
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<tr>
<td>11:30-12:30</td>
<td>JTu3A • Light the Future Talk, Harbor Ballroom I &amp; II</td>
<td>Harbor Ballroom I &amp; II</td>
</tr>
<tr>
<td>12:30-14:00</td>
<td>Complimentary Lunch in Galleria Hall</td>
<td>Sponsored by: LPG Photonics</td>
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<tr>
<td>14:00-16:00</td>
<td>ATu4A • Novel Materials, Lasers and Processes, LTu4B • Lasers for Space Applications</td>
<td></td>
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<tr>
<td>16:00-16:30</td>
<td>Exhibits and Coffee Break, Galleria Hall</td>
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<tr>
<td>16:30-18:30</td>
<td>ATu5A • Frequency Combs and Compact Systems, LTu5B • Extreme UV, X-Ray Generation and Particle Acceleration</td>
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<tr>
<td>19:00-20:00</td>
<td>ATu6A • ASSL Postdeadline Paper Session, Harbor Ballroom I &amp; II</td>
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### Wednesday, 7 November

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<th>Advanced Solid State Lasers</th>
<th>Laser Applications Conference</th>
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<tr>
<td>07:00-18:00</td>
<td>Registration, Harbor Wing Lobby (closed during lunch)</td>
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<tr>
<td>08:00-10:00</td>
<td>AW1A • Harmonic, Raman and THz Conversion</td>
<td>LW1B • Laser Applications for Mobility</td>
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<tr>
<td>10:00-11:00</td>
<td>Exhibits and Coffee Break, Galleria Hall</td>
<td></td>
</tr>
<tr>
<td>11:00-12:00</td>
<td>AW2A • Joint Session: Vortex Sources and Applications (Ends at 12:15)</td>
<td>LW2B • Laser Induced Damage Threshold (LIDT) of Optical Coatings for Applications with High Intensity Lasers</td>
</tr>
<tr>
<td>12:00-13:30</td>
<td>Complimentary Lunch in Galleria Hall</td>
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<tr>
<td>13:30-15:30</td>
<td>AW3A • Joint Session Mid-IR Transition Metal Doped II-VI Materials and Lasers</td>
<td>LW3B • Laser Shock Peening</td>
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<tr>
<td>15:30-16:00</td>
<td>Exhibits and Coffee Break, Galleria Hall</td>
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<tr>
<td>16:00-17:45</td>
<td>AW4A • Mid-IR Sources</td>
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<tr>
<td>18:00-21:00</td>
<td>Congress Banquet, Spirit Cruise</td>
<td>Sponsored by: IOP Publishing</td>
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### Thursday, 8 November

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<tr>
<td>07:30-14:00</td>
<td>Registration, Harbor Wing Lobby (closed during lunch)</td>
<td>OIDA Executive Forum</td>
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<tr>
<td>08:00-10:00</td>
<td>ATh1A • Fiber Materials and Processes</td>
<td>OIDA Executive Forum</td>
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<tr>
<td>10:00-11:30</td>
<td>ATh2A • ASSL Poster Session with Exhibits and Coffee, Galleria Hall</td>
<td></td>
</tr>
<tr>
<td>10:45-12:30</td>
<td>OIDA Executive Forum, Harbor Ballroom III</td>
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<tr>
<td>11:30-12:30</td>
<td>ATh3A • Laser Materials II (Ceramics), Harbor Ballroom I &amp; II</td>
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<tr>
<td>12:30-14:00</td>
<td>Lunch on Your Own</td>
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<tr>
<td>14:00-16:00</td>
<td>ATh4A • Nonlinear Materials and Processes, Harbor Ballroom I &amp; II</td>
<td></td>
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<tr>
<td>16:00-16:30</td>
<td>Coffee Break, Harbor Ballroom Foyer</td>
<td></td>
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<tr>
<td>16:30-16:45</td>
<td>ASSL Student Awards, Harbor Ballroom I &amp; II</td>
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</tr>
<tr>
<td>16:45-18:30</td>
<td>ATh5A • Lasers for Biological and Other Applications, Harbor Ballroom I &amp; II</td>
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High harmonic generation (HHG) is a unique quantum light source with fundamentally new capabilities – producing fully spatially and temporally coherent beams with linear or circular polarization throughout the extreme ultraviolet (EUV) and soft X-ray region, all on a tabletop. This talk will introduce and review recent developments in HHG sources, as well as exciting advances in spectroscopy of materials. A host of applications in nanoscience and nanotechnology have now been demonstrated, including quantifying how nanoscale energy flow differs from bulk, measuring how fast a material can change its electronic or magnetic state, probing how spin currents can control and enhance magnetization in ultra thin films, and visualizing the dynamic band structure of material and electron-electron interactions on sub-femtosecond timescales. In particular, a new technique called attosecond ARPES (angle resolved photoemission) harnesses HHG pulse trains to measure the fastest care and spin dynamics intrinsic to materials, making it possible to distinguish sub-femtosecond electron scattering and screening for the first time, or to identify new phases that traditional spectroscopies are blind to.

Industrial Femtosecond Lasers for Material Processing, Norman Hodgson; Coherent, Inc., USA. Over the last decade, modelocked Yb-based laser architectures have matured to a point where they can reliably generate output powers in excess of 100 W with pulse energies of greater than 100 µJoules. This evolution has led to the development of femtosecond laser products which are now being deployed in various industrial applications that require material removal using sub-picosecond pulses. This talk will provide an overview of the different femtosecond laser architectures, their state-of-the-art performance, and future developments. In addition, the current understanding of laser material interaction with ultrashort pulses is reviewed to find guidelines for the optimization of ultrafast processing in regards to pulse duration and laser wavelength. The talk will conclude with a presentation of the main industrial ultrafast laser applications.
A 4 kW Fiber Amplifier with Good Beam Quality Employing Confined-Doped Gain Fiber, Chu Peng, Seung, Wei Ying, Wendy Lim, Song-Liang, Chua; 1 DS O National Laboratories, Singapore. A confined-doped ytterbium fiber amplifier was tested in a tandem-pump fiber amplifier. The fiber achieved an output power of 4.1 kW and M2 = 1.59, with optical efficiency of 84% and no sign of rollover at maximum power.

Comparison Between Bidirectional Pumped Yb-doped All-fiber Single-mode Amplifier and Oscillator Setup up to a Power Level of 5 kW, Friedrich P. Moller, Ria G. Krämer, Christian Matzdorf, Stefan Nolte, Maximilian Streek, Fabian Stutzki, Marco Plötner, Victor A. Bock, Thomas Schreiber, Andreas Tünnermann, 1 Fraunhofer IOF, Germany; 2 Inst. of Applied Physics, Germany. We present and compare highly robust Yb-doped monolithic amplifier and -oscillator setups in 20/400 μm geometry achieving single mode power levels of M2 ~ 1.3.

Monolithic multi-pass thin-disk laser amplifier providing near fundamental mode 2.3 mJ pulse energy at 1.4 kW average output power and 950 fs pulse duration, Thomas Dietz, Dominik Bauer, Michael Schurun, Helge Höck, Dirk Sutter, Alexander Källi, Alfred Leitenstorfer, 1 Trumpf Laser GmbH, Germany; 2 Dept of Physics and Center for Applied Photonics, Univ of Konstanz, Germany. Monolithic multi-pass thin-disk laser amplifier pumped at 941 nm providing near fundamental mode 2.3 mJ pulse energy at 1.4 kW average output power and 950 fs pulse duration. Zero-phonon-line pumping at 969 nm further improves the beam quality.

Self-Phase Modulation Cancellation in 210-W SESAM-ModeLocked Thin-Disk Oscillator Operated in Air, Francesco Saltarelli, Andreas Diebold, Jan J. Graumann, Christopher R. Phillips, Ursula Keller; ETH Zurich, Switzerland. We exploit cascaded χ(2)2 nonlinearity in an intracavity second-harmonic-generation crystal to cancel the self-phase modulation from air in a thin-disk oscillator. We obtain 210-W output power, a record value for a SESAM-mode-locked laser operated in air.

Phase Control of Two-Dimensional Diffractional Pulse Combination Based on Beam Array Detection, Tong Zhou, Qiang Du, Tyler Sano, Russell Wilcox, Wim Leeman, 1 Lawrence Berkeley National Laboratory, USA. A new phase control approach based on beam array detection is developed for large-array diffractive pulse combination. With this approach, a scalable, two-dimensional array of eight 120fs beams are coherently combined using two diffractive optics.

Coherently combined femtosecond pulses from a multicom core fiber amplifier, Arno Klinger, Michael Mueller, Henrik Stark, Fabian Stutzki, Christian Hupel, Thomas Schreiber, Andreas Tünnermann, Jens Lintelmann; Helmholtz-Institut Jena, Germany, 1 Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; 2 Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. We present a multicores fiber-based amplifier that is suitable for coherent combination of broadband pulses. It demonstrates the combination of two 120fs beams with 80% efficiency.

Highly Scalable Coherent Beam Combining of Femtosecond Fiber-Chirped-Pulse Amplifiers, Anke Heilmann, Jérôme Le Dozt, Louis Danaiult, Inisan Faisal, Sérénèe Bellanger, Jérôme Bourdieronnet, Christian Larat, Eric Lallier, Marie Antier, Eric Durand, Christophe Simon-Boisson, Arnaud Brignon, Jean-Christophe Chanteloup; 1 École Polytechnique, France; 2 Thales Research & Technology, France; 3 Thales LAS France SAS, France. We report on the coherent beam combining of several fiber chirped-pulse amplifiers using a highly scalable architecture. In linear regime, a combining efficiency of 48% is demonstrated, yielding 71 W pump-limited average power after compression.
14:00 - 16:00
AM4A • Laser Materials I (Crystals)
Presider: Sergey Mirov; University of Alabama at Birmingham, USA

AM4A.1 • 14:00
Large Scale Single Crystal Growth, Jana Preclikova1, Karel Bartos1, Jan Kubat1, Michal Kosejka1, Bedrich Rus2, Martin Divoky1, Tomas Moczek1, Jindrich Houzikova1; 2Crytur Company, Czechia; 1Extreme Light Infrastructure, Inst. of Physics, Czechia; 2HILASE, Inst. of Physics, Czechia. A new crystal growth method CRIG (Crystal Improved Growth) has been developed to grow large core-free YAG single crystals. Yb:YAG crystals were used for production of laser slabs for ELI (Extreme Light Infrastructure) Beamlines project.

AM4A.2 • 14:30
Characterization of Absorption Bands in Ti:Sapphire Crystals, Peter F. Moulton1, Jeffrey Cederberg1, Kevin Stevens1, Greg Foundas1, Michal Kosejka1, Jana Preclikova1; 1Massachusetts Inst. of Tech Lincoln Lab, USA; 2Northrop Grumman Synoptics, USA; 3Inst. of Physics, Czech Academy, Czechia; 4Crytur, Czechia. We have measured and characterized, over a wide range of doping levels, the UV-near-IR (190 -1800 nm) absorption properties of Ti:sapphire crystals. Our results have particular application to the design of lasers pumped by blue-green, InGaAs diode lasers.

AM4A.3 • 14:45
Investigation of Optical Defects in Titanium Doped Sapphire Crystals Grown by the Kyropoulos Technique, Cammen Stelian1, Gouar Sen1, Nicolas Barthalay1, Matias Velazquez1, Thierry Duffau1; 1Universite Grenoble Alpes, CNRS, SIMAP, France; 2Le Rubis SA, France; 3ICMCB, UMR 5026 CNRS-Universite de Bordeaux-Bordeaux INP, France. Two optical defects responsible for intensity variations of the emitted laser beam are observed in Ti-doped sapphire crystals grown by Kyropoulos method. These defects are investigated and explained by means of numerical modeling and experiments.

AM4A.4 • 15:00
Laser Crystals Luminescence Parameters under the Influence of an External High Voltage Electrical Field, Vladimir V. Chvykov1, Konstantin Zemskov1, 2ELI-HU Non-Profit Ltd, Hungary; 3Lebedev Physical Inst., Russia; 4Russian Academy of Science, Russia. Experiments of the electrical field impact on Ti: Sapphire crystal optical parameters are reported. Luminescence spectral amplitude reduction and bandwidth increase with the red-shift of the maximal amplitude after high voltage application are demonstrated.

AM4A.5 • 15:15
Tm,Ho:LiYF4: planar waveguide laser at 2.05 μm, Pavel Loik1, Remi Soulard1, Gurvan Brasse1, Jean-Louis Doualan1, Alain Braud1, Alexsey Tyazhev1, Ammar Hideur2, Patrick Camy1; 1CIMAP, France; 2Coria, France. The first holmium fluoride waveguide laser is reported using a 25-μm-thick Tm,Ho:LiYF4 layer grown by liquid phase epitaxy. Pumped at 797.2 nm, it generates 81 mW at 2051 nm with a slope efficiency of 24%.

AM4A.6 • 15:30
Demonstration of Adhesive-Free Bonded Crystaline Yb:YAG for High Energy Laser Applications, Mariantastenia De Vido1, David Meissner1, Stephanie Meissner1, Jonathan Phillips1, Klaus Ertel1, Paul Mason1, Saumyabrata Banerjee1, Thomas Butcher1, Jodie Smith1, Chris Edwards1, Carmen Stelian1, Thierry Duffau1; 1STFC Rutherford Appleton Laboratory, UK; 2Heinrich-Watt Univ., UK; 3Onyx Optics Inc., USA. We describe the application of the adhesive-free bonding (AFB) technique to form crystalline Yb:YAG gain media slabs. We demonstrate that the AFB technique is a viable alternative for producing large aperture slabs for high-energy lasers.

AM4A.7 • 15:45
84-fs Pulse Generation from a Mode-Locked Tm,Ho:CLNGG Laser at 2080 nm, Yongguang Zhao1,2, Zhongben Pan1, Yicheng Wang1,2, Jinun Bae1, Sun Young Choi1, Fabian Rotermund2, Huaile Yuan1, Xiaojun Dai1, Huaqiang Cai1, Pavel Loik1, Wei Zhou1, Deyuan Shen1, Josep Maria Serres1, Xavier Mateos1, Uwe Griebner2, Valentin Petrov1; 1Jiangsu Normal Univ, Germany; 2Max-Born-Inst, Germany; 3Korea Advanced Inst. of Science and Technology, South Korea; 4China Academy of Engineering Physics, China; 5ITMO Univ, Russia; 6Universitat Rovira i Virgili (URV), Spain. We report on a mode-locked Tm:Ho:CLNGG laser employing SWCNTs as saturable absorber. Transform-limited 84-fs pulses are generated at ~2080 nm for a repetition rate of ~102 MHz with an average output power of 69 mW.

14:00 - 16:00
LM4B • Laser Processing for Microelectronic Devices
Moderator: Dirk Mueller; Coherent Inc., USA

LM4B.1 • 14:00
Invited
Laser Based Micro Fabrication Systems for Electronics Manufacturing, Halbin Zhang1; 1ESI, USA. As devices and packages shrink in size, advanced packaging has become a critical avenue in semiconductor and consumer electronics manufacturing industry. Laser based micro-fabrication systems provide benefits in quality, speed, cost, and are playing important roles as the feature sizes in packages shrinks at a increasing rate. In this presentation, we will review several laser based key applications in packaging, including via drilling, wafer cutting, patterning. We also discuss the key technologies for high precision laser systems that enables next generation feature minimization with extremely high speed and low overall cost.

LM4B.2 • 14:30
High-Precision Optical Scanning Technologies for Microelectronic Applications, Megan MacNeil1; 1Novanta, USA. Precise and consistent laser beam steering is critical when manufacturing components in many of today’s electronic devices. State-of-the-art scanners, intelligent trajectory planning, and timed laser control enable high throughput manufacturing with accurate micro-features. In this talk, we will discuss key aspects of commonly used scanning patterns in microelectronic manufacturing, including drilling, trepanning, and large-area processing.

LM4B.3 • 15:00
Novel Laser Processing for Electronic Devices, Ronald Schaeffer1; 1Harmonic Photonics, USA. Lasers are used increasingly in manufacturing environments because they can do things no other technology can do, they can do things cheaper and faster than other technologies and they can be used in conjuction with other manufacturing technologies in hybrid machining applications. What was once a small market is growing rapidly and now there are legitimately at least 6 Billion dollar laser companies. A wide array of available choices in pulse length, wavelength and power output provide manufacturing engineers with a multitude of possibilities. This talk will discuss some novel applications using high peak and average power lasers that are enabling in the electronics industry.

LM4B.4 • 15:30
Invited
Laser for Advanced Microelectronics Packaging, Chong Zhang1; 1Intel, USA. Industry trend of microelectronics packaging, and advance packaging options are presented. Laser applications in packaging are listed and role of laser for packaging advancement is discussed. Challenges and opportunities of laser in future packaging application are summarized.
Lasers with an average power of 16 kW are on the move from basic application development at the universities and applications laboratories to the industry. Moreover, welding processing experiments with up to 100 kW have been reported. The 16 kW+ session will focus on latest applications showing the potential of the next average-power level.

**Invited Challenges in Controlling High Laser Beam Powers in Atmosphere and in Vacuum, Fatma Akyel 1; RWTH Aachen Univ., Germany.** Laser beam welding with high beam power (more than 12 kW) and at the same time high depths of welding have been challenging users for years. The process is usually difficult to control. The higher the desired welding depth, the more porosity and cracking will occur. The formation of a freely solidified root is also made more difficult.

**Benefits of High-Speed Welding with 16 kW Lasers, Florian Fetzer 1; Univ. of Stuttgart, Germany.**

**Novel Optical Concept for Large Area Rapid Thermal Processing, Henrikk Pantzar 1; TRUMPF Inc., USA.** We report on a novel optical concept for laser-based large area rapid thermal processing. The unique feature of this modular concept is the capability to precisely combine optical units to realize a line beam dimension of 0.065 mm x 3300 mm.
Monday, 5 November

AM6A.1 Interaction of Laser Beam with colloidal suspension of plasmonic nanoparticles for high photonic applications
Avesh Kumar
Department of Chemistry, Dr. B. R. Ambedkar Univ., Agra, India
"AMOPH, Physical Research Laboratory, India. Interaction of input laser beams with colloidal suspensions of plasmonic nanoparticles is studied. It results in different types of structures after propagation through a suspension.

AM6A.2 Spherical Approximation for combination of Mechanical and Optical Path Difference thermal lenses in Nd:YAG slab amplifier, ehsan tanhaee, Mohamad Mahdi Majdof, Mohana Najafii, Fanhash Abdezzadeh, Seyed Hassan Nabavi, "Univesity of Tehran, Iran (the Islamic Republic of); "Iranian National Center for Laser, Iran (the Islamic Republic of); "Shahid Beheshti Univ., Iran (the Islamic Republic of); "physics and photonic nano science, Tarbiyat Modares Univ., Iran (the Islamic Republic of). We pave the way for preconception of thermal lens by amalgamation of Mechanical Deformation and Optical Path Difference via Spherical Approximation with analytical and experimental results at Nd:YAG slab amplifier up to 420W pump power.

AM6A.3 Novel CW and actively Q-switched 1064 nm laser with Nd:GdYbO4 under direct pumping, Xuodong Li, Guichuan Xu, "Harbin Inst. of Technology, China. CW and acousto-optically Q-switched operations with a novel Nd:GdYbO4:NbO4 mixed crystal were demonstrated under direct pumping.

AM6A.4 Reconfigurable Sum-Frequency Phase-Matching by Temperature Gradient in Step-Chirped MgO:PPLN, Dismas Choge, "Chinese Academy of Sciences, China. We demonstrate reconfigurable broadband orange laser in a step-chirped MgO:PPLN crystal using temperature-gradient technique. Multiple wavelengths at 600 nm spectral region are achieved using a 20 mm long MgO:PPLN crystal via sum frequency generation.

AM6A.5 A femtosecond pulse fiber laser using a CoSb3 skutterudite-based passive mode-locker, Jinho Lee, Yoontae Kim, Kuyntgeek Lee, Ju Han Lee, "Univ. of Seoul, Korea. We experimentally demonstrate a femtosecond pulse fiber laser incorporating a CoSb3 skutterudite-based passive mode-locker. Using the mode-locker, stable soliton pulses with a ~833-fs temporal width is shown to be obtainable from an erbium fiber cavity.

AM6A.6 Room Temperature Infrared Photo- and Electroluminescence from Ion Implanted Silicon Germanium, Nikolay S. Balakleski, Nikolay N. Gerasimenko, Vadim Pirgov, "National Research Univ. MIEET, Russia. We report strong IR photo- and electroluminescence in the temperature range of 225 to 303 K as well as morphology measurements in Ge quantum dot layers being grown by ion beam implantation technique via high temperature annealing.

AM6A.7 Sellmeier equations for periodically poled LaB6Ge3O12, Yasuhiro Nakahara, Junji Hirohashi, Yasunori Furukawa, Nobuhiro Umemura, "Chisato Inst. of Science and Technology, Japan; "Oxide Corporation, Japan. We report the accuracy Sellmeier equations for LaB6Ge3O12, which reproduce well the quasi-phase-matching conditions at 22°C in the 0.256-1.064μm range. This index formula is highly useful for designing a period of periodically poled LaB6Ge3O12.

AM6A.8 Depressed cladding waveguides in Pr:CaF2:YAG fabricated by femtosecond laser inscription, Limu Zhang, Taiyong Guo, Yingjing Ren, "Shanghai Normal Univ., China; "Shanghai Jiao Tong Univ., China. We report on the fabrication via femtosecond laser inscribed of cladding waveguides in Pr:CaF2:YAG. Micro-photoluminescence mapping shows that the original fluorescence properties in the waveguide region are very well preserved.

AM6A.9 Thermal diffusion of Erbium in ZnS under hot isostatic pressing, Ozfarar Gafarov, Vladimir Fedorov, Sergey B. Mirov, "Univ. of Alabama at Birmingham, USA. Thermal diffusion or Erbium in ZnS in a mixture of Er3+ and ZnS powders under hot isostatic pressing was studied. Obtained Er:ZnS ceramics featured strong visible-near-IR photoluminescence of Er ions.

AM6A.10 Gigahertz Mode-Locked Waveguide Lasers Modulated by PdSe2 Saturable Absorbers, Xudong Li, Ningjing Dong, Jun Wang, Haoji Yu, Feng Chen, "Shandong Univ., China; "Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China. We demonstrate Q-switched mode-locked waveguide laser modulated by platinum diselenide (PdSe2) saturable absorber, achieving 8.82 GHz fundamental repetition rate and 27 ps pulses. Our work indicates the promising applications of PdSe2 for on-chip ultrafast photonics.

AM6A.11 Saturation spectroscopy of NV−centers in diamond, Shoua Subedi, Vladimir Fedorov, Sergey B. Mirov, Linbo Shao, Marco Loncar, "Physics, Univ. of Alabama at Birmingham, USA; "Engineering and Applied Sciences, Harvard School of Engineering and Applied Sciences, USA. We report saturation of NV− centers resulting in ~40% inversion level under 632nm pumping. Absorption kinetics revealed long recovery time of NV− centers after photoionization under 532nm pump, which involved different relaxation channels depending on the probe beam wavelengths.

AM6A.12 Application of Gas Cluster Ion and Accelerated Neutral Atom Beam Surface Treatments to Yb:YAG Gain Material, Mariestefania De Vido, Michael Walsh, Richard Siviluga, Sean Kirkpatrick, Klaus Ertel, Jonathan Phillips, Paul Mason, Samyabara Banerjee, Jodie Smith, Thomas Butcher, Chris Edwards, Cristina Hernandez-Gomez, John Collier; "STFC Rutherford Appleton Laboratory, UK; "Heriot-Watt Univ., UK; "Exogenesis Corporation, USA. We propose the application of the Gas Cluster Ion Beam (GCIB) and of the Accelerated Neutral Atom Beam (ANAB) surface treatments to ceramic Yb:YAG gain material and demonstrate their suitability for high-energy laser applications.

AM6A.13 Fabrication of broadband antireflection microstructures on ZnSe single crystal for mid-IR applications, Mikhail K. Tarabin, Andrey A. Bushunov, Vladimir A. Lazarev, Valery E. Karasik, Dmitriy Sivdivod, Yuri V. Korostelnik, Mikhail P. Frolov, Yan K. Skasyrsky, Vladimir I. Kozlovsky, Bauman Moscow State Technical Univ., Russia; "P. N. Lebedev Physical Inst. of the Russian Academy of Sciences, Russia; "National Research Nuclear Univ., Russia. We report the method of microstructure formation on ZnSe single crystal surface for reflectivity reduction in a wide spectral range of 3 to 14 μm up to 10% by using dry etching in CH3I ion plasma through a Ti-mask fabricated by a femtosecond laser ablation.


AM6A.15 Mode-locked oscillator phase stabilization using a Gires-Tournois interferometer, Yifei Cui, Hanzhong Pei, John Nees, Almantis Galvanaskas, "Univ. of Michigan, USA. Mode-locked oscillator phase pulse is stabilized and locked to an external cavity in a novel way by using a phase-sensitive peak power response of the Gires-Tournois interferometer, which enables significant increase in phase-measurement sensitivity.

AM6A.16 High-energy pulse amplification in partly quenched highly Er3+-doped fiber, Pablo R. Hernandez, Colin Baker, Shankar Pidisetty, Mohammad Belal, Edward Friebele, Ashley Burdett, Daniel Rhonehouse, Brandon Shaw, Jasbinder Sanghera, Johan Nilsson, "Univ. of Southampton, UK; "Naval Research Laboratory, USA; "Sotera Defense Solutions, USA; "Univ. of Research Foundation, USA. We investigate high-energy pulse amplification in a counter-directionally cladding-pumped partly-quenched heavily erbium-doped fiber. Despite the quenching, we reach a pulse energy of 0.56 mJ, several times the saturation energy at the 1563 nm signal wavelength.

AM6A.17 High Energy, 100 Hz, Picosecond Laser for OPCPA Pumping, Hongpeng Su, Yufei Peng, Junchi Chen, Xinlin Li, Yanyan Li, Pengfei Wang, Yuxin Leng, Zhihong - "Shanghai Inst. of optics and Fine Mechanics, China; "Univ. of Chinese Academy of Science, China. A diode-pumped picosecond laser system for OPCPA pumping was demonstrated, which can deliver laser pulses with energy of 316.5 mJ, pulse duration of 50 ps were obtained at 100 Hz repetition rate.

AM6A.18 4-kWatt all-fiber distributed side-pumped oscillators, Heng Chen, Jianqi Cao, Zhihe Huang, Yarkun Ren, Aimin Liu, Jinbao Chen, "National Univ of Defense Technology, China. The 4-kW all-fiber distributed side-pumped oscillator are firstly demonstrated with the distributed side-coupled cladding-pumped (DSCCP) fiber, to the best of our knowledge. Using four cascaded gain sections, the 3.96-kW output power with 73.0% slope efficiency is obtained.
AM6A.19 Demonstration of Two Generation Regimes in High Power Passively Mode-locked Thulium-doped All-fiber Ring Laser at Fully Negative Intracavity Dispersion, Vasily Voropayev, Alexander I. Donizond, Andrei I. Voronenets, Vladimir A. Lazaren, Mikhail K. Tarabrin, Valery E. Karasik, Alexander Krylov, Bauman Moscow State Technical Univ., Russia; 9P. Lebedev Physical Inst. of the Russian Academy of Sciences, Russia; 9Fiber Optics Research Center of the Russian Academy of Sciences, Russia. Two generation regimes of bandwidth-limited femtosecond pulses with an average power and energy of 560 mW and 45 nJ were demonstrated in a passively mode-locked thulium-doped all-fiber ring laser at fully negative intracavity dispersion.

AM6A.20 High-energy, Quasi-CW 355 nm UV Pulses Generation From a Diode-Pumped Sub-nanosecond Nd:YAG System, Yaneck Gottesman, Zhongyi Gao, Zhiyong Pan, Shanghai Inst. of Optics and Fine Mechanics, China; 1Uni. of Chinese Academy of Sciences, China. We have constructed a diode-pumped 200 mJ, 500 ps Nd:YAG laser system centered at 1064 nm.

AM6A.21 Hybrid Quasi-phase-matched and Birefringently Phase-matched Parametric Frequency Conversion Architectures, Sean P. Kelley,1,2 Kenton Green,1 1Northrop Grumman Mission Systems, USA; 2Electro Optics Department, Univ. of Dayton, USA. We present spectrally bright, scalable hybrid QPM/BPM NLO architectures down-converting from 1 µm and pumping ZGP OPOs to cover a broad range of the Mid-IR spectrum.

AM6A.22 Continuous-wave operation of LED-pumped Nd: YAG laser with thermal isolated and light guided design, Hong-Ru Chang,1,2 Kuan-Yen Huang,1,2 Yen-Chieh Huang1; 1National Tsing Hua Univ., Taiwan. We report a continuous-wave 810-nm LED pumped Nd: YAG laser with thermal isolated and light-guided pump scheme. At 14-W pump power, we generated 270-mW power with slope efficiency of 5.3%.

AM6A.23 Quantum-Dash Semiconductor Laser Characterization Using Continuous Tuning Optical Swept Source, Mohktar Korti,1 Svetlana Stepenava,1 Tatiana Habrubeva1,2, Kamel Merghem1, Guillame Huyet1, Yaneck Gottesman,1,2 Abderrahman Ramdane,1 Badr-Eddine Benkelfat2,1 Omar Seddiki2,1 Telecom SudParis, France; 2Univ. of Tlemcen, Algeria; 3Technological Univ., Singapore. We characterized Quantum-Dash semiconductor mode-locked laser using a continuous tuning swept source is presented. This technique is linear, simple and does not require any prior information about the signal under test.

AM6A.24 Experimental study of transverse mode instability in a high power monolithic tapered fiber laser oscillator, Baoli Yang,1 Chen Shi1, Hanwei Zhang1, Xiaolin Wang1, Pu Zhou1, Zhiyong Pan1, Xiaojun Xu1; 1College of Advanced Interdisciplinary Studies, National Univ. of Defense Technology, China. We have constructed a monolithic fiber laser oscillator based on tapered double cladding ytterbium-doped fiber. The performance of the output laser, especially on the aspect of the transverse mode instability (TMI) was studied in details.

AM6A.25 Pulse fragmentation and multi-soliton states in mid-infrared mode-locked fiber laser, Jiapeng Huang1, Meng Pang1, Xiong Jiang1, Philip Russell2; 1Max-Planck Inst. for the Science of Light, Germany; 2Weserm, in a highly pumped 2.8 µm mode-locked fiber laser, a variety of stationary multi-soliton states, including phase-locked soliton-pair and soliton-triplet states and stable harmonic mode-locking at two and three times the round-trip frequency.

AM6A.26 Ultra-short wavelength thulium doped mode-locked fiber laser in both soliton and noise-like pulse regimes, Zhengyi Ren1, Shaoyang CHEN1,2, Raghuraman Sidhanthar1, Seongyoo Yoo1, David Richardson1, Shaiuf Alami1; 1Univ. of Southampton, UK; 2Nanyang Technological Univ., Singapore. We demonstrate an ultra-short wavelength mode-locked thulium-doped fiber laser (TDFL) based on nonlinear-loop mirror (NOLM) in both soliton and noise-like pulse regimes. Stable soliton and noise-like pulses at ultra-short wavelengths of 1656 nm are achieved.

AM6A.27 Generation of Self-Q-Switching in a Diode-Pumped Monolithic Yb:KGW Laser, Tat-Lun Huang1, Hsing-Chih Liang1, Kuan-Wen Su1, Kai-Feng Huang1, Yung-Fu Chen1; 1National Chiao Tung Univ., Taiwan; 2National Taiwan Ocean Univ., Taiwan. Mode-to-pump size ratio of the laser system was experimentally found to be the key factor leading to self-Q-switching. The maximum pulse energy was estimated to be 1.4 µJ at the repetition rate of 880 Hz.

AM6A.28 Single-mode Yb-doped Double-clad All-solid Photonic Bandgap Fiber Laser Generating 27.8W at 976nm, Thomas W. Hawkins1, Joshua Parsons1, Guancheng Gu2, Wensong Li1, Max Fayku1, Bradley Selee1, Jonathan A. Dong1, Liang Dong1; 1Clemson Univ., USA; 2Coherent/Nullem, USA. We demonstrated a 50 mJ, 100 Hz, 355 nm laser. Energy stability is better than 5% RMS. The third harmonic generated in a diode-pumped 200 mJ, 500 ps Nd:YAG laser system centered at 1064 nm.

AM6A.29 Modal Decomposition of Optical Fiber Output in OAM Basis Using Optical Correlation Technique, Pachava Srinivas1, Awakash Dixit1,2, Bajaj Srinivasan1,3, National Institute of Technology Madras, India. We represent the optical fiber output beam as a linear superposition of orbital angular momentum (OAM) modes to quantify its purity. Through controlled experiments, we observe good agreement between the experimentally measured OAM and simulated spectrum.

AM6A.30 Green wavelength tuning and switching operation in holmium-doped all-fiber lasers, Wensong Li1,2, Zhengqi Ren1, Zhiyong Pan1, Xiaojun Xu1; 1College of Advanced Interdisciplinary Studies, National Univ. of Defense Technology, China; 2HCelome Department of Electrical and Computer Engineering/Center for Optical Materials Science and Engineering Technologies, Clemson Univ., USA. We experimentally developed tunable and switchable Ho3+-doped all-fiber lasers operating at green wavelengths. With an increase of incident pump powers, tunable single-wavelength and switchable multi-wavelength emissions between 542.6 nm and 549.9 nm are achieved, respectively.

AM6A.31 A watt-level efficient continuous wave Er:YAP laser at 2.92 µm, Hiroki Kawase1, Ryo Yasuhara1,2; 1SOKENDAI (The Graduate Univ. for Advanced Studies), Japan; 2National Inst. of Natural Sciences, National Inst. for Fusion Science, Japan. A watt-level CW operation at 2.92µm was demonstrated by diode-pumped Er:YAO3 laser. The near quantum defect slope efficiency of 30% was obtained without optimization. These results show the great potential for high power mid-IR lasers.

AM6A.32 High energy, high beam quality active multipass stretcher for chirped-pulse amplification, Pengpeng Su1,2, Yueji Peng1, Junchi Chen1, Xinlin Li1,2, Yanyan Li1, Pengfei Wang1,2, Yuxin Leng1; 1Shanghai Inst. of Optics and Fine Mechanics, China; 2Univ. of Chinese Academy of Science, China. An active multipass chirped pulse stretcher is demonstrated, which can deliver pulses with 5 mJ energy and 12 ns duration. The stretched pulses also feature good beam quality with M2 factor of 1.1.

AM6A.33 Exploring the Stress-Induced Birefringence in Dual-Central-Wavelength Single-Longitudinal-Mode Monolithic Nd:YAG Laser at 1319 nm and 1338 nm, We have represented stage of 1550 nm pulsed fiber system. Pulse energies of 355 nm are achieved with careful designing coating specification for monolithic Nd:YAG lasers. The beat frequency can be linearly varied by increasing the external force.

AM6A.36 Investigation of a Large Mode Area Pulsed 1550 nm Laser System, Michael Klopfer1, Leanne J. Henry, Air Force Research Laboratory, USA; 2Univ. of New Mexico, USA. An erbium-doped fiber having 52 micron core was investigated as high power stage of 1550 nm pulsed fiber system. Pulse energies of 355 nm and 12 ns duration. The stretched pulses also feature good beam quality with M2 factor of 1.1.

AM6A.37 Study on Thermal-Lens Induced Coupling of Transverse Modes in High-Power Fiber Amplifiers, Jiaqiu Cao,1 Wenbo Liu1,2 Jinbao Chen1,2 National Univ. of Defense Technology, China. Thermal-lens induced coupling between the fundamental and higher-order modes in the high-power fiber amplifier is revealed firstly, to the best of our knowledge, and the variation of pertinent coefficient is discussed.

AM6A.38 Exploring the Stress-Induced Birefringence in Dual-Central-Wavelength Single-Longitudinal-Mode Monolithic Nd:YAG Laser at 1319 nm and 1338 nm, Hao-Feng Cheng1, Hsing-Chih Liang1, Kuan-Wen Su1, Kai-Feng Huang1, Yung-Fu Chen1; 1National Chiao Tung Univ., Taiwan; 2National Ocean Univ., Taiwan. The single-longitudinal-mode operation with dual-wavelength emission at 1319 and 1338 nm are realized by carefully designing coating specification for monolithic Nd:YAG lasers. The beat frequency can be linearly varied by increasing the external force.

AM6A.39 Study on Thermal-Lens Induced Coupling of Transverse Modes in High-Power Fiber Amplifiers, Jiaqiu Cao1, Wenbo Liu1, Jinbao Chen1,2 National Univ. of Defense Technology, China. Thermal-lens induced coupling between the fundamental and higher-order modes in the high-power fiber amplifier is revealed firstly, to the best of our knowledge, and the variation of pertinent coefficient is discussed.

AM6A.40 The near quantum defect slope efficiency of 30% was obtained without optimization. These results show the great potential for high power mid-IR lasers.
08:00 – 10:00
ATu1A • Unconventional Techniques
Presider: Norihiko Nishizawa; Nagoya Univ., Japan

ATu1A.1 • 08:00
Low-birefringence 120 W Yb fiber amplifier producing linearly polarized pulses with 69-GHz linewidth at 1083 nm, Zhimeng Huang1, Shankar Pidishety1, Thomas W. Hawkins1, Yujun Feng1, Yutong Feng1, Sheng Zhu1, Yujun Feng1, Yutong Feng1, Sheng Zhu1, Liang Dong2, Johan Nilsson1; 1Univ. of Southampton, UK; 2Clemson Univ., USA. A low-birefringence 5-m-long fiber amplifier with a highly Yb-doped 40-μm, 0.028-NA phosphosilicate core produces linearly polarized (7.2-dB PER) 20-ns, 0.8-mJ pulses with 69-GHz linewidth, M² = 1.2, and 120 W of average output power at 1083 nm.

ATu1A.2 • 08:15
LED Pumping of Solid-state Lasers, Francois Balembois1, Pierre Pichon1,2, Frederic Druon1, Jean-Philippe Blanchot2, Patrick Georges1; 1Institut d’Optique, France; 2Effilux, France. With the recent development of LED-pumped luminescent concentrators, we report the recent advances on LED-pumping of transition-metal-doped crystals lasers (Alexandrite, Cr:LiSAF and Ti:Sapphire). Laser performances, tunability and small-signal gain measurements are reported in free-running operation.

ATu1A.3 • 08:45
Sub-100-fs pulse generation from a Kerr-lens mode-locked Alexandrite laser, Can Cihan1, Abdullah Muti1, Isinsu Baylam2, Akin Kocabas1, Umit Demirbas3, Alphan Sennaroglu1,2; 1Koç Univ., Turkey; 2Koç Univ. Surface Science and Technology Center (KUYTAM), Turkey; 3Antalya Bilim Univ., Turkey. We report, to the best of our knowledge, the shortest pulses obtained from a Kerr-lens mode-locked multipass-cavity Alexandrite laser operating near 750 nm. The resonator produced 70-fs pulses with a time-bandwidth product of 0.331.

ATu1A.4 • 09:00
Femtosecond Mamyshev Oscillator at 1550 nm, Michel Olivier1,2, Vincent Boulanger1, Felix Guilbert-Savary1,2, Pavel Sidorenko3, Frank W. Wise3, Michel Piche1; 1Centre d’optique, photonique et laser (COPL), Universite Laval, Canada; 2Physique, Cagge, Gameau, Canada; 3School of Applied and Engineering Physics, Cornell Univ., USA. We demonstrate an environmentally stable Mamyshev Oscillator at 1550 nm. The oscillator delivers 19 nJ linearly chirped pulses compressed externally to 125 fs using a grating pair to achieve a peak power of 67 kW.

ATu1A.5 • 09:15
Optimized (Quantum) Photonics, Jelena Vuckovic1; 1Stanford Univ., USA. Our inverse design approach offers a powerful tool to implement classical and quantum photonic circuits with superior properties, including robustness to errors in fabrication and temperature, compact footprints, novel functionalities, and high efficiencies. We illustrate this with a number of demonstrated devices in silicon and in diamond.

ATu1A.6 • 09:45
Thresholdless superradiance laser, Kyungwon An1; 1Seoul National Univ., Korea. We present a thresholdless laser by time-separated coherent superradiance. Contrary to the conventional approach of maximizing the beta factor, we utilized collective interaction of phase-aligned atomic dipoles in a high-Q cavity to achieve thresholdless lasing.

08:00-10:00 • Directed Energy Defense Special Session (Restricted Access), Harbor Ballroom III

Please note pictures and recording of presentations are not allowed.
Galleria Hall

10:00 - 11:30
ATu2A • ASSL Poster Session with Exhibits and Coffee Break

ATu2A.1
Surface modification of Invar via polarization mixing by a femtosecond laser irradiation, Jeonghwan Kim1, Jungyu Hur2, Doh Hoan Kim1, Jong Kab Kim1; 1AP systems, Korea. We report the surface modification of Invar film through periodically switching of the polarization direction using the scanning of femtosecond laser to eliminate the micro holes and surface ripples, which are unwillingly generated by LIPSS.

ATu2A.2
Ni2+ :ZnF2 Glass-Ceramics Waveguide Beam Splitters Inscribed by Femtosecond Laser, Jiabei Tang1, Quan Hu1, Junli Wang1, Changgui Lin1, shixun dai1, liangfeng Zhu1, Zhiyi Wei1, 1Xidian Univ., China; 2Ningbo Univ., China. The 1 × 2 beam splitters with different beam splitting angles are fabricated in the Ni2+ :ZnF2 glass-ceramics by femtosecond laser. The minimum propagation loss is determined at 1030nm, and its guiding properties are investigated.

ATu2A.3
Laser-Induced Periodic Surface Structures in GaP, Reza Sanatinia1, Alexander W. Raymond1, Eric Mazur1; 1Harvard Univ., USA. Laser-induced periodic surface structures (LIPSS) in GaP with high and low spatial frequencies were systematically investigated. We fabricated these structures using a fs laser as a feasible alternative method to realize nonlinear photonic metasurfaces.

ATu2A.4
Fluorescence spectrum of an Yb:Er:Tm:Ho Doped Germanate Glass, Ali Albalawi1, Marc Kochanowicz2, Jacek Zmoodzja1, Piotr Miliukski1, Dominik Doroz2, Stefan Taczec2; 1Swansea Univ., UK; 2Bialystok Univ. of Technology, Poland; 1AGH - Univ. of Science and Technology, Poland. In this paper we present preliminary fluorescence measurement of an Yb:Er:Tm:Ho. We show a flat emission spectrum of about 450 nm and, in principal, continuous emission from 1500 nm to about 2200 nm.

ATu2A.5
Absorption measurement of layer or material: how to calibrate?, Herve Piombini1, 1CEA Le Ripault, France. The purpose of this paper is to provide a method for measuring the absorption of material with a low extinction coefficient and to establish simple ratios for estimating the absorption of materials or thin layers.

ATu2A.6
Infrared emissions around 8µm in rare-earth doped chalcogenide fibers, Alain Braud1; 1CIMAP, France. The long wave infrared (LWIR) emission around 8µm of Sm3+ and Tb3+ doped chalcogenide fibers is reported. These rare-earth doped fibers exhibit a significant emission band from 6.5 to 8.5µm with a maximum emission around 7.3 µm with the Sm3+ doping while the Tb3+ emission is centered at 8µm.

ATu2A.7
Withdrawn

ATu2A.8
Maintaining high performance of optical parametric amplification in a chalcogenide hybrid microstructured optical fiber, Hoang Tuan Tong1, Nguyen P. Ho1, Takenobu Suzuki1, Yasutake Ohishi2; 1Toyota Technological Inst., Japan. FOPA signal gain spectrum with broad bandwidth ~5540 nm at 20 dB can be maintained even when fiber structure fluctuation occurs by using a chalcogenide hybrid microstructured optical fiber with buffer layer.

ATu2A.9
Suppression of high order modes in large mode area optical fiber using highly-absorbing inclusions, Mikhail M. Bubnov1, Mikhail E. Likhachev1, Michal M. Bu2; 1High Tech Instruments, Inc, USA; 2Institute of Photonic Technology, Czechia. We propose a new approach for high order mode suppression in few-mode optical fibers. The technique is based on distortion and absorption of undesirable modes by additional highly-absorbing rods incorporated in to the fiber cladding.

ATu2A.10
Understanding of crazing of sol-gel layers and improvement for components submitted to high power laser, Hiroaki Furuse1, Junli Wang1, Alexander W. Raymond1, Eric Mazur1; 1Oki Electric Industry Co., Ltd., Japan; 2Fiberoptics Research Center the RAS, Russia. We demonstrated an approach to understand the phenomenon and suggest solutions.

ATu2A.11
Hot-wire CVD Based SIN Films For Linear and Nonlinear Photonics Device Applications, Kentaro Furuwasawa1, Yoshimi Yamashita1, Kanna Aoki1, Noriko Sekine1, Akifumi Kasamatsu1, Yoshinori Uzawa1; 1National Inst. of Information & Comm Tech, Japan; 2AIST, Japan. The laser MegaJoule needs numerous optical components coated by sol gel which need a post treatment that induces crazing. We are going to present the characterizations made to understand the phenomenon and suggest solutions.

ATu2A.12
Observation of Intensity Distribution of Second Harmonic Generation in PPLN waveguide by Microscopy, Tadashi Kishimoto1, Hitoshi Murai1, Hironori Sasaki1, Yoshihiro Ogawa1; 1Ok Electric Industry Co., Ltd., Japan; 2Department of Physics, Toyo University, Education, Japan. We observed SHG intensity distribution along a PPLN waveguide by a microscopic technique. We demonstrated that the SHG conversion efficiency is not proportional to the square of the device length due to non-negligible propagation losses.

ATu2A.13
Efficient Nonlinear Cross-Polarized Wave Conversion in Photonic Band-gap Structure, Prathan Buranasiri1, Surawut Wicham2; 1KMITL, Thailand; 2Physics, Siriprakan Witt University, Thailand. We demonstrated an enhancement of cross-polarized wave generation in a photonic band-gap structure composed of two periodic arrangement of barium-fluoride and silicon-dioxide numerically. We found that the conversion efficiency of XFW generation is obviously enhanced by band-edge field enhancement.

ATu2A.14
Spectral and Lasing Characteristics of Er:YAP Crystal in Temperature Range 80 to 300 K, Michal Nemec1, Richard Svejkar1, Jan Sulc1, Hervé Piombini1, 1Czech Technical Univ. in Prague, Czechia. Spectral and laser characteristics of Er:YAP active material are presented in the temperature range from 80 to 300 K. The laser generation at 1623 nm pumped by fiber coupled 1453 nm laser diode was obtained.

ATu2A.15
Withdrawn

ATu2A.16
Uni-Wavelength Cascade Lasing ~1900 nm from 2× to 4×Nd Transitions, George Dubé1, Roland E. Juhala2; 1Telkwa Stabilized Instruments, Inc, USA; 2AIST, Japan. We reported a new approach for high order mode suppression in few-mode optical fibers. The technique is based on distortion and absorption of undesirable modes by additional highly-absorbing rods incorporated in to the fiber cladding.

ATu2A.17
Bonding condition for sapphire/Nd:YAG composite by pulsed electric current technique, Hiroaki Furuse1, Yuki Koike1, Ryo Yasuhara2; 1Kitami Inst. of Technology, Japan; 2National Inst. for Fusion Science, Japan. Pulsed electric current bonding condition for Sapphire/Nd:YAG composite was studied to improve optical and laser quality. Further, bonding of a sapphire-sandwich structure was demonstrated.

ATu2A.18
Co-doping Nd:CaF2 with buffer ions for inertial fusion application, Rémi Soulard1, Diane Stoffel1, Jean-Louis Doualan1, Alain Braud1; 1CIMAP, France. We demonstrated an approach to understand the phenomenon and suggest solutions.

ATu2A.19
Withdrawn

ATu2A.20
Broadly-tunable Diode-pumped Tm:Ca(VO4)2 Laser, Han Sulc1, Jan Kratochvil1, Michal Nemec1, Richard Svejkar1, Maxim E. Doroshenko1, Alexander G. Papashvili1, Irina S. Voronina1, Lyudmila I. Ivelava1; 1Czech Technical Univ. in Prague, Czechia; 2Prokhorov General Physics Inst. of Russian Academy of Sciences, Russia. Diode-pumped laser based on new Tm:Ca(VO4)2 crystal was investigated at 300 K. Smooth continuous tuning from 1834 nm to 2072 nm was achieved using quartz plate as a tuning element.

Tuesday, 6 November

OSA Laser Congress 2018 4 November - 8 November 2018
Galleria Hall

10:00 - 11:30

ATu2A • ASSL Poster Session with Exhibits and Coffee Break (Continued)

ATu2A.21
Growth, spectroscopy and laser operation of "mixed" Tm:Ca(Gd,Lu)AlO3 - A novel crystal for mode-locked lasers, Zhongbin Pan1, Josep Maria Serres2, Pavel Loiko1, Huaile Yuan1, Xiaojun Dai3, Huaqiang Cai4, Yicheng Wang4, Yonggang Zhao4, Magdalena Agulio3, Francesc Diaz5, Xavier Mateos6, Ulle Griebner3, Valentijn Petrov4, Esrom Kifle1, Jerang Su6, Normal Univ., China; 2Max-Born-Inst., Germany; 3ITMO Univ., Russia; 4China Academy of Engineering Physics, China; 5Universitat Rovira i Virgili (URV), Spain. A tetragonal "mixed" Tm:Ca(Gd,Lu)AlO3 crystal is grown by the Czochralski method. The Lu+-doping broadens the Tm3+-gain spectra. A diode-pumped Tm:Ca(Gd,Lu)AlO3 laser generated 1.82 W at 1945 nm with a slope efficiency of 29%.

ATu2A.22
Investigation of the Ultrafast Response and Saturable Absorption of Voltage-Controlled Graphene, Isinsu Baylan1, Melissa N. Czemician1, Nurbek Kakenov1, Coskun Kocabas1, Alphon Semnarougli1, Koç Univ., Turkey; 2Physics, Bilkent Univ., Turkey; 3Aviv Univ., Israel. Ultrafast pump-probe measurements show that at a bias voltage of 1V, voltage reconfigurable graphene supercapacitors can operate as fast saturable absorbers with adjustable insertion loss over an ultrabroad spectral range from 630 to 1100 nm.

ATu2A.23
Withdrawn

ATu2A.24
Nonlinear Beam Shaping via the Geometric Phase in Sum Frequency Generation, Aviv Karnieli1, Ady Arie1, 1Tel-Aviv Univ., Israel. We propose and analyze the generation of a controllable and robust adiabatic geometric phase via a quadratic nonlinear optical process. This approach enables wavefront shaping tasks such as focusing and mode conversion in sum-frequency processes.

ATu2A.25
Two micron All-normal-dispersion NPR mode-locked Tm:ZBLAN fiber laser, Hitomi Sagara1, Anna Suzuki2, Shotaro Kitajima1, Masaki Tokurakawa1, 1Univ. of Electro-communications, ILS, Japan. We demonstrated a two micron all-normal-dispersion nonlinear polarization rotation mode-locked Tm:ZBLAN fiber laser. An output power of 57 mW at 70.6MHz repetition rate with a cat-ear-like shape spectrum of 50 nm bandwidth were obtained.

ATu2A.26
Experimental Demonstration of the Coherent Mid-IR Supercontinuum Source Using All-normal Dispersion Engineered Tellurite Fiber, Than Singh Saini1, Tong H. Tuan1, Luo Xing1, Nguyen P. Hoa1, Takebou Sakozi1, Yutaka Ohishi1, 1Toyota Technological Inst., Japan. Broadband coherent mid-IR supercontinuum spectrum spanning 1.34–2.84 μm is demonstrated using all-normal tellurite step-index fiber. Spectrum is obtained with 200 fs laser pulse of coupled peak power of 5.5 kW at 20 μm.

ATu2A.27
Nonlinear-mirror mode-locked Er3+-ZBLAN fiber laser, Lina Zhao1, Jiarrang Wang2, Shu-hui Huang1, 1Univ. of Colorado Boulder, USA. We report the first nonlinear-mirror mode-locked Er3+-ZBLAN laser fiber at 2.8 μm. Continuous-wave mode-locking with an 88-mW average power at 33 MHz is observed. Simulation suggests a 300-fs pulse duration, which remains to be characterized.

ATu2A.28
High performance Ho:YAG single-crystal fiber laser inband pumped by a Tm-doped all-fiber laser, Jiangle Li1, Qingsong Song1, Yongguang Zhao2,3, chongfeng Shen1, Weichao Yao1, Li Wang1, Wei Zhou1, Donghui Li1, Xiaodong Xu2, Jun Xu2, Deyuan Shen1, 1Jiangsu Normal Univ., China; 2Max-Born-Inst., Germany; 3Chinese Academy of Sciences, China; 4Tongji Univ., China. We report on a Ho:YAG SCF laser inband pumped by an all-fiber Tm-Laser. CW laser with output power of 12.5 W output power and Q-switched laser with 1.44 mJ pulse energy and 7.5 ns pulse duration are demonstrated.

ATu2A.29
Extreme ultrafast pulsation in Tm:Ho mode-locked linear cavity fiber lasers, Ahmet E. Akosman1, Junjie Zeng2, Michelle Y. Sander1, 1Boston Univ., USA. In a Tm:Ho-doped ultrafast linear cavity fiber laser, extreme optical pulsation is demonstrated. Single-pulsing behavior at the fundamental repetition rate is maintained while the level of chaotic pulsation is adjusted by an intracavity polarization controller.

ATu2A.30
Q Switched Tunable milli-Joule Level Tm Laser, Salmon Noach1, Uziel Shainrot1, Rotem Naheuri1, Eytan Perez1, 1Jerusalem College of Technology, Israel. High energy continuous tunable Q switch Tm laser is demonstrated for the first time. Tuning range of 33 nm and 11 nm in active and passive Q switch, respectively, was achieved around 1.9 μm.

ATu2A.31
Passively Mode-locked (Tm,Ho):YLF Laser, Aleksey Tyazhev1, Marlène Paris1, Rémi Soulard2, Pavel Loiko2, Jean-Louis Doualan1, Grunve Brasse1, Alan Braud, Thomas Godin1, Patrice Camy2, Ammar Hideur1, 1UMR 6614 CORIA, Université de Rouen, France; 2Centre de recherche sur les ions, les Matériaux et la Photonique (CIMAP), UMR 6252 CEA-CNRS-ENSICAEN, Normandie Université, 6 Blvd Maréchal Juin, 14050 Caen, France. A passively mode-locked (Tm, Ho):YLF laser is reported for the first time. The laser is pumped with a high-power multimode laser diode and mode-locked with a graphene saturable absorber, delivering 52 mW of output power with a repetition rate of 75 MHz at a central wavelength of 2051 nm.

ATu2A.32
Efficient bulk and waveguide lasers at 2306 nm, Rémi Soulard1, Pavel Loiko1, Grunve Brasse1, Jean-Louis Doualan1, Alan Braud, Aleksey Tyazhev1, Ammar Hideur1, Blanche Guichard2, Laurence Guillemet1, Frédéric Druon3, Patrice Camy2, 1CIMAP, France; 2CORIA, France; 3FEMTO ST, France; 4LCF, France. The Ho3+-Tm transition of Tm3+ in YLF is characterized. Efficient 2.3-μm bulk and waveguide lasers are demonstrated. A CW diamond-saw-diced channel waveguide laser generated 147 mW at 2306 nm with a slope efficiency of 33.5%.

Harbor Ballroom I & II

Light the Future Talk

JTu3A.1 • 11:30 –12:30

Directed Energy Propulsion - Enabling the First Interstellar Missions, Philip Lubin1, 1UC Santa Barbara, USA. Recent advances in photonics and directed energy systems allow us to begin the path to both extremely rapid solar system travel as well as relativistic flight for the first interstellar missions. From wafer-scale spacecraft capable of speeds greater than c/4 that could reach the nearest star in 20 years to 10 kg spacecraft travelling at c/50 to large missions capable of supporting human life for rapid interplanetary transit - all can be enabled by the same system. Photonics, like electronics, and unlike chemical propulsion is an exponential technology with a current double time of about 20 months. The same system can be used for many other purposes including kilometer scale telescopes for specialized applications including exoplanet searches and imaging, planetary defense, space debris mitigation among many others. This would be a profound change in human capability. We will discuss the results of our NASA Starlight and Breakthrough Starshot programs, the many technical challenges ahead, current laboratory prototypes and our recent data on kilometer baseline arrays as well as the many transformative implications of this program.

12:30—14:00 • Complimentary Lunch in Exhibits Hall
absorption losses. apertures (>3.5 mm), improved grating propagation, and lower linear and nonlinear nonlinearity and deepest infrared transparency of any demonstrated quasi

Recent advances in all

as short as 500 nm. The crystals are used for counter
damage and thereby enable a repetition rate stabilized SESAM-modulated 10-GHz Yb:CALGO laser delivering 127 fs at 0.81 W from a compact straight laser cavity with normal dispersion.

ATu4A.4 • 15:00 Invited
Adiabatic QPM processes and frequency comb generation, Christopher R. Phillips¹, Leonard Kruger¹, Aline Mayer², Ursula Keller³; ¹ETH Zurich, Switzerland. Self-defocusing nonlinearities enabled by an adiabatic QPM device suppress Q-switching damage and thereby enable a repetition rate stabilized SESAM-modulated 10-GHz Yb:CALGO laser delivering 127 fs at 0.81 W from a compact straight laser cavity with normal dispersion.

ATu4A.5 • 15:30
Highly-efficient sub-μm periodically poled RKT for mirrorless OPO: fabrication, characterization, and performance, Carlota Canalias¹, Valdas Paskevicius¹, Andrius Zukauskas¹, Riaan Coetzee², and Kungliga Tekniska Hogskolan, Sweden. We present a highly-reliable fabrication technique for sub-μm PPRKTP demonstrating periodicities as short as 500 nm. The crystals are used for counter-propagating three-wave mixing interactions with a conversion efficiency exceeding 50% and mJ-level output energy.

ATu4A.6 • 15:45
Recent advances in all-epitaxial growth and processing of OP-GaAs, Peter G. Schunemann²; ²BAE Systems Inc, USA. Orientation-patterned GaAs has the highest nonlinearity and deepest infrared transparency of any demonstrated quasi-phased matched material. Continued efforts are reported towards achieving larger apertures (>3.5 mm), improved grating propagation, and lower linear and nonlinear absorption losses.

The space industry is presently undergoing a strong change - often referred to as "new space" - driven by new aerospace companies and ventures. Mega constellations of satellites are planned for distributing internet worldwide, laser communication to and between satellites allows a drastic increase of the available communication bandwidth, space based laser sensors enable monitoring of a variety of important parameters on Earth, new and cheaper launch systems are developed, etc. Laser technology plays an important role in many of these applications which will be addressed in this session.

LTu4B.1 • 14:00 Invited
Power Scaling Lasers for Space-Based Applications, Floyd Hovis¹; ¹Fibertek, Inc., USA. The reported highest power space-based lasers are the 20 W class lasers used in the Ice, Cloud and Land Elevation Satellite-2 (ICESat-2) and the Cloud Aerosol Transport System on the International Space Stations (CATS-ISS) missions. We will discuss our ongoing activities for scaling this and other laser technologies to the 100 W class and beyond.

LTu4B.2 • 14:30 Invited
Progress in Developing Satellite and UAV Laser Communication Modules and Sub-Systems, Efstratios Kehayas¹; ¹Gooch & Housego, UK. Photonics is expected to play a key role in space applications as optics and fiber-optics penetrate into satellite payloads and photonic components and sub-systems become integral functional parts of telecommunication, on-board signal distribution and/or remote sensing instrumentation. During this talk we will review the progress in developing and qualifying photonic components and sub-systems for communication and sensing in space.

LTu4B.3 • 15:00 Invited
Laser Guide Stars for Atmospheric Corrections, Frank Lison¹; ¹TOPTICA Projects GmbH, Germany. Atmospheric distortions limit seeing from earth into space, affecting optical astronomy and optical communication to satellites. Adaptive optics can compensate these distortions using measurements from guide stars. Bright natural guide stars are only available in a fraction of the sky. Instead, one can use lasers for creating artificial guide stars, either by Rayleigh scattering in the atmosphere or using fluorescence from a naturally occurring atomic sodium layer in the mesosphere. Only latter allows full compensation of the atmospheric distortions and requires a high power narrow line with laser resonant with the D2 sodium transition (589.2 nm). Today, most big telescopes use so-called 3rd generation sodium guide star lasers. These lasers use a diode laser as master oscillator, which is amplified in a Raman fiber amplifier and then resonantly frequency doubled delivering more than 20 W of optical output at 589 nm. In this presentation, we will review the current state of guide star lasers, their current use in astronomy as well as upcoming applications such as optical communication.

The session will end with a 30 minute round table discussion.
wavelength and temperature optimisation of a diode pumped Alexandrite oscillator producing 3.8mJ pulse energy is described with high Energy Diode Pumped Alexandrite Slab Amplifier as part of a future Alexandrite design for satellite-based lidar.

1Imperial College London, UK; 2Unilase Ltd, UK: Development of a Q-switched diode-pumped Alexandrite oscillator producing 3.8mJ pulse energy is described with wavelength and temperature optimisation of a diode-pumped Alexandrite slab amplifier as part of a future Alexandrite design for satellite-based lidar.

The rapid progress in extreme-power laser technology opened a path to the development of a new generation of small-scale EUV, X-ray, and Gamma-ray light sources with unprecedented brightness and short pulses. These sources, which could fit on a tabletop or in a small-scale laboratory, will revolutionize many industrial, research, medical, defense, and security applications. Their development relies on the progress in laser technology and performance. This session will give an update on the latest development, needs and challenges in high-power laser technologies tailored to methods for short (EUV, X- and Gamma-ray) wavelength generation (laser-produced plasma, high harmonic generation, inverse Compton scattering), and laser plasma acceleration.

From Nuclear Security to Medicine: Development and Applications of Compact Laser-Compton Light Sources, Christopher Barty; 1Univ. of CA, Irvine, USA. The development and optimization of compact, high-peak and high-average brilliance laser-Compton x-ray and gamma-ray sources is reviewed. Markets span a wide range of precision imaging and material identification applications including: nuclear security, high-efficiency mining, additive manufacturing, precision medical imaging, rapid drug development and theranostics.

High Average Power and High Energy Picosecond Thin-Disk Amplifiers, Christian Grebing; 1TRUMPF Scientific Lasers GmbH + Co. KG, Germany; Industrial high power thin-disk laser technology was originally developed by TRUMPF for laser cutting and laser welding. Up to 10 kW of average power can be obtained from a single thin-disk. Today this technology is also routinely used for ultrafast amplifiers. Pulse durations < 1 ps, multi-millijoule pulse energies at kilohertz repetition rates, average powers beyond 1 kW can be easily achieved with near-diffraction-limited output beams. Already in 2015, pulse energies of 220 mJ were demonstrated at 1 kHz and recently record values >1 kW average power with up to 200 mJ. Further increase of the pulse peak power can be obtained via spectral shaping resulting in pulse durations below 700 fs. Efficient non-linear pulse compression schemes can result in even shorter pulses well below 50 fs. Moreover, new developments with thin-disk based multipass amplifiers should lead to multikilowatt average output powers with pulse energies reaching even the Joule level, uncovering new perspectives of applications. Besides pumping optical parametric amplifiers (OPA), Laser lightning rod, X-ray lasers, inverse Compton scattering and particle acceleration are among them. Lately, TRUMPF Scientific Lasers has been developing a Joule class thin-disk based multipass amplifier at 1 kHz. The talk will give an overview of the current status and development at TRUMPF Scientific Lasers regarding ultrafast thin-disk amplifiers.

The rapid progress in extreme-power laser technology opened a path to the development of a new generation of small-scale EUV, X-ray, and Gamma-ray light sources with unprecedented brightness and short pulses. These sources, which could fit on a tabletop or in a small-scale laboratory, will revolutionize many industrial, research, medical, defense, and security applications. Their development relies on the progress in laser technology and performance. This session will give an update on the latest development, needs and challenges in high-power laser technologies tailored to methods for short (EUV, X- and Gamma-ray) wavelength generation (laser-produced plasma, high harmonic generation, inverse Compton scattering), and laser plasma acceleration.
This result paves the way towards compact Watt oscillator delivering 120 W average power. We measured up to 78 µW at 0.8 THz.

**AW1A.1 • 08:00**

180 W picosecond green laser from a frequency-doubled rod fiber amplifier, Zhi Zhao; *Brookhaven National Laboratory, USA.* We report on a 180 W picosecond green laser from a frequency-doubled Ytterbium-doped rod fiber amplifier. The fiber laser is designed to generate 270 W infrared and 180 W green power through efficient frequency doubling.

**AW1A.2 • 08:15**

Picosecond Ultraviolet Pulses at 257 nm with Variable Transform Limited Linewidth and Flexible Repetition Rate, Daniel Kiefer, Thomas Walther; *Technische Universität Darmstadt, Germany.* We present a fiber-based laser system generating transform limited pulses with adjustable duration (240 - 735 ps) and repetition rate (1 - 10 MHz). The pulses are frequency quadrupled to the ultraviolet at 257 nm.

**AW1A.3 • 08:30**

Ti:Sa CEP-Stabilized Laser System Allowing Wavelength Tunability or 1kHz, sub-18fs, TW-class Level Amplification, Anna Gololini, Xiaowei Chen, Emilien Gontier; Benoit Bussiere, Pierre Mary Paul, Olivier Tcherbakoff, Pascal D’Oliveira; Jean-Francois Hergott; *Amplitude Laser Group - Laseres operations, France; LIDYL, CEA, CNRS, Université Paris-Saclay, UMR 9222, CEA-SACLAY, France.* *Amplitude Laser Group – San Jose operations, USA.* We present a Ti:Sa laser system based on an original 10 kHz front-end design allowing either CEP-stabilized (350 mrad), 1 kHz, 17.8 fs TW-class pulses amplification or direct 80 nm wavelength tunability range.

**AW1A.4 • 08:45**

High power 1st and 2nd Stokes diamond Raman frequency conversion, Matthias Heinzig, Till Wallbaum, Gonzalo Palma Vega; Thomas Schreiber, Ramona Eberhardt, Andreas Tunnermann; *Fraunhofer IOF, Germany.* *Inst. of Applied Physics, Friedrich Schiller Univ. Jena, Germany.* We report high power frequency conversion in a diamond Raman laser operating on the first and second Stokes shift. At the first Stokes, a maximum output power of 125 W at 1178 nm was achieved.

**AW1A.5 • 09:00**

External Cavity Diamond Laser at 2.52 µm, Giorgos Demetriou; Vasili Savitski; Alan Kemp; *Inst. of Photonics, Strathclyde Univ., UK.* An external-cavity diamond Raman laser at 2.52 µm, pumped by a home-built Ti:YLF laser, is reported. The maximum output pulse energy is 1.1 mJ for 4.74 mJ incidence yielding a total conversion efficiency of 23%.

**AW1A.6 • 09:15**

Hundred watt 10th order random Raman fiber laser, Jinyan Dong, Lei Zhang, Huawei Jiang, Yan Feng; *Shanghai Inst. of Optics & Fine Mechanics, China.* With a high power Yb doped fiber laser as pump source, 10th cascaded Raman scattering to 1.95 µm in a half-open random fiber laser is demonstrated with an output power of 110 W.

**AW1A.7 • 09:30**

High Repetition-Rate Fiber Laser Driven THz Source Based on Two-Color Air-Plasma, Joachim Buldt; Cesar Jauregui; Michael Mueller, Jens Limpert; *Friedrich Schiller Universität Jena, Germany.* *Helmholtz-Institut Jena, Germany.* We demonstrate a first fiber-laser driven two-color air-plasma based THz source operating at 30 kHz repetition rate. The generated THz spectrum covers 0.1 – 5 THz and has an average power in the mW-range.

**AW1A.8 • 09:45**

Mode-Locked Thin-Disk Oscillator Driven THz Generation at 106 W of Average Power, Frank Meyer, Nesar Hekmat, Samira Mansoorzadeh, Martin Hofmann; Clara J. Saraceno; *Photonics and Ultrafast Laser Science, Ruhr-Universität Bochum, Germany.* We demonstrate THz generation in GaP driven by a mode-locked thin-disk oscillator delivering 120 W average power. We measured up to 78 µW at 0.8 THz. This result paves the way towards compact Watt-level, ultrafast oscillator pumped THz sources.

### Schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
<th>Location</th>
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<tr>
<td>08:00 - 10:00</td>
<td><strong>Harbor Ballroom I &amp; II</strong></td>
<td><strong>Harbor Ballroom I &amp; II</strong></td>
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<tr>
<td><strong>AW1A</strong> • Harmonic, Raman and THz conversion</td>
<td>Presider: Mark Bowers; Lockheed Martin Aculight Corp, USA</td>
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<tr>
<td>08:00</td>
<td><strong>Laser Applications for Mobility</strong></td>
<td><strong>Harbor Ballroom III</strong></td>
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<td><strong>LW1B</strong> • Laser Applications for Mobility</td>
<td>Moderator: Gerald Uyeno, Raytheon, USA</td>
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<tr>
<td>LW1B.1 • Holographic HUD and LiDAR Systems, Pierre-Alexandre Blanche; <em>Univ. of Arizona, USA.</em> Holography can offer unique solutions to the specific problems faced by embarkead optical systems. Head up display (HUD) and LiDAR for autonomous vehicles are two of these systems where we have used diffractive optical elements to provide original answers.</td>
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<td>LW1B.2 • Component and Module Technologies for Rugged and Low Cost LiDARs for Autonomous Vehicles, Scott Davis; <em>Analog Devices Inc., USA.</em> The combined move toward increased automation and improved safety has created a market opportunity for low cost, rugged, Light Detection and Ranging systems. At Analog Devices Inc., we are developing component and module technologies to support this emerging market. These include non-mechanical laser beamsteering devices, high current laser drivers, detection and digitization electronics, and others. In this talk we will discuss our strategy for technology development to support LiDAR and give details of some new emergent capabilities. In particular we will present our non-mechanical beamsteering technology and how it can be implemented into a LiDAR system to meet automotive sensing requirements.</td>
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**10:00-11:00 • Exhibits and Coffee Break, Galleria Hall**

**OSA Laser Congress 2018** 4 November - 8 November 2018
AW2A • Joint Session: Vortex Sources and Applications
Presider: Balaji Srinivasan; Indian Inst. of Technology, India

AW2A.1 • 11:00
Versatile Vortex Laser Sources and Their Application, Takashige Omatsu; Chiba Univ., Japan. We review wavelength versatile optical vortex sources in an ultraviolet~THz wavelength region. Such wavelength versatile vortex sources should open an avenue towards advanced sciences and innovative technologies, including nondestructive super-resolution molecular spectroscopy and chiral microfabrication of organic materials.

AW2A.2 • 11:30
Vortex Laser Output with a Fundamental Gaussian Internal Mode using a Sagnac Interferometer, William R. Kerridge-Johns, Jan W. Geberbauer, Andrea Volpini, Michael J. Damzen; Photonics Group, Imperial College London, United Kingdom. We experimentally demonstrate a simple technique to convert any linear laser cavity into an optical vortex source using a Sagnac interferometer as an output coupler. No specialist optics are needed, the vortex has controlled handedness.

AW2A.3 • 11:45
Generation of polygonal vortex beams in quasi-frequency-degenerate states of Yb:CALGO laser, Yijie Shen, Zhensong Wan, Yuan Meng, Xing Fu, Mali Gong; Tsinghua Univ., China. We originally demonstrate the vortex beams carrying large OAM with exotic patterns of closed polygons, which is generated by a Yb:CALGO laser resonator with astigmatic transformation in quasi-frequency-degenerate SU(2) states.

AW2A.4 • 12:00
15-dB Raman Amplification of an Optical Orbital Angular Momentum Mode in a Step-Index Fiber, Sheng Zhu, Shankar Pidishety, Johan Nilsson; Univ. of Southampton, UK. We experimentally demonstrate 15-dB Raman amplification of 1115-nm, 20-ns pulses of charge \( |e| \) = 2 orbital angular momentum mode in a 5-m multimode-pumped step-index fiber with measured mode purity of 83.2%.

12:00-13:30 • Complimentary Lunch in Galleria Hall

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Highly efficient continuous wave single mode Cr^2+:CdSe laser generation. For the first time, luminescence lifetime dependent on temperature for Cr^2+:CdSe single crystal in 236-391 K range was obtained.

Laser peening has great potential to prolong the service life of various products and components, and is expanding the application area based on the advancement in high-power laser technology. The purpose of this session is to provide a forum for exchanging the latest results of research, development and innovation in laser peening and related technologies including high-power lasers, new processes such as adhesion/damage testing, laser interaction models and application to different types of materials and components with emerging interest.

LW3B.1 • 13:30  
Diode-Pumped Production Laser Peening Equipment, Jeff Dulaney; 'LSP Technologies Inc., USA. Dr. Dulaney will discuss the advancement in production laser peening equipment and its increasing adoption throughout the commercial manufacturing sector. This presentation will cover the technological innovations of LSP Technologies’ high-repetition-rate production laser peening systems.

LW3B.2 • 14:00  
A New Additive Manufacturing Hybrid Process Combining Selective Laser Melting with Laser Shock Peening, Roland Logel; 'EPFL, Switzerland.' 3D LSP is a hybrid process resulting from the combination of Selective Laser Melting (SLM) with Laser Shock Peening (LSP). It consists in applying LSP periodically, during 3D printing of metallic alloys, and leads to the 3D control of residual stresses. This is used to improve fatigue life of SLM parts, and leads to enhanced results compared to standard 2D LSP treatments, due to the increased penetration depth of LSP-induced compressive stresses. Other benefits of 3D LSP include reduced process failure related to cracking, and improved geometrical accuracy. The approach also provides new degrees of freedom for the 3D control of material hardness and grain size.

LW3B.3 • 14:30  
Invited  
Laser Shock Peening Technology Development: a South African Initiative, Claudia Polese; 'Univ. of the Witwatersrand, South Africa. Laser Shock Peening (LSP) is a cutting edge technology capable of drastically extending the operative life of critical metallic components. The synergic collaboration within the South African LSP Group succeeded in establishing a research work cell, a total first for a laboratory in Africa and probably in the entire Southern Hemisphere. Excellent performances for aluminum airframe structures were obtained and innovative process features were characterized, spearheading the group at the forefront of this rapidly emerging technology.

The current group activity is aimed at further extending the potential applications of LSP for the national and international aerospace and power generation industries. A more robust technology demonstrator is under development on a Thales laser platform, integrating a prototype of a patented “heartbeat” diagnostic system. This innovative monitoring device is based on the unique acoustic signature of the LSP process, which is directly proportional to the laser-material interaction.
Wednesday, 7 November

AW4A • Mid-IR sources

Presider: Jim Kafka, Spectra-Physics Lasers, USA

AW4A.1 • 16:00

Highly-Stable 2.8 µm MOPA System with Fluoride-Fiber-Based Pump Combiners, Hiyori Uehara¹, Daisuke Konishi¹, Christian Schäfer², Kenji Goya¹, Masanao Murakami², Shigeki Tokita¹; ¹Osaka Univ., Japan; ²Mitsubishi Diamond Industrial Co., Ltd., Japan. We have demonstrated a stable CW operation with output power of 24 W by an Er:ZBLAN fiber MOPA system at 2.8 µm wavelength. It is our unique technology that fabrication of a fluoride-fiber-based pump combiner which inhibits thermal loading of the fiber.

AW4A.2 •

Withdrawn

AW4A.3 • 16:15

2.3-12 µm Tunable, Sub-10 Optical Cycle, ZnGeP2-based OPA Directly Pumped by a Tm:fiber Laser at 1.96 µm and 100 kHz, Matthias Baudisch¹, Marcus Beutler¹, Martin Gebhardt¹, Christian Gaida¹, Fabian Stutzki³, Steffen Hädrich¹, Robert Herds¹, Kevin Zawilski³, Peter G. Schunemann⁴, Armin Zach¹, Jens Limpert⁵, Ingo Rimke¹; ¹APE Angewandte Physik & Elektronik GmbH, Germany; ²Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Germany; ³Helmholtz-Inst. Jena, Germany; ⁴Active Fiber Systems GmbH, Germany; ⁵TOPTICA Photonics AG (Germany), Germany; ⁶BAE Systems, MER15 1813, P.O. Box 868, Nashua, New Hampshire 03061, USA; ⁷Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. We demonstrate the first ZnGeP2-based, femtosecond OPA system driven directly by a Thulium-based fiber-laser system operated at 100 kHz. The OPA delivers mid-to-long-infrared tunable pulses with idler energies up to 2.2 μJ (23% quantum efficiency).

AW4A.4 • 16:45

Multi-mJ, 8.8 µm, Mid-infrared Laser with a Flat Spectrum Supporting Single-cycle Pulses from a GaSe-based Optical Parametric Amplifier, Kun Liu¹,², Houkun Liang¹, Lifeng Wang¹, Shizhen Qu¹,², Hao Li¹, Qijie Wang², Ying Zhang¹; ¹Precision Measurements Group, Singapore Inst. of Manufacturing Technology, Singapore; ²Centre for Optoelectronics and Biophotonics, School of Electrical & Electronic Engineering & The Photonics Inst., Nanyang Technological Univ., Singapore. We report an 8.8 µm, carrier-envelope phase stable, mid-infrared optical parametric amplifier based on a GaSe nonlinear crystal, with 3.4-mJ idler pulse energy, and a flat spectrum covering 4.2- to 16-µm which supports single-cycle pulses.

AW4A.5 • 17:00

High-Average-Power, 100-kHz OPCPA System with Dual Output at 1.55/3.1 µm, Mark Mero¹, Zsuzsanna Heiner²,³, Valentin Petrov¹, Horst Rottke¹, Federico Branchi¹, Gabrielle M. Thomas¹, Marc J. Vrakking¹; ¹Max Born Inst., Germany; ²School of Analytical Sciences Adlershof SALSA, Humboldt-Universität zu Berlin, Germany; ³Department of Chemistry, Humboldt-Universität zu Berlin, Germany. We present a 100-kHz OPCPA system based on noncollinear KTA booster amplifiers delivering 43-W, 51-fs, CEP-stable pulses at 1.55 µm and angular-dispersion-compensated, 12.5-W, 73-fs pulses at 3.1 µm.

AW4A.6 • 17:15

Multi-mJ sub-100 fs Midwave-infrared OPCPA at a 1 kHz Repetition Rate, Lorenz von Graffenstein¹, Martin Bock¹, Kevin Zawilski³, Peter G. Schunemann², Uwe Griebner¹; ¹Max Born Inst., Germany; ²BAE Systems, USA. The parametric generation of 2.5-mJ ultrashort pulses at 5 µm is reported using a 2-µm pump source which delivered pulses with 43-mJ energy and 2.8 ps duration at a 1 kHz repetition rate.

AW4A.7 • 17:30

High-Average-Power Few-Cycle Pulses at 2.5 µm, Nicolas Bigler¹, Justinas Pupeikis¹, Stefan Hisafov¹, Lukas Gallmann¹, Christopher R. Phillips¹, Ursula Keller¹; ¹Department of Physics, Inst. of Quantum Electronics, ETH Zurich, Switzerland. We present a high-power mid-infrared (mid-IR) optical parametric chirped-pulse amplifier (OPCPA) generating 13.4 fs pulses centered at 2.5 µm at an average power of 12.2 W and a repetition rate of 100 kHz.

18:00-21:00 • Congress Banquet, Spirit Cruise
Advances in Semiconductor-core Fiber, Ursula J. Gibson, Norges Tekniske Naturvitenskapelige Univ, Norway; Applied Physics, KTH, Sweden. Silicon, silicon-germanium and GaSb-core fibers fabricated with the molten-core drawing technique demonstrate non-linear effects, long wavelength transmission, and potential as fiber-based sources. Material processing aspects of these fibers will be discussed.

Efficient Lasers at 1.6-1.8 µm Based on Bismuth-Doped Germanosilicate Fibers with Thermally Induced Active Centers, Evgeny M. Dianov, Sergei Firssov, Alexandr Kharakhordin, Sergey Alyshev, Konstantin Riumkin, Mikhail Melkumov; Fiber Optics Research Center, RAS, Russia. 2 Ogarev Mordovian State Univ., Russia. The laser performance at the wavelength 1700 nm with a slope efficiency of 18% has been demonstrated using a 8.5-m long bismuth-doped fiber containing thermally induced active centers.

Tapered photonic crystal fiber for wide repetition rate tuning of optoacoustically mode-locked fiber laser, Dung-Han Yeh, Wenbin He, Meng Pang, Xin Jiang, Gordon Wang, Phillip Russell; MPI Science of Light, Germany. Tapering a few-m length of solid-core PCF results in a three-times-broadened optoacoustically gain bandwidth, enabling the GHz repetition rate of an optoacoustically mode-locked fiber laser to be continuously tuned over more than 50 MHz.

Study of fiber fuse induced damage in chalcogenide photonic crystal fibers, Sida Xing, Siyatoslav Khartonov, Jianqi Hu, Camille-Sophie Brès; Ecole Polytechnique federale de Lausanne, Switzerland. We observed fiber fuse in relatively low-melting temperature chalcogenide photonic crystal fibers at 7 MW/cm² in-core intensity. The voids structure and period were investigated. Chalcogenide vapor traveling in air holes modified fiber dispersion beyond fiber fuse region.

Large-mode-area Photonic Crystal Fiber Towards Pulse Laser Amplification Based on YbAl/P/F CodopedSilica Glass, Fan Wang, Meng Wang, Suya Feng, Shikai Wang, Chunlei Yu, Lili Hu; Shanghai Inst of Optics & Fine Mech Lib, China; Univ. of Chinese Academy of Sciences, China. A low NA heavy Yb-doped large-mode-area photonic crystal fiber based on YbAl/P/F codoped silica glass with a 50-µm diameter core has been prepared. The laser oscillation and pulsed laser amplification behaviors have been investigated.

Large-core Hollow-Core Antiresonant Fiber with Low-Loss and Truly Single-Mode Guidance for N-IR Wavelengths, Laurent Provino, Adil Haboucha, Melanie Havranek, Achille Monteville, David Landais, Olivier Le Goffic, Xavier Insou; Margaux Barbier, Thierry Chartier, Monique Thual; UMR 6082, PERFOS, RTO Photonics Bretagne, France; Univ Rennes, CNRS, Institut FOTON – UMR 6082, France. We report on the modeling and characterization of a truly single-mode hollow-core antiresonant fiber with a transmission band covering part of the near-infrared spectral region. Measured losses are 0.075 dB/m and 0.052 dB/m at 1.55 µm and 2.0 µm respectively.

High Average Power Transmission Through Hollow-core Fibers, Gonzalo Palma Vega, Franz Beier, Fabian Stutzki, Simone Fabian, Thomas Schreiber, Ramona Eberhardt, Andreas Tünermann; Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany; Institut of Applied Physics, Friedrich Schiller Univ. Jena, Germany. We present our latest test of hollow-core fibers for applications in high-power beam delivery. A negative-curvature hollow-core fiber has been tested with a single mode fiber laser, with up to 1.2 kW average power transmission.

Energy use and energy efficiency is the engine of human progress. Lasers in many applications are central to the more useful and efficient use of energy. We are still in early stages of reaping the benefits of lasers in many different market applications. This panel will focus on the dynamics, size, and growth outlook of different applications of lasers and the fundamental energy drivers of the outlook for key applications.

This panel will feature presentations followed by a moderated panel discussion on the laser industry from a financial perspective. The panel will feature speakers from private investment banking and M&A (mergers and acquisitions) and corporate investment. It will address perennial questions about consolidation, the availability or challenges to obtaining financial resources, and trends in the field that will affect the trajectory of the laser market.

Keynote Presentation: Lasers and Human Progress; How Much Further?
David Townes; Needham & Company, LLC

This panel will feature presentations followed by a moderated panel discussion on the laser industry from a financial perspective.
A1Th2A.1  
Dual comb laser system for time-resolved spectroscopy of laser induced plasmas from the UV to VUV, Carolina Lecaplain1,2,  
Reagan Weeks1, Yu Zhang1, Jeremy Yeakle1, Sivanandan Hanilal1,2, Mark C. Phillips1, R. Jason Jones1,2,  
1College of Optical Sciences, Univ. of Arizona, USA; 2OpticsLab, USA. A dual-comb Yb laser system is used to measure the time-resolved evolution of absorption spectra from multiple atoms/ions following laser ablation of metal alloys. These results will be extended into the VUV utilizing high-harmonic generation.

A1Th2A.2  
Reconversion of Higher-Order-Mode (HOM) Output from a Cladding-Pumped Hybrid Yb:YbHOM Amplifier, Kazi S. Abedin1, Raja Ahmad2, Anthony DeSantolo1, Jeffrey Nicholson1, Paul Westbrook1, Clifford Headley1, David DiGiovanni1, OFS Laboratories, USA. We demonstrate low HOM output from a Yb:HOM amplifier to Gaussian-shaped beam by use of axicon based re-converter. Clean Gaussian-like beam was achieved with ~67% efficiency, close to theoretical value.

A1Th2A.3  
High Peak Power Tunable DUV Source around 275 nm from a Frequency quadrupled Nanosecond Yb-doped fiber MOPA, Jing He1, Lin Li1, Lin Xu1, Martyna Berezina1, Michalis Zervas1, Shauf-ul Alam1, Gilberto Brambilla1, Optoelectronics Research Center, UK. A kW-class peak power wavelength tunable DUV source operating in the range of 272-276 nm is demonstrated by frequency quadrupling a diode-seeded, nanosecond, polarization-maintaining (PM), Yb-doped fiber master oscillator power amplifier (MOPA) system.

A1Th2A.4  
Nonlinear pulse compression in single-mode Yb-doped hybrid fiber with high anomalous dispersion at 1.064 μm, Svetlana Aleshkina1, Mikhail Y. Salganskii1, Denis S. Lipatov1, Andrei K. Senatorov1, Mikhail M. Bubnov1, Alexey N. Guryanov2, Mikhail Melkumov1, Mikhail E. Likhaichev1, 1Fiber Optics Res. Ctr the RAS, Russia; 2Inst. of High Purity Substances of the Russian Academy of Sciences, Russia. We demonstrate nonlinear pulse compression down to 250 fs and peak power of up to 3 kW using newly developed asymptometrically single-mode Yb-doped hybrid fiber with extremely high (~400 ps/(nm*km)) anomalous dispersion at 1.064 μm.

A1Th2A.5  
Sub-40 fs, 2 W Kerr-lens mode-locked Yb:CYA laser, Wenlong Tian1, Jinfeng Zhu1, Zhaoqiang Wang2, Xiaodong Xu1, Jun Xu1, Zhiyi Wei2, 1Xidian Univ., China; 2Inst. of Physics, CAS, China; 3Jiangsu Normal Univ., China. We demonstrate a high power single-mode single-frequency fiber laser pumped Kerr-lens mode-locked Yb:CYA solid-state laser. As high as 2.1 W average power with down to 36 fs pulse duration is obtained after extra-cavity compression.

A1Th2A.6  
Enhancement Cavity with Elliptical Focusing for CW UV Generation Eliminating the Degradation Problem in BBO, Daniel Kiefer1, Daniel Preissler1, Thorsten Führer1, Thomas Walther1, 1Technische Universität Darmstadt, Germany. We present a novel design for an efficient enhancement cavity for frequency doubling into the UV. Radiation of 150 mW has been generated at 257 nm and remained stable for more than 15 hours.

A1Th2A.7  
Narrow-Linewidth Operation of Folded VECSL Cavity with Twist-Mode Configuration, Yushi Kameda1, Michal L. Hart1, Stephen H. Werner1, Jussi-Pekka Penttinen2,5, Mircea Guina4,5, 1Univ. of Arizona, USA; 2Har SC, USA; 3Vexlum Ltd, Finland. VECSLs exhibit much different longitudinal mode behavior when the device is placed at a fold of a standing wave cavity. Lasing spectrum can be narrowed by employing mode-twisting, stabilizing the standing-wave pattern at the VECSL.

A1Th2A.8  
14 MW doughnut beam Nd:YAG/CR:YAG ceramic microchip laser with unstable cavity, Hwanhyong Lim1,2, Ajoy Kumar Kar1,2,3, Feng Chen1,2, 1Inst. of Spectroscopy of the Russian Academy of Sciences, Russia; 2Weizmann Inst. of Science, Israel; 3Shandong Normal Univ., China. We present a high-brightness doughnut beam laser based on a passively Q-switched monolithic Nd:YAG/CR:YAG ceramic microchip laser with unstable cavity having the pulse-energy of 8.3 mJ, pulse-width of 570 ps, and M² value of 2.

A1Th2A.9  
50 Watts Single-Frequency Ytterbium MOPA Fiber Laser Operating at 1013 nm, Benoit Gouhier1, Sergio Rota-Rodrigo1, Germain Guraud2, Nicholas Traynor3, Giorgio Santarelli1,1LP2M, IGS - CENS- Univ. de Bordeaux, France; 2Azur Light Systems, France. We have developed a 50W all-fiber, single-frequency, low-noise Yb-based master oscillator power amplifier laser operating at 1013 nm, with an efficiency of 67%, an optical signal-to-noise ratio of 50dB and excellent noise properties.

A1Th2A.10  
Optical Frequency Divider and Synthesizer Based on Ti:sapphire Lasers, Long-Sheng Ma1, East China Normal Univ., China. An optical frequency divider (ODF) with division uncertainty of 1.4 × 10⁻¹² has been realized based on a Ti:sapphire femtosecond laser. Using the ODF and CW Ti:sapphire laser, an optical frequency synthesizer with resolution of 1 Hz has been demonstrated in 700-990 nm.

A1Th2A.11  
SWCNT-Based Bismuth-Doped Fiber Laser at 1.32 μm, Aleksandr Khegai1,2, Mikhail Melkumov1,2, Sergei Firstov1, Konstantin Riumkin1, Yuri Gladush1, Sergey Alyshev1, Alexey Labanov1, Vladimirt Kropin1, Fedor Alekseev1, Albert Nasiukov1, 1Fiber Optics Research Center of the Russian Academy of Sciences, Russia; 2A M Prokhorov General Physics Inst. of the Russian Academy of Sciences, Russia. We present a high power bismuth-doped fiber laser with the emission at 1.32 μm.

A1Th2A.12  
Switchable single-dual-wavelength Yb:NaWGeO₄ waveguide lasers operating in continuous-wave and pulse regimes, Ajoy Kumar Kar1, Yingning Ren1, Mark Mackenzie1, Feng Chen1, 1Heriot-Watt Univ., UK; 2Shandong Normal Univ., China; 3Shandong Univ., China. Depressed-cladding waveguides are produced in Yb,Na:CaF₂ crystal by applying ultrafast laser inscription. Under pumping at 946 nm, continuous-wave (CW) and Q-switched laser oscillations with switchable single- and dual-wavelength are realized in these waveguide structures.

A1Th2A.13  
Comparative Study of Techniques for Measurement of Linewidth and Frequency Noise of Single-Frequency Lasers, Gerald M. Bonner1, Craig Hunter2, Brynner E. Jones1, Matthew S. Warden1, Jack Thomas1, Loyd J. McKnight1, Alexander A. Lagatsky1, David J. Stothard1, Jonathan M. Jones1, Yeshpal Singh1, Bongtai Fedor1, V. Karpushina1, 1Fraunhofer Centre for Applied Photonics, UK; 2Inst. of Photonics, Department of Physics, Univ. of Strathclyde, UK; 3School of Physics and Astronomy, Univ. of Birmingham, UK; 4UniKLasers Ltd, UK. Measuring the linewidth of single-frequency lasers is challenging, and great care must be taken to understand the capabilities and limitations of different measurement techniques to obtain consistent results. A detailed comparative study will be presented.

A1Th2A.14  
High-Power Synchronized Dual-Channel Laser Enabling Fast Brain Imaging in vivo, Robert J. Riedel1, Michael Schuel2, Ivanka Grguras1, Torsten Golz1, Mark Prandolini1, 1Class S Photonics, Germany. To study the in vivo functional dynamics of deep brain tissue, a high-power, synchronized dual-channel laser has been developed providing laser pulse parameters: 3.8 W (4.7 MHz) at 960 nm (<9 fs) and 1.2 W (1 MHz) at 1300 nm (<70 fs). Both channels are synchronized to within 5 fs (rms).

A1Th2A.15  
High Power Picosecond Parametric Mid-IR Source Tunable Between 1.5 and 3.2 μm, Ondrej Novak1,2,1Banka Csanková1,2, Lukas Roskot2,3, Michal Vyvlec1,3, Jiri Muzik1,2, Martin Smrž1, Akira Endo1,4, Helena Jelinkova1,2, Tomas Mocek1,2, 1Inst. of Physics, AS CR, v.v.i., Czechia; 2Faculty of Nuclear Sciences and Physical Engineering, Czech Technical Univ., Czechia. Picosecond parametric mid-IR source pumped by a thin disk laser delivers up to 9 W signal and 5 W idler beam. The signal and idler tuning ranges are 1.52 – 1.96 μm and 2.14 – 3.15 μm, respectively.

A1Th2A.16  
Optical Parametric Amplification Using Dual Chirps, Michael H. Helle1, Naval Research Laboratory, USA. A new type of optical parametric amplifier based on dual chirps is presented. Simulations indicate an increase in bandwidth when compared to existing systems as well as the potential for active carrier envelope phase control.

A1Th2A.17  
Simulations and Experimental Demonstration of Large Aperture Harmonic Generation Energy Clamping Due to Wavefront Distortion/Defocus in Glass Amplifier Systems for Nanosecond Pulses at 1 GW/cm², Waseem Shaikh1, Pedro Oliveira1, Ian musgrave1, Marco Galimberti1, Trevor Winstone1, Christina Hernandez2, 1CCLRC, UK. The efficient frequency doubling is needed in the next generation of high pulse power OPCPA amplifiers. We model and observe energy clamping in thick crystals due to wavefront distortion in the Nd:Glass amplifier systems.
3.2W in continuous signal amplification operation and the output power of a waveguide laser amplifier pumped by a laser diode bar, Yanagisawa.

Small Cr:ZnSe laser amplifier is presented.

Weidong Chen, Hailong Lin, Zhiangang Lin, Yujin Chen, Yidong Huang, Ge Zhang, Weidong Chen; Fujian Inst of Res Structure of Matter, China. We report on the first femtosecond pulse sequence generated by a SESAM mode-locked Yb:BiSiO₃:Yb (B5O) laser pumped with a single-mode fiber-coupled diode laser at 976 nm. Near Fourier transform limited 165-fs pulses centered at 1037.8 nm were obtained.

Temperature dependence of the resonance line of optically pumped distributed feedback lasers, Cristina C. Kores, Nur Ismail, Dimitri Geskus; KTH, Sweden; Univ. of Twente, Netherlands; Univ. of Surrey, UK. We characterize experimentally and theoretically a distributed-feedback laser resonator subject to a thermal chirp. The total accumulated phase shift determines the resonance wavelength. The reflectivities (outcoupling losses) at the resonance wavelength govern the resonance linewidth.

Accumulation of distributed phase shift in distributed-feedback lasers, Cristina C. Kores, Nur Ismail, Meindert Dijkstra, Edward Bernhardii, Markus Pollnaau; KTH - Royal Inst. of technology, Sweden; Univ. of Twente, Netherlands; Univ. of Surrey, UK. In distributed-feedback lasers, a distributed phase shift of p/2, seemingly placing the resonance at the Bragg wavelength, is not accumulated because of light confinement and asymmetry, leading to a systematic resonance shift to shorter wavelengths.

Studying on the KGa(WO₄)₂ crystal based Raman laser with output energy reaching 800mJ, Junchu Chen, Yujie Peng, Hongpeng Su, Xinlin Lv, Yingbin Long, Yuxin Leng; Shanghai Inst of Optics and Fine Mech, China. The Raman oscillator and amplifier based on KGa(WO₄)₂ crystals pumped by the 1064nm laser is established. Under the 3.5J energy of 1064nm laser, the maximum energy of the Raman laser are about 800mJ.

Investigation of the End Pump Surface Gain Medium Slab Laser, Chao Wang, Yang Liu, Ke Wang, Wentao Wang, Jiao Liu, Xiaojun Tang, Hong Zhao; Science and Technology on solid-state laser laboratory, China. We present a design and analysis for the surface gain medium slab laser. This single slab laser is potential to output 12kW class laser. The experiment already achieved 5kW CW laser power output.

ACTeA2.18
S32 nm Random Laser Based on Yb-Assisted Random Distributed Fiber Laser Frequency Doubling, Sergio Rota-Rodrigo, Benoit Goucher, Clément Dineux, L'aura Antoni-Micilloir, Gemain Guiraud, Daniel Leandro, Manuel Lopez-Amo, Nicholas Traynor, Giorgio Santarelli; UP2N, IOGS-CNRS, Univers de Bordeaux, France; Azur Light Systems, France; UOPNA/ISC, Spain. We have developed a Watt-level random laser at S32nm based on second harmonic generation of a 1.064nm random distributed ytterbium-gain assisted fiber laser. The laser exhibits instability <1%, OSNR >70dB, 0.1nm linewidth and excellent beam quality.

ACTeA2.19
69 fs SESAM mode-locked Yb:GaYCOB oscillator, Weidong Chen, Hailong Lin, Zhiangang Lin, Ruuxue Bai, Liheng Zhang, Zhoubin Lin, Ge Zhang; Fujian Inst of Res Structure of Matter, China. We present an efficient femtosecond SESAM mode-locked oscillator based on a "mixed" Yb:GaYCOB crystal. Near Fourier transform limited pulse duration of 69 fs was obtained under the pulse repetition rate of 109 MHz.

ACTeA2.20
Passively Q-switched Er:Lu₂O₃ Ceramic Laser at 2.8 μm using Graphene Saturable Absorber, Hyori Uehara, Shigeki Tokita, Junji Kawasaki, Daitsuke Konishi, Masanori Murakami, Seiji Shimizu, Ryo Yasuhara; Osaka Univ, Japan; National Inst. for Fusion Science, Japan; Mitsubishi Diamond Industrial Co., Ltd., Japan. We have demonstrated a passively Q-switched Er:Lu₂O₃ ceramic laser using a monolayer graphene saturable absorber. The stable pulse operation with watt-level average power was performed, and the maximum pulse energy of 9.4 μJ and peak power of 33W were achieved in 250 ns pulse duration.

ACTeA2.21 Diode End Pump External KGW/ Tm:YLF Raman Laser, Salman Noach, Uziel Sheintop, Daniel Sebbag, Pavel Kornm, Gilad . Marcus; Jerusalem College of Technology, Israel. A hybrid laser scheme in which parametrically generated, carrier to envelope phase stable, mid-IR pulses with picosecond energies are amplified by three to six orders of magnitude in a Cr:ZnSe laser amplifier is presented.

ACTeA2.22 Cr:ZnSe hybrid laser system for μJ level CEP-stable pulses with spectral tunability, Gilad . Marcus; Jerusalem College of Technology, Israel. A hybrid laser scheme in which parametrically generated, carrier to envelope phase stable, mid-IR pulses with picosecond energies are amplified by three to six orders of magnitude in a Cr:ZnSe laser amplifier is presented.

ACTeA2.23 Small-sized Er:Yb glass planar waveguide laser amplifier pumped by a laser diode bar, Yukaki Takada, Kenichi Hiroswa, Shumpei Kameyama, Takayuki Yanagisawa; Mitsubishi electric corporation, Japan. We developed a small-sized Er:Yb glass planar waveguide laser amplifier pumped by a laser diode bar with the butt joint configuration. We demonstrate the signal amplification operation and the output power of 3.2W in continuous-wave mode.
11:30 -12:30

A-Th3A • Laser Materials II (Ceramics)
Presider: Brandon Shaw, US Naval Research Laboratory, USA

A-Th3A.1 • 11:30
Transparent magneto-optic ceramic Faraday rotator, Ryo Yasuhara1; 'National Inst. for Fusion Science, Japan. Transparent magneto-optic ceramics can realize the unique function by superior material properties and capability of large size fabrication. It should accelerate developments of high-pulse-energy lasers, high-power lasers, and their applications with wide wavelength range.

A-Th3A.2 • 12:00
Sub-100 fs Kerr-Lens Mode-Locked Thin-Disk Lasers Based on Ceramic Gain Media, Shotaro Kitajima1, Akira Shirakawa1, Hideki Yagi1, Takagimi Yanagitani2; 'Univ. of Electro-communications, Japan; 'Knoshima Chemical Co. Ltd., Japan. KLM thin-disk lasers with Yb:LuAG ceramic and Yb:Lu2O3 ceramic were demonstrated. The output power of 13 W in 151 fs pulses and 3.7 W in 97 fs were obtained from Yb:LuAG and Yb:Lu2O3 ceramics, respectively.

A-Th3A.3 • 12:15
Suppression of the Secondary Phase at Grain Boundaries in Yb:FAP Anisotropic Laser Ceramics, Yoichi Sato1, Takunori Taira1; 'Inst. for Molecular Science, Japan. By energy dispersive x-ray spectroscopy we identified the source of the secondary phase in Yb:FAP ceramics that limit the lasing volume. We also found that the reduction of Yb3+-concentration drastically reduced this secondary phase.

12:30-14:00 • Lunch on Your Own

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ATH4A • Nonlinear Materials and Processes
Presider: Alan Petersen; Spectra-Physics, USA

ATH4A.1 • 14:00
Measurement of d-coefficients of CdSiP² and ZnPGeP², Shekhar Guha¹, Jean Wei¹, Joel Murray¹, Kevin Zawilski¹, Peter G. Schunemann²; ¹US Air Force Research Laboratory, USA; ²BAE Systems, USA. A novel experimental approach, based on re-derivation of the Maker-fringe technique using only controllable physical variables, yielded d-coefficient values dₓ, dᵧ, and d₂xy for CdSiP² and ZnPGeP² from measured 2137-nm second harmonic generation data.

ATH4A.2 • 14:15
Magnitude and Relative Sign of the Quadratic Nonlinear Coefficients of the BGS© Monoclinic Acentric Crystal, Feng Guo¹, Patricia Segonds¹, Elodie Boursier¹, Jerome Debray¹, Valéry Badikov¹, Vladimir Panyutin², Dimitri Badikov¹, Benoît Boulanger¹; ¹Univ. Grenoble Alpes CNRS, Grenoble INP, Institut Néel, France; ²High Technologies Laboratory, Kuban State Univ., Russia. By combining out of phase-matched and phase-matched SHG conversion efficiencies recorded as a function of wavelength, we determined the magnitude and relative sign of five of the six nonlinear coefficients of the BGS© crystal.

ATH4A.3 • 14:30
Phase-Matching Conditions and Refined Sellmeier equations up to the near-infrared for THz generation in BNA, Cyril Bernerd¹, Patricia Segonds¹, Jerome Debray¹, Takashi Notake², Mio Koyama², Hiroaki Minamide¹, Hiromasa Ito², Benoît Boulanger¹; ¹Univ. Grenoble Alpes CNRS, Grenoble INP, Institut Néel, France; ²Tera-photronics laboratory, RIKEN Sendai, 519-1399, Japan; ³Aomori-Poba, Aoba-ku, Japan. Measurements of the phase-matching conditions from second-harmonic and sum-frequency generation allowed us to refine the Sellmeier equations of BNA up to the near-infrared and to improve the tuning curve of THz emission from difference-frequency generation.

ATH4A.4 • 14:45
Advantages of noncritical modal quasi-phase-matching in ÿ based nonlinear integrated optics devices, Maxim Neradovski¹, Elizaveta Neradovskaya¹, Martin Richter¹, Ulrich Kuhl¹, Pierre Aschiéri¹, Hervé Tronche², Florent Doutre¹, Pascal Baldi¹, Marc D. Micheli¹; ¹INPHYNI, France. Combining quasi-phase-matching and modal phase-matching allows designing nonlinear devices presenting a noncritical phase-matching configuration. Presenting numerical and experimental studies dedicated to Soft Proton Exchanged waveguides on PPLN, we illustrate he advantages of this configuration.

ATH4A.5 • 15:00
Angular Quasi-Phase-Matching in the biaxial crystal PPRKTP, Dazhi Lu¹, Alexandra Pena², Patricia Segonds¹, Jerome Debray¹, Simon Joly¹, Andrius Zukauskas³, Fredrik Laurell⁴, Valdas Pasiskevicius⁴, Haozhi Yu⁴, Jiayang Wang⁴, Huanjii Zhang⁴, Carlota Canalias¹, Benoît Boulanger¹; ¹Univ. Grenoble Alpes CNRS, Grenoble INP, Inst. Neel, France; ²Univ. Bordeaux, France; ³Max-Born Inst. for Nonlinear Optics & Ultrafast Spectroscopy, Germany. We present a novel approach for generation at 213nm, corresponding to the fifth harmonic of an infrared laser pumped 266 nm generation, Hideki Ishizuki¹, Takunori Taira¹; ¹Inst. for Molecular Science, Japan. Second-harmonic 266 nm generation was demonstrated using QPM-structured quartz. The QPM structure was constructed by stacking of multi quartz plates, and high-intensity microchip laser with sub-nanojoule pulse duration was used as a pump source.

ATH4A.6 • 15:15
A flux grown KTP crystal ridge optical waveguide for birefringence phase-matched second-harmonic generation, Augustin Vermay¹, veronique boutou¹, Corinne Felix¹, Florent Bassignot¹, Mathieu Chalvet¹, Dominique Lupinski¹, Benoît Boulanger¹; ¹Univ Inst., France; ²NEEL Inst., France; ³Univ. of Bordeaux, France; ⁴KTH, Sweden; ⁵Tianjin Univ. of Technology, China; ⁶Shandong Univ., China. We performed the first measurements of angular quasi-phase-matching (AQPM) of second-harmonic generation in the periodically-poled 805-doped KTiOPO₄ crystal cut as a sphere, which validates the theory of AQPM in the case of a biaxial crystal.

ATH4A.7 • 15:30
Study on QPM quartz for intense-laser pumped 266 nm generation, Hideki Ishizuki¹, Takunori Taira¹; ¹Inst. for Molecular Science, Japan. Second-harmonic 266 nm generation was demonstrated using QPM-structured quartz. The QPM structure was constructed by stacking of multi quartz plates, and high-intensity microchip laser with sub-nanoscale pulse duration was used as a pump source.

ATH4A.8 • 15:45
Scalable Approach for Continuous-Wave Deep-Ultraviolet Laser at 213nm, Yushi Kaneda¹, Tsuyoshi Tago¹, Toshiaki Sasa¹, Masahiro Sasaura¹, Hiroaki Nakao², Junji Hirohashi¹, Yasunori Funakawa¹; ¹Univ. of Arizona, USA; ²Oxide Corp., Japan. We present a novel approach for generation at 213nm, corresponding to the fifth harmonic of common 1064nm laser, in pure continuous-wave mode. Starting from two infrared fiber laser sources, we demonstrated 0.45W output at 213nm.

16:00—16:30 • Coffee Break, Harbor Ballroom Foyer

16:30-16:45 • ASSL Student Best Presentation Awards, Harbor Ballroom I & II
16:45 - 18:30

ATh5A • Lasers for Biological and Other Applications
Presider: Clara Saraceno; Ruhr Universität Bochum, Germany

ATh5A.1 • 16:45
Invited
Engineering Laser Coherence for Imaging Applications, Hui Cao¹; ²Applied Physics, Yale Univ., USA. We develop lasers with low spatial coherence to achieve speckle-free full-field imaging. We also invent a fast and efficient method of switching the spatial coherence of a laser for multimodality microscopy.

ATh5A.2 • 17:15
Novel fiber-based ultrafast platform for multimodal optical virtual skin biopsy, Hsiang-yu Chung¹,², Wei Liu¹,², Rüdiger Greinert³, Franz Kärtner¹,², Guoqing Chang¹,²; ²DESY, Germany; ³Physics, Universität Hamburg, Germany; ²Skin Cancer Center Buxtehude, Germany; ³The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Germany. We demonstrate a fiber-based ultrafast platform generating energetic femtosecond pulses at 1250 nm and 775 nm simultaneously, which enables label-free second-harmonic generation, third-harmonic generation, and two-photon excitation fluorescence imaging in human skin.

ATh5A.3 • 17:30
Invited
Semiconductor Laser Micro-particles for Bio Imaging, Seok-Hyun A. Yun¹; ¹Harvard Medical School, USA. Laser particles with sizes of optical wavelengths that are injectable and implantable into biological systems are new, promising light sources and probes. We present biocompatible semiconductor laser disks for tracking many cells.

ATh5A.4 • 18:00
Sub-kHz linewidth VECSEL for cold atom experiments, Paulo Hisao Moriya¹, Jennifer E. Hastie¹; ¹Inst. of Photonics, Department of Physics, SLUPA, Univ. of Strathclyde, UK. We report sub-kHz linewidth operation of a frequency-stabilized, AlGaN-P-based vertical-external-cavity surface-emitting laser (VECSEL) at 689nm, suitable for Strontium cold atom experiments. 170mW was emitted with linewidth ≤200Hz, determined via an optical beat note measurement.

ATh5A.5 • 18:15
1 to 18 GHz tunable intra-burst repetition rate high-power picosecond fiber laser for ultrafast material processing, Denis Marion¹, Jérôme Lhermite¹, Lilia Pontagnier¹, Adrien Aubourg¹,², Pierre Héricourt¹, Giorgio Santarelli², Eric Cormier¹; ¹CEIL, Université Bordeaux-CNRS-CEA, France; ²LP2N, UMR5298, CNRS-IOGS-Université Bordeaux, France. We report on a laser system emitting picosecond pulses at repetition rates tunable from 1 to 18 GHz. The system emits up to 20 W at 1030 nm in burst mode. Application to ablation is demonstrated.

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