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This program contains the latest information up to 3 February 2017.

While program updates and changes until the week prior to the conference may be found on the Update Sheet, Exhibit Buyers’ Guide and Addendum distributed in the registration bags, consult the Mobile App for the latest changes. Program updates and changes may be found on the Update Sheet, Exhibit Buyers’ Guide, and Addendum distributed in the registration bags.

Technical Registrants: Download digest papers by visiting ofcconference.org and clicking on the “Download Digest Papers” on the home page. Recorded presentations are available from the same page by clicking “View Presentations.”

OFC® and Optical Fiber Communication Conference® are registered trademarks of The Optical Society (OSA).
# Conference Schedule

All times reflect Pacific Time Zone

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<td>OFC Career Zone Live Career Event (online kiosks open during registration hours)</td>
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<tr>
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<tr>
<td>Workshops (Sunday and Monday morning) and Panels</td>
<td>15:30–18:30</td>
<td>09:00–16:00</td>
<td>14:00–18:30</td>
<td>13:00–17:30</td>
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<tr>
<td>Technical Sessions</td>
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<td>Symposium: Overcoming the Challenges in Large-scale Integrated Photonics</td>
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<td>Network Operator Summit</td>
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<tr>
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<tr>
<td>Market Watch - Expo Theater I</td>
<td>10:30–16:00</td>
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<tr>
<td>Network Operator Summit (formerly Service Provider Summit) - Expo Theater I</td>
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<tr>
<td>OIDA Workshop on Manufacturing Trends for Integrated Photonics (separate registration required)</td>
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<td>Lab Automation Hackathon</td>
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<td>OIDA VIP Industry Leaders Speed Meetings Event connecting Industry Executives with Students and Early Career Professionals (separate registration required)</td>
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<td>Photonic Society of Chinese-Americans Workshop &amp; Social Networking Event</td>
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OFC thanks the following corporate sponsors for their generous support:

- AC Photonics, Inc.
- ColorChip
- CORNING
- EXFO
- FINISAR
- GoFoton
- HUAWEI
- Infinera
- Intel
- Jabil
- Juniper
- Mellanox
- OIF
- NTT Electronics
- Nextrom
- Phoenix Software
- Picometrix
- Precision Optical Transceivers
- Sumitomo Electric
- VP Photonics
- Xilinx
- Yenista

OFC thanks the following media partners:

- EE Catalog
- Fiber Systems
- ISE
- Lightwave
- Photonics

OFC 2017 • 19–23 March 2017
Welcome to the 2017 Optical Fiber Communication Conference and Exhibition

On behalf of the many individuals, including countless volunteers who are organizing OFC 2017, it is our sincere pleasure to welcome you to Los Angeles, California. OFC is the foremost meeting in optical communications and networking, and this year’s conference continues the tradition of providing an excellent program that captures advances in research, development and engineering.

In the plenary session on Tuesday morning, three excellent speakers will address recent developments and future challenges in optical communications and networking. Urs Hölzle, Senior Vice President for Technical Infrastructure, Google, Inc., USA will speak on Google’s groundbreaking cloud network in terms of reach, scale, and capability; and Meint Smit, Professor at Eindhoven University of Technology, Netherlands will speak about affordable photonic integration and the wide range of applications that the photonic foundry model is enabling; Mischa Döhler, Professor at King's College London, UK will share his joint loves of communications research and music and will look at the disruptive technology approaches combining wireless 5G and next-generation optical networks.

The 2017 conference provides an exceptionally strong technical program consisting of a portfolio of 50 short courses, 500+ contributed and 110+ invited papers, 20 tutorial presentations, 10 workshops, and 6 panels. The range of topics that will be addressed includes advances in deployable optical components, fibers and field installation equipment; passive optical devices and circuits for switching and filtering; active optical devices and photonic integrated circuits; fibers and propagation physics; fiber-optic and waveguide devices and sensors; advances in deployable subsystems and systems; optical, photonic and microwave photonic subsystems; radio-over-fiber, free-space and non-telecom fiber-optic systems; digital and electronic subsystems; digital transmission systems; advances in deployable networks and their applications; control and management of multilayer optical networks; network architectures and techno-economics; optical access networks for fixed and mobile services; and optical devices, subsystems, and networks for Datacom and Computercom.

The main emphasis of the OFC program is on research and development that addresses long-term issues in optical communications and networking. This year, the technical program includes two symposia: What is Driving 5G, and How Can Optics Help? and Overcoming the Challenges in Large-Scale Integrated Photonics. Tuesday features a 2-part Data Center Summit on Open Hardware and Software Platforms; Session I: Open Platforms for Optical Innovation and Session II: SDN & NFV Demo Zone featuring 15 live demonstrations and prototypes of collaborative research projects, pre-commercial products and proof-of-concept implementations in the SDN and NFV space. On Tuesday evening, there is a rump session entitled Sub $0.25/Gbps Optics; How and When will Fiber Finally Kill Copper Cable Interconnects in the Data Center (DC)? organized by Chris Cole, Finisar Corp. and Dan Kuchta, IBM. Poster sessions will be held on Wednesday and Thursday, providing the opportunity for in-depth discussion with presenters.

Hot topics this year include advanced devices and fibers for high-speed data center links; enabling 5G and IoT through next-generation optical access; manufacturing and packaging of photonic and electronic subsystems; multiplexing, transmission and switching techniques for Tb/s networks; new network architectures and applications enabled by SDN and NFV, open hardware and software platforms for cloud scale networks; optical wireless and visible light communications; and silicon and integrated photonics for datacom and telecom.

The OFC Exhibit hosts more than 600 exhibitors from all over the world representing every facet of the optical communications market: communication and network equipment, data center interconnects, electronic components and subsystems, fiber cables and assemblies, integrated photonics, test equipment, lasers, optical components, optical fibers, transmitters and receivers, sensors and much more. In addition to meeting with vendors and seeing new products, the Market Watch program and the Network Operator Summit (formerly known as Service Provider Summit) form the core of the business-related programming of the meeting. Market Watch includes six panel discussions that will address the current state of the optical industry, market outlook for high bandwidth optical technologies, subsea networking applications, pluggable optics, photonic integration and SDN and optics. The Network Operator Summit includes a keynote address by Zhang Chengliang, Vice President of China Telecom, China on China Telecom's View of the All Optical Network and two panels on next-generation access and metro and optical mobile network access. Be sure to check out the other programs on the show floor addressing business solutions and emerging technologies. This year many industry groups will present: COBO, Ethernet Alliance, IEEE Cloud computing, IEEE Big Data, MEF, OCP, OIF, ONF, Open Config and TIP.

The OFC Short Course program provides attendees with an excellent opportunity to learn about the latest advances in optical communications from some of the leading academic and industrial professionals in the field. The program covers a broad range of topical areas including devices and components, sub-systems, systems and networks at a variety of educational levels ranging from beginner to expert.

Organizing a successful OFC conference each year is an enormous task that is undertaken by many dedicated volunteers. We are indebted to the OFC Technical Program Chairs, Gabriella Bosco, Jörg-Peter Elbers, and Laurent Schares, for their expertise and dedication in coordinating the technical content through OFC’s technical program committee. The high quality of the OFC program is a direct result of the efforts of the technical program chairs, subcommittee chairs, and technical program committee members, all of whom have dedicated an enormous amount of their valuable time to ensure the quality of the conference, and maintain the highest standards by reviewing and selecting papers, nominating invited speakers and organizing workshops and panels. It is also our pleasure to thank the staff of The Optical Society, whose ceaseless hard work and professionalism make it possible for OFC to continue as the foremost optical communications and networking conference in the world.

Andrew Lord
BT Labs, UK

Shu Namiki
AIST, Japan

Peter Winzer
Nokia Bell Labs, USA
General Information

Conference Services

ATM

There is an ATM machine conveniently located across from the Galaxy concession stand in our West Hall next to Hall A and one is also located in the Concourse walkway leading to the South Hall.

Business Service Center

Concourse Lobby

Image Quest Plus can provide events, vendors and guests at the LACC an array of rapid delivery business services including: copying, digital printing, scanning, visual graphics, communication tools, document finishing services, computer usage, fax services, inbound/outbound shipping and consulting services. For ordering & online help: +1.888.486.7350.

Customer Service Desk

Registration

The Customer Service Desk is open during registration hours and offers translation services in multiple languages.

Conference Information Desk

Registration

The Conference Information Desk services as a “One Stop Shop” for any information concerning the OFC Conference. Staff will be equipped to help you understand the program book, find room locations, and accept small Lost and Found items, and will operate during registration hours.

E-Center

South Lobby

The E-Center provides access to webmail services. Multiple stations allow attendees to check email, identify and locate exhibiting companies, and view a list of accepted postdeadline papers, presentation times and locations. The E-Center Kiosks will be open during registration hours.

Exhibition

Exhibit Halls G-K

The OFC Exhibition is open to all registered attendees. Schedule plenty of time to roam the halls, visit with the hundreds of companies represented and see the latest products and technologies. For more information about what’s happening on the exhibit floor, see pages 39-48.

Exhibition Hours

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Lost and Found

Information Desk

Lost and Found will operate during registration hours at the OFC Information Desk. Please check with Lost and Found if you are missing any items. For after-hours Lost and Found, please go to the OFC Security Office located in Show Office J just outside the Exhibit Hall Entrance (look for security sign).

OFC Career Zone Live & Online

South Lobby

The OFC Career Zone connects employers and skilled job seekers from all areas of optical communications. Choose your method of interaction, online or in person during the conference.

Conference attendees are encouraged to visit the OFC Career Zone Live and be prepared to discuss their futures with representatives from the industry’s leading companies.

Job Seekers

OFC Career Zone Live - Meet Participating Companies

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Register Online at OFCconference.org/careerzone to:

- Search job postings freely
- Post your résumés online confidentially
- Network and schedule interviews Employers/Recruiters

Employers

Didn’t sign up for the onsite OFC Career Zone Live? It’s not too late.

Participate online at OFCconference.org/careerzone to:

- Post jobs online
- Review résumés before, during or after the conference
- Create alerts to inform you of newly submitted résumés and openings

For more information, call +1.888.491.8833 or e-mail careercenter@ofcconference.org.
Media Center
Rooms 308A, 308B, 309

The OFC Media Center consists of a Media Room, PR and Media Lounge and private interview space for booking. While the media room itself is restricted to registered media/analysts holding a media badge, the adjoining PR and Media Lounge will provide a place for registered public relations personnel of exhibiting companies to work during the day and interact with attending media.

Media Center Hours

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Advance, Exhibitor and Onsite Registration
South Lobby

Registration Hours

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Speaker Presentation Room
Room 405

All speakers and presiders are required to report to the Speaker Preparation Room at least one hour before their sessions begin. Computers will be available to review uploaded slides.

Speaker Ready Room Hours*

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*Market Watch and Network Operator Summit speakers should go directly to Expo Theater I in Exhibit Hall G to upload presentations.

Restaurant Reservation Desk and Concierge Kiosk
South Lobby

This kiosk is staffed by local volunteers providing reservations, information and directions.

Show Your Badge & Save

Participants have the benefit of great merchant discounts under our “Show Your Badge Program.” Find more information on the OFC website.

Sponsoring Society Exhibits
South Lobby and Exhibit Floor

Catch up on the latest product and service offerings of the OFC sponsoring societies by visiting the IEEE Booths and Member Lounge located in the South Lobby and the OSA booth on the Exhibit Floor. IEEE is the world’s largest technical professional organization dedicated to advancing technology for the benefit of humanity. OSA is the leading professional association in optics and photonics, home to accomplished science, engineering, and business leaders from all over the world.

Wireless Internet Access

OFC is pleased to offer complimentary wireless Internet service throughout the Los Angeles Convention Center for all attendees and exhibitors. The wireless internet can be used for checking email, downloading the conference mobile app, and downloading the OFC Technical papers, etc.

SSID: OFC
Password: OFC-2017

Transportation Services

Ground Transportation

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**Conference Materials**

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The OFC 2017 Technical Digest, composed of the 3-page summaries of invited and accepted contributed papers, as well as tutorial presentations slides will be on a USB Slap Band. The Technical Digest USB is included with a technical conference registration. These summaries will also be published in OSA Publishing's Digital Library and submitted to the IEEE Xplore Digital Library, providing the author attends and presents their paper at OFC 2017.

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2. Select the “Download Digest Papers” button on the right side of the web page
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 links at the top of the page. [Please note: if you are logged in successfully, you will see your name in the upper right-hand corner.]

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The available paper summaries will also be published in OSA Publishing’s Digital Library and submitted to the IEEE Xplore Digital Library (www.ieeexplore.ieee.org), provided that the paper is presented by a co-author during the conference.
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Short Course notes typically include a copy of the presentation and any additional materials provided by the instructor. Each course has a unique set of notes, which are distributed on-site to registered course attendees only. Notes are not available for purchase separately from the course.

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We are delighted to announce that 40% of the sessions at this year’s conference are being digitally captured for on-demand viewing and accessible with your technical registration. The pre-selected content represents the full breadth of the OFC program including symposia, oral presentations, and the postdeadline sessions. Session content will be available for on-demand viewing until 26 June 2017. All captured session content will be live for viewing within 24 hours of being recorded. Just look for the symbol in the Agenda of Sessions and abstracts to easily identify the presentations being captured.

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Special Events

Workshops

Sunday, 19 March, 15:30–18:30

S1A • Will Machine Learning and Big-data Analytics Relieve Us From the Complexity of System and Network Engineering?
Room: 403A

Organizers: Sethumadhavan Chandrasekhar, Nokia Bell Labs, USA; Neil Guerrero Gonzalez, Universidad Nacional de Colombia, Colombia; Massimo Tornatore, Politecnico di Milano, Italy

Complexity of optical networks is growing rapidly. On a system side, coherent technologies introduced a plethora of adjustable design parameters (modulation formats, symbol rates, among others) to optimize transport systems. On a networking side, dynamic control, as in SDN, promises to enable on-demand reconfiguration and virtualization. This variety of “degrees of freedom” does pose challenges when deciding the best system configuration. This workshop examines the application of machine learning and big-data analytics as disruptive solutions to relieve design of future networks/systems from such complexity. These techniques allow to infer, from monitored data (signal quality, traffic samples, etc.), useful characteristics that cannot be easily measured. Speakers from academia, vendors, and operators will debate how beneficial these techniques could be and which are their killer applications.

Speakers:
Satyajeet Ahuja, Facebook, USA
Shoukei Kobayashi, NTT, Japan
Maurice O’Sullivan, Ciena, Canada
Moises Ribeiro, Universidade Federal do Espírito Santo, Brazil
Vishnu Shukla, Verizon & OI!, USA
Luis Velasco, UPC, Spain
Peter Winzer, Nokia Bell Labs, USA
Huizing Xu, Huawei, China
Darko Zibar, Technical University of Denmark, Denmark

S1B • Making the Case for SDM in 2027
Room: 403B

Organizers: Cristian Antonelli, Università degli Studi dell’Aquila, Italy; Yoshinari Awaji, National Inst of Information & Communications Technology, Japan; Nicolas Fontaine, Nokia Bell Labs, USA; Sheryl Woodward, AT&T, USA

In the year 2027, after 10 years of exponential internet traffic growth, it will become clear that traditional DWDM transmission systems using a single fiber cannot keep up with demand. Although coherent communications may be a “cheap” commodity, the cost of constantly deploying new line systems will be untenable. Network operators will be looking for dramatic new technologies to evade Shannon’s fundamental limits on capacity – space-division multiplexing (SDM) is the prime candidate. But, in what type of network will SDM be most effective (passive, data center, short reach, metro, long haul, submarine, or any unconventional communications frameworks), what level of integration will provide the biggest cost savings (transponders, amplifiers, fibers, switching), how will SDM co-exist/complement existing SMF/DWDM technologies, and is there a killer fiber structure (hollow core, coupled core, few-mode fiber) that outperforms multiple strands of single-mode fiber?

Four teams will present their solutions to a panel of experts—imagine they represent venture capitalists who are looking to capitalize on the next technology wave. Both the audience and the experts will pose questions and decide the winning solutions.

Teams:
- Koji Igarashi, Osaka University, Japan (Team Leader)
- Tetsuya Hayashi, Sumitomo Electric, Japan
- Katsunori Imamura, Furukawa Electric, Japan
- Takayuki Kobayashi, NTT, Japan
- Taiji Sakamoto, NTT, Japan

S1C • Optical Wireless — Can it Become a Gigabit Wireless Alternative? Capabilities, Opportunities, Challenges and Threats
Room: 404AB

Organizers: Ton Koonen, Einhoven University of Technology, The Netherlands; Volker Jungnickel, Fraunhofer Heinrich-Hertz Institute, Germany; Thas Nirmalathas, University of Melbourne, Australia

Optical wireless communications and networking is seeking to deliver wireless connectivity over the free-space using optical wavelengths in the visible and infrared spectrum. However, optical wireless needs to complement the existing radio technologies, including the rapidly maturing mm-wave and future Terahertz communication systems being under development and research, respectively. Optical wireless can also play a complimentary role for example
offloading the burden from the radio technologies in situations such as high-capacity picocells. In the future 5G and 5G-beyond networks, optical wireless may provide crucial roles in meeting the 5G grand challenges such as 1000x throughput, ms latency, 0.01x power consumption, etc. All this needs not only further technical research efforts but also the identification of practical use cases in which optical wireless has unique selling points.

While the technology-oriented research has attracted major attention within the optical communications research community, with demonstrations of multi-Gbit/s wireless transmission and major research projects getting started, it is the use case which paves the way into the market. Besides superior capabilities like bandwidth on demand, support for user mobility and low cost, optical wireless increasingly needs to offer additional features, which are tailored to the identified use cases.

This workshop is intended as a forum that brings together competing ideas and leading experts from research and industry into a collision space and to facilitate a critical debate on the fundamental capabilities of optical wireless technologies and its chance in the very competitive wireless market. This will require putting the focus onto capabilities and opportunities of optical wireless, its key challenges and ways forward towards commercializing the outcomes of the exciting developments in the optical wireless field.

**Speakers:**
Carsten Behrens, Deutsche Telekom, Germany
Harald Haas, Li-Fi Centre, UK
Steve Hranilovic, McMaster University, Canada
Jean-Paul Linnartz, Philips Lighting, Netherlands
Dominic O’Brien, Oxford University, UK
Joanne Oh, Eindhoven, Netherlands
Maximilian Riegel, Nokia, Germany
Nikola Serafimovski, PureLiFi, UK
Stan Skafidas, Nitero/University of Melbourne, Australia
Ke Wang, University of Melbourne, Australia

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**S1D • Scaling Datacenter Bandwidth: Novel Optics, Advanced Electronics or New Architectures?**

*Room: 408A*

**Organizers:** Piero Gambini, STMicroelectronics, Italy; Ming-Jun Li, Coming, USA; Ilya Lyubomirsky, Facebook, USA

Bandwidth and power consumption are two key factors to be considered for cost-sensitive datacenter applications. As datacenter switch port bandwidths continue scaling to 400Gb/s and beyond, the datacenter network hardware power dissipation is increasing exponentially. The coming “power crunch” associated with the increased bandwidth will be a major problem for datacenter operators.

- What are the most effective solutions to mitigate the increasing power problem?
- Are there novel optics, for example novel high speed directly modulated lasers (DMLs) or Silicon Photonics technology that reduce power consumption?
- How can we leverage DSP and spectrally efficient modulation techniques, e.g. is it feasible to drive analog optics modules directly from the host ASIC, similar to the 10G SFP+ solution?
- Can novel multi-mode or multi-core fibers provide a new approach?
- What is the role of FEC?
- Is there room for optimizing the FEC triple tradeoff in gain, latency, power to achieve an overall lowest power system design?
- How can we leverage the mature DWDM technology for datacenter applications?
- Are there novel topologies or network architectures that can radically reduce power consumption?
- Is there a role for ROADMs, optical switches, or coherent technology inside the datacenter? Clearly a holistic system view is necessary for finding the optimal solution.

This workshop will bring together experts from optics, fiber, SerDes design, DSP/FEC, and network architecture for an interdisciplinary discussion.

**Speakers:**
Andy Bechtolsheim, Arista, USA
Sudeep Bhoja, InPh, USA
Brad Booth, Microsoft, USA
Bruce Chow, Coming, China
Peter De Dobbeleere, Luxtera, USA
Laura Giovane, Broadcom, USA
Chris Kocot, Finisar, USA
Benny Mikkelsen, Acacia, USA
Brian Taylor, Facebook, USA

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**S1E • III-V + Silicon: To Integrate or to Co-package?**

*Room: 408B*

**Organizers:** Mike Larson, Lumentum, USA; Anders Larsson, Chalmers University of Technology, Sweden; Bert Offrein, IBM, Switzerland

Silicon photonics provides a path to the cost-effective realization of transceiver chips but lacks a straightforward solution to integrate the light source. Today, co-packaging (hybrid integration) is used commercially, while intense research is pursued on III-V to silicon bonding techniques (heterogeneous integration) and even hetero-epitaxial III-V on silicon growth (monolithic integration).

In this workshop some of the main III-V on silicon integration approaches will be reviewed by leading experts in the field and discussed among the participants. In addition to the technological characteristics, the presentations will address system-level aspects such as functionality, power efficiency, form factor and anticipated cost. What are the prospects and challenges and what is ultimately the best method to combine III-V and silicon technology for future applications?

Questions to be addressed during the workshop are:
- What is generally the best technique for bringing light to the silicon photonics PIC, from cost/size/efficiency/performance perspectives? Is it application dependent?
Special Events
OFC 2017 • 19–23 March 2017

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Monday, 20 March, 09:00–12:00

M1A • Processors and Switches with Integrated Optical Engines — Researchers’ Dream or a Commercial Reality Soon?
Room: 403A

Organizers: Dominic Goodwill, Huawei Technologies Canada Co Ltd, Canada; Ken Morito, Fujitsu Laboratories Ltd., Japan; Sam Palermo, Texas A&M University, USA; Thomas Schrans, Rockley Photonics, USA

On-board optics or optics-in-packaging - which integration strategy will happen on a large scale in data center and HPC systems? Or indeed will both types of integration co-exist? On-board optics is currently fashionable, but many researchers propose including photonics inside the chip package to increase data rates and decrease energy per bit. Large scale integration reduces cost for many technologies, but yield and other constraints may set practical limits. What are the challenges and benefits of these two approaches? Will cost-driven data center systems and performance-driven engineered systems have radically different solutions? This workshop covers views and expectations from systems builders, perspectives from photonic module suppliers, and assessments from technologists in packaging, high speed circuits and signal integrity, to explore the true benefits and costs.

Speakers:
John Bowers, University of California Santa Barbara, USA
Craig Ciesla, Kaim, USA
Greg Fish, Juniper, USA
Richard Grzybowski, Macom, USA
Takahiro Nakamura, PETRA, Japan
Gunther Roelkens, Ghent University & IMEC, Belgium
Lars Zimmermann, IHP Berlin, Germany

M1B • Connected OFCity Challenge: Optical Innovations for Future Services in a Smart City
Room: 403B

Organizers: Jun Shan Wey, ZTE, USA; Denis Khotimsky, Verizon, USA; Domaniç Lavery, University College London, UK

The Connected OFCity Challenge team competition was first held at the OFC 2016 as a representative platform to discuss technological innovations of a smart city project. The OFCity Challenge returns this year to debate technologies concerning future services in a smart city, building upon the results of last year’s competition.

This time, the OFCity Council is planning the Septicentennial (700-year anniversary!) celebration in 2023 and once again organizes an open competition to select the best proposal for the preparation and broadcasting of the Septicentennial Concert and three major sports events.

Four multidisciplinary teams consisting of experts from a cross-section of the industry will compete to recommend innovative optical solutions and complementary technologies to realize the required services. Two distinctions, Judges Award and Audience Award, will be handed out at the conclusion of the competition.

Teams:
- Naoto Yoshimoto, Chitose Institute of Science and Technology, Japan (Team Leader)
  Ning Chang, Huawei, China
  Elaine Wong, University of Melbourne, Australia
  Yuki Yoshida, NICT, Japan
- Marco Ruffini, Trinity College Dublin, Ireland (Team Leader)
  Dave Hood, Huawei, USA
  Thomas Pfeiffer, Nokia Bell Labs, Germany
- Luca Valcaregghi, Scuola Superiore Sant’Anna, Italy (Team Leader)
  Hal Roberts, Calix, USA
  Rajesh Yadav, Verizon, USA
- Dimitra Simeonidou, University of Bristol, UK (Team Leader)
  Harald Haas, University of Edinburgh, UK
  Stephen Hilton, Bristol Futures, UK
  Sergi Figuerola, i2CAT in Barcelona, Spain

Judges Panel:
Rod Tucker (Team Leader, Winner of OFCity 2016 Judges’ Award)
Julie Kunstler (OVUM)
Kazuhide Nakajima (Rapporteur, ITU-T Q5/SG15)
Inder Monga (Energy Sciences Network, OFC N2 Subcommittee Chair)
Peter Vetter (Mayor of OFCity 2016)
M1C • Frequency Combs for Communications — Real Potential or Hype?
Room: 404AB

Organizers: Toshihiko Hirooka, Tohoku University, Sendai, Japan; Christian Koos, Karlsruhe Institute of Technology, Germany; Michael Vasilyev, University of Texas at Arlington, USA

Rapid progress in the research and development of optical frequency comb sources has opened new possibilities in communications, ranging from replacing a multitude of parallel lasers by a single multi-line source to employing wideband coherence to enhance nonlinearity mitigation. The workshop will discuss whether these advances can translate into practical systems by addressing key questions including:

- What are the benefits, drawbacks, and challenges of single-source communications?
- Do expected power/complexity reductions justify possible reliability issues (single source failure)? How to increase reliability? What are the options for ultra-narrow linewidth seed laser?
- What power or OSNR per comb line is acceptable? What linewidths are required?
- What are the tradeoffs in comb source choices: fiber versus integrated, mode-locked versus parametric, travelling-wave versus oscillator?
- What are the options for monolithic or hybrid integration with other components, e.g., (de) multiplexers and modulators?
- What are the prospects of using optical frequency combs in data center networks?

Speakers:
Peter Andreksson, Chalmers University, Sweden
Nicolas Fontaine, Nokia, USA
Hao Hu, Technical University of Denmark, Denmark
Tobias Kippenberg, EPFL, Switzerland
Masataka Nakazawa, Tohoku University, Japan
Stojan Radic, University of California San Diego, USA
Jeremie Renaudier, Nokia, France
Nicola Sambo, Scuola Superiore Sant’Anna, Italy

M1D • Capacity Crunch: When, Where and What Can be Done?
Room: 408A

Organizers: Dmitri Foursa, TE Subcom, USA; Qunbi Zhuge, Ciena Corporation, Canada; David Millar, Mitsubishi Electric Research Labs, USA

Recent theoretical research has indicated that we might soon reach a “capacity crunch,” as the limits of conventional single mode fiber transmission systems are approached. While technologies such as spatial diversity, ultra-broadband Raman amplification, optical and digital nonlinearity compensation have been proposed, none has yet demonstrated an ability to overcome these limitations in practical systems. This workshop will examine the conflicts and opportunities that are emerging in optical transmission systems in this context. Key questions will include:

- What are the causes of the theoretical and practical capacity limits?
- How and when will the coming capacity limitations arrive considering the various applications from submarine to metro networks?
- What solutions have been proposed, and how will they address the problems?
- Will the reduction of cost per bit continue by economic solutions such as photonic integration after we reach the “capacity crunch”?

Speakers:
Erik Agrell, Chalmers University of Technology, Sweden
Chris Doerr, Acacia Communications, USA
Domanic Lavery, University College London, UK
Alexei Pilipetskii, TE SubCom, USA
Kim Roberts, Ciena Corporation, Canada
Peter Winzer, Nokia Bell Labs, USA

M1E • White Box Optics: Will it Kill or Encourage Innovations?
Room: 408B

Organizers: Chongjin Xie, Alibaba Group, USA; Filippo Cugini, CNIT, Italy; David Boertjes, Ciena, Canada

Disaggregated networks can bring many benefits to networks operators, including better control of networks, no vendor lock in, and reduced cost. Recently the concept of white box optics is rapidly emerging as can be seen in initiatives such as Open ROADM and Open Line System. However, there is a fear that white box optics may commoditize the industry and squeeze the profit margins for equipment vendors, which will eventually stop the industry from investing on innovations. On the other hand, there is an argue that white box optics may open up closed and proprietary optical networks and give small business and new comers more chances, which will encourage more innovations. This workshop is to bring together experts from equipment vendors and network operators to express their opinions on white box optics and discuss where it will head to.

Speakers:
Martin Birk, AT&T, USA
Rick Dodd, Ciena, Canada
Niall Robinson, ADVA, USA
Peter Roorda, Lumentum, USA
Brian Taylor, Facebook, USA
Vijay Vusirikala, Google, USA
Glenn Wellbrock, Verizon, USA
Szilard Zsigmond, Nokia Corporation, USA
**Speakers:**
Kevin Williams, TKU Eindhoven, Netherlands

**Speakers:**
Ashok Krishnamoorthy, Roe Hemenway, Macom, USA
Shinji Matsuo, NTT, Japan
Greg Fish, Juniper, USA
John Bowers, University of California Santa Barbara, USA

**Integrated Photonics**
**Monday, 20 March**
Part I 13:30–15:30; Part II 16:00–18:00
Room 403A

Organizers: Po Dong, Nokia, USA; Benjamin Lee, IBM, USA; Erik Penning, 7 Pennies, USA; Takuo Tanemura, University of Tokyo, Japan

Integrated photonics provides significant opportunities to develop highly compact and extremely functional components and subsystems for a wide range of communication and sensor applications. However, photonic integration brings with it unique manufacturing and packaging challenges, which can limit the commercial exploitation of novel integration concepts and slow the time-to-market. These challenges can be economic or technical in nature, and are often most apparent during the transition from prototype development to manufacturing. This symposium will provide a balanced view of the promises and challenges of integrated photonics, and it will focus on what is being done to get beyond the many roadblocks in order to enable a much larger market adoption. During the symposium, leaders in the field will address applications in traditional and non-traditional markets for integrated photonics, finding the right fabrication model using MPW or custom processing services, choosing Si versus InP platforms, optical and electrical packaging approaches, and other fundamental component challenges.

**Speakers:**
John Bowers, University of California Santa Barbara, USA
Greg Fish, Juniper, USA
Dominic Goodwill, Huawei, Canada
Roe Hemenway, Macom, USA
Ashok Krishnamoorthy, Oracle, USA
Shinji Matsuo, NTT, Japan
Pascual Munoz, VLC, Spain
Bardia Pezeshki, Kaiam, USA
Kevin Williams, TU Eindhoven, Netherlands

**What is Driving 5G, and How Can Optics Help?**
**Wednesday, 22 March**
Part I 13:30–15:30; Part II 16:00–18:00
Room 403B

Organizers: Björn Skubic, Ericsson Research, Broadband Technol., Sweden; Gee-Kung Chang, Georgia Institute of Technology, USA; Anna Tzanakaki, University of Athens, Greece; Jun Terada, NTT, Japan

The vision of 5G is commonly presented as part of the network vision for 2020 and beyond, which in turn embodies a number of services for the future information society in which everything that can connect to this society will do so. The typical services identified span across areas such as enhanced mobile broadband services, media distribution, Smart Cities, and the Internet of Things (IoT), with massive as well as ultra-reliable and low latency (critical) machine-type communications to support both end-user and operational purposes. Besides new services and applications, 5G will also need to support a wide range of business ecosystems and cooperation models supporting digitalization of industry and trends of business horizontalization. 5G goes far beyond the definition of new radio interfaces. 5G is about a new end-to-end network vision, in which softwarization and virtualization allow a common network infrastructure to be flexibly used for a variety of diverse applications.

The symposium will consist of two sessions. The first session will focus on “What is driving 5G?” with speakers from the 5G community as well as vertical industries that can be benefited adopting the 5G vision. This session will give an overview of the services, applications and ecosystems that are driving 5G and provide some insight on how these can create a new and substantial business opportunity for optical networking and its most advanced technologies. The second session will focus on the role of optics and will include speakers from the optical networking/communications community. This session will give an overview of how optics can play a key role for realizing 5G networks and will cover topics such as evolved x-haul, radio over fiber, distributed cloud connect (including edge/fog computing) and support for tactile (low latency) Internet applications.
Transport SDN — What is Ready, What is Missing?
16:00–18:00
Room: 402AB
Organizers: Doug Freimuth, IBM, USA; Karthik Sethuraman, NEC, USA

The dynamic compute model provided by the cloud has gained acceptance by business and consumer markets. A new network is required to match the resource scalability, faster automated service deployment model and high resource utilization of the cloud. The promise of Transport SDN to fulfill these requirements has been shown in various demonstrations, proof of concepts and by early adopters. The industry is working to define it in standards bodies for production use in NFV, cloud and IoT.

This panel will discuss what it takes to operationalize Transport SDN. We will discuss business drivers, use cases, progress in standards and prototypes shown to date. We will further discuss what can be put into production now, related technologies such as SD-WAN and what the future holds for new Transport SDN capabilities.

Panelists:
Hwa Jung, Verizon, USA
Victor Lopez, Telefonica, Spain
Naoki Miyata, NTT Communications, Japan
Kathy Tse, AT&T, USA

Tuesday, 21 March

Coherent Interoperability Beyond QPSK — Is it Needed and What Will it Take?
14:00–16:00
Room: 402AB
Organizers: Marc Bohn, Coriant GmbH & Co. KG, Germany; Sebastian Randel, Nokia Bell Labs, USA

Within the last decade, coherent DSP technology has emerged as the key enabler for optical transmission at rates from 100 Gbps up to 400 Gbps per wavelength. Today, around seven DSP solutions from different companies are offered, all competing to best answer to the operators needs such as performance, cost, and power.

Up to now, this competition seems to drive innovation in the direction of increased speed and capacity as vendors introduce high-performance soft-decision FEC codes, fiber nonlinearity compensation, and probabilistic constellation shaping. With all these advanced features, performance is getting closer and closer to the Shannon limit, making significant performance improvements in the range of >1dB unlikely to occur. At the same time, power consumption is getting more and more important and the timeline of new ASIC generations is following closer and closer the availability of new lower power CMOS process nodes, for which the end of Moore’s law has been predicted.

This brings up the question whether the industry as a whole would benefit from a successive standardization of coherent DSPs. Today, pretty much all coherent DSPs include a 100G DP-QPSK mode which is interoperable. However, it uses a hard-decision FEC which cannot compete with more advanced soft-decision FECs. Looking forward, the following questions arise:

- What would it take to standardize higher-order modulation schemes e.g. 16QAM and 64-QAM as well as high-performance FECs?
- Do operators see potential benefits in this?
- Will standardization of coherent DSPs finally be driven by the need for high-capacity short-reach?
- Is the optics market truly unique or will it ultimately be shared among 2-3 players (compare markets like CPU, GPU, LTE, PON, DSL, …)?

On this panel, we want to elude answers to these questions by bringing together speakers from key operators and system vendors.

Panelists:
Marco Bertolini, Nokia Corporation, Italy
Dirk van den Borne, Juniper Networks, Inc., Germany
Markus Weber, Acacia Communications Inc., Germany
Werner Weiershausen, Deutsche Telekom, Germany

Direct vs. Coherent Detection for Metro-DCI
16:30–18:30
Room: 402AB
Organizers: Robert Griffin, Oclaro, UK; Tom Issenhuth, Microsoft, USA

Coherent systems are widely deployed for high capacity long-haul networks, whereas direct detection (DD) implementations with low cost and low power consumption dominate short reach. Both approaches overlap in new fast-growing applications of short reach Metro and data center interconnects (DCI), requiring DWDM transport over distances around 100 km. In 2016 a commercial 100G PAM4 DD solution for 80km DWDM DCI was announced, and single-carrier 400G coherent solutions targeting similar applications have been demonstrated by multiple vendors. Will these solutions happily coexist, will one become the dominant solution over time, or will new alternatives become available? The panel will discuss the merits of different approaches and what progress we can expect as the technologies develop.

Panelists:
Brandon Collings, Lumentum, USA
Mark Filer, Microsoft Corporation, USA
Radha Nagarajan, Inphi Corporation, USA
Atul Srivastava, NEL-America, USA

Wednesday, 22 March

Are Electronic & Optical Components Ready to Support Higher Symbol Rates & Denser Constellations?
13:00–15:00
Room: 402AB
Organizers: Rich Baca, Microsoft, USA; Gary Nicholl, Cisco, Canada

The optical interconnect industry is embracing higher speeds and higher order modulation formats to meet the continuing growth in bandwidth demand. Does the industry have a technology roadmap consistent with these market needs? Are there bottlenecks in the electronics: drivers, TIA’s, ADCs, DSP’s or the optics: lasers, modulators, detectors? This panel discussion will address these questions with industry experts sharing their view of optimal solutions with
constraints such as cost and power consumption, and insight into future innovations that may be needed. Come be a part of the discussion and gain an understanding of what the industry is doing and where it is headed.

Panelists:
Beck Mason, Oclaro, USA
Torben Nielsen, Acadia, USA
Vasudevan Parthasarathy, Broadcom, USA
Kim Roberts, Ciena, Canada

Quantum Communication Programs Around the World
15:30–17:30
Room: 411
Organizers: Andrew Lord, BT Labs, UK; Masahide Sasaki, National Inst of Information & Comm Tech, Japan

In a future where quantum computers will break much current cryptography, quantum communications offers the potential for unbreakable security, through untappable distribution of secret keys over optical fibres and free space, including satellite communications. This panel will take stock of the huge, current worldwide interest in and funding of quantum communications programs including developments in the US, China, Japan and Europe.

What will be the killer applications of quantum communications—will it be for bespoke point to point short-haul secure systems or can it form the basis of unprecedented long-lived security solutions even enabling data storage? Will it extend to core and access networks? Will quantum satellites create secure international communications or will classical, quantum-safe cryptography render quantum communications obsolete before it even starts?

Panelists:
Johannes Buchmann, Technische Universitat Darmstadt, Germany
Lijun Ma, NIST, USA
Gregoire Ribordy, ID Quantique, Switzerland
Qiang Zhang, University Science and Technology, China

OIDA Workshop on Manufacturing Trends for Integrated Photonics
Sunday, 19 March, 07:30–19:00
Petree Hall D

Integrated photonics presents significant opportunities to develop compact and highly functional systems for a range of communication and sensor applications. However, it has unique manufacturing challenges which can limit its commercial exploitation. These challenges are most apparent during the transition from research prototyping to product development and volume manufacture.

This workshop will focus on applications for integrated photonics and the manufacturing challenges related to these applications; from product design, device fabrication, integration and packaging, through to test and reliability. Although most applications present their own unique design and manufacturing challenges, this workshop will identify common themes where users can meet their unique set of requirements within a standardized design and manufacturing framework.
Separate registration fees apply.

Lab Automation Hackathon
Sunday, 19 March, 20:00–22:00
Location: 503
Organizers: Nicolas Fontaine, Nokia Bell Labs, USA; Jochen Schroeder; Chalmers University of Technology, Sweden

Lab work is most efficient when data can be acquired in an automated way, sometimes over long durations, without introducing human error, which allows researchers to concentrate on the fun part of experimental work. Open source software in easy to learn languages such as Python provides just as much, or more features/interoperability for lab automation than alternative commercial software. Several professionals with 10+ years of lab automation, will show you the power of using python to quickly get a lab experiment running and display the measurements in a browser. Bring a laptop to participate in the exercise. There will also be plenty of time for mingling and discussion.

OIDA Executive Forum
Monday, 20 March, 07:30–19:30
Petree Hall D

Held every year in conjunction with OFC, the OIDA Executive Forum features C-level panelists in an informal, uncensored setting discussing the latest issues facing companies in the business. Join more than 150 senior-level executives as they convene to discuss key themes, opportunities, and challenges facing the next generation in optical networking and communications. Highly valued by participants for the frank and open discussions, OIDA Executive Forum sessions explore emerging trends and action plans for tackling today’s toughest business challenges.
Separate registration fees apply.

Sponsored by: PICOMETRIX, CNL, OSA Industry Development Associates

Presented by:

Media Sponsor: LIGHTWAVE

IEEE Women in Engineering “Lunch & Learn”
Monday, 20 March, 12:00–14:00
Room: 515A

The IEEE Photonics Society and IEEE Communications Society are hosting an inclusive Women in Photonics and Women in Communications Engineering (WICE) “Lunch & Learn”, sponsored by IEEE Women in Engineering. This event will provide conference attendees with an opportunity to better hone their interpersonal skills and receive professional advice beyond the classroom or lab, as well as learn from successful women in photonics and optical communications.
The event includes a complementary lunch. All attendees must formally register prior to event.

Visit the IEEE Photonics Society or IEEE Communications Society booths for more details.

Exhibit Hall Training

How to Leverage the Exhibit as a Student or Early Career Professional
Tuesday, 21 March, 11:00-12:00
Room: 402AB

Join professionals in the industry to learn how to leverage the Exhibit Hall throughout the meeting for networking and professional development. This workshop will give you the confidence to walk the floor and engage with exhibitors to enhance your experience.

Hosted by: OSA Foundation

OIDA VIP Industry Leaders Speed Meetings Event
Tuesday, 21 March, 12:00–13:30
Room: 515B
Pre-registration required

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

Sponsored by: GDFoton

Data Center Summit: Next Generation Optical Technologies Inside the Data Center
Tuesday, 21 March, 12:15–13:45
Expo Theater II
Moderator: Lisa Huff; Principal Analyst, Discerning Analytics, USA

The data center summit panel will focus on next generation optical technologies likely to be used inside the data center. It will include both standard solutions as well as custom ones. Panelists will discuss the following:

- What are the evolving data center requirements?
  - Hyperscale perspective
  - Non-hyperscale perspective
- What will be needed as data centers evolve and grow?
- How are data centers working with optical components suppliers and equipment vendors to achieve their goals?
- What is missing in the ecosystem?

This panel will have members from a cross-section of the value chain – data center operators, equipment suppliers and component suppliers.

Presenters:
Robert Blum, Director of Strategic Marketing and Business Development, Intel, USA
Mike Connaughton, Market Segment Manager, Nexans, USA
Raju Kankipati, Product Manager, Arista Networks, USA
Chongjin Xie, Senior Director & Chief Optical Network Architect, Alibaba, USA

Cheeky Scientist Workshops
Tuesday, 21 March, 13:00–16:00
Room: 501B

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

Session I: Industry Resumes: How to Ensure Your Resume Gets to the Top of the Pile
13:00–14:30

Would you like learn how to get your resume seen by hiring managers to get an interview? Come learn the tips and tricks to ensure you don’t make the common mistakes. Learn how to layout your resume so the reader can understand what you offer within 7 seconds.

Session II: What are My Transferable Skills? A Common Question
14:30–16:00

Have you ever found yourself asking this this question? You may also not know what types of jobs you should target based on the many transferrable skills you have or may want to develop. This session will show jobseekers how to find out what jobs they should apply to that fit their career goals, personality, and lifestyle.

Hosted by: Cheeky Scientist Foundation

Special Events
**Data Center Summit: Open Hardware & Software Platforms**

**Session I: Open Platforms for Optical Innovation**
Tuesday, 21 March, 14:00–16:00  
Room: 408A

Organizers: Ramon Casellas, CTTC, Spain; Daniel King, University of Lancaster, UK; Noboru Yoshikane, KDDI Research, Japan; Ilya Baldin, RENCI/UNC Chapel Hill, USA

Using open hardware and software platforms for designing, deploying and operating large-scale networks is increasingly seen as a viable strategy for large and complex commercial environments. Most recently, the concepts of open hardware and software are being used within the optical infrastructure domain, and this trend is expected to facilitate innovation, design, adoption and control of future optical infrastructure.

Open hardware initiatives, including the Open Compute Platform, Telecom Infrastructure Project, Open ROADM Multi-Source Agreement, Central Office Rearchitected as Datacenter and Open Platform for NFV are defining open hardware platforms and reference implementations. To facilitate their control and operation, software projects such as OpenStack, OpenDayLight, Open Network Operating System, Open Platform for NFV, Open Source Mano and OpenConfig, are providing extensible frameworks and software tools.

Numerous proof-of-concept implementations and distributions across various research projects and early stage commercial initiatives, have demonstrated that rapid innovation is possible on basis of open hardware, interfaces, and software. Increasingly, these implementations and distributions will have to support the growing need for open optical hardware platforms.

The Open Platform Summit will discuss recent trends on open platforms and its applications to the optical networking space. It will comprise two technical sessions; the first session will have invited talks to introduce the audience to the topic area. The second session will comprise interactive table-top SDN & NFV demos selected from proposal submitted through the OFC system.

**Speakers:**  
Saurav Das, Open Networking Foundation, USA  
Young Lee, Huawei, USA  
Anees Shaikh, Network Architect, Google - Open Management Plan for Transport Networks  
Yasushi Sugaya, Fujitsu, Japan

**Session II: SDN & NFV Demo Zone**
Tuesday, 21 March, 16:30–18:30  
400 Foyer

The Data Center Summit (OPS) Session II, “SDN & NFV Demo Zone”, will provide the OFC audience with the opportunity to see live demonstrations and prototypes of collaborative research projects, pre-commercial products and proof-of-concept implementations in the SDN and NFV space. See page 96 for more details on the demonstrations.

**Exhibitor Reception**
Tuesday, 21 March, 17:30-19:00  
Lucky Strike LA Live  
800 W Olympic Blvd

OFC 2017 exhibitors are invited to celebrate the opening of the show. Join your colleagues, customers, and friends for drinks and appetizers.

**Conference Reception**
Tuesday, 21 March, 18:30-20:00  
Concourse Hall

Enjoy food and drinks with your friends and colleagues during the conference. The reception features live music from Ciena’s OTN-Speedwagon. Additional tickets may be purchased at registration for US $75.

**Rump Session**
Tuesday, 21 March, 19:30–21:30  
Room: 409AB

**Sub $0.25/Gbps Optics; How and When will Fiber Finally Kill Copper Cable Interconnects in the Data Center (DC)?**

Organizers: Chris Cole, Finisar Corp., USA; Dan Kuchta, IBM TJ Watson Research Center, USA  
Provocateurs: Andreas Bechtolsheim, Arista Networks, USA; Mitch Fields, Broadcom Ltd., USA; Tad Hofmeister, Google, USA; Benny Koren, Mellanox Technologies, USA; Brian Kirk, Amphenol Corp., USA; Ashok Krishnamoorthy, Oracle Corp., USA; Beck Mason, Ocalro Inc., USA; Brian Welch, Luxtera Inc., USA

In the DC, switch interconnects are exclusively fiber-based, but copper cables stubbornly hang on as server interconnects at ~$0.50/Gbps per link. Optical transceivers inside active cables or modules will have to be $0.25/Gbps to match cost. The high volume potential of this application can drive development of disruptive technologies and lower the cost of all DC optics. Yet our industry is moving away from common optics. Previously, focus on a few standard types like SR and LR created a huge 10G common market. Today, Operator and System OEM emphasis on optimizing their individual applications is leading to the proliferation of architectures, rates, link specifications, and form factors, fragmenting the volume of all optics types. This is accompanied by stringent port density and power requirements, making simultaneous optics low cost even more difficult to achieve, prolonging the lifespan of copper cables.

**Questions for Discussion:**

- What technologies are required to get to sub $0.25/Gbps optical transceivers?
- What happened to the $1/Gbps optics cost target for switch interconnects? Doesn’t industry have to hit it first before $0.25/Gbps for server interconnects?
- Are technologies for $0.25/Gbps optics and $1/Gbps optics synergistic or unrelated? Does 0dB loss budget cost less than 4dB loss budget?
- What’s the trend in switch-to-server architectures; move them apart as in end-of-row switch topologies or move them closer together as in multiple servers and switch on a card? Is there even a common switch-to-server topology to create a high volume optics market?
- Are optical transceivers inside active cables lower cost compared to inside modules? Are there operational costs that negate this?
- Does matching today’s copper cable cost even matter for connecting servers? If in a few lane rate generations, copper cables cannot support useful reaches, won’t DC Operators just have to pay more?
- How does the industry get to high volume for any optics type with the current trend of fragmentation of requirements and applications?
- Cloud DC Operators insist on low cost and bleeding edge performance on day one. If they have to make a choice, will they stay at lower cost for lower rate or pay higher cost to move to higher rate?
- Cloud DC Operators have identified power as their most critical requirement yet are restricting technical solutions, for example to SMF only. Are low-power technical solutions like VCSELs being arbitrarily excluded?
- Is Silicon Photonics the answer to sub $0.25/ Gbps or $1/Gbps optics?

Format:
- Short introductory presentations by session organizers.
- One slide presentations from diverse group of industry provocateurs.
- Vigorous audience participation after each presentation, with organizers facilitating open discussion.
- Attendees come prepared with tough questions and insightful comments.

Photonic Society of Chinese-Americans Workshop & Social Networking Event
The Emerging Technology Enablers for Next Generation Networks

Wednesday, 22 March
Room 518
17:00–17:30, Registration and Social Networking
17:30–19:30, Panel Discussions, Q&A

Registration Contacts:
David Li, dli@archcomtech.com, +1.630.308.3362
Genzao Zhang: Genzao_Zhang@emcore.com, +1.626.710.8788

To serve our mission of bringing together photonics professionals, enhancing the communication and collaboration in the optical industry, PSC-SC has been organizing technical and social events during OFC in the past 10 years. In OFC2017, the panel of the PSC annual event consists of well-respected experts from telcos and OEMs in the optical industry. The latest silicon photonics, data center, access and 5G wireless technologies will be elaborated. The technology trend of converging the fixed and wireless networks and the mainstream technologies will be discussed, as well as the strategies and demand differences for the next generation networks among US, China and the rest of the world markets.

Co-organizers: The Optical Society (OSA), OFC China Office & Wen Global Solutions, and China International Optoelectronic Expo (CIOE)

2017 Sponsors: Auxora, Bandweaver, BUPT, CoAdna, Emcore, EXFO, Fabrinet, FiberCore, Finisar, General Photonics, GoFoton, Hisense, Innolight, Inphi, MACOM, O-Net, Oplink (Molex), OzOptics, SAN-U, Source Photonics

Postdeadline Paper Presentations
Thursday, 23 March, 18:00–20:00
Rooms: 403A, 403B, 408A, 408B

Discover the best and most cutting-edge research in optical communications. The OFC 2017 Technical Program Committee has accepted a limited number of postdeadline papers for oral presentation. The purpose of postdeadline papers is to give participants the opportunity to hear new and significant material in rapidly advancing areas. Only those papers judged to be truly excellent and compelling in their timeliness were accepted.

Authors will be notified of acceptance on Monday, 20 March. Accepted papers will be posted on the mobile app and on the conference website. See page 7 for instructions on accessing a zip file with accepted papers.
Plenary Session

OFC Plenary Session
Tuesday, 21 March, 08:00–10:00
Concourse Hall

A Ubiquitous Cloud Requires a Transparent Network
Urs Hölzle
Senior Vice President for Technical Infrastructure
Google, Inc., USA

What makes cloud amazing is ubiquity. What makes Cloud ubiquitous is the network. We realized that at Google over a decade back while building the first truly global Cloud infrastructure. Ever since, we have been building a network unparalleled in reach, scale and capability. While we built the network as the backbone of a global super computer, we also turned the network control and management planes into distributed services running on the same Cloud. In the process, we made every network layer, including optical transport, intelligent, fault-tolerant, highly reliable and programmatically manageable to allow for rapid evolution and innovation. We have also applied the lessons of disaggregation, learned from Cloud, widely to our network infrastructure.

Urs Hölzle is Senior Vice President for Technical Infrastructure at Google. In this capacity he oversees the design, installation, and operation of the servers, networks, and datacenters that power Google’s services. Through efficiency innovations, Hölzle and his team have reduced the energy used by Google data centers to less than 50% of the industry average. Hölzle grew up in Switzerland and received a master’s degree in computer science from ETH Zurich and, as a Fulbright scholar, a Ph.D. from Stanford. While at Stanford (and then a small start-up that was later acquired by Sun Microsystems) he invented fundamental techniques used in most of today’s leading Java compilers. Before joining Google he was a professor of computer science at the University of California, Santa Barbara. He is a Fellow of the ACM and a member of the US National Academy of Engineering and the Swiss Academy of Technical Sciences.

Photonic Integrated Circuits for All: How Foundries are Transforming the Prototyping of Exciting New Devices
Meint K. Smit
Professor
Eindhoven University of Technology, Netherlands

In order to provide fabless researchers and developers with access to high-performance photonics integration platforms, the generic micro-electronics foundry model has recently been adapted to photonic integrated circuits. Pioneered in Europe for three different technologies (InP, silicon and silicon nitride), the model is now also being implemented in the United States with the National Photonics Initiative.

The foundry model uses Process Design Kits (PDKs) that allow users to implement complex integrated photonic circuits without detailed knowledge of the underlying photonic integration technologies. This brings the use of photonic ICs within the reach of small companies, and it offers excellent opportunities to introduce integrated photonics into diverse applications, like sensors, security, medical diagnostics, automotive, avionics and metrology. This presentation describes the photonics foundry model and its development in Europe, explains the significant reductions in prototyping costs, and highlights foundry-model developed photonic ICs across a broad range of applications.

Meint K. Smit started research in Integrated Optics in 1981. He invented the Arrayed Waveguide Grating, for which he received a LEOS Technical Achievement award in 1997 and he was closely involved in the introduction of MMI-couplers in semiconductor-based Photonic IC technology. In 2000 he became the leader of the Photonics Integration group at the COBRA Research Institute of TU Eindhoven. His current research interests are in InP-based Photonic Integration and integration of InP circuitry on Silicon.

Internet of Skills – Where Communications, Robotics and AI Meet
Mischa Dohler
Professor
King’s College, London, UK

Today’s internet, accessed by fixed and mobile networks, allows us to transmit files, voice and video across the planet. With the emergence of an ultra-responsive and reliable ‘Tactile Internet,’ advanced techniques in robotics and artificial intelligence, we predict the emergence of an ‘Internet of Skills’ which allows the transmission of labor globally. It will invoke an important shift from content-delivery to skillset-delivery networks, where engineers would service cars or surgeons performing critical operations anywhere on the planet. For this to work, however, we require some fundamental laws of physics to be “reengineered.” This presentation will look at the disruptive technology approaches in wireless 5G and next-generation optical networks which will allow us to break through the next technology frontier.

Mischa Dohler is full Professor in Wireless Communications at King’s College London, driving cross-disciplinary research and innovation in technology, sciences and arts. He is the Director of the Centre for Telecommunications Research, co-founder of the pioneering smart city company Worldsensing, Fellow of the IEEE and the Royal Society of Arts (RSA), and a Distinguished Member of Harvard Square Leaders Excellence. Dohler has pioneered several research fields, contributed to numerous wireless broadband, IoT/M2M and cyber security standards, holds a dozen patents, organized and chaired numerous conferences, was the Editor-in-Chief of two journals, has more than 200 publications, and authored several books.
OFC and Sponsor Awards and Honors

Awards Ceremony and Luncheon
Tuesday, 21 March, 12:00–14:00
Concourse Hall

The conference sponsors – IEEE Communications Society, IEEE Photonics Society, and The Optical Society – will present awards and honors in a special Awards luncheon on Tuesday. The lunch is open to anyone who purchases a ticket, but seating is limited. Tickets can be purchased for $45.00 USD at registration.

OFC will also recognize the winner of the John Tyndall Award and acknowledge all other awards and honors recipients during the plenary session.

John Tyndall Award

The John Tyndall Award is named for the 19th century scientist who was the first to demonstrate the phenomenon of internal reflection. First presented in 1987, the Tyndall Award recognizes an individual who has made pioneering, highly significant, or continuing technical or leadership contributions to fiber optic technology. Corning, Inc. sponsors the award, a prize check and a glass sculpture that represents the concept of total internal reflection. The award is co-sponsored by The Optical Society (OSA) and the IEEE Photonics Society.

The IEEE Photonics Society and OSA will present the 2017 Tyndall Award to Professor Evgeny M. Dianov, Russian Academy of Sciences. He graduated from Moscow State University in 1960 and began his scientific career in the P.N. Lebedev Physics Institute of the USSR Academy of Sciences (1960-1983), then worked in the General Physics Institute (1983-2006) and in the Fiber Optics Research Center of RAS (2006-present). His research interests include laser physics, nonlinear optics and fiber optics and he has published more than 700 scientific papers and patents. He received the State Prize of the Soviet Union for “Neodymium Glass Lasers” in 1974. In 1994 Prof. Dianov became a Full Member of the Russian Academy of Sciences.

Since 1974 he has been involved with most aspects of fiber optics, including fiber technologies, fiber measurements, nonlinear fiber optics, fiber lasers and optical amplifiers. Main results included new types of optical fibers such as high-strength hermetically metal-coated, dispersion-decreasing, nitrogen-doped and low-loss highly nonlinear fibers; new results in nonlinear fiber optics such as the first observation of soliton self-frequency shift, the discovery of electrostriction mechanism of soliton interaction, generation of a train of fundamental solitons at high repetition rate, the proposal and experimental confirmation of a photovoltaic model of second-harmonic generation in glass fibers; the development of highly efficient Raman fiber lasers and optical amplifiers.

Dianov received the State Prize of the Russian Federation for infrared fibers in 1998 and Vavilov Gold Medal for studies of nonlinear processes in optical fibers and the development of fiber sources of radiation in visible and near IR spectral ranges based on nonlinear phenomena.

IEEE Communications Society 2017 Fellows

Xiang Liu, Huawei, USA
Shu Namiki, National Institute of Advanced Industrial Science and Technology, Japan
Seb Savory, University of Cambridge, UK

IEEE Photonics Society 2017 Fellows

John Ballato, Clemson, USA
Chris Cole, Finisar, USA
Joseph Ford, University of California, San Diego, USA
Xiang Liu, Huawei R&D, USA
Shu Namiki, National Institute of Advanced Industrial Science and Technology (AIST), Japan
Aydogan Ozcan, UCLA, USA
Seb Savory, University College, UK
Eric Swanson, Acacia Communications, Inc., USA

The Optical Society Fellows

Gabriella Bosco, Politecnico di Torino, Italy
Walter F. Buell, The Aerospace Corporation, USA
Yijiang Chen, Jet Propulsion Laboratory, USA
Aref Chowdhury, Nokia Corporation, USA
Ivan B. Djordjevic, University of Arizona, USA
Po Dong, Nokia Bell Labs, USA
Andrew Forbes, University of Witwatersrand, South Africa
JianJang Huang, National Taiwan University, Taiwan
Hong Liu, Google, USA
Malin Premaratne, Monash University, Australia
Leslie A. Rusch, Universite Laval, Canada
IEEE Journal of Lightwave Technology (JLT) Best Paper Award

The IEEE and OSA co-sponsored Journal of Lightwave Technology has instantiated a Best Paper Award. This annual award recognizes the most impactful paper published in JLT 2 to 3 years ago.


Copies of these papers will be made available at various places at this conference and will be turned into open-access as well.

Charles Kao Award for Best Optical Communications & Networking Paper, IEEE Communications Society

The Charles Kao Award for Best Optical Communications and Networking Paper is awarded to papers published in the OSA/IEEE Journal on Optical Communications & Networking (JOCN) that open new lines of research, envision bold approaches to optical communication and networking, formulate new problems to solve, and essentially enlarge the field of optical communications and networking. Papers published in the prior three calendar years of JOCN are eligible for the award.


IEEE Photonics Society Fund

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

With the establishment of this fund, you too can play a direct role in this vital work.

Visit the IEEE Photonics Society booth or IEEE-Photonics-Fund.org for more information.

The Corning Student Paper Competition

The winners of the Corning Outstanding Student Paper Competition will be announced during the conference.

The top finalist will receive a grand prize of $1,500 USD, and the two runners-up will receive $1,000 USD. This award, endowed through the OSA Foundation by a grant from Corning, recognizes innovation, research excellence and presentation abilities in optical communications.

Congratulations to the 2017 finalists:

Kaoutar Benyahya, Nokia Bell Labs, France
Zhe Li, University College London, UK
Rafael Puerta, Technical University of Denmark, Denmark
Zeinab Sanjabi, Eznaveh University of Central Florida, USA

The Paul Anthony Bonenfant Memorial Scholarship

Established in 2011 in memory of Paul Anthony Bonenfant, this scholarship enables undergraduate students enrolled in engineering and/or physical science programs to attend semester-abroad programs offered through their accredited college or university.

The goal of the scholarship is to provide international experience to students as they prepare for professional lives that promote global engagement and collaboration.

This $8,000 USD scholarship will rotate among several universities including The California Institute of Technology, Cornell University, and The Ohio State University. For more information on this scholarship and its recipients, please visit www.osa.org/Bonenfant. The recipient will be announced to OFC attendees by email at the conclusion of the conference.

The Tingye Li Innovation Prize

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

Congratulations to our 2017 recipient:

Tetsuya Hayashi, Sumitomo Electric Industries, Ltd., Japan

Michael Theurer, Fraunhofer Heinrich Hertz Institute, Germany
Jing Wang, Georgia Institute of Technology, USA
# Short Course Schedule

## Sunday, 19 March, 2017

<table>
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<tr>
<th>Time</th>
<th>Course</th>
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<tr>
<td>09:00–12:00</td>
<td>SC176: Metro Network: The Transition to Ethernet, Loudon Blair; Ciena Corp., USA</td>
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<td></td>
<td>SC177: High-Speed Semiconductor Lasers and Modulators, John Bowers; Univ. of California at Santa Barbara, USA</td>
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<td></td>
<td>NEW! SC443: Optical Amplifiers: From Fundamental Principles to Technology Trends, Michael Vasilyev¹, Shu Namiki²; ¹University of Texas at Arlington, USA, ²National Institute of Advanced Industrial Science and Technology (AIST), Japan</td>
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<td>NEW! SC444: Optical Communication Technologies for 5G Wireless, Xiang Liu; Futurewei Technologies, Huawei R&amp;D, USA</td>
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<td></td>
<td>NEW! SC447: The Life Cycle of An Optical Network: From Planning to Decommissioning, Andrew Lord; BT Labs, BT, UK</td>
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<tr>
<td>09:00–13:00</td>
<td>SC105: Modulation Formats and Receiver Concepts for Optical Transmission Systems, Peter Winzer, S. Chandrasekhar; Nokia Bell Labs, USA</td>
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<td>SC114: Passive Optical Networks (PONs) Technologies, Frank J. Effenberger; Futurewei Technologies, USA</td>
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<td>SC359: Datacenter Networking 101, Cedric Lam, Hong Liu; Google, USA</td>
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<td>SC384: Background Concepts of Optical Communication Systems, Alan Willner; Univ. of Southern California, USA</td>
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<tr>
<td>13:00–17:00</td>
<td>SC203: 100 Gb/s and Beyond Transmission Systems, Design and Design Trade-offs, Martin Birk, Benny Mikkelsen; AT&amp;T Labs, Res., USA, Acacia Communications, USA</td>
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<td>SC369: Test and Measurement for Metro and Long-haul Communications, Bernd Nebendahl, Michael Koenigsmann; Keysight, Germany</td>
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<td>SC393: Digital Signal Processing for Coherent Optical Systems, Chris Fludger; Cisco Optical GmbH, Germany</td>
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## Monday, 20 March, 2017

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<tr>
<th>Time</th>
<th>Course</th>
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<tr>
<td>08:30–12:30</td>
<td>SC102: WDM in Long-Haul Transmission Systems, Neal S. Bergano; TE Subcom, USA</td>
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<td>SC178: Test and Measurement for Data Center/Short Reach Communications, Greg D. Le Cheminant; Keysight Technologies, USA</td>
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<td>SC327: Modeling and Design of Fiber-Optic Communication Systems, Rene-Jean Essiambre; Bell Labs, Nokia, USA</td>
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<td></td>
<td>SC341: Multi-carrier Modulation: DMT, OFDM and Superchannels, Sander L. Jansen¹, Dirk van den Borne²; ¹ADVA Optical Networking, Germany, ²Juniper Networks, Germany</td>
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<td>SC390: Introduction to Forward Error Correction, Frank Kschischang; Univ. of Toronto, Canada</td>
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<td>SC432: Hands on: Silicon Photonics Component Design &amp; Fabrication, Lukas Chrostowski; University of British Columbia, Canada</td>
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<td>NEW! SC446: Hands-on: Characterization of Coherent Opto-electronic Subsystems, Harald Rohde and Robert Palmer; Coriant, Germany</td>
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**SC325:** Highly Integrated Monolithic Photonic Integrated Circuits, Chris Doerr; Acacia Communications, USA

**SC395:** Modeling and System Impact of Optical Transmitter and Receiver Components, Harald Rohde, Robert Palmer; Coriant, Germany

**SC176:** Metro Network: The Transition to Ethernet, Loudon Blair; Ciena Corp., USA

**SC177:** High-Speed Semiconductor Lasers and Modulators, John Bowers; Univ. of California at Santa Barbara, USA

**NEW! SC443:** Optical Amplifiers: From Fundamental Principles to Technology Trends, Michael Vasilyev¹, Shu Namiki²; ¹University of Texas at Arlington, USA, ²National Institute of Advanced Industrial Science and Technology (AIST), Japan

**NEW! SC444:** Optical Communication Technologies for 5G Wireless, Xiang Liu; Futurewei Technologies, Huawei R&D, USA

**NEW! SC447:** The Life Cycle of An Optical Network: From Planning to Decommissioning, Andrew Lord; BT Labs, BT, UK

**SC105:** Modulation Formats and Receiver Concepts for Optical Transmission Systems, Peter Winzer, S. Chandrasekhar; Nokia Bell Labs, USA

**SC114:** Passive Optical Networks (PONs) Technologies, Frank J. Effenberger; Futurewei Technologies, USA

**SC359:** Datacenter Networking 101, Cedric Lam, Hong Liu; Google, USA

**SC384:** Background Concepts of Optical Communication Systems, Alan Willner; Univ. of Southern California, USA

**SC267:** Silicon Microphotonics: Technology Elements and the Roadmap to Implementation, Lionel Kimerling; MIT, USA

**SC372:** Building Green Networks: New Concepts for Energy Reduction, Rod S. Tucker; Univ. Melbourne, Australia

**SC386:** The “SDN” Evolution of Wireline Transport due to “Cloud” Services and DCI Innovations, Loukas Paraschis; Infinera, Inc., USA

**SC428:** Link Design for Short Reach Optical Interconnects, Petar Pepeljugoski; IBM Research, USA

**SC429:** Flexible Networks, David Boertjes; Ciena, Canada

**NEW! SC451:** Fiber-based Devices and Sensors, Zuyuan He¹, William Shroyer²; ¹Shanghai Jiao Tong University, China, ²SageRider, Inc., USA

**SC325:** Highly Integrated Monolithic Photonic Integrated Circuits, Chris Doerr; Acacia Communications, USA

**SC395:** Modeling and System Impact of Optical Transmitter and Receiver Components, Harald Rohde, Robert Palmer; Coriant, Germany

**SC105:** Modulation Formats and Receiver Concepts for Optical Transmission Systems, Peter Winzer, S. Chandrasekhar; Nokia Bell Labs, USA

**SC359:** Datacenter Networking 101, Cedric Lam, Hong Liu; Google, USA

**SC384:** Background Concepts of Optical Communication Systems, Alan Willner; Univ. of Southern California, USA

**SC267:** Silicon Microphotonics: Technology Elements and the Roadmap to Implementation, Lionel Kimerling; MIT, USA

**SC372:** Building Green Networks: New Concepts for Energy Reduction, Rod S. Tucker; Univ. Melbourne, Australia

**SC386:** The “SDN” Evolution of Wireline Transport due to “Cloud” Services and DCI Innovations, Loukas Paraschis; Infinera, Inc., USA

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**SC325:** Highly Integrated Monolithic Photonic Integrated Circuits, Chris Doerr; Acacia Communications, USA

**SC395:** Modeling and System Impact of Optical Transmitter and Receiver Components, Harald Rohde, Robert Palmer; Coriant, Germany
NEW! SC453A: Hands-on Fiber Optic Handling, Measurements, and Component Testing, Chris Heisler1, Loic Cherel2, Steve Baldo1, Keith Foord4; 1OptoTest Corporation, USA; 2Data-Pixel, France; 3Seikoh Giken Company, USA; 4Greenlee Communications, USA

09:00–12:00

SC208: Optical Fiber Design for Telecommunications and Specialty Applications, David J. DiGiovanni; OFS Labs, USA

SC385: Optical Interconnects for Extreme-scale Computing, John Shalf1, Keren Bergman2; 1Lawrence Berkeley National Laboratory, USA, 2Columbia University, USA

SC411: Multi-layer Interaction in the Age of Agile Optical Networking, Ori A. Gerstel; Sedona Systems, Israel, USA

NEW! SC442: Free Space Switching Systems: PXC and WSS, David Neilson; Nokia Bell Labs, USA

NEW! SC450: Design, Manufacturing, and Packaging of Opto-Electronic Modules, Kevin Williams1, Arne Leinue2, Twan Korthorst3; 1Eindhoven University of Technology, Netherlands, 2LioniX International, Netherlands, 3PhoeniX Software, Netherlands

13:30–17:30

SC160: Microwave Photonics, Vince Urick; DARPA, USA

SC347: Reliability and Qualification of Fiber-Optic Components, David Maack; Corning, USA

SC408: Space Division Multiplexing in Optical Fibers, Roland Ryf; Nokia Bell Labs, USA

NEW! SC449: Hands-on: An Introduction to Writing Transport SDN Applications, Ricardo Vilalta1, Karthik Sethuraman2; 1CTTC, Spain, 2NEC Corporation of America, USA

NEW! SC452: FPGA Programming for Optical Subsystem Prototyping, Noriaki Kaneda1, Laurent Schmalen2; 1Nokia Bell Labs, USA, 2Nokia Bell Labs, Germany

NEW! SC453B: Hands-on Fiber Optic Handling, Measurements, and Component Testing, Chris Heisler1, Loic Cherel2, Steve Baldo3, Keith Foord4; 1OptoTest Corporation, USA; 2Data-Pixel, France; 3Seikoh Giken Company, USA; 4Greenlee Communications, USA

NEW! SC454: Hands-on: Silicon Photonic Circuits and Systems Design, Lukas Chrostonwski1, Chris Doerr2; 1University of British Columbia, Canada, 2Acacia Communications, USA

NEW! SC455: Hands-on: An Introduction to Writing Transport SDN Applications, Ricardo Vilalta1, Karthik Sethuraman2; 1CTTC, Spain, 2NEC Corporation of America, USA

13:30–17:30

SC261: ROADM Technologies and Network Applications, Thomas Strasser; Nistica Inc., USA

SC431: Photonic Technologies in the Data Center, Clint Schow; University of California, USA

NEW! SC445: Visible Light Communications — the High Bandwidth Alternative to WiFi, Harald Haas; LiFi Research and Development Centre, The University of Edinburgh, UK

NEW! SC448: An Introduction to the Control and Management of Optical Networks, Ramon Casellas; CTTC, Spain

Short Courses

Sunday, 19 March, 2017

09:00–12:00

SC176: Metro Network: The Transition to Ethernet
Instructor: Loudon Blair; Ciena Corp., USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:

• Describe how new services are changing metro network traffic characteristics.

• Describe the impact that these new services will have on metro network traffic patterns and network equipment capacity in both aggregation and core metro networks.

• Describe the meaning of Carrier Ethernet and discuss different implementation approaches.

• Describe the key networking technologies used to build next generation metro networks, including DWDM, OTN, and IP/MPLS.

• Discuss the role of Carrier Ethernet in new metro architectures and how it operates in combination with other key technologies.

• Describe how packet and optical technologies are converging to form packet-optical transport and switching systems.

• Discuss how packet-optical systems may be used in different metro application scenarios, including new cloud network architectures.

Intended Audience:
This course is intended for network architects and planners from service providers, engineering and marketing staff to network equipment providers, technologists with an interest in the evolution of networks, industry analysts, and financial analysts.
SC177: High-Speed Semiconductor Lasers and Modulators
Instructor: John Bowers; Univ. of California at Santa Barbara, USA
Level: Intermediate

Benefits and Learning Objectives:
This course should enable you to:
• Compare different technologies.
• Make informed decisions on the design of optical transmitters and their incorporation into optical networks.
• Explain the performance of high-speed transmitters.

Intended Audience:
Attendees should have some knowledge of semiconductor and device physics. A basic knowledge of laser operation is also needed.

SC443: Optical Amplifiers: From Fundamental Principles to Technology Trends NEW!
Instructors: Michael Vasilyev¹, Shu Namiki²; ¹University of Texas at Arlington, USA; ²National Institute of Advanced Industrial Science and Technology (AIST), Japan
Level: Advanced Beginner

Benefits and Learning Objectives:
This course will enable you to:
• Define the roles of optical amplifiers in optical communication networks.
• List the key parameters of optical amplifiers important for system design.
• Identify the stimulated emission phenomenon as the common physical process for optical amplification.
• Explain the difference between phase-insensitive amplifiers (PIAs) and phase-sensitive amplifiers (PSAs).
• List several material platforms of optical amplification and key differences in their performances and characteristics.
• Discuss optical amplification technologies such as erbium-doped fiber amplifier (EDFA), fiber Raman amplifier (FRA), semiconductor optical amplifier (SOA), and fiber-optical parametric amplifier (FOPA).
• Describe the practical issues of each of the optical amplification technologies listed above.
• Identify the future trends in research and development of optical communication enabled by advances in optical amplification technologies.

Intended Audience:
This beginner/advanced-beginner course is intended for a diverse audience including newcomers to the field of optical fiber communication, and especially for lightwave system engineers and opto-electronic sub-system designers. Some basic knowledge of optical fiber communication technologies will help in better understanding the course but is not a prerequisite.

SC444: Optical Communication Technologies for 5G Wireless NEW!
Instructor: Xiang Liu; Futurewei Technologies, Huawei R&D, USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
• Describe 5G wireless trends and technologies such as massive MIMO and coordinated multi-point (CoMP).
• Identify promising applications of optical communication technologies in future 5G wireless networks.
• Identify recent advances on the common public radio interface (CPRI) and the next-generation fronthaul interface (NGFI) for cloud radio access networks (C-RAN).
• Describe emerging optical communication technologies such as 100+Gb/s coherent, low-cost IM/DD transmission, and associated DSP techniques for high-throughput and low-latency wireless fronthaul and backhaul.
• Discuss emerging network architectures and design tradeoffs among various optical transport and access systems for better converged fiber/wireless networks.

Intended Audience:
This advanced-beginner course is intended for a diverse audience including researchers, engineers, and graduate students. Some basic knowledge of optical networks, wireless networks, optical transmission technologies, photonics, and digital signal processing will help in better understanding the course but is not a prerequisite.

SC447: The Life Cycle of an Optical Network: From Planning to Decommissioning NEW!
Instructor: Andrew Lord; BT Labs, UK
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:
• Identify key activities comprising whole-life optical network procurement, design, operation and management.
• Explain the broad time scale for an optical network including reasons for building it and factors affecting how long it should be in operation.
• Appreciate different types of optical network and the range of network operator requirements. Deduce the implications for the solution design.
• List the range of optical network technologies available to build networks, covering legacy through to future roadmap options.
• Understand the need for appropriate resilience and reliability across the network, from devices, sub-systems, network equipment and overall network operation.
• Explore how unpredictable future traffic drives the need for both network flexibility and capacity growth and appreciate that the scope for both flexibility and growth imply increased network cost.
• Appreciate the impact of the quality of the available optical fibre infrastructure on the physical layer system design, including margin allowance.
• Discuss the impact on future networks of new technologies, including flexible transceivers and ROADMs, and finer resolution wavelength grid and a more open control and management based around Software Defined Networking (SDN).

Intended Audience:
This advanced-beginner course is intended for a diverse audience – in fact anyone wanting a broad operator-based perspective on the optical network journey. No in-depth knowledge will be required – the objective is sufficient breadth that anyone will be able to see where their field of expertise fits into the overall picture. This is a brand new course for 2017 with entirely new material, much of which is derived from real network deployment experience.

09:00–13:00

SC105: Modulation Formats and Receiver Concepts for Optical Transmission Systems
Instructors: Peter Winzer, S. Chandrasekhar; Nokia Bell Labs, USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
• Describe the basic concepts behind optical modulation and multiplexing techniques.
• Explain the basic concepts behind advanced optical modulation formats, their performance, and their generation using state-of-the-art opto-electronic components and digital signal processing.

Intended Audience:
This advanced-beginner course is intended for a diverse audience including lightwave system researchers and engineers as well as opto-electronic subsystem designers. Some basic knowledge of optical modulation and detection technologies will help in better understanding the course but is not a prerequisite. Past attendees will find substantial updates to this course, which we continuously adapt to reflect the latest trends in research as well as in product development, and may hence find it useful to attend again.

SC114: Passive Optical Networks (PONs) Technologies
Instructor: Frank J. Effenberger; Futurewei Technologies, USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
• Compare the capabilities and advantages of different PON technologies.
• Describe the practical limitations of real-world G-PON and EPON systems for broadband access.
• Explain the motivations behind the Full-Service-Access-Network initiative and the related IEEE P802.3 and P1904 projects.
• Identify the commercial issues surrounding fiber access, and how PON works to address these.

Intended Audience:
This course is intended to give engineers a general overview of PON technologies that can serve multiple roles depending on their field. Network planners can use this course to better understand the available systems and their applications. Product designers will gain insight as to the fundamental design trade-offs involved in PON. Academic researchers will see how their specific research can fit into the larger technology domain.

SC359: Datacenter Networking 101
Instructors: Cedric Lam, Hong Liu; Google, USA
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:
• Define warehouse-scale computer (WSC) and describe its structure.
• Describe the engineering principles and philosophies behind scalable mega-datacenter infrastructures.
• Compare different datacenter cluster topologies and switching technologies.
• Compare the differences and similarities between traditional telecommunication networks and booming data-communication networks.
• Identify the challenges for intra-datacenter and inter-datacenter communications.
• Select suitable optoelectronic interconnect technologies.
• Explain the roles of optics in transmission, multiplexing and switching.
• List and compare the possible future evolution paths that PON technology may take.
• Explain how to plan PON applications and deployments.
Intended Audience:
This course is beneficial to optoelectronic engineers, fiber optic transceiver designers and optical transmission engineers who would like to understand the requirements of datacenter networking. It also benefits network engineers with the knowledge of high-speed optical communication technologies used to realize various datacenter network applications. For network planners and architects, this course provides outlooks in optical network technology developments in the next 3 to 4 years.

SC384: Background Concepts of Optical Communication Systems
Instructor: Alan Willner; Univ. of Southern California, USA
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Discuss the basic concepts of an optical communication system.
- Identify different types of modulation and multiplexing formats.
- Compute a simple optical power budget.
- Explain key differences between direct and coherent detection systems.
- Attend more advanced OFC short courses and understand better the conference technical sessions.

Intended Audience:
This introductory course is intended for an audience with at least some technical background in engineering, physics or related disciplines, and is ideally suited for engineers who want to learn more about optical fiber communication systems. The audience should gain valuable knowledge enabling them to take more advanced courses as well as understand better the conference technical sessions.

13:00–17:00
SC267: Silicon Microphotonics: Technology Elements and the Roadmap to Implementation
Instructor: Lionel Kimerling; MIT, USA
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Identify trends in the optical components industry.
- Explain the power of a standard platform.
- Discuss the benefits of electronic-photonic integration.
- Evaluate the latest silicon photonic devices and foundry production of chips for datacom, automotive and sensing applications.
- Summarize the findings of the Integrated Photonics System Roadmap.

Intended Audience:
This course is for executives and technologists in the photonic and electronic hardware industries to include planners, engineers, and scientists participating in the optical components technology supply chain.

SC325: Highly Integrated Monolithic Photonic Integrated Circuits
Instructor: Chris Doerr; Acacia Communications, USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Gain a deeper understanding of photonic integrated circuits (PICs) for telecomm and datacom.
- Describe the pros and cons of PICs.
- Recognize the most popular material systems, especially silicon photonics and indium phosphide photonics.
- Explain many of the phenomena in PICs.
- Discover the issues that PIC designers face.
- List the main steps in producing a PIC.
- Get an up-to-date view on PICs in the communication industry.
- Separate hype from reality with regard to PICs.

Intended Audience:
This advanced-beginner course is intended for both industry and academic participants who want to get a realistic view of PICs in industry today and where they might be going in the next five years. A beginners knowledge of optical communication systems would be very helpful. The participant does not need to know anything about PICs, but some understanding of general optics, such as what is refractive index, is needed.

SC395: Modeling and System Impact of Optical Transmitter and Receiver components
Instructors: Harald Rohde, Robert Palmer; Coriant, Germany
Level: Intermediate

Benefits and Learning Objectives:
This course should enable you to:
- Numerically model components for coherent transmission systems.
- Detect real life impairments of such components.
- Model, design and characterize optical transceivers.
- Separate hype from reality with regard to PICs.

Intended Audience:
This course is targeted for researchers and students who want to learn how to model transceiver components for coherent optical transmission systems. Basic knowledge of transmission system related mathematics (e.g. Fourier transforms) and basic communication theory knowledge is required.
13:30–16:30

SC216: An Introduction to Optical Network Design and Planning
Instructor: Jane M. Simmons; Monarch Network Architects, USA
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:

- Compare O-E-O and optical-bypass technology.
- Compare the architectures of various optical network elements.
- Describe the colorless, directionless, contentionless, and gridless attributes of ROADM.
- Describe the basics of routing traffic, including strategies for load balancing and protection.
- Describe the basics of wavelength assignment.
- List some of the networking principles as well as physical effects that determine where regeneration is required in a network.
- Identify the advantages and disadvantages of Elastic Optical Networks (EONs).
- Discuss the ‘hot’ topics in network architecture, including Software Defined Networking (SDN), power consumption issues, and Space Division Multiplexing (SDM).

Intended Audience:
This course is intended for network planners and architects in both carriers and system vendors who are involved in planning optical networks and selecting next-generation optical equipment. The discussion of networking elements and algorithms, as well as the discussion of current research areas, should be helpful to vendors who are developing optical systems and to carriers who are modeling network evolution strategies. The course is introductory level, although a basic understanding of networking principles is assumed.

SC430: SDN Standards and Applications
Instructor: Lyndon Y. Ong; Ciena, USA
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:

- Identify common service provider SDN Use Cases.
- Explain how SDN can support carrier network virtualization and slicing.
- Discuss the basic architecture of SDN for transport networks.
- Distinguish the roles of SDN SouthBound and NorthBound Interfaces.
- Describe OpenFlow and its extensions for optical networking.
- Understand different approaches to SDN NBI and ONF’s Transport API.
- Compare ONF’s common model vs. IETF’s YANG model approaches.
- Review the status of carrier implementation and testing of Transport SDN APIs.

Intended Audience:
The audience for this course includes system and network architects and engineers in network operators and equipment vendors, as well as researchers wanting to understand directions for introducing SDN into wide area networks. The course assumes some familiarity with optical network technologies and basic understanding of the role of higher layer networks and how they connect to the optical layer.

SC433: Photodetectors for Optical Communications
Instructor: Joe C. Campbell; Univ. of Virginia, USA
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:

- Explain the fundamental operation of different types of photodetectors and compare their relative merits. Participants will obtain a broad overview of the photodetectors that are widely deployed in optical communications.
- Present the state-of-the-art for p-i-n, avalanche, and single-photon photodiodes. Participants will be “up-to-date” with respect to device performance and the, concomitant, limitations.
- Describe the design guidelines and tradeoffs for specific photodetector applications. This will enable participants to specify appropriate detectors.

Intended Audience:
This course is intended for those interested in the fundamentals of photodetectors. For example, what are the factors that determine the maximum bandwidth of a photodiode? What are the current “champion” results and what are the inherent tradeoffs with other performance parameters? The device physics will be presented at a high level although some background in semiconductor devices will be beneficial. The course is intended for those who are new to the area, while providing useful information to workers in the field.
SC203: 100 Gb/s and Beyond Transmission Systems, Design and Design Trade-offs

Instructors: Martin Birk¹, Benny Mikkelsen²; ¹AT&T Labs, Res., USA, ²Acacia Communications, USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Identify key requirements and drivers for 100Gb/s applications.
- List key building blocks of coherent systems.
- Describe the availability and performance of 100Gb/s.
- Discuss 100Gb/s transmission limitations.
- Summarize 100Gb/s standards activities.
- Describe drivers and technologies for systems beyond 100Gb/s.
- Discuss applications of flex rate systems.

Intended Audience:
The course is intended for engineers and technical managers who want an up-to-date overview of 100Gb/s transmission systems, including applications, line-card designs, and fiber transmission limitations. This year this course has been extended to 4 hours to accommodate more questions and more material beyond 100Gb/s. The course requires some understanding of basic optical transmission systems.

SC369: Test and Measurement for Metro and Long-haul Communications

Instructors: Bernd Nebendahl, Michael Koenigsmann; Keysight, Germany
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Describe a setup to measure wavelength and polarization dependent properties of DWDM components.
- Determine the required performance of test & measurement equipment to test optical components.
- Measure performance parameters of optical amplifiers and fiber links.
- Compare the quality of various transmitters through the use of EVM measurements.
- Relate details of constellation diagrams to specific device and/or measurement system impairments.
- Identify the root causes of measurement degradation and uncertainty.
- Define test strategies to validate the accuracy of test results.

Intended Audience:
This short course is intended for engineers who start to work or already have experience in manufacturing and development of metro and long-haul communication equipment and components. Attendees should be aware of basic concepts of optical transmission and polarization of light. Research and manufacturing managers as well as technical buyers will get a profound background in order to make optimal decision for their test and measurement needs. Students will extend their knowledge in optimal test concepts for fiber optical testing.

SC393: Digital Signal Processing for Coherent Optical Systems

Instructor: Chris Fludger; Cisco Optical GmbH, Germany
Level: Intermediate

Benefits and Learning Objectives:
This course should enable you to:
- Describe the principle building blocks in a coherent optical transceiver.
- Explain the function of frequency and time-domain filters and their advantages and disadvantages.
- Explain the implementation of pulse shaping and CD filters.
- Describe techniques for frequency and carrier phase estimation.
- Summarize the importance of clock recovery and describe clock recovery methods.
- Describe the components of polarization tracking filters.
- Explain how channel parameter estimation may be performed in coherent transceivers.
- Explain the options for achieving flexible capacity including implications for the network.
- Quantify the effectiveness and complexity of non-linear compensation.

Intended Audience:
This course is intended for individuals having an intermediate knowledge of digital lightwave transmission systems. It will be of value for industrial professionals (system designers, managers) who need to understand the different components in digital coherent transceivers, as well as for researchers who are new to the field.

SC205: Integrated Electronic Circuits for Fiber Optics

Instructor: Y. K. Chen; Nokia Bell Labs, USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Describe the functions and performance of high-speed electronics for optic fiber terminals and associated designs and implementation of physical layer electronics.
- Describe commonly used circuit architectures and broadband digital, analog and mixed-mode circuits.
- Introduce advanced modulation and signal processing architecture and related broadband data converters.
Intended Audience:
This course is intended for engineers, scientists or managers who must make or understand the choice of electronic circuits for optical transmission products or evaluate electronic solutions used in purchased products.

SC217: Optical Fiber Based Solutions for Next Generation Mobile Networks
Instructor: Dalma Novak; Pharad, LLC., USA
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:

- Explain the motivation for the integration of next generation mobile communication systems with optical fiber networks.
- Identify the technical challenges related to the application of photonics and optical networking concepts to wireless communications.
- Compare physical layer technologies that enable the integration of wireless and optical networks.
- Identify technologies that can improve the performance of integrated optical and wireless networks.
- Establish the trade-offs with alternative integrated network architectures.

Intended Audience:
This is an advanced beginner course for people working in either the optical or wireless telecommunications fields who wish to broaden their knowledge and learn how optical fiber solutions are playing a role in the realization of emerging integrated optical/wireless networks.

SC328: Standards for High-speed Optical Networking
Instructor: Stephen Trowbridge; Nokia, USA
Level: Beginner
Benefits and Learning Objectives:
This course should enable you to:

- Describe the concepts that form the basis for an OTN based on ITU-T Recommendation G.709, including the capabilities of the OTN standards to manage client signals and wavelengths.
- Describe the mapping mechanisms used by OTN to transport major client signals.
- Describe the structure and format for higher rates of Ethernet.
- Describe the Flex Ethernet implementation agreement and the network configurations that can be supported.
- Identify sources for information about ITU-T G.709, IEEE 802.3 standards, and the Flex Ethernet implementation agreement.

Intended Audience:
This course is intended for anyone who designs, operates, or supports metro and/or long haul optical networks and who need to understand the new interfaces and capabilities specified by standards on OTN, high-speed Ethernet, and Flex Ethernet.

Instructor: Rod S. Tucker; Univ. Melbourne, Australia
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:

- Explain the principles of energy efficiency in telecommunications networks.
- Compare the energy efficiency of different network architectures.
- Compute an estimate of the energy efficiency of network equipment, designs and architectures.
- Identify key factors and leverage points for improving the energy efficiency future networks.
- Describe the key determinants of network energy efficiency.

Intended Audience:
Telecommunications engineers, managers, policy makers, researchers and educators. A basic knowledge of telecommunications networks and equipment will be advantageous but not essential. Little or no knowledge of energy efficiency issues in telecommunications networks is required.

SC386: The “SDN” Evolution of Wireline Transport due to “Cloud” Services and DCI Innovations
Instructor: Loukas Paraschis; Infinera, USA
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:

- Explain the significant evolution in the Internet wireline transport, due to the proliferation of datacenter based “cloud” service delivery.
- Describe the innovations in interconnecting datacenters (DCI), software defined networking (SDN), and network function virtualization (NFV).
- Determine, beyond any hype, the use-cases and value of SDN and NFV in the “cloud-based” wireline transport.
- Compare the emerging SDN architectures, technologies, and protocols.
- Discuss the DCI innovations in routing and optical transport.
- Identify the synergies of SDN with DCI routing and optical transport.
- Summarize the industry, research, and standards efforts in “cloud” transport.
Intended Audience: This short course is primarily intended for researchers, students, and industry professionals in optical fiber communication who wish to obtain a perspective on the wireline network transport evolution, with particular focus on the implications of cloud service delivery, and SDN/NFV, and DCI technologies. Past attendees of SC386 will find substantial updates and new information, and are welcomed to attend again.

SC428: Link Design for Short Reach Optical Interconnects
Instructor: Petar Pepeljugoski; IBM Research, USA
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:
- Describe the components of short multimode fiber links.
- Describe the basic elements of power budget and possible trade-offs.
- List suitable models for various components of the link to be used in the design phase.
- Describe multimode fiber propagation, including launch conditions and connector effects.
- Explain impact of signal dependent noises in multimode links.
- List the advantages and disadvantages of advanced modulation formats in short optical interconnects.

Intended Audience:
This beginner-intermediate course is intended for engineers and scientists working on short optical interconnects in data centers as well as those working on components and subsystems interested in developing an expertise in link design. The course also addresses academic researchers and graduate students with basic knowledge on multimode fiber modeling and propagation, and link power budgeting. Some basic understanding of optical communication systems is helpful, but is not a pre-requisite. This course is a complement to SC205 and SC327.

SC429: Flexible Networks
Instructor: David Boertjes; Ciena, Canada
Level: Beginner
Benefits and Learning Objectives:
This course will enable you to:
- Describe electro-optic technologies used for coherent transmission.
- Discuss network implications of electric field transmitters and coherent receivers.
- Describe flexible grid & flexible modulation format.
- Discuss CD and CDC ROADM technologies.
- Describe capacity optimization & network defragmentation.
- Describe SDN Photonic Network and Control architectures.

Intended Audience:
This course is intended for individuals with a working knowledge of ROADM networks and coherent modems. It will be of value for industrial professionals (system designers, managers) who need to understand the tradeoffs of performance and capacity in the design and deployment of optical networks, as well as for researchers who are new to the field.

SC451: Fiber-based Devices and Sensors NEW!
Instructors: Zuyuan He¹, William Shroyer²;
¹Shanghai Jiao Tong University, China; ²SageRider, Inc., USA
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:
- Identify basic devices: fiber Bragg gratings, long period gratings, optical fiber interferometers, resonators.
- Describe typical sensors based on above devices: strain/temperature sensors, refractive index sensors (biomedical sensors), hydrophones, gyroscopes.
- Explain multiplexed fiber-optic sensors and sensor networks: wavelength division multiplexing (WDM), time division multiplexing (TDM), frequency division multiplexing (FDM)
- Summarize basic schemes behind space-resolved measurements in distributed fiber-optic sensors: time domain reflectometry (OTDR), optical frequency domain reflectometry (OFDR), optical coherence domain reflectometry (OCDR).
- Measure the scatterings in optical fiber that work for sensing: Rayleigh scattering, Brillouin scattering, and Raman scattering.
- Discuss the trade-offs in performance: spatial resolution vs sensitivity, distance range vs dynamic range; define key limiting factors.
- Identify the value and recognize the future trends of the applications of fiber sensors by discussing the general application of distributed fiber optic sensing in the oil and gas industry with a primary focus on how DTS (distributed temperature sensing) and DAS (distributed acoustic sensing) are being used to monitor wellbore environments.

Intended Audience:
This advanced-beginner course is intended for an audience including not only researchers and engineers working on the development of optical fiber devices and sensors, but also those trying to apply fiber sensors in diverse areas. Some basic knowledge of optics and physics will help in better understanding the course.
Monday, 20 March, 2017

08:30–12:30

SC102: WDM in Long-Haul Transmission Systems
Instructor: Neal S. Bergano; TE Subcom, USA
Level: Beginner
Benefits and Learning Objectives:
This course should enable you to:
- Explain the tradeoffs made in the design of an amplifier chain.
- Summarize the tradeoffs made in the selection of fiber types.
- Describe Q-factor.
- Discuss the concept of margin in fiber optic transmission systems.
- Identify the important polarization effects in long-haul transmission systems.
- Compare the different methods of performing long-haul transmission experiments.
- Discuss circulating loop experiments.
- Discuss the future trends in long-haul transmission systems.
- Discuss the optical propagation of data signals over long distances.

Intended Audience:
This course is intended for the student who wants an understanding of how information is transmitted over long distances using fiber optic transmission lines, with emphasis on undersea cable transmission systems. This includes new entrants into the fiber optic field with an engineering background, engineers with fiber optics exposure, people in the fiber optic telecommunications industry, and fiber optic research and development management.

SC178: Test and Measurement for Data Center/Short Reach Communications
Instructor: Greg D. Le Cheminant; Keysight Technologies, USA
Level: Beginner
Benefits and Learning Objectives:
This course should enable you to:
- Determine the relationships between BER, eye-diagrams and jitter tests.
- Identify common mistakes that degrade measurement accuracy.
- Define how frequency domain analysis provides insights into time-domain performance.
- Identify ways to increase test efficiencies.
- Develop test strategies to verify compliance to industry standards.
- Compare the different approaches to characterizing jitter and recognize what the results imply in a systems context.
- Identify the essential differences between test methods for NRZ and PAM4 signaling formats.

Intended Audience:
This course is appropriate for engineers, technicians and scientists who have a basic or higher knowledge of high-speed communications systems and signals. A basic knowledge of common laboratory measurement instrumentation will be helpful.

SC327: Modeling and Design of Fiber-Optic Communication Systems
Instructor: Rene-Jean Essiambre; Bell Labs, Nokia, USA
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:
- Develop a functional understanding of the basic building blocks of fiber-optic communication systems.
- Describe the basic nonlinear effects present in optical fibers.
- List the tools used to characterize system performance.
- Develop a detailed understanding on how to model nonlinear transmission over fibers, especially how to navigate through the numerous pitfalls.
- Choose a suitable technique for modeling a specific transmission system.
- Compare the performance of various amplification technologies.
- Understand the basic technical issues encountered when configuring optical networks.
- Understand the Shannon limit and estimate the ultimate rate of transmission of information over optical fibers.

Intended Audience:
This course is intended for engineers and scientists working on fiber-optic transmission as well as those working on components and subsystems interested in developing an expertise at the fiber transmission level. The course also addresses academic researchers and graduate students with basic knowledge on optical or digital communication. It will allow them to develop a detailed knowledge of fiber-optic transmission modeling and understanding system implications of advanced transmission technologies.
SC341: Multi-carrier Modulation: DMT, OFDM and Superchannels
Instructors: Sander L. Jansen¹, Dirk van den Borne²; ¹ADVA Optical Networking, Germany, ²Juniper Networks, Germany
Level: Intermediate

Benefits and Learning Objectives:
This course should enable you to:

- Describe modulation and detection concepts of different multicarrier modulation formats such as orthogonal frequency division multiplexing (OFDM) and discrete multi-tone (DMT).
- List different flavors of multicarrier modulation and detail the advantages and disadvantages of each modulation method.
- Discuss the state-of-the-art research on high capacity transmission systems and explore the limits of technology of multicarrier modulation.
- List the different OFDM design trade-offs, such as cyclic prefix, FFT-size, etc. with respect to for instance the dispersion tolerance and oversampling.
- Explain why DMT is often preferred over OFDM modulation for cost-effective short distance applications.
- Explain the multi-input, multi-output (MIMO) technique that is required to equalize a polarization division multiplexed (PDM) or a mode division multiplexed signal.
- Describe the different multicarrier modulation formats in the context of short-reach DCI and how to leverage the trade-off between optical performance and system complexity / cost.
- Illustrate the advantage of multicarrier modulation in next-generation 400G/1T transport networks.

Intended Audience:
This course is intended for engineers, researchers and technical managers who would like to gain a better understanding of multicarrier modulation formats and their applications in optical transport networks. Apart from the theory and concepts behind multicarrier modulation, the implementation and system design will be discussed in detail, such that the participants can obtain a good level of understanding for the different design trade-offs. Participants should have a comprehensive knowledge in the field of fiber-optic transmission systems; no previous knowledge of multicarrier modulation systems is required.

SC390: Introduction to Forward Error Correction
Instructor: Frank Kschischang; Univ. of Toronto, Canada
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:

- Define the key parameters of an error-correcting code.
- Explain the system-level benefits provided by FEC.
- Discuss the existence of fundamental limits (Shannon capacity) on FEC.
- Interpret generator-matrix and parity-check-matrix descriptions of a code.
- Encode and decode a binary Hamming code.
- Describe the key parameters of Reed-Solomon codes and binary BCH codes.
- Combine two or more codes into a product-code or concatenation.
- Combine binary FEC with higher-order modulation.

Intended Audience:
This course is intended for engineers, researchers and managers who need to understand the costs and benefits in applying physical-layer error-control coding in a communications link. No previous background in information theory or algebra is assumed.

SC432: Hands on: Silicon Photonics Component Design & Fabrication
Instructor: Lukas Chrostowski; University of British Columbia, Canada
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:

- Model select silicon photonic components.
- Create compact models for silicon photonic components.
- Use commercial modelling tools (Lumerical Solutions).
- Design a basic silicon photonic circuit.
- Create a silicon photonic layout and submit for manufacturing.
- Analyze experimental data from real measurements.
- Compare modeling with real-life experimental results.

Intended Audience:
This course is targeted for researchers and students who want to learn how to model and design real silicon photonic components. Familiarity with optics and electromagnetics is a prerequisite. No previous silicon photonic design experience is required.

Participants shall bring their own laptop computers, with the required software pre-installed. Licenses and instructions for installing Lumerical Solutions software, and mask layout software, will be provided prior to the course.
SC446: Hands-on: Characterization of Coherent Opto-electronic Subsystems NEW!
Instructors: Harald Rohde and Robert Palmer; Coriant, Germany
Level: Intermediate

Benefits and Learning Objectives:
This course should enable you to:
- Describe the properties of key optical components for coherent communication systems.
- Be able to measure those properties and to evaluate the results in the right context.
- Describe component specifications and specify components themselves.

Intended Audience:
This course targets researchers and system designers who want to get a better insight into the depths of component properties and to understand the properties' interdependencies.

SC453A: Hands-on Fiber Optic Handling, Measurements, and Component Testing NEW!
Instructors: Chris Heisler1, Loic Cherel2, Steve Baldo3, Keith Foord4; 1OptoTest Corporation, USA; 2Data-Pixel, France; 3Seikoh Giken Company, USA; 4Greenlee Communications, USA
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Explain the fundamental optical differences and applications of single-mode fiber (SMF) vs. multimode fiber (MMF), including the different fiber types and fiber sizes.
- Identify and overcome typical pitfalls with testing single and multi-fiber connectors.
- Measure insertion loss (IL) and return loss (RL), while also understanding how these measurements can be affected by wavelength and launch conditions.
- Describe polishing process, the steps involved in creating the proper connector end-face, and the effects of this process on connector performance.
- Explain characterization measurements on passive optical components.
- Measure end face geometry and the value of that measurement as it relates to connectivity.
- Make OTDR measurements while avoiding common pitfalls.

Intended Audience:
This course is valuable to technicians, engineers, and managers interested in measurement and characterization of fiber optic components. Some familiarity with fiber optic test cables and equipment is assumed. Class size is limited to 25.

09:00–12:00

SC208: Optical Fiber Design for Telecommunications and Specialty Applications
Instructor: David J. DiGiovanni; OFS Labs, USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Explain how certain fiber attributes, like attenuation, modal area and dispersion can impact current and next-generation high speed communications technologies.
- Describe the wide array of optical fibers available and discuss how their designs have been engineered for particular applications.
- Compare the benefits of different materials in fiber design, including different glass dopants.
- Discuss the difference between fibers used for different applications, such as transmission fiber, amplifiers, and sensors.
- Determine whether particular applications can benefit from modified or novel optical fiber.
- Explain the potential offered by fiber engineering which may be exploited to improve existing applications or create new functions.
- Discuss how fiber is used in a wide range of applications, including fusion splicing, fiber management and cabling.

Intended Audience:
This course is intended for the technical community seeking to understand the basics of optical fiber and waveguide design and the opportunities to adapt fiber for specific applications. Basic understanding of optical fiber properties is desirable though not required. The course will provide an understanding of the operating principles of fiber while also exploring the limits of waveguide and materials engineering. Specific designs for high speed transmission, optical amplification and fiber lasers will be studied, among others.

SC385: Optical Interconnects for Extreme-scale Computing
Instructors: John Shalf1, Keren Bergman2; 1Lawrence Berkeley National Laboratory, USA, 2Columbia University, USA
Level: Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Describe how new computing technologies enable real-world applications.
- Identify trends in high performance computing architecture.
- Describe innovative technologies on the horizon, such as hybrid memory, optical, interconnects, multicore processors and accelerators, and petascale supercomputers.
- Compare technologies and solutions for real-world applications such climate modeling, biological sciences, and materials discovery.
- Identify opportunities for dramatic improvements in performance for data-movement limited applications.
Intended Audience:
This lecture is designed to introduce students how to use parallel computers to efficiently solve challenging problems in science and engineering, where very fast computers are required either to perform complex simulations or to analyze enormous datasets. The lecture is intended to be useful for students from different backgrounds. The presenter has a strong track record of presenting similar tutorials to academic and industrial audiences, and this material will be accessible by researchers, implementers, innovators, and executives.

SC411: Multi-layer Interaction in the Age of Agile Optical Networking
Instructor: Ori A. Gerstel; Sedona Systems, Israel
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Describe IP layer behaviors that affect multi-layer networking.
- Explain types of multi-layer interactions (physical integration, control plane, SDN, mgmt plane).
- Define multi-layer functionality (restoration, reoptimization, disaster recovery,...).
- Quantify the value for multi-layer functionality.
- Describe the interaction between IP layer protection and optical restoration.
- Explain how multi-layer interaction affects the planning process.
- Describe how elastic flexgrid networking benefits from multi-layer interaction.
- Discuss possible centralized/distributed control plane architectures and their pros/cons.

Intended Audience:
The audience for this course includes system and network architects and engineers in network operators and equipment vendors, as well as researchers wanting to understand realistic methodologies for modeling multi-layer networks. The course assumes some familiarity with optical network architectures and basic understanding of the role of higher layer networks and how they connect to the optical layer.

SC442: Free Space Switching Systems: PXC and WSS NEW!
Instructor: David Neilson; Nokia Bell Labs, USA
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Identify key capabilities and performance metrics of optical switching systems.
- Describe the basic design constrains of free space optical switches.
- Identify and understand the various component technologies that are used to construct these switches.
- Discuss future trends in research and product commercialization of optical switching systems.

Intended Audience:
This advanced-beginner course is intended for a diverse audience including lightwave system and sub-system researchers and engineers. Some basic knowledge of classical optics such as lenses, gratings and polarization optics will help in better understanding the course but is not a prerequisite.

SC450: Design, Manufacturing, and Packaging of Opto-Electronic Modules NEW!
Instructors: Kevin Williams¹, Arne Leinse², Twan Korthorst³; ¹Eindhoven University of Technology, Netherlands; ²LioniX International, Netherlands, ³PhoeniX Software, Netherlands
Level: Advanced Beginner

Benefits and Learning Objectives:
This course should enable you to:
- Identify the distinctive features of packaging and testing for optical integrated modules when compared with discrete optical products and integrated electrical systems.
- Identify the different stages of testing, including the building block methodology used in open-access foundry services.
- Determine the origin of impairments using common measurement methods and describe how test methods can be used to push the yield-performance envelope.
- Recognize common assembly techniques and their impact on chip and multi-chip-module layout and test requirements.
- Determine the motivations for using package and assembly techniques from gold box to glob-top, hermetic to non-hermetic, cooled to uncooled.

Intended Audience:
Course participants will likely already be engaged in either optoelectronic product development, optical systems engineering or photonics research. The course should be of relevance to both systems integrators who are considering the deployment of integrated optical modules and technologists developing integrated optical circuits who are keen to improve their understanding of product specification and evaluation.

A Bachelor or Master level physics or engineering education would provide a solid basis for course participation and a background in semiconductor electronics, optoelectronics and optics will be advantageous. This is the first edition of this highly interdisciplinary course.
13:30–16:30

SC261: ROADM Technologies and Network Applications
Instructor: Thomas Strasser; Nistica Inc., USA
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:

- Describe the architectures and network level benefits of ROADM systems from earliest systems to most sophisticated deployments being planned today.
- Define the different ROADM architectures competing in the market.
- Summarize the functional differences between competing ROADM architectures, which will succeed in the long term and why.
- Compare the network economic advantages of ROADM networks.
- Compare the incremental cost of a ROADM to the network level savings it enables.
- Discuss the types of networks that most fully benefit from ROADM technology and why.
- Explain why the advantages of ROADM networks position the technology to have a role in all parts of the network, including data centers.

Intended Audience:
Anyone interested in more fully understanding the functionalities and benefits of ROADM, including students, researchers, engineers, managers, and executives involved in ROADM development, network design, network planning, and network operations.

SC431: Photonic Technologies in the Data Center
Instructor: Clint Schow; University of California, USA
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:

- Compare the different optical technologies used in data centers today and identify their strengths and limitations.
- Define the requirements for photonic links at different levels of network hierarchy in terms of reach, power, cost, and density.
- Describe the factors that have driven the current implementation of systems and future trends that will drive technologies.
- Discuss research efforts in the worldwide community aimed at increasing the role of photonics in data centers.
- Explain current networking topologies and identify the technology capabilities that drove their adoption.

Intended Audience:
This course is for anyone interested in learning about the underlying technology platforms that underpin the optical networks in data centers. In particular, network engineers involved in designing next-generation systems, researchers working on photonic interconnects and switching, and managers making product decisions will gain insight into the main strengths, limitations, and future prospects of photonic platforms.

Basic knowledge of fiber optic systems, including fiber transmission basics, optical link budgets, and characterization of high-speed links is beneficial but not required.

SC445: Visible Light Communications — the High Bandwidth Alternative to WiFi NEW!
Instructors: Harald Haas; LiFi Research and Development Centre, The University of Edinburgh, UK
Level: Advanced Beginner
Benefits and Learning Objectives:
This course should enable you to:

- Explain the limits to conventional WiFi technology and how light can provide massively higher bandwidth.
- Describe key visible light technologies such as VLC and LiFi.
- Explain practical limitations of VLC communication links such as strong sunlight and non-line of sight conditions.
- Compare different digital modulation techniques used in intensity modulation / direct detection systems in terms of spectrum efficiency and energy efficiency as well as various environmental conditions.
- Discuss pros and cons of angular diversity and multiple input multiple output techniques in VLC systems.
- Summarise methods to achieve multiuser access and to support mobility in LiFi optical attocell networks.
- List practical co-channel interference mitigation techniques in LiFi attocell networks.
- Explain how the downlink capacity of optical attocell networks could be obtained taking into account that effects such as fading do not exist unlike in RF.
- Discuss how LiFi could lead to a merger of the lighting and wireless communication industries.
**Intended Audience:**

This advanced-beginner course is intended for a diverse audience including lightwave system researchers and engineers as well as photonic device researchers and engineers and optical sub-system designers. The course should also be of interest to researchers and practitioners in fibre optic communication who see an all-optical future where light also plays a major role in wireless access networks. Some basic knowledge of intensity modulation and direct detection techniques will be useful, but is not a prerequisite. The same applies to basic knowledge of wireless access networks.

**SC448: An Introduction to the Control and Management of Optical Networks NEW!**

*Instructor:* Ramon Casellas; *CTTC, Spain*

*Level:* Advanced Beginner

**Benefits and Learning Objectives:**

This course should enable you to:

- Define and describe the basic concept(s) of a control plane and its associated functions, such as resource discovery, topology management, path computation, signaling, and routing.
- Identify the objectives & key benefits of a control plane, ranging from the well-known dynamicity, reduction of operational expenses, automation of QoS provisioning and recovery, etc., to newer drivers such as modularity, extensibility and programmability.
- Describe common architectures, including centralized, distributed and hybrid approaches. Describe their applicability in multi-layer and multi-domain networks by composing into hierarchical and peer models. Compare the main advantages and drawbacks of each architecture.
- Detail existing control plane architectures and protocols, ranging from ASON/GMPLS, PCE, to SDN and ONF OpenFlow.
- Recognize and discuss control plane open issues, missing research and standardization gaps such as common information and data models, and highlight the role of de jure and de facto standards as well as OpenSource projects.
- Discuss the new trends including the orchestration of network and IT (computing & storage) resources, and of heterogeneous systems and domains (technological, administrative or network segments)
- Explore the basics and the role of Network Function Virtualization (NFV) and its relationship with SDN.

**13:30–17:30**

**SC160: Microwave Photonics**

*Instructor:* Vince Urick; *DARPA, USA*

*Level:* Advanced Beginner

**Benefits and Learning Objectives:**

This course should enable you to:

- Identify microwave systems which may benefit from utilizing analog optics.
- Design optical systems for microwave applications.
- Discuss, relate and contrast analog and digital fiber optics.
- Design optical systems for microwave applications.
- Identify microwave systems which may benefit from utilizing analog optics.

**Intended Audience:**

The course attendee should have a basic understanding of lasers, photodetectors, and fiber optics. A bachelor’s degree in physics or electrical engineering, or an equivalent level of experience, is prerequisite.

**SC347: Reliability and Qualification of Fiber-Optic Components**

*Instructor:* David Maack; *Corning, USA*

*Level:* Beginner

**Benefits and Learning Objectives:**

This course should enable you to:

- Describe the importance, tools, methodologies, mathematics and benefits of reliability programs.
- List the requirements, tests, benefits and limitations of qualification programs.
- Identify the strategic and tactical differences between qualification testing and reliability modeling.
- Review the multitude of roles, contributions, tools and functions of a reliability group.
- Discuss and learn what constitutes a complete qualification program and get the author’s interpretation of the “letter of the law” for the most popular standards.
- See charts comparing different qualification standards.
- Determine why and when reliability testing and modeling needs to be done.
- Describe the limitation of both reliability modeling and qualification testing.
- Explain how to establish appropriate reliability tests and gather meaningful data.
- Compute the reliability of a device using accelerated testing data.
- Identify information on standards, components, reliability software and other reference materials.
**Intended Audience:**
This course is intended for a general audience including non-technical persons with no particular background except an interest in or need for knowledge of reliability and qualification of photonic components. It is meant to impart valuable information to audiences of all levels.

**SC408: Space Division Multiplexing in Optical Fibers**
*Instructor:* Roland Ryf; *Nokia Bell Labs, USA*
*Level:* Advanced Beginner

**Benefits and Learning Objectives:**
This course should enable you to:
- Compare space-division multiplexing to other multiplexing techniques, and list key advantages and potential fields of application.
- Summarize key advantages and limitations of different fiber types for space-division multiplexing.
- Explain the origin of coupling or cross-talk between light paths in multi-mode and multi-core fibers.
- Measure components with multiple-input and/or multiple-output ports and extract key parameters like mode-dependent loss and differential group delay.
- List the key principles used to build mode-couplers and how the insertion loss and the mode dependent loss scale as function of number of mode.
- Design optical components that support multiple modes and explain how the basic design differs from single-mode components.
- Describe digital signal processing techniques to calculate bit-error rate and multiple-input multiple-output impulse responses from raw receiver data.
- Discuss strategies to reduce the complexity of the receiver digital signal processing in space-division multiplexed transmission.

**SC449: Hands-on: An introduction to Writing Transport SDN Applications NEW!**
*Instructors:* Ricard Vilalta¹; Karthik Sethuraman²; ¹*CTTC, Spain,* ²*NEC Corporation of America, USA*
*Level:* Advanced Beginner

**Benefits and Learning Objectives:**
This course should enable you to:
- Learn and use the necessary open source tools to review and modify models for SDN control of transport networks.
- Develop simple code implementing the models and its applications in a standard REST-based protocol.
- Obtain practical hand-on experience on UML, YANG and JSON for the design of future REST-based interfaces for Control of Carrier Transport Networks.
- Discuss ONF Transport API information model and how to use it for describing multi-domain, multi-technology scenarios.
- Describe ODL/ONOS northbound REST API, and how it might be used to establish T-API connectivity services.

**SC452: FPGA Programming for Optical Subsystem Prototyping NEW!**
*Instructors:* Noriaki Kaneda¹; Laurent Schmalen²; ¹*Nokia Bell Labs, USA,* ²*Nokia Bell Labs, Germany*
*Level:* Advanced Beginner

**Benefits and Learning Objectives:**
This course should enable you to:
- Identify key applications and approaches of FPGA prototyping in optical subsystems.
- Describe the key functionalities and capabilities of FPGAs for intended prototyping applications.
- Define the difference between concurrent and sequential systems in hardware description languages.
- Define the workflow of FPGA projects for implementation ready bit files.
- Design the architecture and write basic codes in hardware description languages to realize selective DSP functionalities.
- Discuss the use of FPGAs and GPUs as simulation utilities for performing low error-rate Monte-Carlo simulations.
- Compare various options for simulating SD-FEC codes and performing error floor analysis using FPGAs and GPUs.

**Intended Audience:**
The course is intended for the students and engineers who have background and experience in optical subsystems and optical testing but a beginner in the FPGA programming and FPGA prototyping of optical subsystems. The course is intended to give insights to participants on FPGA programming by going through
materials that give near hands-on experience. Most of the materials are related to FPGA prototyping of Digital Signal Processing (DSP) and also Forward Error Correction (FEC) algorithms used in coherent optical transceivers.

**SC453B: Hands-on Fiber Optic Handling, Measurements, and Component Testing NEW!**

*Instructors:* Chris Heisler¹, Loic Cherel², Steve Baldo³, Keith Foord⁴; ¹OptoTest Corporation, USA; ²Data-Pixel, France; ³Seikoh Giken Company, USA; ⁴Greenlee Communications, USA

*Level*: Beginner

**Benefits and Learning Objectives:**

This course should enable you to:

- Explain the fundamental optical differences and applications of single-mode fiber (SMF) vs. multimode fiber (MMF), including the different fiber types and fiber sizes.
- Identify and overcome typical pitfalls with testing single and multi-fiber connectors.
- Measure insertion loss (IL) and return loss (RL), while also understanding how these measurements can be affected by wavelength and launch conditions.
- Understand the polishing process, the steps involved in creating the proper connector endface, and the effects of this process on connector performance.
- Explain characterization measurements on passive optical components.
- Measure end face geometry and the value of that measurement as it relates to connectivity.
- Make OTDR measurements while avoiding common pitfalls.

**Intended Audience:**

This course is valuable to technicians, engineers, and managers interested in measurement and characterization of fiber optic components. Some familiarity with fiber optic test cables and equipment is assumed. Class size is limited to 25.

**SC454: Hands-on: Silicon Photonic Circuits and Systems Design NEW!**

*Instructors:* Lukas Chrostowski¹, Chris Doerr²; ¹University of British Columbia, Canada; ²Acacia Communications, USA

*Level*: Intermediate

**Benefits and Learning Objectives:**

This course should enable you to:

- Describe common silicon photonic integrated designs.
- Describe how compact models for silicon photonic components are created.
- Explain how to use compact models to model silicon photonic circuits.
- Use commercial modelling tools (Lumerical Solutions).
- Design a basic silicon photonic circuit.
- Design a silicon photonic layout.
- Identify packaging requirements for silicon photonic chips.

**Intended Audience:**

This course is targeted for researchers and students who want to learn how to model and design silicon photonic circuits. Familiarity with optical communications is a prerequisite. No previous silicon photonic design experience is required.

Participants shall bring their own laptop computers, with the required software pre-installed. Licenses and instructions for installing Lumerical Solutions, and mask layout software, will be provided prior to the course.
What’s Happening on the Show Floor?

The OFC exhibit floor is the perfect place to build and maintain professional contacts and to broaden your knowledge about the companies that lead our industry in product development and technological advances. 600+ exhibits showcase the entire continuum of the supply chain – from communications systems and equipment to network design and integration tools and to components and devices. In addition to the 600+ exhibits, three exhibit hall theaters feature presentations by experts from major global brands and key industry organizations. Learn about the state of the industry, emerging trends and recommended courses of action for how to tackle today’s toughest business challenges.

Exhibition
Exhibit Halls G-K

Schedule plenty of time to roam the Exhibit Hall, visit with the hundreds of companies represented and see the latest products and technologies.

Exhibit Hall Regulations

- All bags are subject to search.
- Neither photography nor videotaping is permitted in the exhibit hall without the express written consent of OFC Show Management. Non-compliance may result in the surrendering of film and removal from the hall.
- Children under 18 are not permitted in the exhibit hall during set-up and teardown.
- Children 12 and under must be accompanied by an adult at all times.
- Strollers are not allowed on the show floor at any time.
- Soliciting in the aisles or in any public spaces is not permitted.
- Distribution of literature is limited to exhibitors and must be done from within the confines of their booths.
- Smoking is only permitted in designated exterior areas of the facility.
- Alcohol is not permitted in the exhibit hall during set-up and tear-down.

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Market Watch, Exhibit Hall G, Expo Theater I  Sponsored by Huawei

This three-day series of panel discussions engages the latest application topics and business issues in the field of optical communications. Presentations and panel sessions feature esteemed guest speakers from industry, research and the investment community. See page 40 for schedule and complete information.

Network Operator Summit, Exhibit Hall G, Expo Theater I  Sponsored by Juniper

Join your colleagues for this dynamic program that presents the inside perspective from service providers and network operators — their issues, drivers and how their requirements may impact the future of the industry. The program features a keynote speaker and 2 panel discussions.

Other Show Floor Programming,  Expo Theater II Sponsored by Juniper

More than 15 sessions will be held in these theaters covering Intra- and Inter- Data Center Connectivity, Infrastructure Makeover and Networking and SDN/NFV/Open Source. Hear leading experts from many industry groups: COBO, Ethernet Alliance, IEEE Big Data, IEEE Cloud Computing, MEF, OCP, OIF, ONF, OpenConfig, POFTO and TIP.

Product Showcases, Exhibit Hall K, Expo Theater III

Exhibitors highlight their newest developments, products and services in 30-minute presentations on the show floor. Refer to page 46 or the OFC Mobile App for presentation schedule.

Poster Presentation, Exhibit Hall K

Poster presentations are an integral part of the technical program and offer an opportunity for lively discussion between the poster presenters and attendees. Beverages and light snacks are served during poster sessions. See pages 106-109 and 134-137 for abstracts of presentations.

Please refer to your OFC Buyers’ Guide and Addendum for more details on the exhibition and other activities on the show floor, including participating company information, a map of the Exhibit Hall and specific presentation schedules for many of the programs. Check the Mobile App for regular updates to show floor programming (see page 8 for details on the app).
Show Floor Programming and Activities

Expo Theater I, Exhibit Hall G

Market Watch

This three-day series of panel discussions engages the latest application topics and business issues in the field of optical communications. Presentations and panel sessions feature esteemed guest speakers from industry, research and the investment community.

N5: Network Operator Summit and Market Watch Sub-Committee Chair and Organizer: Lisa Huff, Discerning Analytics, USA

Sponsored by:

HUawei

Schedule-at-a-Glance

Tuesday, 21 March

10:30–12:00  Panel I: State of the Industry - Analyst Panel

12:30–14:00  Panel II: Market Outlook for High Bandwidth Optical Technologies

14:30–16:00  Panel III: Global Market for Subsea Fiber Optic Networking Applications

Wednesday, 22 March

15:30–17:00  Panel IV: Pluggable Optics – How is the Ecosystem and Value Chain Changing?

Thursday, 23 March

10:30–12:00  Panel V: Photonic Integration Business Case – Reality Check

12:30–14:00  Panel VI: SDN and Optics – What is the Business Case?

Panel I: State of the Industry - Analyst Panel

Moderator: Jim Theodoras, VP of Global Business Development, ADVA Optical Networking AG, USA

This Market Watch panel is one of the most highly attended panels at OFC. Industry and financial analysts give their views of the optical communications markets. Both historical data and forecasts will be included. Top trends in all markets will be presented with a focus on specific market data points that are helpful to a wide audience. The entire optical communications value chain will be represented – components, equipment and services.

Panelists:

Alex Henderson; Senior Analyst, Networking Technology & Optical Equipment, Needham & Company, USA

Vladimir Kozlov; Founder and CEO, LightCounting, USA

Kevin Lefebvre; Principal Analyst, Ovum, USA

Mark Rostick; Director, Intel Capital, USA

Pamela Yu; VP of Optical Transport Market Research, Dell ’Oro Group, USA

Panel II: Market Outlook for High Bandwidth Optical Technologies

Moderator: Tiejun Xia; DMTS, Verizon Communications, USA

The industry is quickly moving beyond current “standard” optical bandwidth, which is represented by 32GBaud. With advancement in electro-optic and DSP components using higher symbol rate transmission, up to 64GBaud has been proved to be a feasible technology and will be commercially available soon. The new high-optical bandwidth technology will significantly decrease the number of components inside modules and systems, and can meaningfully reduce module sizes, power consumption and costs. With this technology, fewer optical carriers are needed to provide 100Gb/s, 200Gb/s and 400Gb/s data equipment interfaces. And to support transport channels, for example, single carrier 400Gb/s-channels will be available. The technology also provides an opportunity to have multiple symbol rates in a module, so that the concept of “liquid bandwidth” can truly be realized. Thus giving the optical channel adaptability that is optimized according to transmission conditions by adjusting its modulation format and symbol rate.

This Market Watch session will provide an overview of market outlook and real benefits of high optical bandwidth technology, review its influence to development in other technology sections, such as high-speed backplane, and address some related challenges in product development, such as high sampling rate. The session will also give a preview of technologies and markets beyond 64 Gaud.

Panelists:

Adam Carter; Chief Commercial Officer, Oclaro, USA

Hideki Isono; Market Segment Director, Fujitsu Optical Components, Japan

Ron Johnson; Sr. Director of Architecture and Product Management, Cisco Systems, Inc., USA

Atul Srivastava; Chief Technology Officer, NTT Electronics America, USA

Winston Way; CTO, Systems, NEOPhotonics Corp, USA

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Panel III: Global Market for Subsea Fiber Optic Networking Applications
Moderator: Eve Griliches; Product Line Manager, Cisco Systems, Inc., USA

Submarine optical networks form the backbone of global communication networks that connect different continents and countries. Conventional submarine networks are mainly for long distance point-to-point links. The rapid growth of the dynamic Internet traffic and IoT services not only lead to exponential bandwidth demand, but also require the network to be more flexible. As a result, submarine optical networks are evolving from the conventional static networks to more flexible ones with different distances and bandwidth requirements. Furthermore, new subsea fiber optic networking applications, such as sensing, scientific observation, security, and oil/gas exploration and production, are adding the opportunities and challenges for subsea fiber optic networks.

This Market Watch session will provide an overview of various technologies and applications in subsea fiber optic networking, such as:

- Trans-oceanic high bandwidth data communication.
- Reconfigurable submarine optical networking and switching.
- Sensing and monitoring of subsea physical structures and systems.
- Control and data transmission between offshore and onshore oil/gas facilities and in subsea tieback system.
- Infrastructure security monitoring and intrusion detection.
- Ocean bottom scientific observation and environmental exploration.

Speakers:
Lisa Bickford; Sr. Program Manager, Google, Inc., USA
Rao Lingampalli; Sr. Manager Optical Network Architecture, Equinix, USA
Georg Mohs; Sr. Director System Design and PLM, TE Subcom, USA
Takaaki Ogata; Assistant General Manager, NEC Corporation, Japan
David Smith; SVP of Network Operations, Hibernia Networks, USA

Panel IV: Pluggable Optics – How is the Ecosystem and Value Chain Changing?
Moderator: Frank Chang; Principal Engineer-Optical, Inphi Corp, USA

Large data centers interconnect bottlenecks are dominated by the switch I/O BW and the front panel BW as a result of pluggable transceiver modules. Recently 50G and beyond transceivers have been developed that significantly reduce power, footprint and cost for three major types of connections: intra- and inter-datacenter, transport client, and metro/access. The detailed designs of the pluggables, however, have many flavors such as: four-wave or four-fiber 28Gb/s NRZ, two-wave 28Gb/s PAM4, single-wave 56Gb/s PAM4, or single-wave DMT, and so on. At the same time, to overcome the front panel BW and the switch ASIC BW limitation one approach is to either move the optics onto the mid-plan or integrate the optics into the switch ASIC. There are many new MSAs in progress to be considered as well including CFP8, QSFP56, QSFP-DD, SFP56 and so on, or even chip on boards directly.

This panel of industry experts will strive to determine the potential winning technology from the wide variety of options as well as answer the following questions:

- What’s the realistic price to expect for 100G pluggable to enable mass adoption?
- Is the cost of a $1/Gb/s for high-speed transceivers ultimately achievable in foreseeable future and what will vendor margins look like?
- How can the market serve a reach distance of 2km at one end and 40/80km at the other?
- What are the lessons learned of deploying the PAM4 versus NRZ pluggables?
- Will various demands of different types of data center operators be adequately accommodated with standardized vs. proprietary solutions?
- When will a new 200 & 400G pluggable be commercialized and how much will it cost?
- What’s the status of 100G coherent CFP2 and CFP4 pluggable modules?

Speakers:
Bardia Pezeshki; CEO, Kaiam Corporation, USA
Chris Pfistner; VP of Product Line Management, Datacom, Lumentum, USA
David Piehler; Sr. Principal Engineer, Dell EMC, USA
Katharine Schmidtke; Optical Technology Strategy, Facebook, USA
Sorin Tibuleac; Director of System Architecture, ADVA Optical Networking, USA

Panel V: Photonic Integration Business Case – Reality Check
Moderator: Rick Dodd; SVP of Open Architecture, Ciena, USA

Driven by 100Gbps in long haul as well as in data center applications, there is continued progress for companies to commercialize products based on integrated photonics on the InP, GaAs and Silicon platforms. InP and GaAs technologies have dominated the market over the last decade, and recently we have seen successes by vendors to ship integrated products using silicon photonics. This panel brings together experts from key players and continues to
review the start of the art in photonic integration with a focus on deployment scenarios for both telecom and datacom.

It aims to address the key questions as follows:

- What are the key challenges to realize the high volume and low cost?
- Which technologies offer the best approach to reduce the cost for manufacturability?
- Will Silicon Photonics ever replace the more mature InP and GaAs technologies?
- What are the lessons learned from the experience of deployment?
- How does photonic integration address the emerging application needs?
- Are there any new and noteworthy products being commercialized today?
- What is the status of new developments and standardization of packaging solutions?
- Where are the market opportunities for optical integration technologies?
- How does the outlook or roadmap look like for next 5 years?

**Speakers:**

Martin Guy; Sr. Director, Packet Optical Platforms, Ciena, Canada

Frederick Kish Jr.; Sr. VP of Optical Integrated Circuit Group, Infinera Corporation, USA

Radha Nagarajan; CTO, Optical Interconnect, Inphi Corporation, USA

James Regan; CEO, EFFECT Photonics B.V., Netherlands

Tom Williams; Sr. Director of Marketing, Acacia Communications, USA

**Panel VI: SDN and Optics – What is the Business Case?**

*Moderator: Sterling Perrin; Sr. Analyst- Optical Networking & Transport, Heavy Reading, USA*

The optics industry was one of the first to seize onto the SDN trend, once it moved out of its campus/data center origins. But, translation from optical layer technical work into operator field trials and real-world deployments has been slow relative to other areas, such as in Ethernet and routing. Still, global operator interest in bringing the benefits of SDN down to the optical layer remains high.

This session is designed to move beyond the hype, focus on the optical layer, and assess the real world business benefits of combining SDN and optics.

Some of the questions addressed in this panel will include:

- Of the various optical layer use cases have been floated over the past three years, which ones are showing the most real promise today?
- What role will SDN play in functional disaggregation of optical equipment?
- How do we use SDN to control and manage the overall network – packet layer, OTN and DWDM?
- What are the primary benefits of multilayer optimization and restoration?
- What SDN lessons can telcos/cable companies take from Web 2.0 providers, and where is the path forward decidedly different?
- Does SDN really breathe new life into IP+optical integration or will the next decade look a lot like the last?

**Speakers:**

Chris Janz; Technical VP Transmission Product Line, Huawei, Canada

Thomas Mueller; Director for Optical & Transport Network Architecture, Juniper Networks, USA

Steve Vogelsang; Vice President, Strategy & CTO, IP/Optical Networks, Nokia, USA

Bill Walker; Director of Network Architecture – SDN/NFV/Cloud, CenturyLink, USA

**Network Operator Summit (formerly the Service Provider Summit)**

This dynamic program presents the inside perspective from service providers and network operators — their issues, drivers and how their requirements may impact the future of the industry. Everyone in the supply chain, from equipment manufacturers to components, will want to hear what’s next in meeting the needs of all network operators.

**NS: Network Operator Summit and Market Watch Sub-Committee Chair and Organizer: Lisa Huff, Discerning Analytics, USA**

**Sponsored by:**

**Schedule-at-a-Glance**

**Wednesday, 22 March**

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<td>10:00–10:30</td>
<td>Coffee Break, Sponsored by Juniper Networks</td>
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<tr>
<td>10:30–11:00</td>
<td>Network Operator Summit Keynote</td>
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<tr>
<td>11:00–12:30</td>
<td>Panel I: Next-Generation Access and Metro – Where is the Money?</td>
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<tr>
<td>12:30–13:30</td>
<td>Networking Lunch, Sponsored by Juniper Networks</td>
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<tr>
<td>13:30–15:00</td>
<td>Panel II: Optical Mobile Network Access</td>
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<td>15:00–15:30</td>
<td>Coffee Break, Sponsored by Juniper Networks</td>
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Keynote Presentation

**China Telecom’s View of the All Optical Network**
Chengliang Zhang, Vice President, China Telecom Beijing Research Institute, China

Optical network technologies develop rapidly in China. Revenues from optical products in China account for roughly half of the worldwide market and include systems, devices, components and fiber. Nowadays, with the massive deployment of 100G, FTTx and ROADM devices, the “all optical” target has never been closer. Meanwhile, challenges have arisen. The continuous growth of traffic from data centers and residential users has pushed the optical network needs to 400G for backbone and 10G PON for access. The next generation 5G mobile networks cannot exist without novel optical solutions to carry its backhaul and fronthaul. This presentation will focus on the current deployment situation of the optical network in China Telecom as well as future goals to meet new services’ requirements.

**Panel I: Next-Generation Access and Metro – Where is the Money?**
Moderator: Julie Kunstler; Principal Analyst, Ovum Inc, USA

Next-gen EPON is shipping with deployments in North America, China and Japan. XGS-PON has been pushed through the standardization process at lightning speed with initial shipments underway. Next-gen PON has been touted to support the 1G bandwidth craze, MDUs and business services.

Will next-gen PON lead to better profitability for both service providers and vendors? Will next-gen PON have an access solution, meaning shipments in the millions?

Some of the questions addressed in this panel will include:
1. Standards progress – both IEEE and ITU
2. Ecosystem status – are the pieces ready – from components to software
3. Applications for next-gen PON
4. Challenges for next-gen PON
5. What are the forecasts for next-gen PON components and equipment?
6. Profitability in the ecosystem – who will make money and why?

**Speakers:**
- Eddy Barker; Assistant VP - Member of Technical Staff, AT&T, USA
- Robert Howald; VP of Network Architecture, Comcast, USA
- Chengbin Shen; Professor, Shanghai Institute of China Telecom, China
- Ken-ichi Suzuki; Group Leader (Senior Research Engineer, Supervisor), NTT Access Network Service Systems Laboratories, NTT Corporation, Japan

**Panel II: Optical Mobile Network Access**
Moderator: Željko Bulut, Product Line Manager, Coriant, USA

Fixed-Mobile convergence (FMC) has been touted for years as saving capex, opex and simplifying network management. Concurrently, IoT is regarded as a major stimulus for 5G, creating demand for small cells throughout indoor and outdoor urban areas.

Will FMC finally happen? Will the two worlds find a common language?

Some of the questions addressed in this panel will include:
1. Will IoT drive Optical Mobile Network Access?
2. What are service providers seeking in terms of solutions?
3. Who are the ecosystem vendors? Who will benefit and why?
4. Are standards needed?
5. How do mobile backhaul and fronthaul need to change to support applications like IoT?

**Speakers:**
- Ray La Chance; President/CEO, ZenFi, USA
- Tim Doiron; Principal Analyst, Intelligent Networking practice, ACG Research, USA
- Hyung-Jin Park; Project Manager, Principal Senior Researcher, Infra Lab, KT R&D Center, South Korea
- Glenn Wellbrock; Director, Optical Transport Network - Architecture, Design & Planning, Verizon Communications Inc., USA

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### Expo Theater II Programming, Exhibit Hall K

**Sponsored by**

![Juniper Networks](image)

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### Schedule-at-a-Glance

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<th>Tuesday, 21 March</th>
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<tr>
<td>12:15–13:45 Data Center Summit</td>
<td>12:00–13:30 Open Config: Open Management and Monitoring of Multilayer Webscale and Carrier Networks</td>
<td>12:00–13:30 ONF: The Path Forward</td>
</tr>
<tr>
<td>14:00–17:00 Advancing Optical Interoperability in Open Networks</td>
<td>13:45–15:15 IEEE Big Data Initiative: Network Analytics in the Next-Generation Optical Transport</td>
<td>15:00–16:00 Transport SDN: Commercial Applications, Solutions and Innovation Areas</td>
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<tr>
<td></td>
<td>15:30–17:00 IEEE Cloud Computing: How will Fog Reshape Computing and Networking</td>
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### Transforming the Future of Data Centers

**Session organized by OCP**  
**Moderator:** Hans-Juergen Schmidtke, Director of Engineering, Facebook, USA  
**Presenters:**
- Open Network Hardware and Software: Anatomy of Disaggregation  
  Oleg Berzin, Sr. Director Technology Innovation, Equinix, USA  
- **Title TBD**  
  Gaya Nagarajan, Network Engineering and Architecture, Facebook, USA  
- **Our Experiences with Datacenter Network Deployments**  
  Srinivasan Ramasubramanian, Chief Architect, Big Switch Networks, USA  

---

### Advancing Optical Interoperability in Open Networks

**Session Sponsored by Juniper**  
**Moderator:**

The following experts will participate in panels and presentations in an interactive setting with the audience:

- Nestor Garrafa, Capacity Planning Senior Consultant, Telxius Cable (A Telefonica Company), USA  
- Mike Sabelhaus, Optical Architect, Fujitsu, USA  
- Madhu Krishnaswamy, Senior Director, Product Line Management, Transport Node, Lumentum, USA  
- Domenico DiMola, Vice President, Optical Engineering, Juniper Networks, USA  
- Rehan Zaki, Senior Optical Product Line Manager, Juniper Networks, USA  
- Peter Landon, Director, Optical Product Line Management, Juniper Networks, USA  
- Xiaoxia Wu, Optical Engineering Staff, Juniper Networks, USA  

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### On-Board Optics – Challenges, Discoveries and the Path Forward

**Session organized by COBO**

**Presenters:**
- Robert Blum, Director of Strategic Marketing and Business Development, Intel, USA  
- Ed Frlan, Senior System Architect, Semtech, USA  
- Hugues Tournier, Senior Manager, Power and Signal Integrity, Ciena, USA  
- Nathan Tracy, Technologist, TE Connectivity, USA  

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OFC 2017 • 19–23 March 2017
### Schedule-at-a-Glance

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<tr>
<td>10:15–10:45</td>
<td><strong>Product Showcase</strong>&lt;br&gt;DWDM to the Edge&lt;br&gt;Huawei USA</td>
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<tr>
<td>11:00–12:00</td>
<td><strong>Ethernet Alliance: The Fracturing and Burgeoning Ethernet Market</strong></td>
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<tr>
<td>12:30–13:30</td>
<td><strong>MEF: Dynamic Third Network Services for the Digital Economy and Hyper-connected World</strong></td>
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<tr>
<td>13:45–14:45</td>
<td><strong>OIF: Enabling Next Generation Physical Layer Solutions</strong></td>
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<tr>
<td>15:00–16:00</td>
<td><strong>OIF Interop - The Key to Unlocking the Benefits of SDN</strong></td>
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<tr>
<td>16:00–17:00</td>
<td><strong>International Photonic Systems Roadmaps</strong></td>
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**Wednesday, 22 March**

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<tr>
<td>10:15–10:45</td>
<td><strong>Product Showcase</strong>&lt;br&gt;Innovative OTN Cluster Solution for Cloud Era Transport Networks&lt;br&gt;Huawei USA</td>
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<tr>
<td>11:00–11:30</td>
<td><strong>Product Showcase</strong>&lt;br&gt;Industries Standard for Pic's Design&lt;br&gt;PhoeniX Software</td>
</tr>
<tr>
<td>11:30–12:00</td>
<td><strong>Product Showcase</strong>&lt;br&gt;Challenges in Optoelectronic Integration for Datacom Applications&lt;br&gt;Jabil AOC Technologies, USA</td>
</tr>
<tr>
<td>13:00–13:30</td>
<td><strong>Product Showcase</strong>&lt;br&gt;Industry's Only All-in-One Spectral &amp; Transport 100G Testing Solution&lt;br&gt;EXFO, Canada</td>
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<tr>
<td>10:15–10:45</td>
<td><strong>Product Showcase</strong>&lt;br&gt;Huawei T-SDN OVPN Solution&lt;br&gt;Huawei USA</td>
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<tr>
<td>11:00–13:00</td>
<td><strong>POFTO: POF Symposium</strong></td>
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<tr>
<td>13:30–14:30</td>
<td><strong>Huawei: Technological Evolution of Next Generation Connect</strong></td>
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### Product Showcase: DWDM to the Edge

**Dr. Sean Long, Director, PLM for Transmission Network, Huawei USA, USA**

Tuesday, 21 March, 10:15–10:45

Bandwidth and latency are becoming critical factors for the new digital services. DWDM to the edge is the best solution to address this concern. The key challenges here are cost and flexibility. Huawei believe DWDM to OLT/Cloud BBU site is a MUST for a future proof network. This presentation introduces our revolutionary solution and latest applications such as CRAN.

### The Fracturing and Burgeoning Ethernet Market

Session organized by the Ethernet Alliance<br>Modifier: John D’Ambrosia, Ethernet Alliance Chairman, USA

**Presenters:** TBD

### Dynamic Third Network Services for the Digital Economy and Hyper-connected World

Session organized by the MEF<br>**Presenter:** Ralph Santitiro, Distinguished Fellow and Director, MEF, Head of SDN/NFV Solutions Practice, Fujitsu Network Communications, USA

### Enabling Next Generation Physical Layer Solutions

Session organized by OIF<br>**Moderator:** Steve Sekel, OIF Physical and Link Layer Interoperability Working Group Chair, Keysight Technologies, USA

**Presenters:**

- Ed Frlan, OIF Technical Committee Vice Chair, Semtech, USA
- Karl Gass, OIF Physical and Link Layer Working Group - Optical Vice Chair, USA
- Tad Hofmeister, Network Architect, Google, USA

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Emerging Integrated Optics Based Solutions for Data Center Interconnect
Yigal Ezra, CEO, ColorChip, Israel
Wednesday, 22 March, 14:30–15:00
ColorChip’s unique approach to addressing datacenter requirement for increasing throughput, embraces a multilane Photonic Integrated Circuit, compatible with compact form factors.
This is a groundbreaking integration and packaging technique, used in ColorChip’s 100G QSFP28 Single Mode solutions and will be used in ColorChip’s 400G roadmap, resulting in cost-effective, compact hyperscale single-mode, pluggable transceivers and On Board Optics (OBO).

Huawei T-SDN OVPN Solution
Dr. Young Lee, Technical Director, Network Architecture of SDN, Huawei USA
Thursday, 23 March, 10:15–10:45
Massive enterprise Cloud applications, VR/AR, real time video are driving need for huge bandwidth, lower latency, flexibility and agility in networks.
Huawei’s Optical innovation Engine drives new innovative solutions that address these needs & challenges. This presentation introduces our OTN Cluster & OXC 2.0 that flatten network architecture, bring smooth scalability, and improve flexibility of service while reducing latency.

POF Symposium
Session organized by POFTO
Organizer and Program Chair: Hui Pan, Chief Economist, POFTO, USA

POF Symposium: Status of GI POF towards Noise-Free 8K Data Transmission
Yasuhiro Koike, Director, Keio Photonics Research Institute and Professor, Keio University, Japan; Azusa Inoue, Keio University, Japan
Presenters:

IEEE Standards on POF Technology in Automotive Applications
Yoshihiro Tsukamoto, Manager, Plastic Molding Material Department, Fiber Optics Section, Mitsubishi Rayon Co., LTD, Japan

POF in Future Access and Home Networks
Eugene Dai, Principal Transport Architect, Cox Communications, USA

High Bitrate Transmission over SI-POF
Marco Dietrich, CTO, ELCON Systemtechnik GmbH, Germany

Technological Evolution of Next Generation Optical Cross Connect
Session organized by Huawei

Presenter:
Ning Deng, Lead Engineer, Optical Networks Research, Transmission Network Product Line, Huawei, China

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Technical Program and Steering Committees

General Chairs
Andrew Lord, BT Labs, UK
Shu Namiki, AIST, Japan
Peter Winzer, Nokia Bell Labs, USA

Program Chairs
Gabriella Bosco, Politecnico di Torino, Italy
Jörg-Peter Elbers, ADVA Optical Networking SE, Germany
Laurent Schares, IBM TJ Watson Research Center, USA

Subcommittees

Track D: Optical Components, Devices and Fiber

OFC D1: Advances in Deployable Optical Components, Fibers and Field Installation Equipment
Alan F. Evans, Corning, USA, Subcommittee Chair
Rich Baca, Microsoft, Inc., USA
Dirk Breuer, T-Nova Deutsche Telekom, Germany
Jose Castro, Panduit Corp, USA
Ji Chen, Finisar Corporation, USA
Nitin Goel, Facebook Inc., USA
Robert Griffin, Oclaro, USA
Shin Kamei, NTT Photonics Laboratories, Japan
Ashok Krishnamoorthy, Oracle Corporation, USA
Jing Li, Yangtze Optical Fibre & Cable Co, China
Haruki Ogoshi, Furukawa Electric, Japan
Erik Pennings, 7Pennies, USA
Yongpeng Zhao, Luster Lightech Corp, China

OFC D2: Passive Optical Devices and Circuits for Switching and Filtering
Ben Lee, IBM T. J. Watson Research Center, USA, Subcommittee Chair
Haoshuo Chen, Nokia Bell Labs, USA
Mark Feuer, CUNY City College, USA
Piero Gambini, STMicroelectronics, Italy
Guo-Qiang Lo, Institute of Microelectronics, Singapore
Dan Marom, The Hebrew University of Jerusalem, Israel
Sylvie Menezo, CEA-LETI, France
Joyce Poon, University of Toronto, Canada
Jochen Schroeder, Chalmers University, Sweden
Hiroyuki Tsuda, Keio University, Japan

OFC D3: Active Optical Devices and Photonic Integrated Circuits
Po Dong, Nokia Bell Labs, USA, Subcommittee Chair
Guang-Hua Duan, III-V lab, France
Dazeng Feng, Mellanox, USA
Christian Koos, Karlsruhe Institute of Technology, Germany
Kazuhiko Kurata, NEC Corporation, Japan
Mike Larson, Lumentum, USA
Anders Larsson, Chalmers Tekniska Hogskola, Sweden
Thomas Schrans, Rockley Photonics, USA
Andreass Steffan, Finisar, Germany
Takuo Tanemura, University of Tokyo, Japan
Zhiping Zhou, Peking University, China

OFC D4: Fiber and Propagation Physics
Francesco Poletti, University of Southampton, UK, Subcommittee Chair
Marianne Bigot, Prysmian Group, France
Wladek Forysiak, Aston University, UK
Andrea Galtarossa, University of Padova, Italy
Ming-Jun Li, Corning, USA
Kazuhide Nakajima, Nippon Telegraph & Telephone Corp (NTT), Japan
Testuya Nakanishi, Sumitomo Electric Industries Ltd, Japan
Axel Schulzgen, University of Central Florida (CREOL), USA
Oleg Slinkin, TE SubCom, USA
Thierry Taunay, OFS Laboratories, USA
Johann Troles, Universite de Rennes, France

OFC D5: Fiber-Optic and Waveguide Devices and Sensors
Camille Sophie Bres, Ecole Polytechnique Federale de Lausanne, Switzerland, Subcommittee Chair
Rodrigo Amezcuca-Correa, University of Central Florida (CREOL), USA
Maxim Bolshhtyskany, TE Subcom, USA
Nicolas Fontaine, Nokia Bell Labs, USA
Miguel Gonzalez Herraez, University of Alcalà, Spain
Takemi Hasegawa, Sumitomo Electric Industries Ltd., Japan
Victor Kopp, Chiral Photonics Inc., USA
Rogério Nogueira, Instituto De Telecomunicacoes, Portugal
Yasutake Ohishi, Toyota Technological Institute, Japan
Kasen Rottwitt, DTU Fotonik, Denmark

Track S: Photonic Systems and Subsystems

OFC S1: Advances in Deployable Subsystems and Systems
Tom Issenhuth, Microsoft, USA, Subcommittee Chair
Marc Bohn, Coriant GmbH & Co. KG, Germany
Chris Cole, Finisar Corporation, USA
Jonas Geyer, Acacia Communications, Inc., USA
Georg Mohs, TE Subcom, USA
Lynn Nelson, AT&T Corp, USA
Gary Nicholl, Cisco, Canada
Katharine Schmidtke, Facebook, USA
Henry Sun, Infinera Corporation, Canada
Sorin Tibuleac, ADVA Optical Networking, USA
Masahito Tomizawa, NTT Network Innovation Labs, Japan

OFC S2: Optical, Photonic and Microwave Photonic Subsystems
Leif Oxenlowe, DTU Fotonik, Denmark, Subcommittee Chair
Jose Azana, INRS- Energie Materiaux et Telecom, Canada
Robert Elschnier, Fraunhofer Heinrich Hertz Institute (HHI), Germany
Toshihiko Hirooka, Tohoku University, Sendai, Japan
Leif Johansson, Freedom Photonics, LLC, USA
Inuk Kang, LGS Innovations LLC, USA
Tsuyoshi Konishi, Osaka University, Japan
Ju Han Lee, University of Seoul, South Korea
Paul Matthews, Northrop Grumman Corp, USA
Colin McKinzie, Huawei, USA
David Neilson, Nokia Bell Labs, USA
Michael Vasilyev, University of Texas at Arlington, USA

OFC S3: Radio-over-Fiber, Free-Space and Non-telecom Systems
Christina Lim, University of Melbourne, Australia, Subcommittee Chair
Gee-Kung Chang, Georgia Tech, USA
Hwan Seok Chung, ETRI, South Korea
Richard DeSalvo, Harris Corporation, USA
Tetsuya Kawanishi, National Institute of Information & Comm Tech (NICT), Japan
Ton Koonen, Einhoven University of Technology, The Netherlands
Jason McKinney, US Naval Research Laboratory, USA
OFC 2017 • 19–23 March 2017

OFC S4: Digital and Electronic Subsystems
Alan Pak Tao Lau, Hong Kong Polytechnic University, Hong Kong, Subcommittee Chair
Yi Cai, ZTE Optics Lab, USA
Liang Dou, ZTE Beijing, China
Gernot Goeberger, Huawei Technologies, Germany
Neil Guerrero Gonzalez, Universidad Nacional de Colombia, Colombia
Takayuki Kobayashi, NTT Network Innovation Laboratories, Japan
David Millar, Mitsubishi Electric Research Labs, USA
Sebastian Randel, Karlsruhe Institute of Technology (KIT), Germany
Andre Richter, VPIphotonics, Germany
Ben Thomesen, University College London, UK
Qunbi Zhuo, Ciena Corporation, Canada

OFC S5: Digital Transmission Systems
Cristian Antonelli, Università degli Studi dell’Aquila, Italy, Subcommittee Chair
Andrea Carena, Politecnico di Torino, Italy
Dmitri Foursa, TE Subcom, USA
Takeshi Hoshida, Fujitsu Laboratories Ltd., Japan
Magnus Karlsson, Chalmers University, Sweden
Robert Killey, University College London, UK
Takayuki Mizuno, NTT, Japan
Colja Schubert, Fraunhofer Institute Nachricht Heinrich-Hertz (HHI), Germany
Chandrasekhar Sethumadhavan, Nokia Bell Labs, USA
Zhuhong Zhang, Huawei Technologies Co Ltd, Canada
Benyuan Zhu, OFS Laboratories, USA

Track N: Networks, Applications, and Access

OFC N1: Advances in Deployable Networks and Their Applications
Sheryl Woodward, AT&T, USA, Subcommittee Chair
Jean-Luc Auge, Orange Labs, France
Fred Bartholf, Comcast Corporation, USA
Nitin Batta, Yahoo, USA
Dave Boertjes, Ciena, Canada
Jeff Bower, Akamai, USA
Herve Fevrier, Facebook, USA
Doug Freimuth, IBM, USA
Weisheng Hu, Shanghai Jiao Tong University, China
Pat Iannone, Nokia Bell Labs, USA
Werner Weiershausen, Deutsche Telekom AG Laboratories, Germany

OFC N2: Control and Management of Optical & Multilayer Networks
Inder Monga, ESnet, USA, Subcommittee Chair
Ramon Casellas, CTC, Spain
Nicola Ciulli, Nextworks, Italy
Vinayak Danqui, Google, USA
Sergi Figuerola, i2CAT Foundation, Spain
Hiroaki Harai, National Institute of Information & Comm Tech (NICT), Japan
Ilya Balin, Renaissance Computing Institute, USA
Mazen Khaddam, Cox Communications, Inc., USA
Daniel King, University of Lancaster, UK
Tom Lehman, University of Maryland, USA
Nic Leymann, Deutsche Telekom AG Laboratories, Germany
Srin Seetharaman, Infinera, USA

OFC N3: Network Architectures and Techno-Economics
Masahiko Jinno, Kagawa University, Japan, Subcommittee Chair
Chris Bowers, Juniper, USA
Jiajia Chen, Kungliga Tekniska Hogsksolan, Sweden
Filippo Cugini, CNIT, Italy
Josué Kuri, Facebook, USA
Víctor Lopez, Telefonica I+D, Spain
Joao Pedro, Coriant Portugal, Portugal
Massimo Torriani, Politecnico di Milano, Italy
Noboru Yoshikane, KDDI Research, Japan
Qiong Zhang, Fujitsu Laboratories of America, USA

OFC N4: Optical Access Networks for Fixed and Mobile Services
Junichi Kani, NTT Labs, Japan, Subcommittee Chair
Ning Cheng, Huawei Technologies, USA
Gabriella Cincotti, Università degli Studi Roma Tre, Italy
Volker Jungnickel, Fraunhofer Heinrich-Hertz Institute, Germany
Denis Khotimsky, Verizon, USA
Dominic Lavery, University College London, UK
Thomas Pfeiffer, Nokia Bell Labs, Germany
Fabienne Saliou, Orange Labs, France
BJÖRN Skubic, Ericsson, Sweden
Jun Shan Wey, ZTE, USA
Lilin Yi, Shanghai Jiao Tong University, China

OFC N5: Market Watch, Network Operator Summit & Data Center Summit
Lisa Huff, Discerning Analytics, USA, Subcommittee Chair
Lisa Bickford, Google, USA
Zeljko Bulut, Coriant, USA
Frank Chang, Inphi Corporation, USA
Eve Griliches, Cisco, USA
Julie Kunstler, Ovum, USA
Sterling Perin, Heavy Reading, USA
Andrew Schmitt, Cignal Active Insight, USA
Jim Theodoras, ADVA Optical Networking, USA
Ting Wang, NEC Labs, USA
Tiejun Xia, Verizon Communications, Inc., USA

Track DSN: Devices, Systems, and Networks

OFC DSN6: Optical Devices, Subsystems, and Networks for Datacom and Computercom
Xuezhe Zheng, Oracle Corporation, USA, Subcommittee Chair
Peter DeDobbelare, Luxtera, USA
Marco Fiorentino, Hewlett Packard Enterprise, USA
Dominic Goodwill, Huawei Technologies Co Ltd, Canada
Ilya Lyubomirsky, Facebook, USA
Ken Morito, Fujitsu Laboratories Ltd., Japan
Bert Offrein, IBM, Switzerland
Sam Palermo, Texas A&M University, USA
Adel Saleh, University of California Santa Barbara, USA
Anna Tzanakaki, University of Athens, Greece
Naoya Wada, NICT, Japan
Ian White, University of Cambridge, UK
Chongjin Xie, Alibaba, USA

Expo Theater Programming
Steve Plote, Nokia, USA
OFC Steering Committee
IEEE/Communications Society
Loudon Blair, Ciena Corp., USA, Chair
Vincent Chan, MIT, USA
Robert Doverspike, Network Evolution Strategies, LLC, USA
Ori Gerstel, Sedona Systems, Israel

IEEE/Photonics Society
Ekaterina Golovchenko, Tyco Telecommunications, USA
David Plant, McGill Univ., Canada
Seb Savory, University of Cambridge, UK
Atul K. Srivastava, NTT Electronics Corporation, USA

The Optical Society (OSA)
Edmund Murphy, Lumentum, USA
Loukas Paraschis, Cisco, USA
Clint Schow, University of California Santa Barbara, USA
Kathleen Tse, AT&T, USA

Ex-Officio
Neal Bergano, TE SubCom, USA
Martin Birk, AT&T Labs, USA
Gabriella Bosco, Politecnico di Torino, Italy
Jörg-Peter Elbers, ADVA Optical Networking SE, Germany
Dan Kuchta, IBM TJ Watson Research Center, USA
Xiang Liu, Huawei Technologies, USA
Andrew Lord, BT Labs, UK
Shu Namiki, AIST, Japan
David Richardson, University of Southampton, UK
Laurent Schaeres, IBM TJ Watson Research Center, USA
William Shieh, University of Melbourne, Australia
Peter Winzer, Nokia Bell Labs, USA

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Chris Jannuzzi, IEEE Photonics Society, USA
Liz Rogan, The Optical Society, USA

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Chris Jannuzzi, IEEE Photonics Society, USA
Frederick Leonberger, EOvation Advisors LLC, USA
Mike Loomis, Nokia Corporation, USA
Liz Rogan, The Optical Society, USA
Clint Schow, University of California Santa Barbara, USA
Kathleen Tse, AT&T Corp, USA
Bachar Yuval, LinkedIn, USA
Doug Zuckerman, USA
Explanation of Session Codes

The first letter of the code denotes the day of the week (Sunday=S, Monday=M, Tuesday=Tu, Wednesday=W, Thursday=Th). The third element indicates the session series in that day (for instance, 1 would denote the first parallel sessions in that day). Each day begins with the letter A in the fourth element and continues alphabetically through a series of parallel sessions. The lettering then restarts with each new series. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.). For example, a presentation coded M1C.4 indicates that this paper is being presented on Monday (M) in the first series of sessions (1), and is the third parallel session (C) in that series and the fourth paper (4) presented in that session.

- **Invited**: Invited Presentation
- **Tutorial**: Tutorial Presentation
- **Record**: Record Presentation
- **Top Scored**: Top Scored Papers
### Agenda of Sessions — Sunday, 19 March

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<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>07:30–19:00</td>
<td>OIDA Workshop on Manufacturing Trends for Integrated Photonics, Petree Hall D (separate registration required)</td>
</tr>
<tr>
<td>09:00–12:00</td>
<td>Short Courses: SC176, SC177, SC443, SC444, SC447 (additional fee required)</td>
</tr>
<tr>
<td>09:00–13:00</td>
<td>Short Courses: SC105, SC114, SC359, SC384 (additional fee required)</td>
</tr>
<tr>
<td>13:00–17:00</td>
<td>Short Courses: SC267, SC325, SC395 (additional fee required)</td>
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<tr>
<td>13:30–16:30</td>
<td>Short Courses: SC216, SC430, SC433 (additional fee required)</td>
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<tr>
<td>13:30–17:30</td>
<td>Short Courses: SC203, SC369, SC393 (additional fee required)</td>
</tr>
<tr>
<td>15:30–18:30</td>
<td>Workshops</td>
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<tr>
<td></td>
<td>S1A • Will Machine Learning and Big-data Analytics Relieve Us From the Complexity of System and Network Engineering?</td>
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<tr>
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<td>S1B • Making the Case for SDM in 2027</td>
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<td>S1C • Optical Wireless — Can it Become a Gigabit Wireless Alternative? Capabilities, Opportunities, Challenges, and Threats</td>
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<td>S1D • Scaling Data Center Bandwidth: Novel Optics, Advanced Electronics or New Architectures?</td>
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<td>S1E • III-V + Silicon: To Integrate or to Co-package?</td>
</tr>
<tr>
<td>17:00–20:00</td>
<td>Short Courses: SC205, SC217, SC328, SC372, SC386, SC428, SC429, SC451 (additional fee required)</td>
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<tr>
<td>20:00–22:00</td>
<td>Lab Automation Hackathon, 503</td>
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**Key to Shading**

- Short Courses
- Recorded Session
<table>
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<td>07:30–19:30</td>
<td>OIDA Executive Forum, Petree Hall D (separate registration required)</td>
</tr>
<tr>
<td>08:30–12:30</td>
<td>Short Courses: SC102, SC178, SC327, SC341, SC390, SC432, SC446, SC453A (additional fee required)</td>
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<tr>
<td>09:00–12:00</td>
<td>Workshops</td>
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<tr>
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<td>M1A • Processors and Switches with Integrated Optical Engines — Researchers' Dream or a Commercial Reality Soon?</td>
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<td>M1B • Connected OFCity Challenge: Optical Innovations for Future Services in a Smart City</td>
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<td>M1C • Frequency Combs for Communications — Real Potential or Hype?</td>
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<tr>
<td>09:00–12:00</td>
<td>Short Courses: SC208, SC385, SC411, SC442, SC450 (additional fee required)</td>
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<tr>
<td>10:00–10:30</td>
<td>Coffee Break, 400 Foyer</td>
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<tr>
<td>12:00–13:30</td>
<td>Lunch Break (on own)</td>
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<tr>
<td>12:00–14:00</td>
<td>IEEE Women in Engineering “Lunch &amp; Learn” (separate registration required), 515A</td>
</tr>
<tr>
<td>13:30–15:30</td>
<td>M2A • Panel: Lessons Learned From Global PON Deployment</td>
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<tr>
<td></td>
<td>M2B • Symposium: Overcoming the Challenges in Large-Scale Integrated Photonics I</td>
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<td>M2C • Coherent Transceivers</td>
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<td>M2D • SDM Transmission I (begins at 14:00)</td>
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<tr>
<td></td>
<td>M2E • Advanced and Open Systems</td>
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<tr>
<td>13:30–16:30</td>
<td>Short Courses: SC261, SC431, SC445, SC448 (additional fee required)</td>
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<tr>
<td>13:30–17:30</td>
<td>Short Courses: SC160, SC347, SC408, SC449, SC452, SC453B, SC454 (additional fee required)</td>
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<tr>
<td>15:30–16:00</td>
<td>Coffee Break, 400 Foyer</td>
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<tr>
<td>16:00–18:00</td>
<td>M3A • Panel: Transport SDN — What is Ready, What is Missing?</td>
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<tr>
<td></td>
<td>M3B • Symposium: Overcoming the Challenges in Large-Scale Integrated Photonics II</td>
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<td>M3C • Probabilistic Shaping and Advanced Modulation Formats</td>
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<td>M3D • High-Speed Subsystems (ends at 17:45)</td>
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<tr>
<td></td>
<td>M3E • Radio-over-fiber Systems</td>
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<tr>
<td>407</td>
<td>408A ⬤</td>
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<td><strong>OIDA Executive Forum, Petree Hall D</strong> (separate registration required)</td>
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<td>Short Courses: SC102, SC178, SC327, SC341, SC390, SC432, SC446, SC453A  (additional fee required)</td>
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<tr>
<td>Workshops</td>
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<tr>
<td>M1D • Capacity Crunch: When, Where and What Can be Done?</td>
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<tr>
<td>M1E • White Box Optics: Will it Kill or Encourage Innovations?</td>
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<tr>
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<tr>
<td>IEEE Women in Engineering “Lunch &amp; Learn” (separate registration required), 515A</td>
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<tr>
<td>M2F • New Fiber Concepts  (ends at 15:15)</td>
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<tr>
<td>M2G • Metro and 5G Transport ⬤</td>
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<tr>
<td>M2H • Control Architecture and Network Modeling I ⬤</td>
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<tr>
<td>M2I • Deployable Optical Access and Edge Networks</td>
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<tr>
<td>M2J • Optical Frequency Combs and Their Applications</td>
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<tr>
<td>M3F • Frequency Combs and Waveguide Devices</td>
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<td>M3G • Fibers and Amplifiers for Deployed Networks ⬤</td>
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<tr>
<td>M3H • TDM and TWDM PON I ⬤</td>
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<tr>
<td>M3I • Control and Management for Future PON</td>
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<tr>
<td>M3J • Optical Characterization and Performance  (ends at 17:30)</td>
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<td>M3K • Optical Data Center Networks</td>
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<td>07:30–08:00</td>
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<td>08:00–10:00</td>
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<td>19:30–21:30</td>
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**Key to Shading**
- Short Courses
- Market Watch/Data Center Summit
- Recorded Session
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<th>408B</th>
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</thead>
<tbody>
<tr>
<td><strong>Coffee Break, Concourse Hall Foyer</strong></td>
<td><strong>Plenary Session, Concourse Hall</strong></td>
<td><strong>Unopposed Exhibit-Only Time, Exhibit Halls G-K</strong> (coffee service 10:00–10:30)</td>
<td><strong>Exhibition and Show Floor, Exhibit Halls G-K</strong> (concessions available) and OFC Career Zone Live, South Lobby</td>
</tr>
<tr>
<td><strong>Exhibit Hall Training, 402AB</strong></td>
<td><strong>OIDA VIP Industry Leaders Speed Meetings Event, 515B</strong> (separate registration required)</td>
<td><strong>Awards Ceremony and Luncheon, Petree Hall D</strong> (additional fee required)</td>
<td><strong>Cheeky Scientist Workshops, 501B</strong></td>
</tr>
<tr>
<td><strong>Tu2H • Silicon Photonic Modulators</strong></td>
<td><strong>Tu2I • Integrated Circuits for Signal Processing</strong></td>
<td><strong>Tu2I • Fibers and Components for Mode Division Multiplexing</strong></td>
<td><strong>Tu2K • Operation and Architecture for Optical Access</strong> (ends at 15:45)</td>
</tr>
<tr>
<td><strong>Tu2H • Tailored Propagation Effects</strong> (ends at 18:15)</td>
<td><strong>Tu3I • Direct-Detection Transmission Systems</strong> (ends at 18:00)</td>
<td><strong>Tu3J • Fiber-based Spatial Mode Multiplexers</strong></td>
<td><strong>Tu3K • Photonic Packaging</strong></td>
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<tr>
<td><strong>Tu3L • Data Center Summit: SDN &amp; NFV Demo Zone, 400 Foyer (extended coffee break)</strong></td>
<td><strong>Coffee Break, 400 Foyer; Exhibit Hall</strong></td>
<td><strong>Exhibit Hall G Expo Theater I</strong></td>
<td><strong>Exhibit Hall K Expo Theater II</strong></td>
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<tr>
<td><strong>Exhibit Hall K Expo Theater III</strong></td>
<td><strong>Exhibit Hall G Expo Theater I</strong></td>
<td><strong>Exhibit Hall K Expo Theater II</strong></td>
<td><strong>Exhibit Hall K Expo Theater III</strong></td>
</tr>
<tr>
<td><strong>Panel II: Market Watch</strong> Panel I: State of the Industry — Analyst Panel 10:30–12:00</td>
<td><strong>Panel II: Market Outlook for High Bandwidth Optical Technologies</strong> 12:30–14:00</td>
<td><strong>Panel III: Global Market Watch</strong> 12:30–14:00</td>
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**OFC 2017 • 19–23 March 2017**

### Agenda of Sessions

- **Product Showcase DWDM to the Edge Huawei USA 10:15–10:45**
- **The Fracturing and Burgeoning Ethernet Market Ethernet Alliance 11:00–12:00**
- **Dynamic Third Network Services for the Digital Economy and Hyper-connected World MEF 12:30–13:30**
- **Enabling Next Generation Physical Layer Solutions OIF 13:45–14:45**
- **The Key to Unlocking the Benefits of SDN OIF Interop 15:00–16:00**
- **International Photonic Systems Roadmaps 16:00–17:00**
### Agenda of Sessions — Wednesday, 22 March

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<thead>
<tr>
<th>Time</th>
<th>Session Details</th>
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<tr>
<td>07:30–08:00</td>
<td>Coffee Break, 400 Foyer</td>
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<tr>
<td>08:00–10:00</td>
<td>W1A • Photonic/Electronic Integration and Packaging</td>
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<td></td>
<td>(ends at 09:45)</td>
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<tr>
<td>08:00–10:00</td>
<td>W1B • SDM Multiplexers and 3D Waveguides</td>
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<tr>
<td>08:00–10:00</td>
<td>W1C • Novel Fronthauling Techniques</td>
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<tr>
<td>08:00–10:00</td>
<td>W1D • Control Architecture and Network Modeling II</td>
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<tr>
<td>08:00–10:00</td>
<td>W1E • Tunable Lasers and Transmitters</td>
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<td>08:00–10:00</td>
<td>W1F • Advanced Fiber Lasers</td>
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<td>08:00–10:00</td>
<td>W1G • Nonlinearity Mitigation and Monitoring</td>
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<tr>
<td>10:00–17:00</td>
<td>Exhibition and Show Floor, Exhibit Halls G-K (coffee service 10:00–10:30)</td>
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<tr>
<td>10:00–17:00</td>
<td>OFC Career Zone Live, South Lobby</td>
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<tr>
<td>10:00–12:00</td>
<td>W2A • Poster Session I, Exhibit Hall K</td>
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<tr>
<td>12:00–13:00</td>
<td>Unopposed Exhibit-Only Time, Exhibit Halls G-K (concessions available)</td>
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<tr>
<td>13:00–15:00</td>
<td>W3A • Panel: Are Electronic and Optical Components Ready to Support Higher Symbol Rates and Denser Constellations?</td>
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<td>13:00–15:00</td>
<td>W3B • Direct- Detection Transceivers</td>
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<tr>
<td>13:00–15:00</td>
<td>W3C • Symposium: What is Driving 5G, and How Can Optics Help I</td>
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<tr>
<td>13:00–15:00</td>
<td>W3D • Inter/Intra Data Center Networks (ends at 14:45)</td>
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<tr>
<td>13:00–15:00</td>
<td>W3E • III-V/Silicon Integrated Devices</td>
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<tr>
<td>13:00–15:00</td>
<td>W3F • Low Cost Systems for Wireless and Non-telecom Applications (ends at 14:45)</td>
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<td>13:00–15:00</td>
<td>W3G • Data Center Interconnect Technologies</td>
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<tr>
<td>13:30–15:00</td>
<td>IEEE Women in Photonics/WICE Luncheon, 515A (separate registration required)</td>
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<tr>
<td>15:00–15:30</td>
<td>Coffee Break, 400 Foyer; Exhibit Hall</td>
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<tr>
<td>15:30–17:30</td>
<td>W4A • Coded Modulation</td>
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<tr>
<td>15:30–17:30</td>
<td>W4B • Microwave Photonic Subsystems</td>
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<tr>
<td>15:30–17:30</td>
<td>W4C • Symposium: What is Driving 5G, and How Can Optics Help II</td>
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<tr>
<td>15:30–17:30</td>
<td>W4D • PAM-4 Inter-data Center Transmission</td>
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<td>15:30–17:30</td>
<td>W4E • Photonic and Planar Switches</td>
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<td>15:30–17:30</td>
<td>W4F • WDM and SDM Networking</td>
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<td>15:30–17:30</td>
<td>W4G • Indium Phosphide Photonic Integration</td>
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<tr>
<td>17:00–19:30</td>
<td>Photonic Society of Chinese-Americans Workshop &amp; Social Networking Event, 518</td>
</tr>
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**Key to Shading**
- Short Courses
- Market Watch/Network Operator Summit
- Recorded Session
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<thead>
<tr>
<th>Time</th>
<th>Session 1</th>
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<th>Session 3</th>
<th>Session 4</th>
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<tbody>
<tr>
<td>08:00–10:00</td>
<td>W1A • SDM</td>
<td>W3A • Panel: Unopposed Exhibit-Only Time</td>
<td>W2A • SDM</td>
<td>W4A • Microwave Transceivers</td>
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<tr>
<td></td>
<td>Architecture for Packet and Physical Layer Optical</td>
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<td>W3B • Waveguides and 3D Multiplexers and 3D</td>
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<tr>
<td>10:00–17:00</td>
<td>W2A • Poster Session I, Exhibit Hall K</td>
<td>W4B • Photonic and Integrated Devices</td>
<td>W3C • Symposium: Optics Help I</td>
<td>W4C • Symposium: Optics Help II</td>
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<td>Unopposed Exhibit-Only Time, Exhibit Halls G-K (concessions available)</td>
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<tr>
<td>11:00–12:30</td>
<td>W3D • Multicore and Multimode Fibers (ends at 14:45)</td>
<td>W4D • PAM-4 Center Networks (ends at 14:45)</td>
<td>W3E • III-V/Silicon Lasers and Transmitters</td>
<td>W4E • Photonic and Integrated Devices</td>
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<tr>
<td>12:00–13:00</td>
<td>W1B • SDM</td>
<td>W3I • Control of Multi-layer Networks</td>
<td>W3F •  Low Fiber Lasers</td>
<td>W4F • WDM and Applications (Non-telecom for Wireless and Cost Systems)</td>
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<td>Architecture for Packet and Physical Layer Optical</td>
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<tr>
<td>13:00–15:00</td>
<td>W2E • SDM</td>
<td>W3J • Subcarrier Multiplexing and Nonlinear Tolerant Transmission (13:00–14:00)</td>
<td>W3G • Data Center Technologies</td>
<td>W4G • Indium Phosphide Photonic Devices</td>
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<td></td>
<td>Elastic Optical Networks</td>
<td>W3K • Perspectives in Quantum Communication (14:00–15:00)</td>
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<td>14:00–15:00</td>
<td>W1F • SDM</td>
<td>W4I • High-speed Interconnects</td>
<td>W3H • Multicore and Multimode Fibers (ends at 14:45)</td>
<td>W4H • Evolution of Optical Networks</td>
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<tr>
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<td>Forward Error Correction and Coding (begins at 08:30)</td>
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<tr>
<td>15:00–15:30</td>
<td>W1G • SDM</td>
<td>W4J • SDN/NFV and Service Function Chaining</td>
<td>W4J • SDN/NFV</td>
<td>W4I • High-speed Interconnects</td>
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<td></td>
<td>Forward Error Correction and Coding (begins at 08:30)</td>
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<td>and Service Function Chaining</td>
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<tr>
<td>15:30–17:00</td>
<td>W1H • SDM</td>
<td>W4K • Panel: Quantum Communication Programs Around the World</td>
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<td></td>
<td>Forward Error Correction and Coding (begins at 08:30)</td>
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**Exhibit Halls G-K**

- Coffee Break, 400 Foyer
- Coffee Break, 400 Foyer; Exhibit Hall K
- IEEE Women in Photonics/WICE Luncheon, 515A (separate registration required)
- Exhibit Hall G Expo Theater I
- Exhibit Hall K Expo Theater II
- Exhibit Hall K Expo Theater III

**OFC Career Zone Live, South Lobby**

- W2A • Poster Session I, Exhibit Hall K
- Unopposed Exhibit-Only Time, Exhibit Halls G-K (concessions available)

**Exhibition and Show Floor, Exhibit Halls G-K (coffee service 10:00–10:30)**

- Coffee Break, 400 Foyer

**IEEE Women in Photonics/WICE Luncheon, 515A (separate registration required)**

- Coffee Break, 400 Foyer; Exhibit Hall K

**Photonic Society of Chinese-Americans Workshop & Social Networking Event, 518**
## Agenda of Sessions — Thursday, 23 March

<table>
<thead>
<tr>
<th>Time</th>
<th>402AB</th>
<th>403A</th>
<th>403B</th>
<th>404AB</th>
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<th>407</th>
<th>408A</th>
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<tr>
<td><strong>07:30–08:00</strong></td>
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<td>Coffee Break, 400 Foyer</td>
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<tr>
<td>08:00–10:00</td>
<td>Th1A</td>
<td>Th1B</td>
<td>Th1C</td>
<td>Th1D</td>
<td>Th1E</td>
<td>Th1F</td>
<td>Th1G</td>
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<tr>
<td></td>
<td>Detectors/Receivers</td>
<td>Silicon Photonics</td>
<td>SDM Transmission II (begins at 08:30)</td>
<td>Advances in Coherent Subsystems (ends at 09:45)</td>
<td>Visible Light Communications (ends at 09:45)</td>
<td>Applications of Parametric Nonlinear Processors (ends at 09:45)</td>
<td>Gratings and Filters</td>
</tr>
<tr>
<td>10:00–16:00</td>
<td>Exhibition and Show Floor, Exhibit Halls G-K (coffee service from 10:00–10:30)</td>
<td><strong>OFC Career Zone Live, South Lobby</strong></td>
<td>Th2A • Posters Session II, Exhibit Hall K</td>
<td>Unopposed Exhibit-Only Time, Exhibit Halls G-K (concessions available)</td>
<td>Th3A • Optical Technologies for Radio Access Network I</td>
<td>Th3B • Practical Solutions to Transceiver Integration</td>
<td>Th3C • Optical Wireless Systems (ends at 14:45)</td>
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<tr>
<td>13:30–15:30</td>
<td>Th4A</td>
<td>Th4B</td>
<td>Th4C</td>
<td>Th4D</td>
<td>Th4E</td>
<td>Th4F</td>
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<td>15:00–15:30</td>
<td>Coffee Break, 400 Foyer; Exhibit Hall</td>
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<td>15:30–17:30</td>
<td>Th4A</td>
<td>Th4B</td>
<td>Th4C</td>
<td>Th4D</td>
<td>Th4E</td>
<td>Th4F</td>
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<tr>
<td>17:30–18:00</td>
<td>Beverage Break, 400 Foyer</td>
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<tr>
<td>18:00–20:00</td>
<td>Postdeadline Papers, 403A, 403B, 408A and 408B</td>
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**Key to Shading**
- Short Courses
- Market Watch/Network Operator Summit
- Recorded Session
Agenda of Sessions

OFC 2017 • 19–23 March 2017

Exhibit Hall G
Expo Theater I

Exhibit Hall K
Expo Theater II

Exhibit Hall K
Expo Theater III

408B 409AB 410 411

Coffee Break, 400 Foyer

Th1H • Advances in Multicore Fiber Technology
Th1I • Network Architecture Evolution
Th1J • Data Analytics and Machine Learning
Th1K • Coherent Technologies for Access
(begins at 08:30)

Exhibition and Show Floor, Exhibit Halls G-K (coffee service from 10:00–10:30)

OFC Career Zone Live, South Lobby

Th2A • Posters Session II, Exhibit Hall K

Unopposed Exhibit-Only Time, Exhibit Halls G-K (concessions available)

Th3H • Sensors for Telecom and Biomedical Applications
Th3I • Novel Photonic Devices
Th3J • Nonlinear Mitigation Techniques (ends at 14:30)
Th3K • Network Survivability (ends at 14:45)

Coffee Break, 400 Foyer; Exhibit Hall

Th4G • Laser Transmitters
Th4H • Characterizations of SDM Fibers
(ends at 17:15)
Th4I • Coherent Optical Signal Processing
(ends at 17:15)

Beverage Break, 400 Foyer

Postdeadline Papers, 403A, 403B, 408A and 408B

Exhibit Hall G
Expo Theater I

Exhibit Hall K
Expo Theater II

Exhibit Hall K
Expo Theater III

Market Watch
Panel V: Photonic Integration
Business Case – Reality Check
10:30–12:00

Market Watch
Panel VI: SDN & Optics — What is the Business Case?
12:30–14:00

Open Packet DWDM
TIP
10:15–11:45

ONF: The Path Forward
12:00–13:30

Transport SDN
15:00–16:00

Product Showcase
Huawei T-SDN
OVPN Solution
10:15–10:45

POF Symposium
POFTO
11:00–13:00

Technological Evolution of Next Generation Optical Cross Connect
Huawei
13:30–14:30
We discuss the possibilities of opening a new wave of dense integration and packaging approaches, and other fundamental component challenges.

Passive Optical Networks have seen a dramatic growth over the past decade. There are now many large deployments, such as those in the US, Japan, and China, and the total number of homes passed with PON technology is approaching 200 million. We have also seen an alphabet soup of PON technologies, including B, E, G, 10GE, XG, and TWDM. But the one constant in all of this is that PON deployment is as difficult as it is rewarding. This panel brings together representatives of operator and vendor companies that are driving the industry forward in a wave of ultra-broadband deployment. This will be a great forum to hear of their experiences, discoveries, happy accidents, and expensive lessons. These challenges can be economic or technical in nature, and are often most apparent during the transition from prototype development to manufacturing. This symposium will provide a balanced view of the promises and challenges of integrated photonics, and it will focus on what is being done to get beyond the many roadblocks in order to enable a much larger market adoption. During the symposium, leaders in the field will address applications in traditional and non-traditional markets for integrated photonics, finding the right fabrication model using MPW or custom processing services, choosing Si versus InP platforms, optical and electrical packaging approaches, and other fundamental component challenges.

Speakers (in speaking order)
Roe Hemenway, Macom, USA
Dominic Goodwilli, Huawei, Canada
Pascual Munoz, VLC, Spain
John Bowers, Univ. of California Santa Barbara, USA

FPGA-based Real-Time Receiver for Nyquist-FDM at 112 Gbit/s Sampled with 32 GSa/s, Benedikt Baehrleit, Ame Josten1, Marco Epenberger1, Edwin Dornberger1, David HillerlKü1, Juerg Leuthold1, ‘ETH Zurich, Switzerland’. We demonstrate an efficient multi-format real-time Nyquist-FDM receiver implemented on a single FPGA. The single-polarization receiver with only 8/7 oversampling receives 56 Gbit/s 4QAM and 112 Gbit/s 16QAM transmitted over 300 km SSMF.

Simple Frequency-domain Hybrid-QAM Superchannel with Path-fitted Pre-filtering and Collaborative-subcarrier Frequency Self-tuning for Flexible ROADM Systems, Takahiro Kodama1, Masashi Binkai1, Tatsuyoshi Yoshida1, ‘Optical Communication Technology Department, Mitsubishi Electric Corporation Information Technology R&D Center, Japan. Flexible spectral efficiency was demonstrated by a frequency-domain hybrid-QAM based 400 Gbit/s superchannel with path-fitted pre-filtering. Subcarrier frequency tuning was also evaluated through offline emulation of laser frequency drift, and mitigated a 2.1 dB Q degradation.
Room 408A  Room 408B  Room 409AB  Room 410  Room 411

Details on all Workshops (both Sunday and Monday) can be found on pages 9-13

13:30–15:30 M2G • Metro and 5G Transport
Presider: Jiajia Chen; Kungliga Tekniska Hogskolan, Sweden

M2G.1 • 13:30 Techno-economic Analysis of Transmission Technologies in Low Aggregation Rings of Metropolitan Networks, Tamara Jimenez1, Victor Lopez2, Felipe Jimenez Arribas3, Oscar Gonzalez de Dios4, Juan Pedro Fernandez-Palacios5,6, Optical Communications Group, Univ. of Valladolid, Spain;7 Telephoneica I+D, Spain. A techno-economic comparison of dark fiber and passive architectures to evolve low aggregation metro rings of 1G is presented. Results demonstrate that there are alternatives more cost-effective than just migrating to 10G.

M2G.2 • 13:45 Integrating Wireless BBUs with Optical OFDM Flexible-grid Transponders in a C-RAN Architecture, Avishhek Nag1, Yi Zhang1, Luiz DaSilva2, Linda Doyle1, Marco Ruffini1, Trinity College Dublin, Ireland. We propose a case study on hardware-level virtualisation of C-RAN BBUs and optical flex-grid OFDM transponders, showing cost savings of integrating fixed and mobile network devices in a realistic converged network scenario.

Lyndon Ong is Principal, Network Architecture at Ciena Corporation and a Ciena Technical Fellow. He currently chairs the Open Transport Working Group of the Open Networking Foundation (ONF), and has been a major contributor to work on SDN architecture and APIs and optical control plane. He is an active member of the Optical Internetworking Forum (OIF), previously serving as Technical Committee Chair and on its Board of Directors, and an active participant in IETF. Dr. Ong joined Ciena in 2001, after previous stints at Nortel Networks, Bay Networks and Bellcore. He received his doctorate from Columbia University in 1991.

13:30–15:30 M2H • Control Architecture and Network Modeling I
Presider: Sergi Figuerola, i2CAT Foundation, Spain

M2H.1 • 13:30 Tutorial ONF SDN Architecture and Standards for Transport Networks, Lyndon Y. Ong1, Ciena Corporation, USA. This talk reviews ONF SDN standards development for transport networks, focusing on the Transport API (TAPI) NorthBound Interface. This includes basic concepts and modeling, TAPI open source SDK and recent TAPI interop testing, in the context of related industry work such as IETF YANG models.

M2H.2 • 13:45 Demonstration of Radio and Optical Orchestration for Improved Coordinated Multi-point (CoMP) Service over Flexible Optical Fronthaul Transport Networks, Jiawei Ji1,2, Hao Yu1, Yuefeng Ji1, Hui Li2, Xiaoshong Yu1, Yongli Zhao2, Han Li1, State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts & Telecom, China;1 Beijing Advanced Innovation Centre for Future Internet Technology, Beijing Univ. of Technology, China;2 China Mobile Research Inst., China. We propose an SDN-enabled orchestration for the convergence of radio and optical networks in the 5G. Improved coordinated multi-point service is experimentally demonstrated in the cloud radio over flexible optical fronthaul transport networks (C-RoFlex) testbed.

M2I.1 • 13:30 Antenna, Spectrum and Capacity Trade-off for Cloud-RAN Massive Distributed MIMO over Next Generation PONs, Irene Macaluso1, Bruno Comaglia1,2, Marco Ruffini1,2, Univ. of Dublin Trinity College, Ireland; Vodafone, Italy. We propose a cost-optimal antenna vs. spectrum resource allocation strategy for mobile 5G MDO-MIMO over Next-Generation PONs. Comparing wavelength overlay and shared wavelength approaches, split-PHY leads to solutions with higher mobile capacity than fronthaul.

M2I.2 • 13:45 Demonstration of Radio and Optical Orchestration for Improved Coordinated Multi-point (CoMP) Service over Flexible Optical Fronthaul Transport Networks, Jiawei Ji1,2, Hao Yu1, Yuefeng Ji1, Hui Li2, Xiaoshong Yu1, Yongli Zhao2, Han Li1, State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts & Telecom, China;1 Beijing Advanced Innovation Centre for Future Internet Technology, Beijing Univ. of Technology, China;2 China Mobile Research Inst., China. We propose an SDN-enabled orchestration for the convergence of radio and optical networks in the 5G. Improved coordinated multi-point service is experimentally demonstrated in the cloud radio over flexible optical fronthaul transport networks (C-RoFlex) testbed.

M2J.1 • 13:30 invited Computation-free Signal Mapping to Fourier Domain, Bill Kuo1, Vahid Ataie2, and Stojan Radic,1,2 ‘Univ. of California, San Diego, USA. Conventional lightwave receiver incorporates high-speed Fast Fourier Transform (FFT) computation core in order to aid carrier recovery and perform channel equalization. This talk examines a computation-free FFT alternative architecture and discussed its implications.

M2J.2 • 13:45 Demonstration of Radio and Optical Orchestration for Improved Coordinated Multi-point (CoMP) Service over Flexible Optical Fronthaul Transport Networks, Jiawei Ji1,2, Hao Yu1, Yuefeng Ji1, Hui Li2, Xiaoshong Yu1, Yongli Zhao2, Han Li1, State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts & Telecom, China;1 Beijing Advanced Innovation Centre for Future Internet Technology, Beijing Univ. of Technology, China;2 China Mobile Research Inst., China. We propose an SDN-enabled orchestration for the convergence of radio and optical networks in the 5G. Improved coordinated multi-point service is experimentally demonstrated in the cloud radio over flexible optical fronthaul transport networks (C-RoFlex) testbed.

10:00-10:30 Coffee Break, 400 Foyer

12:00–13:30 Lunch Break (on own)
Monday, 20 March

M2A • Panel: Lessons Learned From Global PON Deployment—Continued

M2B • Symposium: Overcoming the Challenges in Large-Scale Integrated Photonics I—Continued

M2C • Coherent Transceivers—Continued

M2D • SDM Transmission I—Continued

M2E • Advanced and Open Systems—Continued

M2F • New Fiber Concepts—Continued

M2C.3 • 14:00
Colorless C-Band WDM System Enabled by Coherent Reception of 56-GbD PDM-16QAM Using an High-bandwidth ICR with TiAs, Robert Emmerich1, Robert Elschner1, Carsten Schmidt-Langhorst1, Gijs v. Elzakker1, Jan Hoffmann1, Andreas Umbach1, Colja Schubert1, Fraunhofer Heinrich Hertz Inst., Germany; Finish-germany GmbH, Germany. We demonstrate error-free 80-km transmission of a 400-Gb/s channel in a colorless coherent C-band WDM system using a high-bandwidth micro-ICR. The WDM channels are colorlessly combined at the transmitter and colorlessly split detected at the receiver.

M2C.4 • 14:15
A Memory Polynomial Based Digital Pre-distorter for High Power Transmitter Components, Ginni Khanna1, Bernhard Spinninger2, Stefano Calabró2, Erik De Man3, Uwe Feiter2, Tomislav Drenski4, Norbert Hank1; Technical Univ. of Munich, Germany; Coriant R&D GmbH, Germany; Socionext Europe GmbH, UK. An adaptive digital pre-distortion method based on memory polynomials to compensate for non-linearities in high power optical transmitters is presented. Gains up to 2dB for DP-64QAM are achieved beyond linear pre-distortion.

M2D.1 • 14:00
12 Mode, MIMO-free OAM Transmission, Kasper Ingerslev1, Patrick Gregg2, Michael Galli1, Francesco Da Ros1, Hao Hu1, Fangdi Bao1, Mario A. Usuga Castaneda1, Paul Kristensen3, Andrea Rubano1, Lorenzo Marrucci, Siddharth Ramachandran1, Karsten K. Rottwitt1, Toshio Morikawa1, Leif K. Oxenlowe1; Department of Photonics Engineering, Technical Univ. of Denmark, Denmark; Electrical and Computer Engineering Department, Boston Univ., USA; OFS-Fitel, Denmark; Dipartimento di Fisica, Università di Napoli Federico II, Italy. Simultaneous MIMO-free transmission of a record number (12) of orbital angular momentum modes over 1.2 km is demonstrated. WDM compatibility of the system is shown by using 60 WDM channels with 25 GHz spacing and 10 GBaud QPSK.

M2D.2 • 14:15
5Tb/s Transmission Over 2.2 km of Multimode OM2 Fiber with Direct Detection Thanks to Wavelength and Mode Group Multiplexing, Kaoutar Benyahya1, Christian Simonneau1, Amirhossein Ghazaeaeidi1, Nicolas Barri3, Pu Jian1, Jean-François Morzur1, Guillaume Labroille1, Pierre Sillard1, Jérémie Renaudier1, Gaetan Ginistrelli1, Michael Galili1, Greg Tomblin2, John O’Shea2, Cody Tomin1, Vijay Vusirikala1, Xiaoxue Zhao; Google, Inc., USA. We present on the design and operational aspects of our open line system approach for overcoming cost, capacity and flexibility limitations. Dramatic growth of datacenter traffic was supported by separation of the terminal equipment from the optical layer allowing the introduction of multi-vendor, best-of-breed coherent terminal equipment.

M2E.2 • 14:00
Lessons Learned from Open Line System Deployments, Valeys Kamalov1, Vinayak Dangui1, Tad Hofmeister1, Bikash Koley1, Chris Mitchell1, Matt Newland1, John O’Shea2, Cody Tomblin1, Vijay Vusirikala1, Xiaoxue Zhao; Google, Inc., USA. We present on the design and operational aspects of our open line system approach for overcoming cost, capacity and flexibility limitations. Dramatic growth of datacenter traffic was supported by separation of the terminal equipment from the optical layer allowing the introduction of multi-vendor, best-of-breed coherent terminal equipment.

M2F.2 • 14:00
Phosphate Glass Fibers for Optical Amplifiers and Biomedical Applications, Daniel Milanese1, Diego Pugliese1, Nadia G. Boetti3, Edoardo Cecini-strelli2, Davide Janner1, Vincenzo M. Sglavo1, Chiara Vitale-Brovarone1, Joris Loustau2; Department of Applied Science and Technology, Politecnico di Torino, Italy; IFN, CNR, Italy; Applied Photonics, Istituto Superiore Mario Boella, Italy; Optoelectronics Research Centre, Univ. of Southampton, UK; Department of Industrial Engineering, Università di Trento, Italy. Phosphate glass optical fibers were designed and fabricated for applications in the fields of remote sensing and biomedicine. Main results are reported together with the recent developments.

Presentations selected for recording are designated with a link. Visit www.ofcconference.org and select the View Presentations link.

OFC 2017 • 19–23 March 2017
**M2G • Metro and 5G Transport—Continued**

**M2H • Control Architecture and Network Modeling I—Continued**

**M2I • Deployable Optical Access and Edge Networks—Continued**

**M2J • Optical Frequency Combs and Their Applications—Continued**

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**M2G.3 • 14:00 Invited**

Benefits of Programmability in 5G Transport Networks, Muhammad Rehan Raza1, Matteo Fiorani1, Ahmad Rostami2, Peter Ohlen2, Lena Wosinska1, Paolo Monti1; 1KTH Royal Inst. of Technology, Sweden; 2Ericsson AB, Sweden. This paper shows how programmability can improve operators’ revenues and it presents a dynamic resource slicing policy that leads to more than one order of magnitude better resource utilization levels than conventional (static) allocation strategies.

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**M2I.3 • 14:00 Invited**

The Evolution of Outside Plant Architectures Driven by Network Convergence and New PON Technologies, Kevin L. Bourg1; 1Corning Optical Communications, USA. We show that convergence of access networks together with new PON standards drive lower bandwidth cost, which in turn due to elasticity of demand results in larger number of users. According to Metcalfe’s law that came into existence in 1980’s and explained the wide adoption of Ethernet cards, increase in network value will scale quadratically with the number of users, thus making convergence and new PON standards so valuable to network operators.

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**M2J.2 • 14:00**

Towards an Integrated-photonics Optical-Frequency Synthesizer With <1 Hz Residual Frequency Noise, Daryl T. Spencer1, Aaron Bluestone2, John E. Bowers2, Travis C. Briles1, Scott Diddams1, Tara Drake1, Robert Ilic2, Tobias Kippenberg1, Tin Komljenovic2, Seung H. Lee1, Qing Li1, Nathan Newbury1, Erik Norberg1, Dong Y. Oh1, Scott Papp1, Pfeiffer Martin Hubert Peter4, Laura Sinclair1, Kartik Srinivasan1, Jordan Stone1, Myoung-Gyun Suh5, Luke Theogarajan1, Kerry Vahala1, Nicholas Volet1, Daron Westly1, Kiyoul Yang5; 1National Inst of Standards & Technology, USA; 2Univ. of California Santa Barbara, USA; 3National Inst. of Standards and Technology, USA; 4Ecole Polytechnique Federale de Lausanne, Switzerland; 5California Inst. of Technology, USA; 6Aurrion Inc., USA. We introduce an architecture for optical-frequency synthesis using photonic-chip frequency combs and a heterogeneously integrated CW laser. The Kerr dual-comb that we describe offers a microwave-optical link to discipline the laser to an RF clock.

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**M2J.3 • 14:15**

Comb-Assisted Real-time Discrete Fourier Transform Processor, Huan Hu1, Daniel Esmann1, Vahid Ataie1, Eduardo Temprana1, Bill Kuo1, Nikola Alic1, Stojan Radic1; 1UCSD, USA. We present a high-speed flexible photonic-assisted Discrete Fourier Transform (DFT) processor based on a dual, phase-locked optical parametric combs. A 25-point DFT at 500 Million-DFT-point per second throughput is achieved relying on slow, 20 M5’s Analog to Digital Converter (ADC).

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Maxim Kuschnerov is a Senior R&D Manager at Huawei Technologies in Munich working on innovation projects. He earned his doctorate in 2011 from the University of the Bundeswehr on digital signal processing for optical DSLs. In 2010, he joined Nokia Siemens Networks in R&D, developing 100Gbit/s transceivers. In parallel, he was a project lead for developing space-division multiplexing network technology based on solid core and hollow core fibers. In 2014, he moved to product line management at Coriant creating the Groove G30 data center interconnect product and managing the ultra-long-haul transport system hit 7300.

M2C-3 • 14:30 <invited> Digital Coherent Transceivers: From Algorithm Design to Economics, Maxim Kuschnerov1, Huawei Technologies Duesseldorf GmbH, Germany. The divide between generic 100G coherent interfaces and differentiated solutions is widening. A DSP invest in the age of white box transmission is a careful decision, discussed from a technological and economic point of view.

M2D-3 • 14:30 <invited> Signal Processing Techniques for DMD and MDL Mitigation in Dense SDM Transmissions, Kohki Shibahara1, Takayuki Mizuno1, Dooshan Lee1, Yutaka Miyamoto1, NTN Network Innovation Laboratories, Japan. Methodologies for DMD and MDL mitigation in SDM transmission are reviewed. We clarify frequency selective channels over a multicore few-mode fiber with experimental evaluations, and their impact on signal transmission from a signal processing perspective.
We propose and compare different baseband-processing placement strategies in optical aggregation networks. Proper trade-off between baseband-resources consolidation and network blocking can be obtained by dynamically adapting location of processing resources to traffic conditions.

We propose and compare different baseband-processing placement strategies in optical aggregation networks. Proper trade-off between baseband-resources consolidation and network blocking can be obtained by dynamically adapting location of processing resources to traffic conditions.

Core VNT Adaptation Based on the Aggregated Metro-flow Traffic Model Prediction, Fernando Morales1, Marc Ruiz1, Luis Velasco1, 1Universitat Politècnica de Catalunya, Spain. Aggregation of metro-flow traffic models is proposed to obtain valid core traffic predictive models for core VNT reconfiguration when metro and core networks are independently controlled. Exhaustive simulation results reveal large optical transponders usage savings.

Managing Service Quality in a Software Defined Network, Jennifer M. Yates1; 1AT&T, USA. Service Quality Management (SQM) technologies enable service providers to manage customer experience. In this paper, we focus on SQM innovations and how they apply to software defined networks.

Uncompressed 8K Ultra-high Definition Television Transmission over 100G Ethernet in Broadcasting Station, Junichiro Kawamoto1, Takuya Kurakake1, Junhiro Katsuno1, Japan Broadcasting Corporation, Japan. For live television production, 4K/8K signals are transmitted through 100G Ethernet interfaces. In this paper, we describe experiments combining high core-count, homogeneous single-mode multi-core fibers with a wideband comb for high-capacity transmission without high-order MIMO reception and demonstrate wideband transmission with coded modulation up to 12,300 km.

Ultrafast Demultiplexing of Optical Time-division Multiplexed Signals by Parallel Opto-Electronic Time-frequency Domain Sampling, Takahide Sakamoto1, Guo-Wei Lu1, Naokatsu Yamamoto1; 1National Inst of Information & Comm Tech (NICT), Japan; 2Signals and Systems, Chalmers Univ. of Technology, Sweden; 3RAM Photonics, LLC, USA. We describe experiments combining high core-count, homogeneous single-mode multi-core fibers with a wideband comb for high-capacity transmission without high-order MIMO reception and demonstrate wideband transmission with coded modulation up to 12,300 km.

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**M2D.5 • 15:15**
3x10 Gb/s Mode Group-multiplexed Transmission over a 20 km Few-Mode Fiber Using Photonic Lanterns, Huiyuan Liu¹, He Wen¹², Juan Carlos Alvarado Zacarias¹, Jose Antonio-Lopez¹, Ning Wang¹, Pierre Sillard³, Adrian Amezquita-Corra³, Rodrigo Amezquita-Corra³, Guifang Li¹²; ¹CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA; ²The College of Precision Instruments and Opto-electronic Engineering, Tianjin Univ., China; ³Prysmian Group, France. We experimentally demonstrate 3x10 Gb/s mode group-multiplexed transmission with direction detection in a step-index few-mode fiber over a record reach of 20 km, enabled by low crosstalk photonic lanterns as mode group (de)multiplexers.

**M2E.6 • 15:15**
Shake Before Break: Per-Span Fiber Sensing with In-Line Polarization Monitoring, Jesse E. Simsarian¹, Peter Winzer¹; ¹Nokia Bell Labs, USA. Fast state-of-polarization transients induced by transmission-fiber disturbances can indicate an imminent fiber break even in the absence of transmission errors. We present a simple in-line polarization monitoring scheme that detects fiber disturbances, enabling proactive protection.

### 15:30–16:00 Coffee Break, 400 Foyer
M2G • Metro and 5G Transport—Continued

M2H • Control Architecture and Network Modeling I—Continued

M2I • Deployable Optical Access and Edge Networks—Continued

M2J • Optical Frequency Combs and Their Applications—Continued

M2G.7 • 15:15 Cost-Effectiveness Assessment of Transport Networks based on Disaggregated Optical Platforms, Joao Santos1, Nelson Costa1, Joao Pedro1; 1Coriant Portugal, Portugal. This paper compares the routing performance between disaggregated and proprietary optical line systems. Network simulations show that disaggregated solutions attain minimal traffic blocking while reducing OEO interface count with respect to multi-vendor deployments.

M2I.6 • 15:15 Strategies for VNF Placements in Large Provider Networks, Ashwin Gumaste1, Sidharth Sharma1, Tamal Das1, Aniruddha Kushwaha1; 1Indian Inst. of Technology, Bombay, India. We examine three strategies of VNF placement in a provider network: static service chains; seamless VNF duplication and VNF-dynamic-splitting. A constrained optimization applied to a large provider evaluates these strategies and showcases cost-latency trade-off.

M2J.6 • 15:15 Mitigation of Electrical Bandwidth Limitations using Optical Pre-sampling, Zihan Geng1, Bill Corcoran1,3, Andreas Boes2,3, Arnan Mitchell2,3, Leimeng Zhuang1, Yiwei Xie1, Arthur Lowery1,3; 1Dept. of Electrical and Comp. System Eng., Monash Univ., Australia; 2School of Engineering, RMIT Univ., Australia; 3Centre for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS), Australia. We propose a novel method to improve a system degraded by a low receiver electrical bandwidth. With optical pre-sampling, 4-dB sensitivity improvement at the 7% hard FEC limit is experimentally demonstrated.

15:30–16:00 Coffee Break, 400 Foyer
### Room 402AB
**16:00–18:00**
**M3A • Panel: Transport SDN - What is Ready, What is Missing?**
**Moderators:** Doug Freimuth; IBM, USA; Karthik Sethuraman; NEC, USA

The dynamic compute model provided by the cloud has gained acceptance by business and consumer markets. A new network is required to match the resource scalability, faster automated service deployment model and high resource utilization of the cloud. The promise of Transport SDN to fulfill these requirements has been shown in various demonstrations, proof of concepts and by early adopters. The industry is working to define it in standards bodies for production use in NFV, cloud and IoT.

This panel will discuss what it takes to operationalize Transport SDN. We will discuss business drivers, use cases, progress in standards and prototypes shown to date. We will further discuss what can be put into production now, related technologies such as SD-WAN and high resource utilization of the cloud, and what the future holds for new Transport SDN capabilities.

**Panelists:** Victor Lopez, Telefonica, Spain
Naoki Miyata, NTT Communications, Japan
Kathy Tse, AT&T, USA

### Room 403A
**16:00–18:00**
**M3B • Symposium: Overcoming the Challenges in Large-Scale Integrated Photonics II**
**Presiders:** Benjamin Lee; IBM, USA; Takuo Tanemura; Univ. of Tokyo, Japan

Integrated photonics provides significant opportunities to develop highly compact and extremely functional components and subsystems for a wide range of communication and sensor applications. However, photonic integration brings with it unique manufacturing and packaging challenges, which can limit the commercial exploitation of novel integration concepts and slow the time-to-market. These challenges can be economic or technical in nature, and are often most apparent during the transition from prototype development to manufacturing. This symposium will provide a balanced view of the promises and challenges of integrated photonics, and it will focus on what is being done to get beyond the many roadblocks in order to enable a much larger market adoption. During the symposium, leaders in the field will address applications in traditional and non-traditional markets for integrated photonics, finding the right fabrication model using MPW or custom processing services, choosing Si versus InP platforms, optical and electrical packaging approaches, and other fundamental component challenges.

**Speakers (in speaking order)**
- Shinji Matsuo, NTT, Japan
- Ashok Krishnamoorthy, Oracle, USA
- Bardia Pezeshki, Kaiam, USA
- Greg Fish, Juniper, USA
- Kevin Williams, TU Eindhoven, Netherlands

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### Room 403B
**16:00–18:00**
**M3C • Probabilistic Shaping and Advanced Modulation Formats**
**Presider:** Takeshi Hoshida; Fujitsu Laboratories Ltd., Japan

Integrated photonics provides significant opportunities to develop highly compact and extremely functional components and subsystems for a wide range of communication and sensor applications. However, photonic integration brings with it unique manufacturing and packaging challenges, which can limit the commercial exploitation of novel integration concepts and slow the time-to-market. These challenges can be economic or technical in nature, and are often most apparent during the transition from prototype development to manufacturing. This symposium will provide a balanced view of the promises and challenges of integrated photonics, and it will focus on what is being done to get beyond the many roadblocks in order to enable a much larger market adoption. During the symposium, leaders in the field will address applications in traditional and non-traditional markets for integrated photonics, finding the right fabrication model using MPW or custom processing services, choosing Si versus InP platforms, optical and electrical packaging approaches, and other fundamental component challenges.

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### Room 404AB
**16:00–17:45**
**M3D • High-Speed Subsystems**
**Presider:** Qunbi Zhuge; Ciena Corporation, Canada

**M3D.1 • 16:00**
**Invited**
Advanced Algorithm for High-baud Rate Signal Generation and Detection, Zhang Junwen, Jianjun Yu, Hung-Chang Chien; ‘ZTE (Tai), USA. We review recent progress on the high-baud rate signal generation and detection, and the corresponding advanced algorithms used in the transmitter- and receiver-side for signal pre- and post- equalization and compensation, respectively.

**M3D.2 • 16:15**
**Experimental Comparison of PM-16QAM and PM-32QAM with Probabilistically Shaped PM-64QAM, Luca Bertignoni, Dario Piloni, Antonello Nespoli, Fabrizio Forgieri, Gabriella Bosco; Politecnico di Torino, Italy; ‘Istituto Superiore Mario Boella, Italy; ‘Cisco Photonics Italy , Italy. We experimentally compare the performance of uniformly distributed and probabilistically shaped constellations with either the same asymptotic mutual information or the same FEC overhead, in order to assess the achievable capacity gains.

**M3D.3 • 16:30**
**Experimental Investigation of the Effect of EDFA-generated ASE Noise Added to the Pump of a Kerr Frequency Comb, Peicheng Liao, Changjing Bao, Arne Kords, Karpov Maxim, Pfeiffer Martin Hubert Peter, Lin Zhang, Yinwen Cao, Ahmed Almammad, Morteza Ziyadi, Amrin Hossen Mohajerin Ariaei, Fatemeh Alishahi, Ahmad Fallahpour, Moshe Tur, Tobias Kippenberg, Alan Willner; ‘Electrical Engineering, Univ. of Southern California, USA; ‘Ecole Polytechnique Federale de Lausanne, Switzerland; ‘Precision Instrument and Opto-electronics Engineering, Tianjin Univ., China; ‘Electrical Engineering, Tel Aviv Univ., Israel. We experimentally investigate the effect of EDFA-induced pump ASE noise on cavity-soliton Kerr combs for 64-QAM transmission. We find that all comb optical carrier-to-noise ratios (OCNRs) are similar with a fixed pump OCNR and comb linewidths almost remain unchanged.

**M3D.4 • 16:45**
**High-Efficiency WDM Sources Based on Microresonator Kerr Frequency Combs, Xiaoxiao Xue, Pei-Hsun Wang, Yi Xu, Menghao Qiao, Andrew Weiner, Tsinghua Univ., China; ‘Purdue Univ., USA. We report on micro-combs that achieve ~30% conversion efficiency (~200 mW on-chip comb power) by excluding the pump, with 40 lines between 1513 nm – 1586 nm with an average 7 dBm per comb line.**
First Demonstration of Symmetric 100G-PON in O-band with 10G-Class Optical Devices Enabled by Dispersion-supported Equalization, Lei Xue, Lin Y, Honglin Ji, Peixuan Li, Weisheng Hu, Shanghai Jiao Tong Univ., China. We demonstrate the first symmetric 100G-PON based on 10Gbps optical devices supporting 0.20 km reach in O-band. Dispersion-supported equalization enables 25.78-Gb/s NRZ-OOK modulation/detection based on DMLs/APDs with a combined 3-dB bandwidth of 5 GHz.

Dynamic Wavelength Allocation and Rapid Wavelength Tuning for Load Balancing in A-tunable WDM/TDM-PON, Yumiko Seno, Kota Asaka, Jun-ichi Kanai, Access Network Service Systems Laboratories, NTT, Japan. Dynamic load balancing (DLB) among OLT-ports can keep good user experience by preventing heavy users from occupying the bandwidth. To realize DLB, we present a dynamic wavelength allocation algorithm and a rapid wavelength tuning sequence.

Polarimetry of Polarization-Modulated Signals Based on Polarization-Selective RF Power Detection, Reinhold Nee, Benjamin Koch, Vitali Mirvoda, Paderborn Univ., Germany, Noveptel GmbH, Germany. A novel polarimeter identifies the main polarization axes of polarization-modulated, nominally unpolarized signals such as PDM-QPSK, PDM-QAM, PS-QPSK. It measures the electrical AC power detected behind several polarization analyzers and calculates the axes iteratively.
M3C.3 • 16:30 Invited
Flexible Optical Transmission Close to the Shannon Limit by Probabilistically Shaped QAM, Fred Buchali1, Wilfried Idler1, Laurent Schmalen1, Qian Hu1, ‘Nokia Bell Labs, Germany. We are reviewing the application of probabilistic shaping in long haul optical transmission systems and investigate the linear, nonlinear and implementation limits for this format in comparison to pragmatic QAM formats.

M3D.2 • 16:30
A Simplified Dual-Carrier DP-64QAM 1 Tb/s Transceiver, David Millar1, Lida Galdino1, Robert Maher1, Milutin Pajovic1, Toshiaki Koike-Akino1, Domnic Lavery2, Gabriel Saavedra2, Daniel Elson3, Kai Shi1, Mustafa S. Erkoll2, Eric Sillekens1, Robert Killey4, Benn C. Thomsen1, Keisuke Kojima1, Kieran Parsons1, Polina Bayvel2, ‘Mitsubishi Electric Research Labs, USA; ’Univ. College London, UK. A 1 Tb/s net bitrate transceiver using a low complexity dual-carrier architecture with free running lasers and DP-64QAM, enabled by pilot-aided DSP and low-rate LDPC, is shown to achieve transmission over 400km with 100km amplifier spacing.

M3D.3 • 16:45
246 GHz Digitally Stitched Coherent Receiver, Kai Shi1, Eric Sillekens1, Benn C. Thomsen1, ‘Univ. College London, UK. Phase estimation and 4x2 MIMO equalization techniques are experimentally compared for digital frequency stitching in ultra-wideband coherent reception, using time multiplexing and a single conventional dual polarization coherent receiver, to simultaneously detect a 5x46GbAud super-channel.

M3E.2 • 16:30
60-Gbps W-Band 64QAM RoF System with T-Spaced DD-LMS Equalization, Xinying Li1,2, Jianjun Yu1,2, Yuming Xu1,2, Xiaolong Pan1, Fu Wang1, Zhipei Li1, Bo Liu1, Lijia Zhang1, Xiangjun Xin1, Gee-Kung Chang2, ‘Key Laboratory for Information Science of Electromagnetic Waves (MoE), Fudan Univ., China; ’Georgia Inst. of Technology, USA; ’ZTE (TX) Inc., USA; ’Beijing Univ. of Posts and Telecommunications, China. We experimentally demonstrate the generation and transmission of 60-Gbaud (10-Gbaud) 91-GHz 64QAM-modulated mm-wave signal over 20-km SMF-28 and 3-m wireless distance, with BER under 2x10^-3. Receiver-based T-spaced DD-LMS equalization significantly improves the system performance.

M3E.3 • 16:45
Real-Time Demonstration of over 20Gbps V- and W-Band Wireless Transmission Capacity in one OFDM-RoF System, Xinying Li1,2, Xin Xiao1, Yuming Xu1,2, Kaixui Wang1, Li Zhao2, Jiannan Xiao1, Jianjun Yu1,2, ’ZTE (TX) Inc., USA; ’Key Laboratory for Information Science of Electromagnetic Waves (MoE), Fudan Univ., China. With real-time reception, we experimentally demonstrate the generation and wireless delivery of Vband (57-GHz) and W-band (91-GHz) OFDM-16QAM signals, both with 6.02-GHz-bandwidth (24.08-GbAud net bit rate) and a BER below the 5D-FEC threshold of 2x10^-3.

M3F.3 • 16:30
Cavity-less 50GHz Frequency Comb Generation by Comb Pitch Multiplication, Bofang Zheng1, Qiye Xie1, Qijie Xie2, Takashi Inoue1, Yuming Xu3, Jianjun Yu1,2, ‘Nokia Bell Labs, Germany. A cavity-less optical frequency comb with accurate 50-GHz comb pitch is achieved using a 10-GHz RF source via the temporal Talbot effect. The comb is implemented as a Nyquist-shaped 32-Gbaud 16-QAM data transmitter.

M3F.4 • 16:45
Regeneration of Noise Limited Frequency Comb Lines for 64-QAM by Brillouin Gain Seeded via SSB Modulation, Mark D. Pelusi1, Aron Cloudbury1, Takashi Inoue1, David Marpaung1, Benjamin Eggleton1, Shu Namiki1, ‘CUDOS/Univ. of Sydney, Australia; ‘National Inst. of Advanced Industrial Science and Technology (AIST), Japan. We demonstrate noise suppression from parametrically generated optical frequency comb-lines with low 10GHz-pitch by using narrowband Brillouin amplification pumped self-seeded via single-sideband modulation (SSB). Comb-line carrier performance close to a reference laser is achieved for 96Gb/s-DP-64QAM.
M3H.3 • 16:30 Invited
DSP-Based Multi-Band Schemes for High Speed Next Generation Optical Access Networks, Jinlong Wei1; Optical Technology Department, Huawei Technologies Duesseldorf GmbH, European Research Center, Germany.
40-Gb/s/λ long reach multi-band CAP PONs using 10G-class transceivers were demonstrated with transmission over an 80-km (90-km) SMF and a link power budget of 33 dB (29 dB) considering a FEC threshold BER of 3.8×10⁻³.

M3I.2 • 16:30
Feasibility Demonstration of Low Latency DBA Method with High Bandwidth-efficiency for TDM-PON, Saki Hatta1, Nobuyuki Tanaka1, Takeshi Sakamoto1; NTT Corporation, Japan.
We propose a DBA method with an adaptive DBA cycle for TDM-PON based MFH and campus LANs. Experiments show that the method achieves minimum latency of 60 μs and high bandwidth efficiency, depending on traffic.

M3J.3 • 16:30
Real-time Path Monitoring of Optical Nodes, Takayuki Kurosu1, Satoshi Suda1, Kiyohiro Ishii1, Shu Namiki1; Natl Inst of Adv Industrial Sci & Tech, Japan.
We demonstrate a novel method for monitoring internal paths of optical nodes exploiting light labeling technique. The optical paths of a 2x2 wavelength cross connect could be monitored in 2ms without affecting transmission performance.

M3J.3 • 16:45
Virtual Dynamic Bandwidth Allocation Enabling True PON Multi-Tenancy, Amr Elrasad1, Nima Afraz1, Marco Ruffini1; CONNECT, Trinity College Dublin, the Univ of Dublin, Ireland.
We propose a virtual-DBA architecture enabling true PON multi-tenancy, giving Virtual Network Operators full control over capacity assignment algorithms. We achieve virtualization enabling efficient capacity sharing without increasing scheduling delay compared to traditional (non-virtualized) PONs.

M3J.4 • 16:45
All-optical Reconfigurable Time-lens Based Signal Processing, Jeonghyun Huh1, Jose Azana1; INRS, Canada.
All-optical reconfigurable time-to-frequency conversion and temporal magnification of optical waveforms is proposed and experimentally demonstrated using a XPM-based time lens by exploiting chirp rates being directly proportional to the peak power of a parabolic pump pulse.
M3C.4 • 17:00 On the Impact of Probabilistic Shaping on SNR and Information Rates in Multi-Stage SPM Systems, Tobias Fehenberg1, Alex Alvarado2, Georg Bächer1, Norbert Hanik1, Technical University of Munich (TUM), Germany; 1Univ College London, UK. Numerical simulations and the EGN model show that probabilistic shaping decreases SNR due to modulation-dependent nonlinear effects. This SNR loss, however, is less important than the rate increase from shaping, resulting in an overall gain.

M3C.5 • 17:15 100-Gb/s Complex Direct Modulation over 1600-km SSMF Using Probabilistic Transition Estimation, Di Che1, Fang Yuan1, William Sheih1, 1Univ. of Melbourne, Australia. We demonstrate single-channel 100-Gb/s polarization-multiplexed PAM-4 with 2 independent directly modulated lasers using only 12.5-GHz electrical bandwidth. By probabilistic transition estimation, this complex-modulated PAM system achieves a record distance of 1600 km.

M3D.4 • 17:00 Extreme Speed Power-DAC: Leveraging InP DHB for Ultimate Capacity Single-carrier Optical Transmissions, Agnieszka Konczykowska1, Jean-Yves Dupuy1, Filipe Jorge1, Muriel Riet1, Virginie Nodjadjimi1, 1IN2P3/Univ. of Lyon, Lyon, France. With 100-Gb/s operation and 4-Vpp swing, InP DHB Power-DAC enabled experiments with different types of E/O modulators. Single-carrier 100-Gbd PAM-4 DD transceiver for datacenters and 1.08 Tbd transmitter (90-Gbd PDM-4QAM) were demonstrated.

M3D.5 • 17:30 Optically Generated Single Sideband Radio-over-Fiber Transmission of 60Gbit/s Over 50m at W-Band, Rafael Puerta1, Simon Rommell1, Juan José Veas Olimos1, Idelfonso Tafur Monroy1, 1Department of Photonics Engineering, Technical Univ. of Denmark, Denmark; 1ITMO Univ., Russia. Transmission of 60Gbit/s single sideband multi-band CAP radio-over-fiber transmission at W-band is demonstrated. A spectral efficiency of 3.8bit/s/Hz and bit error rates below 3×10^-4 are achieved after 50m wireless transmission.

M3E.4 • 17:00 Capacity Enhancement for Hybrid Fiber-Wireless Channels with 46.8Gbit/s Wireless Multi-CAP Transmission over 50m at W-Band, Simon Rommell1, Rafael Puerta1, Juan José Vegas Olimos1, Idelfonso Tafur Monroy1, 1Department of Photonics Engineering, Technical Univ. of Denmark, Denmark; 1ITMO Univ., Russia. Transmission of a 46.8Gbit/s wireless multi-band CAP signal is experimentally demonstrated over a 50m W-band radio-over-fiber link. Bit error rates below 3×10^-4 are achieved, employing nine CAP bands with bit and power loading.

M3E.5 • 17:15 Bandgap Engineering in Nonlinear Silicon Nitride Waveguides, Clemens Krueckel1, Attila Fulop1, Peter A. Andrekson1, Victor Torres-Company1, 1Chalmers Univ. of Technology, Sweden. We show that controlling the bandgap of SiN provides an additional degree of freedom for engineering waveguides for nonlinear optics. We show an optimized structure with gamma*max Leff = 0.17 rad/W and absence of nonlinear loss.
M3G.2 • 17:00  Erbium Doped Fiber Amplifier with Passive Temperature Compensation, Lujie Giao, Alan Solheim, Qinian Bu, Yang Liu, Chongpeng Fu, Weiqing Zhang, Menghui Li, ‘GC Photonics Inc., Canada; “Accelink Technologies Co., Ltd., China. Abstract: A commercially viable technique for passive temperature compensation in EDFAs based on a MZ interferometer with a variable splitting ratio is developed and described. It allows system engineers to simultaneously achieve better gain flatness, small size, low power consumption and heat production.

M3G.3 • 17:15  Low-loss Fiber-bundle-type Fan-in/Fan-out Device for 6-mode 19-core Fiber, Kota Shikama, Yoshide Abe, Hirotaoka Ono, Atsushi Arakata, ‘NIT Device Technology Laboratories, Nippon Telegraph and Telephone Corporation, Japan. We describe a low-loss fiber-bundle-type fan-in/fan-out device for 6-mode 19-core fiber, which achieves physical-contact connection. We suppress the mode-dependent loss of the device by accurately arranging fibers and utilizing a precise rotational alignment mechanism.

M3G.4 • 17:30  Invited  G.654.E Fibre Deployments in Terrestrial Transport System, Shikui Shen, Guangquan Wang, Haijun Wang, Yongtao Li, Shuo Wang, Chenfang Zhang, Chuxun Zhao, Jing Li, Hao Chen, ‘China Unicom, China; “COPC, China; “Coming Optical Communication China, China. Multi-vendors G.654.E fibres field trials for 400G terrestrial transport systems were demonstrated. The evaluation works carried out by China Unicom for high bit-rate terrestrial transport application are introduced. Test results in factories and fields are analyzed detailed.

M3H.4 • 17:00  Tutorial  Programmable Access and Edge Cloud Architecture, Peter Vetter, ‘Nokia Bell Labs, USA. We will discuss how converged access deployment will become more flexible thanks to a data center like approach for central offices, in which the control will be disaggregated from access functions in the data plane implemented on servers or specialized hardware.

M3I.5 • 17:00  Optical Spectrum Analysis with a Resolution of 6 fm based on a Frequency-Swept Microwave-photonic Source, Beiwei Zhu, Min Xue, Shilong Pan; ‘Nanjing Univ Aeronautics & Astronautics, China. A full-polarization optical spectrum analyzer is proposed based on a frequency-swept microwave-photonic source and balanced photodetection. A resolution of 0.75 MHz (6 fm) and a dynamic range of >57 dB were experimentally achieved.

M3J.6 • 17:15  On-chip Simultaneous Multi-channel Ultra-wideband Radio Frequency Spectrum Analyzer, Ming Ma, Rhyg Adams, Lawrence R. Chen; ‘McGill Univ., Canada; “Department of Physics, Vanier College, Canada. We demonstrate how to harness mode-selective excitation of nonlinear optical effects to perform simultaneous multi-channel RF spectrum analysis for both 640 GHz and 160 GHz waveforms using a single integrated silicon photonic device.

M3K.2 • 17:10  Novel Intra- and Inter-datacenter Converged Network Exploiting Space- and Wavelength-dimension Switches, Koh Ueda, Yojiro Mori, Hiroshi Hasegawa, Ken-ichi Satō; ‘Nagoya Univ., Japan. We propose a novel network architecture that enables intra- and inter-datacenter converged flow management. By adopting our proposed single large-scale optical circuit switch, intra- and inter-datacenter traffic can be transported without any blocking.
M3E.7 • 17:45  
Fast Statistical Estimation in Highly Compressed Digital RoF Systems for Efficient 5G Wireless Signal Delivery, Mu Xu1,2, Xiang Liu1, Naresh Chand1, Frank Effenberger1, Gee-Kung Chang1; 1Georgia Inst. of Technology, USA; 2Huawei R&D USA, Futurewei Technologies, USA.
A fast data compression algorithm is proposed for wireless-signal delivery in a digital RoF system supporting mobile fronthaul. Combined with resampling and advanced modulation formats, data-transmission efficiency is improved by 5 times in experimental demonstrations.

M3F.7 • 17:45  
Mode-selective Wavelength Conversion of Multicarrier, Multilevel Modulation Signals in a Multimode Silicon Waveguide, Ying Qiu1, Xiang Li1, Ming Luo1, Jing Xu1, Qi Yang1, Shaohua Yu1; 1WRI, China; 2Wuhan National Laboratory for Optoelectronics, Huazhong Univ. of Science and Technology, China.
We design and fabricate a multimode silicon waveguide to achieve mode-selective wavelength conversions of 100-Gb/s optical signals. Experimental results show that less than 2 dB power penalties are observed after wavelength conversion for both modes.
M3H • TDM and TWDM PON I—Continued

M3H.7 • 17:45 25Gb/s PAM4 Burst-Mode System for Upstream Transmission in Passive Optical Networks, Marco Dalla Santa1, Cleitus Antony1, Mark Power1, Anil Jain1, Peter Ossieur1, Giuseppe Talli1, Paul D. Townsend1; 1Tyndall National Inst., Ireland. A 25Gb/s PAM4 burst-mode upstream transmission is demonstrated over 25km of fiber using 10G components and a linear burst-mode TIA with a 14.7dB dynamic range and with differential chromatic dispersion equivalent to 25km of fiber.

M3K • Optical Data Center Networks—Continued

M3K.5 • 17:45 Emulation of a 16×16 Optical Switch Using Cascaded 4×4 Dilated Hybrid MZI-SOA Optical Switches, Minsheng Ding1, Adrian Wonfor1, Qixiang Cheng1, Richard Penty1, Ian H. White1; 1Department of Engineering, Univ. of Cambridge, UK. We demonstrate the first cascaded operation of integrated 4x4 hybrid MZI-SOA optical switches. Experimental studies emulate a 16×16 hybrid switch with 15dB IPDR for 1dB penalty and 43% reduced power consumption than equivalent SOA-based switches.
We demonstrate advanced features, performance constellations, fiber nonlinearity compensation, and probabilistic soft-decision FEC codes for increased speed and capacity. Up to now, this competition seems to drive innovation in the direction of increased speed and capacity as vendors introduce high-performance soft-decision FEC codes, fiber nonlinearity compensation, and probabilistic constellation shaping. With all these advanced features, performance...

continued on page 80
In this paper, we review the Open hardware initiatives, including design, adoption and control of future environments. Most recently, the concepts of open hardware and software are being used within the optical infrastructure domain, and this trend is expected to facilitate innovation, design, adoption and control of future optical infrastructure.

Open hardware initiatives, including the Open Compute Platform, Telecom

Michael R. Watts is a principal investigator in the Research Laboratory of Electronics (RLE) and a member of the Electrical Engineering and Computer

continued on page 81
is getting closer and closer to the Shannon limit, making significant performance improvements in the range of >1dB unlikely to occur. At the same time, power consumption is getting more and more important and the timeline of new ASIC genera-
tions is following closer and closer the availability of new lower power CMOS process nodes, for which the end of Moore’s law has been predicted.

This brings up the question whether the industry as a whole would benefit from a successful standardization of coherent DSPs. Today, pretty much all coherent DSPs include a 10GQ DP-
QPSK mode which is interoperable. However, it uses a hard-decision FEC which cannot compete with more advanced soft-decision FECs. Looking forward, the following questions arise:

- What would it take to standardize higher-order modulation schemes e.g. 16QAM and 64-QAM as well as high-performance FECs?
- Do operators see potential benefits in this?
- Will standardization of coherent DSPs finally be driven by the need for high-capacity short-reach?
- Is the optics market truly unique or will it ultimately be shared among 2-3 players (compare markets like CPU, GPU, LTE, PON, DSL, ...)?

On this panel, we want to elude answers to these questions by bringing together speakers from key operators and system vendors.

Panelists:
Marco Bertolini, Nokia Corporation, Italy
Dirk van den Borne, Juniper Networks, Inc., Germany
Markus Weber, Acacia Communications Inc., Germany
Werner Weiershausen, Deutsche Telekom, Germany

Tu2A • Panel: Coherent Interoperability Beyond QPSK - Is it Needed and What Will it Take?—Continued
Numerous proof-of-concept implementations and distributions across various research projects and early stage commercial initiatives, have demonstrated that rapid innovation is possible on basis of open hardware, interfaces, and software. Increasingly, these implementations and distributions will have to support the growing need for open optical hardware platforms.

The Open Platform Summit will discuss recent trends on open platforms and its applications to the optical networking space. It will comprise two technical sessions; the first session will have invited talks to introduce the audience to the topic area. The second session will comprise interactive table-top SDN & NFV demos selected from proposal submitted through the OFC system.

Speakers:
Saurav Das, Open Networking Foundation, USA
Young Lee, Huawei, USA
Anees Shaikh, Network Architect, Google - Open Management Plan for Transport Networks
Yasushi Sugaya, Fujitsu, Japan

Tu2H.2 • 14:30 Efﬁcient Single-drive Push-pull Silicon Mach-Zehnder Modulators with U-shaped PN Junctions for the O-Band, Zheng Yang1, Wesley D. Sacher1, Ying Huang1, Jared C. Mikkelsen1, Yisu Yang1, Xianshu Luo1, Patrick Dumais2, Dominic Goodwill2, Hadi Bahrami1, Guo-Qiang Lu2, Eric Bernier1, Joyce K. Poon1, 1Univ. of Toronto, Canada; 2Inst. of Microelectronics, A*STAR, Singapore; 2Huawei Technologies Canada Co. Ltd., Canada. We demonstrate silicon Mach-Zehnder modulators with efﬁcient (V_L = 0.46V/cm at a bias of -0.5V) and low-loss phase-shifters for the O-band. A 2.2mm long device had a 3-dB bandwidth of 13GHz and supported 24Gb/s modulation.

Tu2J.2 • 14:30 MIMO-Free Transmission over Six Vector Modes in a Polarization Maintaining Elliptical Ring Core Fiber, Lixian Wang1, Reza M. Nejad1, Alessandra Corsi1, Jachuan Lin1, Younès Messaddeq1, Leslie Rusch1, Sophie La-Rochelle1, 1COPL, Univ. Laval, Canada. We demonstrate an elliptical ring core ﬁber featuring vector modes with high stability and linear polarization states. We achieve six vector mode channel transmission over 0.9 km of 32 Gbaud QPSK without MIMO/PDM signal processing.

Tu2K.2 • 14:30 Multi-dimensional Quasi-passive Reconfigurable (MD-QPAR) Node for Future 5G Optical Networks, Ke Wang1, 2, Apurva Gawda1, Yingying Bi1, Leonid G. Kazovsky2, 1School of Engineering, RMIT Univ., Australia; 2Department of Electrical Engineering, Stanford Univ., USA. A multi-dimensional quasi-passive reconfigurable node is proposed and demonstrated for dynamic power and wavelength allocations in future 5G optical network applications. The traffic delay is reduced by >95% and the power penalty is negligible.

Science Department (EECS) at the Massachusetts Institute of Technology. Professor Watts’ research focuses on photonic microsystems for low-power communications, sensing, and microwave-photonic applications. His current interests include the modeling, fabrication, and testing of large-scale implementations of microphotonic circuits, systems, and networks that are being integrated, directly or through hybrid techniques, with CMOS electronics for high-speed transmitting, switching, and routing applications of digital signals. Additional interests include large-scale microphotonic sensing and imaging arrays, along with optical phased arrays, nanophotonic antennas, nonlinear optics, and manipulations of optical-electromagnetic fields on-chip.

Enabling Next Generation Physical Layer Solutions
OIF
13:45–14:45
For more details, see page 46

Advancing Optical Interoperability in Open Networks
Session Sponsored by Juniper
14:00–17:00
For more details, see page 44

Panel III: Global Market for Subsea Fiber Optic Networking Applications
14:30–16:00
For more details, see page 41

The Key to Unlocking the Benefits of SDN
OIF Interop
15:00–16:00
For more details, see page 47

International Photonic Systems Roadmaps
16:00–17:00
For more details, see page 47
Tu2A • Panel: Coherent Interoperability Beyond QPSK - Is it Needed and What Will it Take—Continued

Tu2B • Advanced VCSEL Links—Continued

Tu2C • SDM Switches—Continued

Tu2D • Modulation, Detection and DSP for PAM-4 Systems—Continued

Tu2E • High Bit-rate Transmission Systems—Continued

Tu2F • Microwave Photonics Enabling Devices—Continued
We present two SiP modulator architectures for multi-level Signal Generation and Transmission. Alixe Samani, Mathieu Chagnon, Essam El Faiky, David Patel, Maxime Jacques, Venkat Veerasubramanian, David Plant, McGill Univ., Canada. We present two SiP modulator architectures for PAM-4 signal generation. We demonstrate the transmission of 56 Gbaud PAM-4 over 1 km of SMF. An 84 Gbaud PAM-4 generation below KP4 FEC threshold is also achieved.

Top-Two A 44Gbps High Extinction Ratio Silicon Mach-Zehnder Modulator with a 3D-Integrated 28nm FD-SOI CMOS Driver, Zheng Yong, Stefan Shopyov, Jared C. Mikkelsen, Robert Mallard, Jason C. Mak, Sorin P. Voinigescu, Joyce K. Poon, Univ. of Toronto, Canada; Innovation Park at Queen’s Univ., CMC Microsystems, Canada. We present a silicon electro-optic transmitter consisting of a 28nm UTBB FD-SOI CMOS driver flip-chip integrated onto a Mach-Zehnder modulator. At 44 Gbps, the extinction ratio was 6.4 dB at the modulator quadrature operation point.

Strongly-Coupled Five-mode Ring-core Fibers for MDM Transmission with MIMO DSB, Takayoshi Mori, Taji Sakamoto, Masaki Wada, Azusa Urushibara, Takashi Yamamoto, Kazuhide Nakajima, NTT Corpora, Japan. The group delay spread reduction induced by a constant bend is experimentally confirmed using a five-mode ring-core fiber. Five spatial modes were successfully transmitted using a low-loss multiplexer composed of a five-core bundle.

For more details, see page 47.
Tuesday, 21 March

Tu2A • Panel: Coherent Interoperability Beyond QPSK — Is it Needed and What Will it Take?—Continued

Tu2B • Advanced VCSEL Links—Continued

Tu2C • SDM Switches—Continued

Tu2D • Modulation, Detection and DSP for PAM-4 Systems—Continued

Tu2E • High Bit-rate Transmission Systems—Continued

Tu2F • Microwave Photonics Enabling Devices—Continued

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**Room 403A**

We experimentally demonstrate 800 Gbit/s Dual Channel Transmitter with 1.056 Tbit/s Gross Rate, Karsten Schuh1, Fred Buchall1, Wilfried Idles2, Tobias A. Eriksson2, Wolfgang Tempel2, Lars Altenhain2, Ulrich Duerler2, Rolf Schmid2, Michael Moeller2, ZTE Tx Inc, ZTE Tx Inc, KAIST, USA. We experimentally demonstrate a 4x50Gb/s SWDM VCSEL link over 50m OM4 multimode fiber achieving error free operation (BER<1E-12). Transmission of 4x44Gb/s SWDM over 100m OM4 fiber with error free is also presented.

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**Room 403B**

We demonstrate for the first time a 4×50Gb/s NRZ SWDM link over 50m Multimode Fiber, Tam N. Huynh1,2, Fuad Doany1, Daniel Kuchta1, Deepa Gazula1, Edward Shaw1, Jason O’Daniel1, Jim Tatum1, IBM T.J. Watson Research Center, USA; R&D, Coriant Advanced Tech, USA; Finisar Corp., USA. We demonstrate for the first time a 4×50Gb/s NRZ SWDM VCSEL link over 50m OM4 multimode fiber achieving error free operation (BER<1E-12). Transmission of 4×44Gb/s SWDM over 100m OM4 fiber with error free is also presented.

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**Room 404AB**

Recent Advances in Short Reach Systems, Kang Ping Zhong1, Xian Zhou1, Yiguang Wang1, Tao Gui1, Yanfu Yang1, Jinhui Yuan1, Liang Wang1, Wei Chen1, Hongyu Zhang1, Jianguo Man1, Li Zeng1, Changyan Yu1, Alan Pak Tao Lau1, Chao Lu1, The Hong Kong Polytechnic Univ., Hong Kong; “CUHK, Hong Kong; “Huawei, China. In this paper, we review recent advances in high speed optical short reach transmission systems. Recent progress on advanced modulation formats, DSP, transmission schemes and devices are discussed.

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**Room 405AB**

Tu2D.6 • 15:15
Transmission of 56-Gb/s PAM-4 Signal over 20 km of SSMF Using a 1.55-μm Directly-Modulated Laser, Minsik Kim1, Sunghyun Bae1, Hoon Kim1, Yun Chul Chung1; KAUST, USA. We demonstrate the transmission of 56-Gb/s PAM-4 signal over 20 km long SSMF by using a 1.55-μm DML without optical dispersion compensation. Instead, a linear electric equalizer is used for the compensation of dispersion-induced waveform distortions.

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**Room 406AB**

Tu2E.5 • 15:15
WDM Transmission of 16-Channel Single-carrier 128-Gbaud PDM-16QAM signals with 6.06 b/s/Hz SE, Junwen Zhang1, Jianjun Yu1, Hung-Chang Chien1; ZTE Tx Inc, USA. We experimentally demonstrate the WDM transmission of 16-channel single-carrier 1.024 Tb/s signals based on 128-Gbaud all-ETDM PDM-16QAM signals over 320-km stand single-mode-fiber with EDFA-only amplification with joint transmitter and receiver-side signal processing.

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**Room 407**

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**Room 402AB**

Tu2B.5 • 15:30
4×50Gb/s NRZ Shortwave-Wave-length Division Multiplexing VCSEL link over 50m Multimode Fiber, Tam N. Huynh1,2, Fuad Doany1, Daniel Kuchta1, Deepa Gazula1, Edward Shaw1, Jason O’Daniel1, Jim Tatum1, IBM T.J. Watson Research Center, USA; R&D, Coriant Advanced Technology, USA; Finisar Corp., USA. We demonstrate for the first time a 4×50Gb/s NRZ SWDM VCSEL link over 50m OM4 multimode fiber achieving error free operation (BER<1E-12). Transmission of 4×44Gb/s SWDM over 100m OM4 fiber with error free is also presented.

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**Room 215x299 to 218x302**

We experimentally demonstrate for the first time a 4×50Gb/s NRZ SWDM link over 50m OM4 multimode fiber achieving error free operation (BER<1E-12). Transmission of 4×50Gb/s NRZ SWDM VCSEL link over 50m OM4 multimode fiber achieving error free operation (BER<1E-12). Transmission of 4×44Gb/s SWDM over 100m OM4 fiber with error free is also presented.
Experiments reveal, for the first time, the mode-dependent loss reduction effect of mode-dependent loss (MDL) in N-WDM transmission over 10 km at a BER of 6.6x10^-6 using a Stokes vector direct-detection receiver. We demonstrate 112 Gb/s DP-OOK reach direct-detection applications. Dual Core Polarization Diverse Silicon Photonic Add/Drop Switch Supporting 400Gb/s PDM-16QAM, Dominic Goodwill1, Chunshu Zhang1, Patrick Dumas1, Dritan Cel0, Jia Jia Jing1, Xueting Tang1, Zhuohong Zhang1, Fei Zhao1, Xin Tu1, Chunhua Zhang2, Shengyang Yan1, Jifang He1, Ming Li1, Wanyuan Liu1, Yuming Wei1, Dongyu Geng1, Hamid Mehr-var1, Eric Bernier1, Zihan Geng2, Mathieu Chagnon3, Mohammed Osman3, David Patel1, Mathieu Chagnon1, David V. Plant1, McGill University, Canada. We present an O-band dual-polarization silicon photonic intensity-modulator for short reach direct-detection applications. We demonstrate 112 Gb/s DP-QDR transmission over 10 km at a BER of 6.6x10^-6 using a Stokes vector direct-detection receiver.
Tu2B.6 • 15:45 4λ x 100Gbps VCSEL PAM-4 Transmission over 105m of Wide Band Multimode Fiber, Justin Lavrencik¹, Siddharth Varughese¹, Varghese A. Thomas¹, Gary Landry², Yi Sun³, Roman Shubochkin¹, Kasyapa Balemarthy³, Jim Tatum¹, Stephen E. Ralph¹, ¹Georgia Inst. of Technology, USA; ²Finisar, USA; ³OFS, USA. We demonstrate 100 Gbps PAM-4 transmission over 105m of wideband-MMF for each of four wavelengths from 850nm to 940nm using 25G VCSELs and thereby demonstrate an architecture that enables 400G over a single MMF.

16:00–16:30  Coffee Break, 400 Foyer; Exhibit Hall
Tu2G • Data Center Summit: Open Platforms for Optical Innovation—Continued

Tu2H • Silicon Photonic Modulators—Continued

Tu2I • Integrated Circuits for Signal Processing—Continued

Tu2J • Fibers and Components for Mode Division Multiplexing—Continued

Tu2H.7 • 15:45 Characterization of Electro-optic Bandwidth of Ultra-high Speed Modulators, Xi Chen¹, Sethumadhavan Chandrasekhar¹, Gregory Raybon¹, Po Dong¹, Borui Li¹, Andrew Adamiecki¹, Peter Winzer¹; ¹Nokia Bell Labs, USA. We propose and demonstrate a method for measuring the bandwidth of electro-optic modulators up to 100 GHz using an RF synthesizer, a Mach-Zehnder modulator, a photodiode, and an optical spectrum analyzer.

Tu2I.5 • 15:45 K-band RF Multi-beamformer Using Si₃N₄ TTD for Home-satellite Communications, Netsanet Tessema¹, Zzheng Cao¹, Johan van Zantoort¹, Ketema Addis Mekonnen¹, Aliee M. Trinidad¹, Eduard Tangdiongga¹, Bart Smolders¹, A. Kooren¹; Eindhoven Univ. of Technology, Netherlands. An optically controlled multi-RF beamformer for targeting more than one satellite is presented. Two beams in K-band of 6 Gbps each are generated by a 2x1 beamformer attached to a wavelength-dependent ring-based optical chip.

Tu2J.7 • 15:45 Experimental Analysis of the Modal Evolution in Photonic Lanterns, Juan Carlos Alvarado Zacarias¹,², Bin Huang¹,², Nicolas K. Fontaine², Haoshuo Chen², Roland Ryf², Jose Antonio Lopez², Rodrigo Amezcua Correa¹, Zeinab Sanjabi Eznaveh¹; ¹Univ. of Central Florida, USA; ²Nokia Bell Labs, USA. We experimentally analyze the modal evolution in a 10 mode-selective photonic lantern along the tapered transition using a swept-wavelength interferometer. Mode conversion to HOM's occurs closer to the beginning of the photonic lantern taper.

16:00–16:30 Coffee Break, 400 Foyer; Exhibit Hall

NOTES

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Coherent systems are widely deployed for high capacity long-haul networks, whereas direct detection (DD) implementations with low cost and low power consumption dominate short reach. Both approaches overlap in new fast-growing applications of short reach Metro and data center interconnects (DCI), requiring DWDM transport over distances around 100 km. In 2016 a commercial 100G PAM4 DD solution for 80km DWDM DCI was announced, and single-carrier 400G coherent solutions targeting similar applications have been demonstrated by multiple vendors. Will these solutions coexist, will one become the dominant solution over time, or will new alternatives become available? The panel will discuss the merits of different approaches and what progress we can expect as the technologies develop.

Panelists:
- Brandon Collings, Lumentum, USA
- Mark Filer, Microsoft Corporation, USA
- Radha Nagarajan, Inphi Corporation, USA
- Atul Srivastava, NEL Americas, USA

Tadao Nagatsuma received B.S., M.S., and Ph.D. degrees in electronic engineering from Kyushu University in 1981, 1983, and 1986, respectively. From 1986 to 2007, he was with Nippon Telegraph and Telephone Corporation. Since 2007, he has been a Professor at Graduate School of Engineering Science, Osaka University. His research interests include millimeter-wave and terahertz photonics and their applications to wireless communications, sensing, and measurement. He is a Fellow of the IEEE, and the Institute of Electronics, Information and Communication Engineers (IEICE), Japan. He currently serves as an Associate Editor of the IEEE Photonics Technology Letters, and a Director of the IEICE.
Tu3G.1 • 16:30 
**Top-Scored** Suppression of Burst-Mode Operation Induced Laser Wavelength Drift for Upstream Transmission in TWD-M-PON by Using an Integrated Heater for Thermal Control, Xuming Wu, Dekun Liu, Huafeng Lin, Xiang Liu, Huawei Technologies, China. We propose and experimentally demonstrate substantial suppression of the wavelength drift of a 10-Gb/s burst-mode directly-modulated laser for TWD-M-PON upstream transmission by using an integrated heater for thermal compensation, reducing the drift by 4.6 times to 5 GHz.

Tu3G.2 • 16:45
**Top-Scored** 50-Gb/s/4a TDM-PON Based on 10G DML and 10G APD Supporting PR10 Link Loss Budget after 20-km Downstream Transmission in the O-band, Zengzhe Xu, Lei Zhou, Wuhan Research Inst. of Posts and Telecommunications, China; 1Huawei Technologies, China; 2America Fixed Access Laboratory, Huawei Technologies, USA. We experimentally demonstrate 50-Gb/s/4a TDM-PON based on PAM4/DMT modulation respectively. By using digital signal processing and 10G-class optoelectronics, 20 dBm/-18 dBm receiver sensitivity is achieved in the O-band after 20-km downstream transmission.

David Richardson joined the Optoelectronics Research Centre (ORC) at Southampton University in 1989. Since 2000 he has been Deputy Director of the ORC with responsibility for optical fibre and laser related research. He has published more than 400 technical journal papers and produced more than 30 patents during his time at Southampton. Professor Richardson is a Fellow of the IEEE, OSA and the IET and was made a Fellow of the Royal Academy of Engineering in 2009. He received a Royal Society Wolfson Research Merit Award in 2013 for his optical communications research.

Tu3I.1 • 16:30
**Tutorial** Hollow Core Optical Fibers and Their Applications, David J. Richardson\(^1\), 1Univ of Southampton, UK. I review the current state-of-the-art in hollow core optical fibers describing in the process the different structural forms and associated guidance mechanisms possible, their key physical attributes and the steadily increasing range of end applications.

Tu3I.2 • 16:45
4×200Gb/s Twin-SSB Nyquist Subcarrier Modulation WDM Transmission over 160km SSFM with Direct Detection, Yuxiao Zhu, Xiaoke Ruan, Zeyu Chen, Minguan Jiang, Kaixing Zou, Yixiao Zhu, Haiying Li, Fanyuan Liu, Feng Liu, Chao-Li, Haifeng Zhou, Huafeng Lin, Huawei Technologies, China. We demonstrate a spectrally-efficient 4×200Gb/s WDM transmission based on twin-SSB Nyquist subcarrier modulation with signal–signal beat interference cancellation. The BER achieves $6.5 \times 10^{-2}$ (<20% HD-LEC) after 160km SSFM transmission.

Tu3J.1 • 16:30
**Invited** Subwavelength Index Engineered Waveguides and Devices, Pavel Cheben\(^1\), National Research Council Canada, Canada. We report our advances in development of subwavelength engineered structures for integrated photonics, specifically high-efficiency fiber-chip couplers, broadband surface grating couplers and ultra-broadband nanophotonic beam splitters.

As required by the optical system. A uniformity of 0.4dB across wafers was also been confirmed, the best performance to our knowledge realized in public-available silicon photonics platform.
In optical fiber, we experimentally demonstrate BER reduction and demonstrate BER reduction and double the capacity of an information channel.

**Temperature Dependent Analysis of 50 Gb/s Oxide-confined VCSELs**

Tu3C.2 • 17:00

**Amplitude Noise Suppression and Orthogonal Multiplexing Using Injection-locked Single-mode VCSEL**

Tu3C.3 • 17:15

**50-Gb/s PDM-DMT-SSB Transmission over 40km SSMF using a Single Photodetector in C-band**

Tu3D.3 • 17:15

**SONET and NFV-based Deployment of Data Receiving-storing-resending Function for Highly Reliable Transmission**

Tu3E.3 • 17:15

**Introducing the Fast Inverse NFT**

Tu3D.2 • 17:00

**First Field Trial Demonstration of Hitless Defragmentation with Signals Overlap in Elastic Optical Networks**

Tu3E.2 • 17:00

**Temperature dependent analysis of a high speed 850 nm oxide-confined VCSEL with 50 Gb/s error-free capability and a -3 dB modulation bandwidth of 24.7 GHz at 85 °C is reported.**

**We experimentally demonstrate transmi**
Tu3G • TDM and TWDM-PON II—Continued

Tu3G.3 • 17:00
40 Gb/s/A Optical Amplified PAM-4 PON with Transmission over 30 km SMF using 10-G Optics and Simple DSP, Jinlong Wei1, Elias Giacoumidis2; 1Optical Technology Department, Huawei Technologies Duesseldorf GmbH, European Research Center, Germany; 2Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), School of Physics, Univ. of Sydney, Australia. We experimentally demonstrate 40-Gb/s/A PAM-4 transmission over a 20-km (30-km) SMF using only 10-G optics and simple post-nonlinear equalizations with a link power budget of 38 dB (30.7 dB) at a threshold BER of 10−3.

Tu3G.4 • 17:15
Demonstration and Application of 37.5 Gb/s Duobinary-PAM3 in PONs, Robbert van der Linden1,2, Nguyen-Cac Tran3, Edward Tandjiongga1, A. Koonen1; 1Inst. for Photonic Integration, Eindhoven Univ. of Technology, Netherlands; 2Genexis B.V., Netherlands. Duobinary-PAM3 enables up to 37.5Gb/s with 10G receivers. It has less linearity requirements on transmitters and gains 2dB sensitivity compared to equal-bitrate PAM8. In a 10G flexible modulation scheme, DB-PAM3 enables 190% network utilization increase.

Tu3H • Tailored Propagation Effects—Continued

Tu3I • Direct-Detection Transmission Systems—Continued

Tu3J • Fiber-based Spatial Mode Multiplexers—Continued

Tu3K • Photonic Packaging—Continued

Tu3J.3 • 17:15
Top scored
Annular Core Photonic Lantern Spatial Mode Multiplexer, Zenas Tamjidi Esmavieh1, Juan Carlos Alvarado Zecarias1, Jose Antonio-Lopez1, Yang-min Jung1, Kai Shi1, Benn C. Thomsen3, David Richardson4, Sergio G. Leon-Saval5, Rodrigo Amezcua Correa1; 1CREOL, Univ. of Central Florida, USA; 2Optoelectronic Research Center, UK; 3Univ. College London, UK; 4Southampton Univ., UK; 5Univ. of Sydney, Australia. We demonstrate an all-fiber, ring core photonic lantern to generate high quality OAM modes up to the second order at 1550nm. We achieved low-loss coupling of the lantern OAM modes into a ring core fiber.
Tu3A • Panel: Direct vs. Coherent Detection for Metro-DCI—Continued

Tu3B • Terahertz Systems—Continued

Tu3C • VCSELs—Continued

Tu3D • Linear and Nonlinear Multicarrier Systems—Continued

Tu3E • Networks Operating in Challenging Environments—Continued

Tu3F • Reconfigurable Network Elements—Continued

Tu3B.2 • 17:30 Coherent Radio-over-Fiber THz Communication Link for High Data-Rate 59 Gbit/s 64-QAM-OFDM and Real-time HDTV Transmission, Andreas Stohl1, Manfred Hermele1, Matthias Steeg1, Boris Shih2, Anthony Ng’oma2; 1Science and Technology Dept., Corning Incorporated, USA; 2Corning Research Center Taiwan, Corning Incorporated, Taiwan. We report a coherent Radio-over-Fiber (CoRoF) THz communication link supporting both, off-line high data-rate 59 Gbit/s transmission using a record spectral efficient 64-QAM-OFDM modulation as well as real-time HDTV transmission at 328 GHz carrier frequency.

Tu3B.3 • 17:45 Top-Scored Demonstration of 352 Gbit/s Photonically-enabled D-Band Wireless Delivery in one 2x2 MIMO System, Rafael Puerta1, Jianjun Tu2, Xinying Li1, Yuming Xu1, Juan José Vegas Olmos1, Idelfonso Tafur Monroy2; 1Department of Photonics Engineering, Technical Univ. of Denmark, Denmark; 2ZTE (TX) Inc, USA. These results were achieved by means of advanced DSP and antenna polarization multiplexing (2x2 MIMO).

Tu3C.4 • 17:30 Tutorial High-Capacity VCSEL Links, Daniel Kuchta1,2; 1IBM TJ Watson Research Center, USA. This tutorial will cover the use and application of directly modulated Vertical Cavity Surface Emitting Lasers (VCSELs), for Data Centers and High Performance Computing (HPC) applications. Topics will include, advances in modulation formats, packaging, and fibers.

Tu3D.4 • 17:30 200-Gb/s Polarization-multiplexed DMT using Stokes Vector Receiver with Frequency-Domain MIMO, Di Che1,2, Feng Yuan1, William Sheih1,2; 1Univ. of Melbourne, Australia. We propose frequency-domain MIMO equalization for the Stokes vector direct detection with OFDM modulation, verified by a 50-Gb/s polarization-multiplexed DMT experiment. The algorithm can be generalized to other OFDM-based Stokes-space modulation systems.

Tu3D.5 • 17:45 Transient Filter Optimization for Improved Performance of Time-frequency Packing System, Qian Hu1, Fred Buchali1, Laurent Schmalen1, Wilfried Idler1; 1Aref Communication Subsystems Department at the IBM Thomas J. Watson Research Center. He received B.S., M.S., and Ph.D. degrees in Electrical Engineering and Computer Science from the University of California at Berkeley in 1986, 1988, and 1992, respectively. He subsequently joined IBM at the Thomas J. Watson Research Center, where he has worked on high-speed VCSEL characterization, multimode fiber links, and parallel fiber optic link research. Dr. Kuchta is an author/coauthor of more than 135 technical papers and inventor/co-inventor of at least 20 patents.

Tu3E.4 • 17:30 Demonstration of Survivable vSD-EON Slicing with Automatic Data Plane Restoration to Support Reliable Video Streaming, Jie Yin1,2, Jiannan Guo1, Bingxin Kong1, Zuqing Zhu1; 1Univ of Science and Technology of China, China. We design and experimentally demonstrate a network slicing system which can not only construct vSD-ECNs dynamically for upper-layer applications but also recover their data plane services automatically and timely during substrate link failures.

Tu3F.4 • 17:30 Optical Tunable Filter for Gridless ROADM, Masaki Niwa1, Yojiro Mori1, Hiroshi Hasegawa2, Ken-ichi Sato1,2; 1Nagoya Univ., USA. We fabricate an optical tunable filter for gridless signal drop in ROADMs. Its effectiveness is confirmed by experiments on 10-Gb/s intensity-modulated signals with 50-GHz spacing and 32-Gb/s dual-polarization QPSK and 16QAM signals with 33.3-GHz spacing.
This paper described how thoughtful consideration of the materials from which the fibers are made can have marked effects on stimulated Brillouin scattering mitigation; more so than achievable through complex microstructuring of the optical fiber.

We propose a digital MFH system exploiting sample bits interleaving and uneven PAM4. Digitized LTE-A signal transmission is experimentally demonstrated via 25Gbps fiber link. The results indicate that, ~13dB EVM reduction can be achieved, compared with evenly-spaced PAM4.

We have demonstrated photonic packaging compatible with standard, high-throughput, microelectronics assembly lines. We show a 1.3dB fiber-to-chip loss and 1.1dB chip-to-chip loss. We discuss the rationale behind this approach and compare to other packaging directions.
Intermediate results from a THz wireless transmission in the 0.4 THz band. We experimentally demonstrate a single channel 106 Gbit/s 16QAM WDM system. The measured Q-factor is greater than 13 dB after 20-km standard single-mode fiber transmission.

We present an FPGA-based QPSK-encoded 9.375 Gb/s layered/enhanced ACO-OFDM transmitter, giving a high spectral efficiency. We numerically and experimentally investigated to predict the bit error rate of a layered/enhanced ACO-OFDM transmitter giving a high spectral efficiency. The measured Q-factor is greater than 13 dB after 20-km standard single-mode fiber transmission.

We demonstrate experimentally the feasibility of a low phase noise CO-MB-OFDM burst transmitter for time and spectral optical aggregation based on our proposition of a 100 kHz linewidth and 100 ns switching time laser source.
Tu3G.7 • 18:00
Directly Modulated and ER Enhanced Hybrid III-V/SOI DFB Laser Operating Up to 20 Gb/s for Extended Reach Applications in PONs, Valentina Cristofori, Francesco Da Ros, Mohamed E. Chaibi, Yunhong Ding, Laurent Bramerie, Alexandre Shen, Antonin Galliet, Guang-Hua Duan, Leif K. Oxenlowe, Christophe Peucheret, DTU Fotonik, Technical Univ. of Denmark, Denmark; FOTON Laboratory, Univ. of Rennes 1, France; Nokia-Thales-CEA, III-V Lab, France. We demonstrate error-free performance of an MRR filtered DML on the SOI platform over 40- and 81-km of SSMF. The device operates up to 17.5 Gb/s over 81 km and 20 Gb/s over 40 km.

Tu3G.8 • 18:15
Requirements on Resolution and Sampling Jitter of ADC in 10G-Class Optics and MLSD based NG-EPON, Zhengxuan Li, Jian Chen, Yingqiong Song, Min Wang, Shanghai Univ., China; ZTE Corporation, China. The impact of sampling jitter and resolution of ADC on the performance of MLSD-based NG-EPON is analyzed. 30-dB loss budget is achieved in 25-Gb/s applications using 25-Gb/s, 3-bit ADC with ±2.5-ps timing jitter tolerance.

Tu3H.3 • 18:00
Tailoring Nonlinear Frequency Generation in Graded-index Multimode Fibers, Mohammad Amin Eftekhari, Zeinab Sanjabi Enezvehi, Jose Antonio Lopez, Miroslav Kolesik, Axel Schulzgen, Frank W. Wise, Demetrios N. Christodoulides, Rodrigo Amezcua Correa, CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA; College of Optical Sciences, The Univ. of Arizona, USA; Applied and Engineering Physics, Cornell Univ., USA. We demonstrate that frequency generation in multimode graded-index fibers can be tailored through appropriate fiber design. This is achieved by exploiting a geometric parametric instability which can be utilized for developing novel fiber light sources.

Tu3J.5 • 18:00
10-Mode Photonic Lanterns Using Low-index Micro-structured Drilling Preforms, Bin Huang, Juan Carlos Alvarado Zacarias, Nicolas K. Fontaine, Haoshuo Chen, Roland Ryf, Francesco Poletti, John R. Hayes, Jose Antonio-Lopez, Rodrigo Amezcua Correa, Guangfeng Li, Univ. of Central Florida, USA; Nokia Bell Labs, USA; Univ. of Southampton, UK. We demonstrate low mode-dependent loss 10-mode photonic lanterns using low-index micro-structured drilling preforms. The adiabatic requirement for lantern tapering can be alleviated by the proposed solution leading to improved performances.

Tu3J.6 • 18:15
Mode-selective Photonic Lanterns from Multicore Fibres, Stephanos Yerolatantis, Kerrienne Harrington, Robert Thomson, Tim A. Birks, Univ. of Bath, UK; Heriot-Watt Univ., UK. We report mode-selective photonic lanterns made from multicore fibres with several dissimilar cores. Six-mode and ten-mode multiplexers are demonstrated. Such designs potentially offer the maximum possible number of multiplexed modes in mode-selective photonic lanterns.

Tu3K.5 • 18:00
Thermally Expanded Core Fiber with a 4-μm Mode Field Diameter Suitable for Low-loss Coupling with Silicon Photonic Devices, Takuya Oda, Keisuke Hirakawa, Kentaro Ichii, Satoshi Yamamoto, Kazuhiko Akawa, Advanced Technology Laboratory, Fujikura Ltd., Japan. We developed thermally expanded core fibers with a 4-μm mode field diameter. The connection loss with conventional single-mode fibers is below 0.2 dB. The coupling loss with silicon devices can be below 1.5 dB/facet.

16:30–18:30 Tu3L • Data Center Summit: SDN & NFV Demo Zone, 400 Foyer (Extended Coffee Break)

17:30–19:00 Exhibitor Reception, Lucky Strike Live LA, 800 W Olympic Blvd (Exhibitor badge required)
Tu3L1
SDN Control Framework with Dynamic Resource Assignment for Slotted Optical Datacenter Networks, Giada Landi¹, Ioannis Patronas¹, Konstantinos Konodimos¹, Muzammil Jazi², Konstantinos Christodouloulopoulos¹, Angelos Kynakos¹, Marco Capitan³, Amireza F. Hamedanid, Dionysis Reiss³, Emmanuel Varvarigos³, Paraskaves Bakopoulou⁴, Hercules Avramopoulou⁴, ¹National Technical Univ. of Athens, Greece; ²Computer Engineering and Informatics Department, Univ. of Patras, Greece; ³Networks, Italy; ⁴Gesellschaft für wissenschaftliche Datenverarbeitung mbH, Germany. An SDN control framework is demonstrated enabling slotted operation for dynamic resource assignment in optically-switched datacenters. The demonstration includes the SDN controller with scheduler plugins and north-southbound interfaces, and the SDN agent communicating to data-plane.

Tu3L2
Fully Automated Peer Service Orchestration of Cloud and Network Resources using ACTN and CSO, Ricard Vilalta¹, Young Lee¹, Haomin Zheng³, Yi Le³, Ramon Casellas¹, Arturo Mayoral⁴, Ricardo Martinez⁴, Raúl Muñoz⁴, Luis Miguel Contreras Murillo⁴, Victor Lopez⁴, CTC, Spain; ²Huawei Technologies USA R&D Center, USA; ³Huawei Technologies Co., China; ⁴Telefónica Global CTO, Spain. This demo proposes the fully automated establishment of a network service using a peer inter-CSO interface in ACTN. The underlying network resources have been abstracted and virtualized in order to provide a network slice.

Tu3L3
Demonstration of the Benefits of SDN Technology for All-optical Data Centre Virtualisation, Chris R. Jackson¹, Reza Nejabati², Fernando Agra³, Albert Pagés³, Michael Galí³, Salvatore Spadaro⁴, Dimitri Simeonidou⁴, ¹Univ. of Bristol, UK; ²Universitat Politècnica de Catalunya, Spain; ³Danmarks Tekniske Universitet, Denmark. An integrated software stack made up of extended OpenStack, OpenDaylight and custom OpenFlow agents enabling Virtual Data Centre deployment on an all-optical architecture exploiting hollow-core fibre, TDM fast switches and a circuit switched backbone.

Tu3L4
E2E Transport API Demonstration in Hierarchical Scenarios, Victor Lopez¹, Luca Nobile², Nethumarian¹, Arturo Mayoral Lopez de Lema³, Lyndon Y. Ong⁴, Rafal Szwezdowski⁴, Fabio Marques⁴, Anurag Sharma⁴, Francesco Bosso³, Oscar Gonzalez de diez⁴, Ori Geret³, Felipe Druesedau¹, Ricard Vilalta⁴, Hector Siva⁴, Achim Autenrieth⁵, Nuno Borges⁵, Chris Liu⁵, Giorgio Cazzagnini⁵, Juan Pedro Fernandez Palacios⁵, CTTCC, Spain; ²GCTC, Spain; ³GCTC, Spain; ⁴Telefónica +D, Spain; ⁵Sedona Systems, Israel; ⁶NEC, USA; ⁷Coriant GmbH, Germany; ⁸Infinea, USA; ⁹SM Optics, Italy; ¹⁰ADIVA, Germany; ¹¹Ciena, USA. We validate the Transport API interoperability with a hierarchical orchestration layer. The demonstration shows the end-to-end provision of connections based on the topology and connectivity services of the Transport API.

Tu3L5
Demonstration of a SDN-based Spectrum Monitoring of Elastic Optical Networks, Matteo Dallaglio¹, Quan Pham Van¹, Fabien Boitier¹, Camille Delezoide¹, Dominique Verchère¹, Patricia Layec¹, Amaud Dupas¹, Nicola Sambro², Sébastien Bipo³, Pierre Castoldi³, Nokia Bell Labs, France; ²Scuola Superiore Sant’Anna, Italy. We demonstrate optical channel monitoring capabilities executed as SDN applications. To guarantee Quality of Transmission, diagnostic is performed by dynamically selecting the list of optical parameters to be monitored and by adjusting their polling rates.

Tu3L6
INDIRA: ‘Application Intent’ Network Assistant to Configure SDN-based High Performance Scientific Networks, Anu Mercian¹, Mariam Kiran¹, Eric Pousoyal, Brian Tierney⁴, Inder Monga⁴, ESN2E Lawrence Berkeley National Labs, USA. We demonstrate INDIRA (Intelligent Network Deployment Intent Renderer Application), an interactive network assistant that will help us configure a data path between two scientific end-point groups (EPGs) to optimize the transfer of elephant data flows.

Tu3L7
APP Store Installed on ONOS-based Multi-layer and Multi-domain Transport SDN Platform with Novel TE Abstraction, Yongli Zhao¹, Boyuan Yan¹, Wei Wang¹, Haomin Zheng³, Yi Le³, Young Lee³, Huaying Xu³, Ruiquan Jing³, Yunbin Xu³, Guangyi Zhang³, Jie Zhang³, Yuefei Ji³, ¹Beijing Univ of Posts & Telecom, China; ²Huawei Technologies Co., China; ³Huawei Technologies, USA Research Center, USA; ⁴China Telecom Beijing Research Inst., China; ⁵China Academy of Information and Communication Technology, China. An APP store is demonstrated over multi-layer and multi-domain transport software defined networks (T-SDN) platform, which is developed based on IETF ACTN standard. A novel traffic engineering (TE) abstraction method is used with different applications demonstrated.

Tu3L8
Open and Disaggregated Multi-layer Networks, Marc De Leeheer¹, Ayaka Kashibashi¹, Yuta Higuchi¹, Naoki Shiota¹, Helen Wu², Toru Furusawa², Tom Tolg³, Guru Parulkar⁴, ¹ON.Lab, USA; ²NICT, Japan; ³AT&T, USA; ⁴NICT Communications, Japan; ⁵AT&T, USA; ⁶Stanford Univ, USA. Disaggregation of both packet and optical networks is driving innovation in transport networks. We demonstrate a proof of concept and detail our plans for a field trial in a major service provider.

Tu3L9
Automation of Optical Provisioning on Multi-vendor Metro Optical Platforms, Marco Razi¹, Facebook, USA. This demonstration is going to automate provisioning of multivendor optical platforms supporting API based configurations, using transport interfaces such as NETCONF/REST.

Tu3L10
Intent-based In-flight Service Encryption in Multi-layer Transport Networks, Mohit Chamania¹, Thomas Szkypek², Michele Santuari², Domenico Siracusa², Achim Autenrieth¹, Victor Lopez¹, Pontus Skoldstrom³, Stefanie Juniqué⁴, ADIVA Optical Networking, Germany; ²CREATE-NET Research Center, Italy; ³Telefónica +D, Spain; ⁴ACREO Swedish ICT AB, Sweden. We demonstrate multi-layer encrypted service provisioning via the ACINO orchestrator. ACINO combines a novel intent interface with an ONOS-based SDN orchestrator to facilitate encrypted services at IP, Ethernet and optical network layers.

Tu3L11
Demonstration of NFV Content Delivery using SDN-enabled Virtual Infrastructures, ALI Hammad¹, Jaume Marhuenda¹, Shuangyi Yan², Reza Nepatbi², Dimitra Simeonidou³, ¹Univ. of Bristol, UK. We will demonstrate the composition and operation of a virtual infrastructure (VI) for NFV content delivery. The demonstrated VI will be controlled through SDN controller. Furthermore, an infrastructure replanning mechanism will be also demonstrated.

Tu3L12
Software-programmed Optical Networking with Integrated NFV Service Provisioning, Victor Mehmeri¹, Xi Wang¹, Shrutashi Basu³, Qiong Zhang⁴, Paparo Palcharia⁴, Tadashi Ikueki⁵, Idfelonsa Tafur Morany⁴, Juan José Vegas Olmos⁴, Nate Foster⁴, ¹Technical Univ. of Denmark, Denmark; ²Fujitsu Laboratories of America, USA; ³Cornell Univ, USA. We showcase demonstrations of “program & compile” styled optical networking as well as open platforms & standards based NFV service provisioning using a proof-of-concept implementation of the Software-Programmed Networking Operating System (SPNS OS).

Tu3L13
Performance-assured Network Function Virtualization for Open and Disaggregated Optical Transport Systems, Ryousei Takano¹, Takahiro Hirofuchi¹, Hirokazu Takahashi¹, Norio Sakaï¹, Katsuhito Shimano¹, Kyo Ishii¹, Satoshi Suda¹, Shu Namiki¹, Tomohiro Kudo¹, ¹AIST, Japan; ²Univ of Tokyo, Japan; ³NTT Network Innovation Laboratories, Japan. A performance-assured Network Function Virtualization (NFV) method for software-based packet processing on an open and disaggregated optical transport networks will be demonstrated. Our technique improves NFV operations by leveraging cache memory allocation and monitoring.

Tu3L14
An End-to-End Programmable Platform for Dynamic Service Creation in 5G Networks, Ahmad Rostami¹, Allan Vital¹, Mateus A. Santos¹, Mohammad Rehan Raza¹, Farnaz Moradi¹, Bertrand Pechenot¹, Zere Ghebretenase¹, Paolo Monti¹, Peter Ohlen¹, ¹Ericsson Research, USA; ²KTH Royal Inst. of Technology, Sweden; ³Acreo, Sweden. We demonstrate how SDN and NFV can bring end-to-end service creation to the 5G era. We present a multi-domain orchestration platform and programmable optical transport, radio and cloud networks, which can in turn be leveraged for agile and resource-optimized service creation.

Tu3L15
A Multi-operator Network Service Orchestration Prototype: The 5G Exchange, Andrea Sgamellini¹, Andrea Milan¹, Janós Czentye¹, Javier Melian¹, Wint Y. Poe¹, Francesco Tusa³, Oscar Gonzalez de diez³, Balazs Sorkoly³, Moltka Gharbasou³, Francesco Paolucci¹, Elisa Meini¹, Giovanni Gionarti¹, Aurora Ramos¹, Paolo Monti¹, Luis Miguel Contreras Murillo¹, Ishan Vashnavi¹, Carlos Jesus Bernardo Cano¹, Robert Szabo¹, ¹KTH Royal Inst. of Technology, Sweden; ²Hewlett Packard Enterprise (HPE), Italy; ³Budapest Univ. of Technology and Economics BME, Hungary; ⁴ATos Spain SA, Spain; ⁵Huawei Technologies Dusseldorf GmbH, Germany; ⁶Univ. of College London, UK; ⁷Telefónica, Spain; ⁸Universidad Carlos de la Nueva, Spain; ⁹Ericsson Research, TrafficLab, Hungary; ¹⁰Sant’Anna di Pisa, Italy. In the context of the 5G Exechange Project, a multi-domain orchestrator is in charge of creating, deploying, and terminating Network Services spreading across multiple operators. This live demo showcases the main functionalities of the 5GEX system.
In this work, we present first, Kai-Ming Feng, Amir Atabaki, Yunsup Lee, Sen Lin, Jonathan Leu, Yu-Hsin Chen, Rimas De Kleine, Luca DeSanctis, Koshin Kogaku Co., Ltd., and OIC, Japan. Two-modeside CRR structure, the other three show comparable narrow-linewidth (~200kHz) and output power (~10mW) across entire wide-tuning ranges (~40nm) with SMF (>40dB).

W1E.1 • 08:00
A Direct Comparison between Heterogeneously Integrated Widely-tunable Ring-based Laser Designs, Linjun Liang, Jared Hulme, Rui-Lin Chao, Tim Komijenovic, Jin-Wei Shi, Shuhasheng Jian, John E. Bowers, Univ. of California Santa Barbara, USA; Inst. of Lightwave Technology, Beijing Jiaotong Univ., China; Dep. of Electrical Engineering, National Central Univ., Taiwan. Four ring-based tunable lasers are demonstrated in the heterogeneous silicon platform. Except for double-sided CRR structure, the other three show comparable narrow-linewidth (~200kHz) and output power (~10mW) across entire wide-tuning ranges (~40nm) with SMF (>40dB).

W1E.2 • 08:15
Top Scored Full C-band, Mode-hop-free Wavelength-Tunable Laser Diode with a Linewidth of 8 kHz and a RIN of ~130 dB/Hz, Keniue Kasai, Masatuka Nakazawa, Yasuomi Tomomatsu, Takashi Endo, Research Inst. of Electrical Communication, Tohoku Univ., Japan; Kasah Kagaku Co., Ltd., Japan. We demonstrate a wavelength-tunable external-cavity laser diode with a linewidth of less than 8 kHz and a RIN below ~130 dB/Hz. The oscillation wavelength can be tuned over the full C-band without mode hopping.

W1F.1 • 08:00
6 kW Yb-doped Laser Fiber Fabricated by Chelate Precursor Doping Technique, Aoxiang Lin, Xuan Tang, Huan Zhan, Qi Li, Yuying Wang, Kun Peng, Li Ni, Xiaolong Wang, Cong Gao, Zhanonian Jia, Yuwei Li, Ani You, Jianjun Wang, Feng Jing, Honghuan Lin, China Academy of Engineering Physics, China. By chelate precursor doping technique, a 30μm-core Yb-doped alumino-phosphosilicate fiber was fabricated and presented 6.03kW laser output at 1080nm. The slope efficiency is 68.37% and the M² factor is 2.38 when stably running at 5.16kW.

W1F.2 • 08:15
Dual-Emission Band All-Fiber Laser Fabricated on Theta Cavity with Thulium- and Holmium-Doped Fibers, Svyatoslav Kharitonov, Camille-Sophie Bres, Ecole Polytechnique Federale de Lausanne, Switzerland. We present first dual-wavelength all-fiber laser, based on isolated-free theta cavity with two fiber Bragg mirrors and thulium- and holmium-doped fibers. Laser provides 350mW total power with 8% slope efficiency, and linewidth less than 0.1 nm.
Experimental Investigation of Nonlinear Signal Distortions in Ultra-wideband Transmission Systems, Gabriel Saavedra, Mingming Tan, Daniel J. Elson, Lida Galdino, Daniel Semrau, Md Asif Iqbal, Ian Phillips, Paul Harper, Naoise MacSuibhne, Andrew Ellis, Domanic Lavery, Benn C. Thomsen, Robert Killey, Polina Bayvel, Univ. College London, UK; 2Aston Univ., UK. The impact of nonlinear interference (NLI) is experimentally investigated in the ultra-wideband regime. For signal bandwidths up to 7.3 THz it is confirmed that NLI continues to accumulate as predicted by the Gaussian Noise model.

Segment Routing for Network Optimizations, Walid Watim, Cisco Systems, Inc., USA. Segment Routing (SR) simplifies network design and operations, enabling open protocol reduction in networks. SR achieves this simplification through the increased utilization of available bandwidth and elimination of distributed protocols such as LDP and RSVP-TE. Optimization around capacity during link failures with Traffic Engineering (SR) will be discussed.

Mixed Channel Traffic Grooming in Shared Backup Path Protected IP over Elastic Optical Networks, Fengxian Tang, Longtie Li, Bowen Chen, Sanjay K. Bose, Gangxiang Shen, Soochow Univ., China; 2IIT Guwahati, India. For mixed channel traffic grooming in shared backup path protected IP over elastic optical network, we develop an auxiliary graph based heuristic algorithm allowing working and protection traffic flows to share common optical channels. Results show that the scheme is efficient in greatly improving capacity and transponder utilization.

Signal Overlap for Efficient 1+1 Protection in Elastic Optical Networks (EONs), Filippo Cugini, Nicola Sambo, Tommaso Foggi, Marc Ruiz, Luis Velasco, Piero Castoldi, CNIT, Italy; 2Scuola Superiore Sant’Anna, Italy; 3Optical Communications Group (GCO), Universitat Politcnic de Catalunya (UPC), Spain. An innovative transmission technique enabling signal overlap is introduced for spectrally-efficient 1+1 protection. Simulation results show that the proposed technique successfully reduces the overall amount of occupied spectrum resources.
Continued

W1A • Photonic/Electronic Integration and Packaging—Continued

W1A.2 • 08:30
Low Crosstalk Simultaneous 12 ch x 25 Gb/s Operation of High-density Silicon Photonics Multichannel Receiver, Tsuyoshi Aoki, Tomoyuki Akiyama, Akio Sugama, Akinori Hayakawa, Hideotsu Murakasa, Takasii Somyama, Shin-suke Tanaka, Motoyuki Nishizawa, Nobuaki Hatori, Yohei Sobu, Yafrei Chen, Toshihiko Mori, Shigeki Sekiguchi, Seok-hwan Jeong, Yu Tanaka, Ken Mori, Hidetsugu Shiro, and Futhisu Laboratories Ltd., Japan. We designed high PI and SI far receiver with the high-density bridge structure and successfully verified simultaneous error-free operations of 12 ch x 25 Gb/s with a small crosstalk penalty of 1.2 dB.

W1A.3 • 08:45
Demonstration of a Packaged Photonic Integrated Network on Chip controlled by an FPGA-based scheduler, Yule Xiong, Nicola Andriolli, Stefano Faralli, Fabrizio Gambini, Paola Pintus, Marco Chiesa, Ruben Ortuño, Odile Labaron-Ladouceur, Isabella Cerutti, McGill Univ., Canada; Scuola Superiore Sant’Anna, Italy; Univ. of California, Santa Barbara, USA; Universitat Politècnica de Valencia, Spain. The dynamic performance of a packaged photonic network-on-chip (NoC) based on multi-microrings is experimentally demonstrated. Controlled by a scheduler implemented in an FPGA, the packaged photonic NoC exhibits a BER penalty of approximately 0.5 dB.

W1B • SDM Multiplexers and 3D Waveguides—Continued

W1B.3 • 08:30 Invited
Capacity Limits for Spatially Multiplexed Free-space Communication, Joseph M. Kahn, Guang Li, Xiaoying Li, Ningbo Zhao, Stanford Univ., USA; CREOL, Univ. of Central Florida, USA; Tianjin Univ., China. We show that OAM multiplexing does not realize the capacity limits of free-space channels, and is outperformed by multiplexing in parallel Gaussian beams or any complete modal basis.

W1B.4 • 08:45
Simultaneous Transmission of Multi-RATs and Mobile Fronthaul in the MMBW Bands over an IFoF System, Pham Tien Dat, Atsushi Kanno, Naokatsu Yamamoto, Tetsuya Kawashiri, NICT, Japan; Waseda Univ., Japan. We propose and demonstrate a simultaneous transmission of LTE-A, 25-GHz OFDM/FBMC radio access, and 96-GHz filtered-OFDM mobile fronthaul signals over a simple and low cost intermediate-frequency-over-fiber system. We confirm the successful transmission for all signals.

W1C • Novel Fronthauling Techniques—Continued

W1C.3 • 08:30
Real-time Measurements of an Optical Reconfigurable Access Unit for 5G Wireless Access Networks, Sebastian Rodriguez, Alvaro Morales, Simon Rommel, Juan José Vegas, ITMO Univ., Russia. A reconfigurable radio access unit able to switch wavelength, RF carrier frequency and optical path is experimentally demonstrated. The system is able to do the switching processes correctly, while achieving BER values below FEC limit.

W1C.4 • 08:45
Simultaneous Transmission of Multi-RATs and Mobile Fronthaul in the MMBW Bands over an IFoF System, Pham Tien Dat, Atsushi Kanno, Naokatsu Yamamoto, Tetsuya Kawashiri, NICT, Japan; Waseda Univ., Japan. We propose and demonstrate a simultaneous transmission of LTE-A, 25-GHz OFDM/FBMC radio access, and 96-GHz filtered-OFDM mobile fronthaul signals over a simple and low cost intermediate-frequency-over-fiber system. We confirm the successful transmission for all signals.

W1D • Control Architecture and Network Modeling II—Continued

W1D.3 • 08:30 Invited
Silicon Photonic Waveguide Tunable Lasers for High-capacity Optical Communication System, Tomohiro Kita, Hiroiyuki Yamazaki, Naokatsu Yamamoto, Hirohito Yamada, Tohoku Univ., Japan; NEC Corporation, Japan; NICT, Japan. Silicon photonic wavelength-tunable laser diodes consist of a wavelength-tunable filter with silicon ring resonators and a semiconductor optical amplifier. Narrow spectral linewidth lasers for coherent optical communication systems and quantum dot heterogeneous laser were demonstrated.

W1E • Tunable Lasers and Transmitters—Continued

W1E.3 • 08:30 Invited
A New Ultrafast and High Peak Power Fiber Laser Operating at 1.5 µm using InN as Saturable Absorber, Marco Jiménez-Rodríguez, Laura Monteagudo-Lema, Eva Monroy, Fernando Naranjo, Miguel González-Herrera, Electronics, Univ. of Alcala, Spain; INAC, CEA-Grenoble, France; Univ. Grenoble-Alpes, France. This work describes a novel ultrafast (<250 fs) fiber laser operating at 1.5 µm and based on InN as saturable absorber (SA). This SA accommodates much higher fluences than comparable semiconductor or graphene-based SAs.

W1F • Advanced Fiber Lasers—Continued

W1F.3 • 08:30
Ultra-Broadband Tunable Fiber Laser, Vladislav Dvoyrin, Nikita Tarasov, Sergei K. Turitsyn, Austron Univ., UK. We demonstrate the ultra-broadband gain medium exploiting cascaded Raman amplification. Pumping the 5-km long linear cavity fiber laser at 1349 nm we show the tunability of the laser operation from 1400 to 1622 nm.
This paper presents a nonlinear mitigation algorithm designed from an ASIC perspective, and analyzes implementation aspects. Given 9 signal and 11 coefficient bits, the reach is increased by 105% compared to linear compensation in single-channel 16-QAM transmission.

Control Plane Architectures for Flexi-Grid Networks, Oscar Gonzalez de Dios1, Telefónica, Spain. Elastic optical networks are based on a flexible allocation of the spectrum and configurable transponders. The control architecture is key to unlock their potential. This paper presents the architectural choices, including GMPLS, SDN and TAPI.

How Much Transport Grooming is Needed in the Age of Flexible Clients?, Antonio Era1, João Pedro1, Instituto Superior Técnico, Av. Rovisco Pais, 1, Instituto de Telecomunicações, Portugal; Coriant, Portugal. We analyze the impact of flexible client interfaces in the client- and line-side requirements of optical transport scenarios. The simulation results identify the network conditions where transport grooming fabrics are a necessary complement to flexibility on the client-side.

Nonbinary Staircase Codes for Spectrally and Energy Efficient Fiber-optic Systems, Alimea Sheikh1, Alexandre Graell i Amat1, Magnus Karlsson2, Chalmers Tekniska Högskola, Sweden. We consider the design of nonbinary staircase codes with higher order modulation for spectrally and energy efficient fiber-optic systems. We optimize the code parameters based on density evolution.

A High Loss Budget 400-Gbps WDM-OFDM Long-Reach PON over 60 km Transmission by 10G-class EAM and PIN without In-line or Pre-amplifier, C. Y. Chuang1, Chia-Chien Wei1, Chun-Ting Lin1, Chia-Chien Wei1, Sien Chi1, Rue-Fang1, National Chiao Tung Univ., Taiwan; National Sun Yat-sen Univ., Taiwan. This paper presents 27.15-Gbit/s spread-OFDM PON receiver via 1-GSample/ADC for each 32-ONU to demodulate signals which greatly reduces complexity. Moreover, DC algorithm is proposed to eliminate DC-located distortion caused by sub-Nyquist ADC.

W1G.3 • 08:30 Toward Blind Nonlinearity Estimation in Back-propagation Algorithm for Coherent Optical Transmission Systems, Lin Jiang1, Lianhan Yan1, Anlin Yi1, Yan Pan1, Jun Ge1, Liangliang Dai1, Wei Pan1, Bin Luo1, Southwest Jiaotong Univ., China. Blind estimation of nonlinear operator product in back-propagation algorithm is proposed. Significantly enhanced flexibility of nonlinear compensation is experimentally demonstrated in a 5x64-Gb/s WDM PDM-QPSK system over 1920-km SMF link with −1.5-dB performance improvement.

W1H.2 • 08:30 Control Plane Architectures for Flexi-Grid Networks, Oscar Gonzalez de Dios1, Telefónica, Spain. Elastic optical networks are based on a flexible allocation of the spectrum and configurable transponders. The control architecture is key to unlock their potential. This paper presents the architectural choices, including GMPLS, SDN and TAPI.

W1I.1 • 08:30 Nonbinary Staircase Codes for Spectrally and Energy Efficient Fiber-optic Systems, Alimea Sheikh1, Alexandre Graell i Amat1, Magnus Karlsson2, Chalmers Tekniska Högskola, Sweden. We consider the design of nonbinary staircase codes with higher order modulation for spectrally and energy efficient fiber-optic systems. We optimize the code parameters based on density evolution.

Distributed Rate-adaptive Staircase Codes for Connectionless Optical Metro Network, Laurent Schmalen1, Lei M. Zhang1, Ulrich Gebhardt1, Bell Labs, Nokia, USA; ÉCE, Univ. of Toronto, Canada. We demonstrate a multi-point-to-point network architecture for optical metro networks with distributed staircase codes. We present a simple rate-adaptation scheme and demonstrate throughput maximization on the network.

W1J.2 • 08:45 A High Loss Budget 400-Gbps WDM-OFDM Long-Reach PON over 60 km Transmission by 10G-class EAM and PIN without In-line or Pre-amplifier, C. Y. Chuang1, Chia-Chien Wei1, Jun-Jie Liu1, Hsin-Yu Wu1, Hong-Minh Nguyen1, Chun-Wei Wang1, Shao-Yu Lu1, Young-Kai Chen1, Jyehang Chen1, Department of Photonics, National Chiao Tung Univ., Taiwan; Department of Photonics, National Sun Yat-sen Univ., Taiwan; Communication Science Research Department, Bell Laboratories, Alcatel-Lucent at Murray Hill, USA. A 400-Gbps WDM-OFDM LR-PON over 60-km SMF is demonstrated with a 10G-class EAM and PIN. 25-dB loss budget is realized without in-line or pre-amplifier to economically support 128 ONUs with 3.1-Gbps/ONU capacity.
Fiber lasers enjoy...
We propose a concept for implementation of a 100G OFDM-PON for a converged 5G network. A real-time OLT prototype and the DSP functions for an ONU are characterized.

**W1J • Forward Error Correction and Coding—Continued**

**W1J.3 • 09:00** Top-Ordered Single-Carrier 400G PM-256QAM Generation at 34 Gbaud Trading off Bandwidth Constraints and Coding Overheads, Hung-Chang Chien1, Junwen Zhang1, Jianjun Yu2, Yi Cai3, UT CT Inc., USA. For the first time, single-carrier 400G generation using PM-256QAM at record 34 Gbaud is experimentally demonstrated, reaching 1.6-dBQ BTB system margin to the SD pre-FEC limit enabled by both higher coding gain and nonlinearity compensation.

**W1J.4 • 09:15** Lattice Precoding for IM/DD POF Interconnects, Toshiaki Koike-Akino1, Keisuke Kojima1, David Millar1, Keisuke Kojima1; Mitsubishi Electric Research Labs, USA. We introduce lattice precoding (LP) as an improved version of Tomlinson-Harashima precoding (THP) for direct intensity modulation & direct detection (IM/DD) communications over plastic optical fiber (POF). We show that LP offers a significant gain greater than 5 dB over conventional methods for short-range IM/DD SI-POF systems.
A Mode-hop-free III-V/Si Hybrid External-cavity Laser, Jin Hyoung Lee1, Ivan Shubin1, Jack Bovington1, Ying Luo1, Daniel Y. Lee1, Stevan S. Djordjevic1, Shiyou Lin1, Jin Yao1, Niren D. Thacker1, John E. Cunningham1, Kannan Raj1, Nabil V. Krishnamoorthy1, Xuezheng Zhang1, Oracle, USA. We propose a novel approach of passive stabilization for on-chip hybrid laser over temperature variation by thermo-optic compensation. By engineering the effective thermal-optic coefficient of the cavity, we demonstrated mode-hop-free operation of an on-chip hybrid laser over 35°C temperature change without any active controls.

Demonstration of Fast Cooperative Operations in Disaggregated Optical Node Systems, Kiyo Ishii1, Satoshi Suda1, Shigeaki Tsuchida1, Dai Suzuki1, Takaumi Teraoka1, Shu Namiki1, AIST, Japan; 2Intel Device Labs, NEC Corporation, Japan; 3Network Products Business Unit, Fujitsu Ltd., Japan. A node controller is addressed to ease operations such as alarm monitoring and path provisioning for the centralized controller. It is actually implemented on off-the-shelf servers to successfully perform fast protections in disaggregated optical nodes.

Field Trial of Data Analysis-based Autonomic Bandwidth Adjustment in Software Defined Multi-Vendor OTN Networks, Yue Li1, Yongli Zhao1, Xiaoxiong Yu1, Beijing Univ. of Posts and Telecommunications, China. To achieve cost-effective bandwidth provisioning, this paper proposes an autonomic bandwidth adjustment scheme based on data analysis of traffic load. The scheme is verified in field trial networks with commercial OTN equipment from three vendors.

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Experimental Study of Nonlinearity Tolerant Modulation Formats Based on LDPC Coded Non-uniform Signal- ing, Zhen Qu; Changyu Lin; Tao Liu; Ivan B. Djordjevic; Univ. of Arizona, USA. Nonlinearity tolerant 5-QAM and 9-QAM are experimentally studied for long-haul WDM transmission. Compared to QPSK and 8-QAM, the transmission reach is extended for 12% and 222% by using LDPC-coded non-uniform 5-QAM and 9-QAM, respectively.

W1H.4 • 09:30
TDM based Optical Bypass for Intrarack Elephant Flow with a DPKD Based Online Timeslot Allocator, Bingli Guo, Shutong Li, Shan Yan, Shanguo Huang; Beijing Univ. of Post and Telecomm., China. An optical TDM system is experimentally demonstrated with a flow based elephant flow detection and a DPKD based online timeslot allocator. With proposed timeslot allocation algorithm, allocator could have 383 Gbps throughput and continuous timeslots allocation.

W1I • Elastic Optical Networks—Continued
W1I.1 • 09:00
Forward Error Correction and Coding—Continued
W1I.2 • 09:15
Elastic Optical Networks, Dominique Verchere, Sbastien Bigo; Nokia Bell Labs, France. We review the architecture of Elastic Optical Networks. We focus on 10-100Gbit/s elastic coherent transmission performances and high speed switching time enabling SDN controlled zero packet loss operation.

W1I.3 • 09:30
Load and Nonlinearity Aware Resource Allocation in Elastic Optical Networks, Rui Wang; Sarvesh Biddarkar; Dimitra Simeonidou; Univ. of Bristol, UK. We propose a novel routing and spectrum allocation solution for elastic all-optical networks based on load-aware nonlinearity impairment estimation that significantly improves service acceptance ratio and spectrum utilization compared to nonlinearly assignment based on fixed-margins.

W1I.4 • 09:30
Invited: Bandwidth Variable Transmitter for Software Defined Networks, Arnaud Dupas; Patricia Layec; Dominique Verchere; Sbastien Bigo; Nokia Bell Labs, France. We review the architecture of Bandwidth Variable Transmitter designed for Software Defined Networks. We focus on 10-100Gbit/s elastic coherent transmission performances and high speed switching time enabling SDN controlled zero packet loss operation.

W1I.5 • 09:45
Bit-interleaved Polar-coded Modulation for Low-latency Short-block Transmission, Toshiaki Kojima; Koji Kondo; Daichi Sugihara; Wataru Matsumoto; Rong Hu; Caixi Li; Li Haibo; Shutong Li; Keisuke Kojima; Masahiro Electric Research Labs, USA; Univ. of Toronto, Canada; MELCO, Japan. We show that polar codes with list+CRC decoding can outperform state-of-the-art LDPC codes in short block lengths. In addition, we introduce an efficient interleaver for polar-coded high-order modulations, achieving greater than 0.5dB gain for 256QAM.

W1I.6 • 10:00
Real-time VLCC-OFDM HD-SDI Video Transmission System with TS-based SFO Estimation Real-time VLCC-OFDM HD-SDI Video Transmission System with TS-based SFO Estimation, Rui Deng; J He; Ming Chen; Yiran Wei; Jin Shi; Lin Chen; Hunan Univ., China; Hunan Normal Univ., China. An SFO estimation method based on simple training symbols is proposed in real-time OFDM system. By using the SFO estimation scheme, we implement an asynchronous software configurable real-time VLCC-OFDM system, and experimentally demonstrate an HD-SDI Video transmission over the system.

W1J.1 • 09:00
Digital OFDM-PON Employing Binary Intensity Modulation and Direct Detection Channels, Rong Hu; Cai Li; Li Haibo; Qi Yang; Ming Luo; Shaohua Yu; William Sheih; WRI, China; Uni. of Melbourne, Australia. In this paper, a delta-sigma modulation is proposed to enable transmission of OFDM signals by cost-effective binary IM-DD channels. Compared to traditional OFDM-PON, around 4-dB improvement in receiver sensitivity is achieved with the 20% average EVM.

W1J.2 • 09:15
FPGA Demonstration of Stretched Continuously Interleaved BCH Code with Low Error Floor for Short-Range Optical Transmission, Fan YU; Mo LI; Nebosja Stojiljkovic; Changsong Xie; Zhuyu Xiao; Liangchuan Li; Huawei Technologies Co. Ltd, China. A novel SCI-BCH code and an error pattern breaking decoding algorithm are proposed. Compared with the CI-BCH code, the error floor is lowered from BER of 1e-9 to 1e-16 at small latency and storage cost.

W1J.3 • 09:30
OFDM for Access Networks—Continued
W1J.4 • 09:45
Real-time VLCC-OFDM HD-SDI Video Transmission System with TS-based SFO Estimation Real-time VLCC-OFDM HD-SDI Video Transmission System with TS-based SFO Estimation, Rui Deng; J He; Ming Chen; Yiran Wei; Jin Shi; Lin Chen; Hunan Univ., China; Hunan Normal Univ., China. An SFO estimation method based on simple training symbols is proposed in real-time OFDM system. By using the SFO estimation scheme, we implement an asynchronous software configurable real-time VLCC-OFDM system, and experimentally demonstrate an HD-SDI Video transmission over the system.
W2A.1 Tunable Mode-locked Laser Photonic Integrated Circuit using Intracavity Phase Modulators, Mu-Chieh Li1, Robinson Guzman1, Carlos Gordon1, Guillermo Carpenter1, 2,3 Universidad Carlos III de Madrid, Spain. A 30 GHz mode-locked laser in PIC is presented using InP-based active-passive integra-
tion technology. The 2.8 nm long cavity contains phase modulators enabling sub-nm fine tuning of the las-
ing spectrum which is experimentally demonstrated.

W2A.2 Fiber Random Grating Feedback Induced Chaos in Semiconductor Laser with Highly Suppressed Time-
Delay Signature, Yanping Xu1, Liang Zhang1, Mingjiang Zhang1,2, Ping Lu1, Stephen Mihalov1, Xiaoyi Bao1, 2,3 University of Ottawa, Canada; 2,3 Inst. of Optoelec-
tronic Engineering, Department of Physics and Optoelectronics, Tsaiyuan Unv. of Technology, China; 3, National Research Council Canada, Canada. A semiconductor laser with distributed feedbacks from a novel fiber random grating is perturbed to emit chaoti-

W2A.3 Athermal Operation of a Multi-
section Laser for Optical Communi-

cations, Michael Wallace1, 2, Rudi O’Reilly1, Ryan Enright1, Frank Bello1, John Donegan1, 3, School of Physics, Trinity College Dublin, Ireland; 3Future Networks and Communications (CON-
NECT), Trinity College Dublin, Ireland; 2Efficient Energy Transfer Department, Bell Labs, Nokia, Ireland; 3Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Trinity College Dublin, Ireland; 2Advanced Materials and BioEngineering Centre (AMBER), Trinity College Dublin, Ireland. Two distinct athermal bias current control procedures are demon-
strated for a low-cost, monolithic, three section slotted single mode laser, achieving wavelength stability of ±0.01 nm over a temperature range of 10-85 C. An analytical model has been developed to provide further insight into the athermal operation of these devices.

W2A.4 Hybrid Integration of Modified Uni-
traveling Carrier Photodiodes on a Multi-layer Silicon Nitride Platform Using Total Internal Reflection Mir-
rors, Shaqo Feng1, Yang Shen1, Xiaojun Xie1, Jiahao Zang1, Siewei Li1, Tiehui Su1, Kuanping Shang1, Weicheng Lai1, Guanyao Lai1, Joe C. Campbell1, S. J. Ben Yoo1, 2Department of Electrical and Computer Engineering, Univ. of California, Davis, USA; 1Department of Electrical and Computer Engineering, Univ. of Virginia, USA. We demon-
strate hybrid integration of modified uni-traveling carrier photodiodes on a multi-layer silicon nitride platform using total internal reflection mirrors. Low-loss high-efficiency coupling of InGaAs detector on a silicon substrate has been realized.

W2A.5 A Passive Optical Alignment Tech-
nique for Single-Mode Fiber Laser with Light-

source Arrays, Koshio Adachi1, Akira Nakanishi1, Takarori Suzuki1, Hiroki Inoe1, Hiroyasu Sasaki1, Tetsuya Aoki1, Masato Shikikura1, Kazuhiro Nose1, Shigeoishita Tanaka1, 2Oclaro Japan, Inc., Japan. A passive optical alignment based on a lens-integrated surface-emitting laser array and a single-mode fiber array was dem-
strated. The proposed alignment technique enables better coupling efficiency than that of conventional DBR laser with active alignment.

W2A.6 Frequency Noise of a Normal Dis-

tersion Microresonator-based Fre-

quency Comb, Attila Fulop1, Mikael Mazur2, Abel Lorences-Riesgo3, Pei-Hsuan Wang1, Yi-Xuan1, Dan E. Leard1, Minhao Qiu2, 3, Peter A. Andrekson1, 2Andrew Weiner2, 3, Victor Torres-

Company1, 2Photonics Laboratory, Department of Microtechnology and Nanoscience, Chalmers Univ. of Tech-
nology, Sweden; 3School of Electrical and Computer Engineering, Purdue University, USA. Using delayed self-heterodyne coherent detection, we characterized the FM noise across the C-band of a widely spaced microresonator-based fre-
quency comb. The resulting linewidth depends on both the pump laser and the comb line position.

W2A.7 Optimal Design of Ge-dot photo-

crystal MOSFETs for Highly-integrated Monolithic Si Photonics, Ming-Hao Kuo1, Meng Chun Lee1, Che-Wei Tien1, Wei-Ting Lai1, Pei-Wen Li1, National Central Univ., Taiwan; 2National Chiao Tung Univ., Taiwan. Ge-dot/ SiO/SiGe-channel photoMOSFETs are demonstrated on Si substrate. A decrease in the dot size and gate oxide thickness significantly enhances the photoreponsitivity (9000A/W) with 6mW under 850nm illumination, and improves response time (0.48ns) and power consumption.

W2A.8 Evanescent Field-assisted Mode-
llocked Laser Based On Short Sin-

gle-wall Carbon Nanotubes And Photonic Crystal Fiber, Lei Gao1, Tao Zhu1, Chongqing Univ., China. We report a passively mode-locked fiber laser based on a saturable absorber via short single-wall carbon nanotubes interact with evanescent wave in clading-

holes of grapefruit-type photonic crystal fiber.

W2A.9 Compact 4x5 Gb/s Silicon-on-Insu-
lator OFDM Transmitter, Yu-Xie Yi1, 2, Leimeng Zhuang1, Ronald Broeke1, Qibing Wang1, Binhuang Song1, Zhi-

han Gong1, Arthur Lowery1, Monash Univ., Australia; 2Bright Photonics B.V, Netherlands. We characterize an integrated silicon 4x5 Gb/s OFDM transmitter PIC (2.1 x 4.8 mm2) with four modulators and an optical Fourier transform. This PIC features a channel spacing of 5 GHz and an 80-GHz free spectral range.

W2A.10 C-C Bond Enriched SiC Add-drop Microring Based All-Optical Gate, Shih-Chang Syu1, 2, Yi-Chieh Chi1, Chih-Hsien Cheng1, Hsiu-Yung Wang1, Gou-Ru Lin1, Graduate Inst. of Photonics and Optoelectronics, and Department of Electrical Engineer-

ing, National Taiwan Univ., Taiwan. An all-optical AND gate made by PECVD grown C-C bond enriched SiC film based add-drop micro-ring with nonlinear refractive index up to 2.4×10-13 cm/W and 8.7-dB TE/TM polarization discrimination throughout the wavelength range is demonstrated.

W2A.11 Novel Broadband Gain-spectrum Measurement Technique for Raman and Parametric Amplifiers, Vladim-

imir Gordinenko1, Marc F. Stephens1, Atalla El-Tayer1, Nick J. Doran1, Aston Univ., UK. We report a quick and ac-

curate gain-spectrum measurement technique for broadband (>10THz) Raman and parametric amplifi-

ers. Using a depolarized broadband signal source we predict WDM signal gain experimentally for both single and diverse polarization schemes.

W2A.12 Periodically Poled LiNbO3 Ridge Waveguide with 21.9 dB Phase- 

Sensitive Gain by Optical Parametric Amplification, Tadashi Kishimoto1, 2, Koichi Inaude1, Yoh Ogawa1, Norihiko Sekine1, Hitoshi Mura1, Hiroshi San-

saki1, 2, Oki Electric Industry Co., Ltd., Japan; 1, National Inst. of Information and Communications Technology, Japan. We develop a periodically poled LiNbO3 (PPLN) ridge waveguide de-
vice and experimentally demonstrate a phase-sensitive amplification based on a cascaded SHG and OPA process. We successfully obtain the high phase-sensitve parametric gain of 21.9 dB.

W2A.13 Three-stage Quasi-phase-matched Fiber Optical Parametric Amplifier with Flat 30-dB Gain with 31-nm 

Bandwidth, Shigehito Takasaki1, Ryuchi Sugizaki1, Furukawa Electric Co., Ltd., Japan. We demonstrate a PM-FOPA using three dispersion stable PM-HNLs alternately concatenated with PM pump phase shifters for quasi-phase-matching. We achieve gain as high as 30 dB with 31 nm bandwidth.

W2A.14 Femtosecond Laser Inscribed Axial Long-period Fiber Gratings in Two-

tube fiber for Efficient Optical Angular Momentum Generation, Yunhe Zhao1, Quan Yu2, Chengbo Mao1, Neil Gordon1, Kaiming Zhou1, Lin Zhang1, Tingyun Wang1, Shang-

hai Univ., China; 2Aston Univ., UK. We demonstrate a novel all-fiber mode converter based on an axial long-period fiber grating which was inscribed in two-mode fiber using a femtosecond laser. The OAM±1,1 modes can be effectively generated using this mode converter.

W2A.15 High-efficiency Light Injection and Extraction Using Fiber Bending, Taku Uematsu1, Takanori Koyokura1, Hidenobu Hirota1, Tomohiko Kawano1, Tetsuya Manabe1, TTT Corporation, Japan. We achieve a temporary opti-
coupler that injects/extracts light into/from a fiber with high efficiency by using fiber bending. We demon-
strate experimentally that extraction efficiency is improved by using a double-clad fiber.

W2A.16 Simple Geometric Approach for Opti-
nization of Phase-sensitive Fiber 

Optic Parametric Amplifiers, Alexey Redyuk1, 2, Anastasia Bednyakova1, 2, Sergey Medvedev1, Mikhail Fedoruk1, 2, Serguei K. Turitsyn3, 2Novosibirsk State Univ., Russia; 3Inst. of Computational Technologies SB RAS, Russia; 2Aston Inst. of Photonics Technologies, UK. We demonstrate application of a simple design method - geometric approach for optimisation of the performance of phase-sensitive fiber optical para-
metric amplifier.

Exhibit Hall K

10:00–12:00
W2A • Poster Session I

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Black Phosphorus-coated Tilted Fiber Bragg Grating for Ultra-sensitive Ion Sensing, Chen Liu, Zheng-bao Sun1, Liang Zhang2, Jiancheng Lu, Feng Yu1, Xianfeng Chen1, Bangor Univ., UK; ‘Shenzhen Inst. of Advanced Technology, Chinese Academy of Sciences, China. We propose a broad frequency range based on black phosphorous coated 81°-tilted fiber grating for Pb2+ ion detection, demonstrating significant performance characteristics in terms of high sensitivity (8.6×10⁻⁶ dB/ppb) and low detection limit (0.4ppb) and wider concentration range (0.1ppb – 1.5×10⁴ ppb).

Demonstration of Orbital Angular Momentum (OAM) Fiber Amplifier in Data-Carrying OAM-Division Multiplexing and Wavelength-Division Multiplexing (WDM) System, Jun Liu1, Hongya Wang1, Shi Chen1, Shuang Zhang1, Long Zhu1, Andong Wang1, Nan Zhu1, Shuhui Li1, Li Shen1, Cheng Du1, Qi Mo1, Qian Yu2, Jihong Liu1, Wei Zhang2, Xiaohua Cheng1,2, ‘Sun Yat-Sen Univ., China; ‘Institute of Photoelectronics, Chinese Academy of Sciences, China. We present a novel OAM-based amplifier for data-carrying OAM-Division Multiplexing and WDM system. It is realized using a single-wavelength pumping configuration with high performance, including high gain (81°-tilted fiber grating for Pb2+ ion detection, demonstrating significant performance characteristics in terms of high sensitivity (8.6×10⁻⁶ dB/ppb) and low detection limit (0.4ppb) and wider concentration range (0.1ppb – 1.5×10⁴ ppb).

Design of Elliptical-core Few-mode Fibers for Optical Parametric Amplitude and Phase Modulation, Cheng Guo1, Zhenzhen Zhang1, Ningbo Zhao1, Lin Zhang1, Xiaoying Li1, Guangli Li1, ‘The College of Precision Instruments and Opto-electronic Engineering, Tianjin Univ., China; ‘The College of Optics & Photonics, Univ. of Central Florida, USA. We present a dispersion-compensated elliptical-core few-mode fiber for broadband parametric amplification in the C-band. The asymmetric structure is beneficial to eliminate crosstalk in transmission system and degradation to parametric gain.

Demonstration of Orbital Angular Momentum (OAM) Fiber Amplifier in Data-Carrying OAM-Division Multiplexing and Wavelength-Division Multiplexing (WDM) System, Jun Liu1, Hongya Wang1, Shi Chen1, Shuang Zhang1, Long Zhu1, Andong Wang1, Nan Zhu1, Shuhui Li1, Li Shen1, Cheng Du1, Qi Mo1, Qian Yu2, Jihong Liu1, Wei Zhang2, Xiaohua Cheng1,2, ‘Sun Yat-Sen Univ., China; ‘Institute of Photoelectronics, Chinese Academy of Sciences, China. We present a novel OAM-based amplifier for data-carrying OAM-Division Multiplexing and WDM system. It is realized using a single-wavelength pumping configuration with high performance, including high gain (81°-tilted fiber grating for Pb2+ ion detection, demonstrating significant performance characteristics in terms of high sensitivity (8.6×10⁻⁶ dB/ppb) and low detection limit (0.4ppb) and wider concentration range (0.1ppb – 1.5×10⁴ ppb).

Design of Elliptical-core Few-mode Fibers for Optical Parametric Amplitude and Phase Modulation, Cheng Guo1, Zhenzhen Zhang1, Ningbo Zhao1, Lin Zhang1, Xiaoying Li1, Guangli Li1, ‘The College of Precision Instruments and Opto-electronic Engineering, Tianjin Univ., China; ‘The College of Optics & Photonics, Univ. of Central Florida, USA. We present a dispersion-compensated elliptical-core few-mode fiber for broadband parametric amplification in the C-band. The asymmetric structure is beneficial to eliminate crosstalk in transmission system and degradation to parametric gain.
W2A.32 Experimenting with Multi-controller Collaboration for Large-scale Intra-data Center Networks, Yingyu Jia1,2, Nan Hao1, Yi Yang1, Yanfei Ma2, Xiaojun Shi3, Mengfan Cheng1, Jyehong Chen1, Zhang Junwen2, Xiaocheng Wang2, Zih-Yi Yang2, Arthur Yuan1, Mengjie Zhang1, Mudong Jin1, Hai-Han Yang1, Chang-Kai Lu1, Meng Shi1, Yufang Yu1, Yi Dong2, Ming-Te Cheng1, Jiaqi Zhao1, Xinran Wang1, Nan Chi1, Yuanda Huang1, Edson P. da Silva1, Nan Chi2, Francesco Serafini2, Sheng-Jhe Huang1, A. Koonen1, Boris Poupart3, Yingyi Fan4, Xie Wang1, Lei Deng1, Ming Luo1, Darko Zibar1

W2A.35 SINR-based Equalization for Multiband LTE-A and 4Gbps 4-PAM Transmission over 50m Thick-core Plastic Optical Fiber Wireless Link, Federico Forni1,2, Yan Shi1, Hennie V. Boom1, Eduard Tangdiongga1, A. Koonen1,1 Eindhoven University of Technology, Netherlands; 2Genex, Netherlands. A signal-to-interference-plus-noise-ratio based SINR-based equalization scheme is proposed and tested for the coexistence of 8 bands of 64-QAM LTE-A signal and a 1.8Gbps 4-PAM signal over 50m of thick core diameter GI-POF and 3.5mm wireless for in-home networks.

W2A.36 Optimal Synchronization Based on Anchor Phase Linear Regression for Self-interference Cancellation in Software-Defined Radio Fiber-wireless Systems, Lin Cheng1,2, Boris Shah1, Anthony Ng Omar1, Glee-Kung Fung1,2, Ching-Chung Chang1, Georgia Inst. of Technology, USA; 2Science and Technology Division, Optical Networks, Shanghai Jiao Tong Univ., China; 3Laboratoire AIME Cot, CNRS-Universite Paris Sud 11-ENS Cachan-Universite Paris-Saclay, France. Highly linear analog photonic link based on optical phase-locked loop techniques is proposed. A 5km transmission of RF signals with a shot-noise-limited spur-free dynamic range of 126 dBc/Hz is demonstrated.

W2A.34 A Broadband Beam-steered Fiber Mm-Wave Link with High-Energy-spectral-spatial Efficiency for 5G Coverage, Zheheng Cao1, Xinran Zhao1, A. Koonen1, Technische Universiteit Eindhoven, USA. Utilizing an integrated optical-tunable-delay-line, reversely-modulated single sideband modulation, and Nyquist subcarrier modulation, we demonstrate an 8 Gbps mm-wave beam steered link with a spatial-spectral efficiency of 16 bits/s/Hz.

W2A.38 Improving Performance of Mobile Fronthaul by high-order Delta-sigma Modulation based on PM4-IM-DD Channels, Rui-Hua Hsu1,3, Hsin-Chyuan Yang1, Ming Luo1, Lilin Yi1, Shawhua Wu1, WRI, China; 2Shanghai Jiaotong Univ., China. A transmission of 32 aggregated 4G-LTE signals is demonstrated in mobile fronthaul using high-order delta-sigma modulation and PM-4 IM-DD channels, achieving 68% improvement in average EVM compared to the 1st-order modulation of 1-bit resolution.

W2A.39 6.36 Gbit/s RGB LED-based WDM MIMO Visible Light Communication System Employing OFDM Modulation, Chong Li1, Cheng Lu1, Chih-Han Lai1, Chien-Hung Yeh1, Jye-Hong Chen1, Department of Photonics, National Chiao Tung Univ., Taiwan; 2Information and Communications Research Labs, Industrial Technology Research Inst., Taiwan; 3Department of Photonics, Feng Chia Univ., Taiwan. An aggregate data rate of 6.36 Gbit/s of RGB 2×2 MIMO VLC system is demonstrated for the proof-of-concept. Moreover, the corresponding VLC rates under the free-space transmissions of 1 to 3 air distance, resulting in 1.89 times SE increase.

W2A.40 A Novel Memoryless Power Series Based Adaptive Nonlinear Pre-distortion Scheme in High Speed Short Light Channels, Yung-Yu Chou1,2, Yung-Yun Zhai1, Zhang Junwen1, Can Wang1, Jiao Zhao1, Mengjie Zhang2, Mudong Zeng1, Nan Chi1, Fujun Univ., China. We proposed and experimentally demonstrated a novel memoryless power series based adaptive nonlinear pre-distortion scheme to mitigate nonlinear impairments for high-speed VLC system. Performance improvements with pre-distortion has been verified through 1.6Gb/s 16QAM-OFDM VLC transmission.

W2A.41 Non-orthogonal Multiple Access Based on SCMA and OFDM/OQAM Techniques in Bidirectional RoF Systems, Cheng Liu1, Lei Deng1, Jiale He1, Di Li1, Songnian Fu1, Ming Tang1, Mengfan Cheng1, Deming Liu1, Huazhong Univ. of Sci.& Tech., China. Bidirectional RoF system based on SCMA-OFDM/OQAM is proposed to increase spectral efficiency (SE) and support massive users. 1.932Gbps SCMA-OFDM/OQAM signal is transmitted over 24.5km SSF and 0.3m air distance, resulting in 1.89 times SE increase.

W2A.42 4.05-Gbps RGB LED-based VLC System Utilizing PS-Manchester Coded Nyquist PAM-8 Modulation and Hybrid Time-frequency Domain Equalization, Mengjie Zhang2, Meng Shi1, Fumin Wang1, Jiaqi Zhao1, Yung-Yun Zhai1, Zhang Junwen1, Fujun Univ., China. A novel PS-Manchester coded Nyquist PAM-8 modulation with hybrid time-frequency domain equalization scheme is proposed and experimentally demonstrated in a RGB LED-based VLC system. An aggregate data rate of 4.05 Gbps is successfully achieved.

W2A.43 Reconfigurable Radio-over-multiplexer Optical Fronthaul for Seamless 2G, UMTS and LTE-A MIMO Wireless Provision, Maria Morant1,2, Roberto Gaudioso1,2, Nan G. Calabretta1,2, FDR Technology, Universitat Politècnica de Valencia, Spain. A flexible and reconfigurable radio-over-multiplexer fiber fronthaul capable of providing simultaneous 2G, 3G and 4G cellular wireless services in the same frequency band with the advantage of antenna equipment reusability is proposed and evaluated experimentally.

W2A.44 Faster-than-Nyquist Signal Generation of Single Carrier 483-Gbaud (120.75-Gbaud) PDM-QPSK with 92-Gbaud DAC, Yanzhou Lu1, Yi Yao1, Ling Lu1, Yuanda Huang1, Xie Wang1, Liabao Jiang1, Nan Chi1, Huawei Technologies Co. Ltd., China. We propose a method of combining multi-tap pre-coding and faster-than-Nyquist filter for generating sub-symbol-rate sampling signal. Single carrier of 483-Gbaud (120.75-Gbaud) PDM-QPSK modulation is demonstrated by using 92-Gbaud’s DAC with sampling rate of 0.76-sample/symbol.

W2A.45 Modified Constant Modulus Algorithm Based on Minimization of Mutual Information for Mode-division Multiplexed Transmission, Xiang Lu1, Ming Luo1, Rong Hu1, Cai Li1, Ying Gu1, Qi Yang1, W. Keneth Research Inst. and Telecommunications, Zhejiang University, China. We propose a modified CMA based on minimization of mutual information for mode-division multiplexing. In comparison with conventional CMA, the modified algorithm can improve the convergence speed by more than 50% after few-mode fiber transmission.

W2A.46 Kalman-MLSE Equalization of Non-linear Noise, Ori Golan1, Mer Feder1, Mark Shalti2, Tel Aviv Univ., Israel. We investigate the potential of adaptive equalization techniques to mitigate intra-channel nonlinear interference noise (NLI). We develop an equalizer tailored for NLI reduction, based on Kalman filtering and maximum likelihood sequence estimation (MLSE).

W2A.47 Correlation-Based Polarization Demultiplexing for Clock Recovery in Coherent Optical Receivers, Valery N. Rosenzweig1, Rafael Morán1,2, Frederic Lowrey1, Dept. of Electrical & Computer Systems Engineering, Monash Univ., Australia. We propose and experimentally validate a novel method for polarization demultiplexing, based on intensity sample cross-correlation of polarization-multiplexed signals. The method allows to avoid PMD-induced failure conditions in digital clock recovery with limited computational complexity.

W2A.48 Experimental Analysis of Pilot-based Equalization for Probabilistically Shaped WDM Systems with 256QAM/1024QAM, Metodi P. Yankov1, Edison P. da Silva1, Francesco De Ros1, Darko Zibar2, Department of Photonics Engineering, Technical Univ. of Denmark, Denmark. Pilot based equalization is studied in a 5×10 Gbaud WDM transmission experiment. The equalization is independent of the modulation format and is demonstrated for 256/1024QAM with uniform and probabilistically optimized distribution using an optimized pilot insertion rate of 2.5%.

W2A.49 Symbol Flipping Decoding Algorithm Based on Prediction for Non-binary LDPC Codes, Shuai Wang1, Zizheng Cao1, Qin Huang, Nan Chi2, Huawei Technologies Co., Ltd., China; 3Collaborative Innovation Center of Geospatial Technology, China. This paper proposes a symbol flipping decoding algorithm based on prediction for non-binary LDPC codes, considering not only soft reliability, but also hard reliability. It provides 2.6 dB improvement compared with the weighted Algorithm B.
High Performance and Low Complexity Carrier Phase Recovery Schemes for 64-QAM Coherent Optical Systems, Jaime Rodrigo Navarro1, Aditya Kakkar2, Richard Schatz1, Xiaodan Pang1, Oskars Ozolins1, Fredrik Nordwall1, Hadrien Louchet1, Sergei Popov1, Gunnar Jacobsen1, Optics and Photonics Division, KTH Royal Inst. of Technology (KTH), Sweden.

Experimentially validate two novel CPR schemes outperforming existing CPFRs in complexity and performance. A complexity reduction of at least a factor of 4 is reported compared to the BPS algorithm for a 64QAM system.

Low Complexity Timing Recovery Algorithm for PAM-8 in High Speed Direct Detection Short Range Links, Aditya Kakkar1, Jaime Rodrigo Navarro1, Xiaodan Pang1, Oskars Ozolins1, Richard Schatz1, Urban Westergren1, Gunnar Jacobsen1, Sergei Popov1, Optics and Photonics Division, KTH Royal Inst. of Technology (KTH), Sweden.

We propose a novel parallel cycle slip recovery method employing soft-decision slip-state estimation at pilots. Through mutual information analysis, we show that the proposed method achieves 0.6dB gain in the presence of frequent cycle slips and strong phase noise.

Calibration of In-Phase/Quadrature Amplitude and Phase Response Imbalance for Coherent Receiver, Cheng Ju1, Zhenning Tao1, Yangyang Fan1, Ying Zhao1, Hao Chen1, Xiaofei Su1, Takeshi Hoshida3, Fujitsu Research and Development Center, China.

We propose an In-phase/Quadrature imbalance calibration method which only uses the transmitter itself for coherent receiver. Experiment shows that IQ skew calibration accuracy reaches 0.2 ps and the method is robust to many practical imperfections.

Maximization of the Achievable Mutual Information using Probabilistically Shaped-Squared-QAM Constellations, Dario Piloni1, Fabiano Forghieri1, Gabriella Bosco1, Poitecni di Torno, DET, Italy; Cisco Photonics Italy srl, Italy. Probabilistically-shaped QAM constellations are compared to uniformly distributed ones in terms of maximum values of achievable mutual information, showing that the potential gain depends on both target transmission rate and reference constellation cardinality.

Super-resolution Spectral Reconstruction for DWDM Channel Monitoring, Molly Piels1, Darko Zibar1, Technical Univ. of Denmark, Denmark.

We demonstrate a super-resolution algorithm to estimate channel power and spacing. We show minimal loss in power accuracy and frequency accuracy 1000× below the spectrometer resolution.

Low-Complexity Embedded BICM-ID Structure for Multi-Dimensional Coded Modulation, Zhiyu Xiao1, Mo Li1, Fan Yu1, Nebosja Stojanovic1, Changsong Xie1, Lianchuan Li1, Huawei Technologies Co., Ltd., China.

A low-complexity BICM-ID structure which embeds demappers inside the iterative FEC decoder is proposed and demonstrated. 0.47-dB SNR gain over BICM can be obtained for the 8-dimensional modulation format with 8.5-million extra ASIC gates at 100-Gbaud throughput.

10:15-10:45
Product Showcase
Cisco

11:00–11:30
Product Showcase
Phoenix Software

11:00–12:00
Panel I: Next-Generation Access and Metro – Where is the Money?

11:00–12:30
For more details, see page 43

11:30–12:00
Product Showcase
Jabil AOC Technologies

For more details, see page 47

12:00–13:00
Unopposed Exhibit-Only Time, Exhibit Hall G-K (concessions available)

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Wednesday, 22 March

Exhibit Hall K

W2A.50 Performance Evaluation of Clock Recovery for Coherent Mode Division Multiplexed Systems, Julio C. Díaz1, Molly Piels1, Darko Zibar1, DTU Fotonik, Denmark. The impact of mode mixing and group delay spread on clock tone quality of a 6-mode 32 Gbd NRZ-QPSK MDM system is investigated. Even for low group delay spread, strong coupling causes clock tone disappearance.

W2A.51 Experimental Estimation of Optical Nonlinear Memory Channel Conditional Distribution using Deep Neural Networks, Rafael Rios-Müller1, José Manuel Estaran1, Jeremy Renaudier2, Nokia Bell Labs, France. We demonstrate that neural networks can approximate the conditional distribution of non-linear channels with memory. This distribution then feeds conventional algorithms in a 32-GBd NRZ-QPSK MDM system.

112-Gb/s C-band Transmission using 4-Level/7-Level Coding PAM with Chromatic-Dispersion Pre-compensation under 25-GHz Bandwidth Limitation, Akira Masuda1, Shuto Yama1, Xiaodan Pang1, Zhenhua1, Zhenning Tao1, Fujitsu Laboratories Ltd., Japan.

We investigate 112-Gb/s C-band transmission using pre-compensation under 25-GHz bandwidth limitation in a conventional direct-detection system. We confirm the scheme has higher residual-CD tolerance and requires fewer receiver-side FFE taps.

11:30–12:00
Product Showcase
Huawei

For more details, see page 47

Network Operator Summit Keynote

10:30–11:00
For more details, see page 43

Network Operator Summit Panel I: Next-Generation Access and Metro – Where is the Money?

11:00–12:30
For more details, see page 43

Product Showcase
COBO

10:15–11:45
For more details, see page 44

On-board Optics — Challenges, Discoveries and the Path Forward

Show Floor Programming
The optical interconnect industry is embracing higher speeds and higher order modulation formats to meet the continuing growth in bandwidth demand. Does the industry have a technology roadmap consistent with these market needs? Are there bottlenecks in the electronics: drivers, TIA, ADCs, DSPs or the optics: lasers, modulators, detectors? This panel discussion will address some of these questions with industry experts sharing their view of optimal solutions with constraints such as cost and power consumption, and insight into future innovations that may be needed. Come be a part of the discussion and gain an understanding of what the industry is doing and where it is headed.

Panelists:
Beck Mason, Oclaro, USA
Terben Nielsen, Acadia, USA
Vasudeva Parthasarathy, Broadcom, USA
Kim Roberts, Ciena, Canada

David V. Plant received the Ph.D. degree from Brown University in 1989. He was a Research Engineer at UCLA 1989 to 1993, and has been a Professor at McGill University, Montreal, QC, Canada, since 1993, where he holds a James McGill Professorship. He has received five teaching awards and other awards including the IEEE Photonics Society Distinguished Lectureship, the IEEE Microwave Theory and Techniques Society Microwave Prize, the IEEE Photonics Society Distinguished Service Award, and a Killam Research Fellowship. He is a Fellow of the Royal Society of Canada, IEEE OSA, CAE, and EIC.
This paper proposes the...over the past decade, then outline future technology directions which, along with a more holistic design approach, will be needed to keep pace with the requirements and growth of the datacenter.

A novel approach for presenting the...is demonstrated.

We experimentally demonstrate that it prevents the violation of application requirements...compared to Volterra-based NLE.
optical networking/communications community. This session will give an overview of how optics can play a key role for realizing 5G networks and will cover topics such as evolved x-haul, radio-over-fiber, distributed cloud connect (including edge/fog computing) and support for tactile (low latency) Internet applications.

Speakers:
Chih-Lin I, China Mobile Research Inst., China
Theodore Sizer, Nokia Bell Labs, USA
Takehiro Nakamura, NTT Docomo, Inc., Japan
Tao Zhang, Cisco Systems, Inc, USA
**Room 408A**

**W3G • Data Center Interconnect Technologies—Continued**

**W3G.2 • 13:30**

Impact of Damping on 50 Gbps 4-PAM Modulation of 25G Class VCSELs, Tamás Lengyel¹, Emanuel P. Haglund², Johan Gustavsson¹, Krzysztof Szczepanowski¹, Anders G. Larson¹, Magnus Karlsson¹, Peter A. Andrekson¹, Chalmers Univ. of Technology, Sweden; Finisar Corp., USA. We investigate the effects of photon lifetime and damping of the modulation response on the quality of 50 Gbps 4-PAM signal generation with directly modulated 25G class VCSELs and identify the appropriate values for the K-factor.

**W3G.3 • 13:45**

Top-scored Eye Skew Modeling, Measurements and Mitigation Methods for VCSEL PAM-4 Channels at Data Rates over 66 Gb/s, Jose M. Castro¹, Rick Pimpinella¹, Bulent Kose¹, Paul Huang¹, Asher Novick¹, Brett Lane¹, Panduit Corp., USA. Investigation of eye skew and techniques for reducing its impact on system performance at data rates from 64 Gb/s to 70 Gb/s using PAM-4 directly modulated VCSELs over 100 m MMF is presented.

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**Room 408B**

**W3H • Multicore and Multimode Fiber Devices—Continued**

**W3H.3 • 13:30**

Application of Multicore Optical Fibers in Astronomy, Nemanja Jovanovic³, Oliver Guyon¹, Hajime Kawahara¹, Takayuki Kotani¹, Subaru Telescope, USA; Physics and Astronomy, Macquarie Univ., Australia; Department of Earth and Planetary Science, The Univ. of Tokyo, Japan; National Astronomical Observatory of Japan, Japan. Multicore fibers are desirable for astronomy as they offer superior fill factors and can transport light in many channels with the overhead of only a single fiber. We provide an overview of several astronomical applications.

**W3H.4 • 13:45**

High Performance SDN Hardware Architectures and Their Uses in the Evolving Transport Network, Yatish Kumar¹, Corsa Technologies, Canada. L2/L3 forwarding requirements determine what Programmable (SDN) Networking means for transport networks. The end of Moore’s law (16.7 nm silicon) and optical channel capacity (Shannon-Nyquist limits) pose constraints on hardware architectures. We look at how programmable L2/L3 SDN maps to technology constrained physical architectures.

**Room 409AB**

**W3I • Control of Multi-layer Networks—Continued**

**W3I.3 • 13:30**

Effectiveness of Symbol-rate Optimization with PM-16QAM Subcarriers in WDM Transmission, Fernando Guimon¹, Andrea Carena¹, Gabriella Bosco¹, Antonella Nespoli¹, Luca Bertignorio¹, Pierluigi Poggio², Politecnico di Torino, Italy; Istituto Superiore Mario Boella, Italy. We demonstrate up to 9% reach gain provided by symbol-rate optimization over PM-16QAM subcarriers in WDM transmission. Applying an ideal CPE, we also discuss on the potentially achievable SRO gains enabled by enhanced phase noise compensation.

**W3I.4 • 13:45**

Electronically Subcarrier Multiplexed PM-32QAM with Optimized FEC Overheads, Tobias A. Eriksson¹, Fred Buchali¹, Wilfried Idler¹, Laurent Schmaler¹, Nokia CHARLET¹, Nokia Bell Labs, Germany; ‘Nokia Bell Labs, France. We experimentally investigate PM-32QAM with up to 16 subcarriers per wavelength and demonstrate that at a net bitrate of 350 Gbit/s, the distance can be increased by 300 km in WDM transmission using variable rate FEC.
W3B.2 • 14:00 Top-Performing 504 and 462 Gb/s Direct Detect Transceiver for Single Carrier Short-reach Data Center Applications, Mathieu Chagnon1, David Plant1;1McGill Univ., Canada. We demonstrate a single carrier direct detect transceiver operating at 84 Gsymbols/s providing 5.5 and 6 bits per symbol delivering 462 and 504 Gb/s employing a novel modulation format and DSP for 400+ GbE PMD.

W3B.3 • 14:15 Experimental Demonstration of Novel Simple Blind Polarization-demultiplexing Algorithm for Stokes Vector Direct Detection Receivers, Shota Ishimura1, Kosuke Nishimura1;1KDDI Research, Inc., Japan. We propose a novel blind polarization-demultiplexing algorithm for SV-DD receivers which significantly reduces computational complexity. We numerically confirmed that the algorithm is robust against SOP fluctuations and experimentally demonstrated its effectiveness by 20-km transmission.

W3D.4 • 14:00 Invited Disaggregated Compute, Memory and Network Systems: A New Era for Optical Data Centre Architectures, Georgios S. Zervas1, Fangsheng Jiang1, Gianqiao Chen1,2, Vaibhava Mishra1, Hui Yuan1, Kostas Katrinis1, Dimitris Syrivelis1, Andrea Reale1, Dionysios Pnevmatikatos1, Michael Enrico1, Nick Parsons1;1Univ. College London, UK, 2Univ. of Bristol, UK; IBM Research, Ireland; 3UITH, Greece; 4FORTH, Greece; 5Huber-Suhner Polatis, UK. The disaggregated dRedBox Data Centre architecture is proposed that enables dynamic allocation of pooled compute and memory resources. An orchestration platform is described and algorithms are simulated that demonstrate the efficient utilization of IT infrastructure.

W3D.5 • 14:15 Three Modes Multiplexed Photonic Integrated Circuit for Large Capacity Optical Interconnection, Guanyu Chen1, Yu Yu1, De Zhou1, Wenhao Wu1, Xi Xiao1, Songnian Fu1, Xinliang Zhang1;1Wuhan National Lab for Optoelectronics, China; 2State Key Laboratory of Optical Communication Technologies and Networks, Wuhan Research Inst. of Posts Telecommunications, China. We demonstrated a three modes multiplexed photonic integrated circuit suitable for chip-scale large capacity optical interconnection. The 30 Gb/s link including modulation, multiplexer/demultiplexer and detection is experimentally demonstrated with superior performance.
In an SDN-based network, we study how to...

We characterized Brillouin scattering technology, China; YOFC, China. We characterized Brillouin scattering in heterogeneous multicore fiber (H-MCF), and unveil new perspective in heterogeneous multicore fiber.

Distributed and Discriminative Brillouin Optical Fiber Sensing based on Heterogeneous Multicore Fiber, Ming Tang1, Zhiyong Zhao1, Songnian Fu1, Wejun Tong1, Deming Liu1, Huashong Univ of Science and Technology, China; YOFC, China. We characterized Brillouin scattering in heterogeneous multicore fiber (H-MCF), and unveil new perspective for distributed sensing using H-MCF based spatial-division multiplexing, in which discriminative measurement is achieved and bending induced uncertainty has been eliminated.

Cost-Efficient Multi-layer Restoration to Address IP Router Outages in IP-over-EONs, Siqi Liu1, Wei Lu1, Zuqing Zhu1, Univ of Science and Technology of China, China. We study how to address the IP router outages in an IP-over-EON with multi-layer restoration (MLR), and propose an auxiliary-graph (AG) based scheme that can minimize the additional OPEX with the help of the spectrum expansion capability of sliceable bandwidth-variable transponders (SBV-T).

Nicolas Gisin was born in Geneva, Switzerland, in 1952. He received his Ph.D. degree in theoretical physics from the University of Geneva in 1981. After a post-doc at the University of Rochester, NY, and four years in industry, he joined the Group of Applied Physics at the University of Geneva where he has led the optics section since 1988. His activities range from the foundations of quantum physics to applications in quantum communications. He received two consecutive ERC Advanced Grants. In 2009 he was the first awardee of the John Steward Bell prize and in 2014 the Swiss Science prize delivered by the Marcel Benoist Foundation.
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<tr>
<th>Time</th>
<th>Session Description</th>
<th>Location</th>
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<tbody>
<tr>
<td>W3A.4: 14:30</td>
<td>Top-Septed 280-Gb/s 320-km Transmission of Polarization-division Multiplexed QAM-PAM with Stokes Vector Receiver, Thang M. Hoang, Mohammed Sowailen, Mohammed Osman, Carl Paquet, Stephane Paquet, Ian Woods, Qunbi Zhuge, David Plant, Carl Paquet, Stephane Paquet, Ian Woods, Qunbi Zhuge, David Plant,</td>
<td>Room 402AB</td>
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<tr>
<td>W3B.4: 14:30</td>
<td>H-V Plane Projection Based Polarization Recovery and Probabilistic Shaping for Stokes Vector Direct Detection, An Li, Wei-Ren Peng, Clarence Kan, Yanjun Zhu, Zhong Li, Samina Chowdhury, Yan Cui, Yusheng Bai,</td>
<td>Room 403A</td>
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<td>W3C.4: 14:30</td>
<td>Network Performance Trade-off in Optical Spatial Division Multiplexing Data Centers, Li Yan, Mattea Fiorani, Ajmal Muhammad, Massimo Tornatore, Erik Agrell, Lena Wosinska, ’Chalmers Univ. of Technology, Sweden, ’Optical Network Lab, Royal Inst. of Technology, Sweden, ’Politecnico di Milano, Italy. We propose close-to-optimal network resource allocation algorithms modular data centers using optical spatial-division multiplexing. A trade-off between the number of established connections and throughput is identified and quantified.</td>
<td>Room 403B</td>
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<td>W3D.4: 14:30</td>
<td>850 nm Hybrid Vertical Cavity Laser Integration for On-chip Silicon Photonics Light Sources, Gunther Roelkens, Emanuel P. Haglund, Sulakshna Kumasi, Erik Haglund, Johan Gustavsson, Roel Baets, Anders G. Larsen, ’Ghent Univ. - imec, Belgium; ’Chalmers Univ. of Technology, Sweden. The realization of 850 nm hybrid III-V/dielectric VCSELs is reported in order to realize low power consumption integrated light sources for SiN waveguide circuits, which find applications both in short-reach optical communication and optical sensors.</td>
<td>Room 404AB</td>
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<td>W3E.4: 14:30</td>
<td>Low-cost Visible Light Communication System based on Off-the-shelf LED for up to 4.3 Gb/s/λ Transmission, Bernhard Schrenk, Markus Hofer, Fabian Laudenbach, Hannes Hubel, Thomas Zemen, ’AIT Austrian Inst. of Technology, Austria. Multi-Gb/s/λ visible light communication is demonstrated using a commodity LED rated for 150 Mb/s and OFDM/Nyquist-FDM with 256-QAM subcarrier modulation. 1Gb/s/λ throughput and real-time video streaming is achieved over 10dB optical budget and PIN receiver.</td>
<td>Room 406AB</td>
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<td>W3F.4: 14:30</td>
<td>Invited 850 nm Hybrid Vertical Cavity Laser Integration for On-chip Silicon Photonics Light Sources, Gunther Roelkens, Emanuel P. Haglund, Sulakshna Kumasi, Erik Haglund, Johan Gustavsson, Roel Baets, Anders G. Larsen, ’Ghent Univ. - imec, Belgium; ’Chalmers Univ. of Technology, Sweden. The realization of 850 nm hybrid III-V/dielectric VCSELs is reported in order to realize low power consumption integrated light sources for SiN waveguide circuits, which find applications both in short-reach optical communication and optical sensors.</td>
<td>Room 407</td>
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13:30–15:00 IEEE Women in Photonics/WICE Luncheon, 515A (separate registration required)

15:00–15:30 Coffee Break, 400 Foyer; Exhibit Hall

17:00–19:30 Photonic Society of Chinese-Americans Workshop and Social Networking Event, Room 518

W3A • Panel: Are Electronic and Optical Components Ready to Support Higher Symbol Rates and Denser Constellations?—Continued

W3B • Direct-Detection Transceivers—Continued

W3C • Symposium: What is Driving 5G, and How Can Optics Help!—Continued

W3D • Inter/Intra Data Center Networks—Continued

W3E • III-V / Silicon Integrated Devices—Continued

W3F • Low Cost Systems for Wireless and Non-telecom Applications—Continued
W3G • Data Center Interconnect Technologies—Continued

W3G.5 • 14:30  High Bit-Rate Distance Product of 128 Gbps•km 4-PAM Transmission over 2 km OM4 fiber Using an 850-nm VCSEL and a Volterra Nonlinear Equalizer, Jun-Jie Liu¹, Kai-Lun Chi², Chia-Chien Wei¹, Tien-Chien Lin¹, C. Y. Chuang³, Xin-Nan Chen¹, Jin-Wei Shi¹, Jiayong Chen¹; ¹Department of Photonics, National Chiao Tung Univ., Taiwan; ²Department of Electrical Engineering, National Central Univ., Taiwan; ³Department of Photonics, National Sun Yat-sen Univ., Taiwan. We successfully demonstrate a 64-Gbps 4-PAM transmission over 2-km OM4 fiber incorporating a Volterra equalizer with BER of 6.5×10⁻⁵. Record high bit-rate distance product of 128 Gbps•km is confirmed for optical-interconnect applications.

W3G.6 • 14:45  Experimentally Benchmarked Fiber Propagation Model for 50Gbps PAM-4 MMF Links Employing Multimode VCSELs, Alirio Melgar¹, Varghese A. Thomas¹, Justin Lavrencik¹, Siddharth Varughese¹, Stephen E. Ralph¹; ¹Georgia Inst. of Technology, USA. MMF propagation of multimode VCSEL signals with preferential coupling of VCSEL modes into fiber modes and colored noise is modeled and benchmarked using 50Gbps PAM-4 and 25Gbps PAM-2 experimental results at 850nm and 940nm.

W3H • Multicore and Multimode Fiber Devices—Continued

W3H.6 • 14:30  Simultaneous Measurement of Temperature and Strain Based on a Polarization-Maintaining Few-Mode Fiber, Liyao Yu¹, Jian Zhao¹, Qi Mo², Lin Zhang¹, Guifang Li¹; ¹Key Laboratory of Optoelectronic Information Technical Science of Ministry of Education, School of Precision Instruments and Optoelectronics Engineering, Tianjin Univ., China; ²Fiberhome & Fujikura Optics Co., Ltd, China; ³CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA. An optical sensor based on a polarization-maintaining few-mode fiber (PM-FMF) for simultaneous sensing of temperature and strain is demonstrated, for the first time. The sensor has a temperature sensitivity of about 175 pm/°C and a strain sensitivity of about 5 pm/με with an accuracy of 0.1°C and 10 με.

W3I • Control of Multi-layer Networks—Continued

W3I.6 • 14:30  Invited  Packet-Optical Integration and Trend Towards White Boxes, Hans-Juergen Schmidtke¹, Ilya Lyubomirsky¹, Brian Taylor¹; ¹Facebook Inc., USA. Many implementations have been developed to integrate Packet (mostly IP) networks with underlying transport networks. The paper describes the benefits of packet-optical integration and an opportunity how to use the white box approach to realize the integration. Voyager as an example is described.

W3K • Perspectives in Quantum Communication—Continued

W3K.6 • 14:30  Invited  High Bit-Rate Distance Product of 128 Gbps•km 4-PAM Transmission over 2-km OM4 fiber Using an 850-nm VCSEL and a Volterra Nonlinear Equalizer, Jun-Jie Liu¹, Kai-Lun Chi², Chia-Chien Wei¹, Tien-Chien Lin¹, C. Y. Chuang³, Xin-Nan Chen¹, Jin-Wei Shi¹, Jiayong Chen¹; ¹Department of Photonics, National Chiao Tung Univ., Taiwan; ²Department of Electrical Engineering, National Central Univ., Taiwan; ³Department of Photonics, National Sun Yat-sen Univ., Taiwan. We successfully demonstrate a 64-Gbps 4-PAM transmission over 2-km OM4 fiber incorporating a Volterra equalizer with BER of 6.5×10⁻⁵. Record high bit-rate distance product of 128 Gbps•km is confirmed for optical-interconnect applications.

13:30–15:00  IEEE Women in Photonics/WICE Luncheon, 515A (separate registration required)

15:00–15:30  Coffee Break, 400 Foyer; Exhibit Hall

17:00–19:30  Photonic Society of Chinese-Americans Workshop and Social Networking Event, Room 518
We present an overview of analog microwave photonic circuits.

The vision of 5G is commonly presented as part of the network vision for 2020 and beyond, which in turn embodies a number of services for the future information society in which everything that can connect to this society will do so. The typical services identified span areas such as enhanced mobile broadband services, media distribution, Smart Cities, and the internet of things (IoT), with massive as well as ultra-reliable and low latency (critical) machine-type communications to support both end-user and operational purposes. Besides new services and applications, 5G will also need to support a wide range of business ecosystems and cooperation models supporting digitalization of industry and trends of business horizontalization. 5G goes far beyond the definition of new radio interfaces. 5G is about a new end-to-end network vision, in which softwarization and virtualization allow a common network infrastructure to be flexibly used for a variety of diverse applications.

The symposium will consist of two sessions. The first session will focus on “What is driving 5G?” with speakers from the 5G community as well as vertical industries that can be benefited adopting the 5G vision. This session will give an overview of the services, applications and ecosystems that are driving 5G and provide some insight on how these can create a new and substantial business opportunity for optical networking and its most advanced technologies. The second session will focus on the role of optics and will include speakers from the optical networking/communications community. This session will give an overview of how optics can play a key role for realizing 5G networks and will continue on page 120
15:30–17:30
W4G • Indium Phosphide Photonic Integration
Presider: Michael Larson; Lumentum, USA

W4H.1 • 15:30 Tutorial
InP Photonic Integrated Circuits, Larry A. Coldren, Univ. of California Santa Barbara, USA; InP Photonic IC (PIC) materials, integration technology and platforms will be reviewed. Motivations for integration, particularly with active elements, will be summarized. Examples of early PICs and their evolution to today’s state-of-the-art will be given. Applications, primarily related to optical fiber communications, will be indicated. Some comparisons with other integration technologies, e.g., Si-photonics, will be given.

Larry A. Coldren is the Fred Kavli Professor of Optoelectronics and Sensors at the University of California, Santa Barbara, CA. He received his Ph.D. in EE from Stanford Univ. and spent 13 years in research at Bell Labs before joining UCSB in 1984, where he holds appointments in the ECE and Materials Departments. He acted as Dean of Engineering at UCSB from 2009-2011. In 1991 he co-founded Optical Concepts, acquired as Gore Photonics, to develop novel Vertical-Cavity Surface-Emitting Laser (VCSEL) modules; and later in 1998, Agility Communications, acquired by JDS-Uniphase (now Lumentum), to develop widely tunable integrated optical transmitters. He has authored continued on page 121

15:30–17:30
W4H • Evolution of Optical Networks
Presider: David Boerjaez; Ciena Corporation, Canada

W4H.2 • 15:45 Top 250 Field Trial Transmission of 1.5 Tb/s Superchannel over 875 km, with 250 Gb/s Real-Time Transponders and EDFA Amplification, Jean-Luc Auge, Bruno Lavigne, Marek Dabrowski, Florian Palka, Mael Le Monnier, Zbigniew Klimas, Xiaoxia Wu, Jamie Gaudette, Jeffrey L. Cox; Microsoft Corp., USA; Astaro Networks, USA. Astaro, Cisco, and Juniper’s layer-2/3 modular switches with integrated coherent optics are interopertated over 2000 km at 150G 8QAM and 1000 km at 200G 16QAM on Microsoft’s open line system.

15:30–17:30
W4I • High-speed Interconnects
Presider: Chongjin Xie; Inst. of Technology , USA.

W4I.1 • 15:30 Optical Interconnects: Design and Analysis, Azita Emami; California Inst. of Technology, USA. This paper focuses on design challenges and solutions for realization of low-power high-speed electronics for optical interconnects. Design methodologies for high sensitivity receivers and optimized driver circuitries at the transmitter side are presented.

15:30–17:30
W4J • SDN/NFV and Service Function Chaining
Presider: Ramon Casellas; Ctr Tecnològic de Telecom de Catalunya, Spain

W4J.1 • 15:30 Invited SDN/NFV Futures at Verizon, Bryan C. Larsh; Verizon, USA. We provide a brief overview of Verizon’s initial SDN/NFV deployments and then describe future directions being evaluated and implemented to expand the SDN/NFV infrastructure’s usefulness. We will discuss ideas for implementing performance-sensitive VNFs, to include optical network elements, and using SDN/NFV to improve infrastructure security.

15:30–17:30
W4K • Panel: Quantum Communication Programs Around the World
Moderators: Andrew Lord; BT Labs, UK; Masahide Sasaki; National Inst of Information & Comm Tech, Japan

In a future where quantum computers will break much current cryptography, quantum communications offers the potential for unbreakable security, through untappable distribution of secret keys over optical fibres and free space, including satellite communications. This panel will take stock of the huge, current world-wide interest in and funding of quantum communications programs including developments in the US, China, Japan and Europe.

What will be the killer applications of quantum communications –will it be for bespoke point to point short-haul secure systems or can it form the basis of unprecedented long-lived security solutions even enabling data storage? Will it extend to core and access networks? Will quantum satellites create secure international communications or will classical, quantum-safe cryptography render quantum communications obsolete before it even starts?

Panelists: Johannes Buchmann, Technische Universität Darmstadt, Germany
Lijun Ma, NIST, USA
Gregoire Ribordy, ID Quantique, Switzerland
Qiang Zhang, University Science and Technology, China
We propose a novel post-probabilistically-shaped PAM as a simple channel coding being applicable to optical communication systems with SD-FEC. It directly controls the distribution and communication systems with SD-FEC. Coding being applicable to optical transmission over 3,500km without penalty. For 8D-16QAM, experiments confirm that of conventional optimal decoding 3.5868e-4 times the signal-to-noise ratio (SNR) reduction over 80km and quantify tolerance to chromatic dispersion and nonlinearity over a wide range of fiber types.

We propose a novel post-probabilistically-shaped PAM as a simple channel coding being applicable to optical communication systems with SD-FEC. It directly controls the distribution and communication systems with SD-FEC. Coding being applicable to optical transmission over 3,500km without penalty. For 8D-16QAM, experiments confirm that of conventional optimal decoding 3.5868e-4 times the signal-to-noise ratio (SNR) reduction over 80km and quantify tolerance to chromatic dispersion and nonlinearity over a wide range of fiber types.
or co-authored over a thousand journal and conference papers, including numerous plenary, tutorial and invited presentations. He has co-authored 8 book chapters and two textbooks. He has been issued 61 patents and is a recipient of several awards, including the John Tyndall, Aron Kressel, David Sarnoff and IPRM Awards. He is a Life Fellow of the IEEE, and a Fellow of the OSA and IEE as well as a member of the National Academy of Engineering.

W4H.3 • 16:00 Migrating Elastic Optical Networks from Standard Single-Mode Fibers to Ultra-low Loss Fibers: Strategies and Benefits, Yanxin Guan1, Haomin Jiang1, Mingyi Gao1, Sanjay K. Bose1, Gangxiang Shen1; 1Soochow Univ., China. We consider replacing standard single-mode fibers with ultra-low loss fibers in an elastic optical network. Replacement strategies are compared based on bandwidth blocking performance. Simulations show that the OSNR-blocking-based strategy is efficient and saturation exists between the fiber attenuation factor and blocking performance improvement.

W4H.4 • 16:15 Evolution of Core Traffic for Growing CDNs: Is the Growth Rate of Core Network Traffic Overestimated?, Pablo Pavon-Munoz1, Francesco-Javier Moreno-Munoz2, Nina Skorin-Kapov2; 1Politecnical Univ. of Cartagena, Spain; 2Univ. Center of Defense, Spain. The dramatic growth of user traffic will precipitate CDN expansion, both in capacity and new datacenter locations, the latter bringing content closer to the user. We investigate how this may partially alleviate core traffic growth.

W4I.3 • 16:15 Intra-Datacenter Links Exploiting PCI Express Generation 4 Interconnections, Alberto Gatto1, Paola Panolan1, Marco Brunero1, Francesco Corapi1, Viscardo Costa2, Claudio Meani1, Pierpaolo Boffi1; 1Politecnico di Milano, Italy; 2ITALTEL S.p.A., Italy. We demonstrate few-km reaches for PCIe-based optical fiber interconnections according to latency limitations, characterizing 16-Gb/s per lane Generation4 up to 10 km and confirming the Generation3 compliance of 2-km links employing suitable PCIe cards.

W4J.2 • 16:00 Efficient and Verifiable Service Function Chaining in NFV: Current Solutions and Emerging Challenges, Ying Zhang2, Sujata Banerjee1; 2Hewlett Packard Labs, USA. The ability to deploy Service Function Chains (SFC) efficiently and correctly is important in Network Functions Virtualization (NFV) infrastructures. This talk discusses the challenges and emerging solutions for scalable instantiation and verification of SFCs.

W4J.3 • 16:15 Intra-Datacenter Links Exploiting PCI Express Generation 4 Interconnections, Alberto Gatto1, Paola Panolan1, Marco Brunero1, Francesco Corapi1, Viscardo Costa2, Claudio Meani1, Pierpaolo Boffi1; 1Politecnico di Milano, Italy; 2ITALTEL S.p.A., Italy. We demonstrate few-km reaches for PCIe-based optical fiber interconnections according to latency limitations, characterizing 16-Gb/s per lane Generation4 up to 10 km and confirming the Generation3 compliance of 2-km links employing suitable PCIe cards.
Wednesday, 22 March

**Room 402AB**

**W4A • Coded Modulation—Continued**

**W4A.4 • 16:30** Achievable Rates of Multidimensional Multispherically Distributed Information, Jean J. Essiambre, Johnny Karout, Erik Agrell, Antonia Tulino, Keisuke Matsuda, Fei Zhao, Sang-Pil Han, David Millar, Mohammad Kiaei, Eui Su Lee, Chunshu Ouyang. We review challenges in digital signal processing techniques for PAM4 intra-data center and data center interconnect applications. DSP & FEC parameters for PAM4 direct-detection transceiver IC that achieves 100Gbps in 28nm CMOS process for 80km DWDM Data Center Interconnect (DCI) in a QSFP28 form factor will be discussed.

**Room 403A**

**W4B • Microwave Photonic Subsystems—Continued**

**W4B.4 • 16:30** Semiconductor-based Terahertz Photonics for Industrial Applications, Kyung Hyun Park, Eui Su Lee, Il Min Lee, Kwon Moon, Hyun-So Soo Kim, Jeong-Woo Park, Dong-Woo Park, Dong Hun Lee, Sang-Pil Han. With a vision of easily-accessible terahertz industrial applications, we are in pursuit of small and cost-effective terahertz technologies. Various approaches for the enhanced performances, including arrayed devices and nano-based devices will be presented.

**Room 403B**

**W4C • Symposium: What is Driving 5G, and How Can Optics Help II—Continued**

**W4C.5 • 16:45** Nonlinearity-tolerant Time Domain Hybrid Modulation for 4-8 bits/symbol based on 2A8PSK, Keisuke Kojima, Tsuyoshi Yoshida, Kieran Parsons, Toshiaki Koike-Akino, David Millar, Keisuke Matsuda, Mitsubishi Electric Research Labs, Japan. We propose time domain hybrid modulation to cover 4-8 bits/symbol range, based on 5, 6, and 7 bits/symbol 4D-2A8PSK. Simulation results indicate that they have up to 1.6 dB higher span loss budget than the hybrid modulation based on conventional modulation formats in nonlinear channels.

**Room 404AB**

**W4D • PAM-4 Inter-data Center Transmission—Continued**

**W4D.4 • 16:30** Top Scored Silicon Photonic Switch Subsystem with 900 Monolithically Integrated Calibration Photodiodes and 64-Fiber Package, Patrick Dunais, Dominic Goodwill, Mohammad Kiae, Dritan Celik, Jia Jiang, Chunjie Zhuang, Fei Zhao, Xin Tu, Chunhui Zhang, Shengyong Yan, Jifang He, Ming Li, Wanyuan Liu, Yuming Wei, Dongyu Geng, Hamid Mehrvar, Eric Bernier, Huawei Technologies Canada, Canada; Huawei Technologies, China. Monolithic germanium photodiodes on every cell calibrate a 32x32 silicon photonic switch of 448 Mach-Zehnder in 10 minutes. 64 fibers permanently attached through a waveguide concentrator in a wire-bonded BGA achieve 2Rb C-band TE fiber-to-die.

**Room 406AB**

**W4E • Photonic and Planar Switches—Continued**

**W4E.4 • 16:30** Top Scored Fully Integrated Non-Duplicate Polarization-diversity 8 x 8 Si-Wire PILOSS Switch, Ken Tanizawa, Keijiro Suzuki, Kazuhiro Ikeda, Shu Namiko, Hitoshi Kawashima, NTT Inst of Adv Industrial Sci & Tech, Japan. We demonstrate a polarization-diversity 8x8 thermo-optic Si-wire switch that uses only a single PILOSS switch matrix integrated with polarization splitter-rotators. A PDL of 2 dB and OGD of 1.5 ps are achieved in C-band.

**Room 407**

**W4F • WDM and SDM Networking—Continued**

**W4F.5 • 16:30** Top Scored Multi-core Fibers in Submarine Networks for High-capacity Undersea Transmission Systems, Md. Nooruzza, Nokia Bell Labs, France, Canada; Technical Univ. of Denmark, Denmark. Application of multi-core fibers in undersea networks for high-capacity submarine transmission systems is studied. It is demonstrated how different architectures of submersed branching unit affect network component counts in long-haul undersea transmission systems.

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**W4A.5 • 16:45** Invited Tutorial Coded Modulation—Continued

**W4A.5 • 16:45** Nonlinearity-tolerant Time Domain Hybrid Modulation for 4-8 bits/symbol based on 2A8PSK, Keisuke Kojima, Tsuyoshi Yoshida, Kieran Parsons, Toshiaki Koike-Akino, David Millar, Keisuke Matsuda, Mitsubishi Electric Research Labs, USA. We propose time domain hybrid modulation to cover 4-8 bits/symbol range, based on 5, 6, and 7 bits/symbol 4D-2A8PSK. Simulation results indicate that they have up to 1.6 dB higher span loss budget than the hybrid modulation based on conventional modulation formats in nonlinear channels.

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W4G • Indium Phosphide Photonic Integration—Continued

W4H • Evolution of Optical Networks—Continued

W4I • High-speed Interconnects—Continued

W4J • SDN/NFV and Service Function Chaining—Continued

W4K • Panel: Quantum Communication Programs Around the World—Continued

W4G.2 • 16:30
Multi-channel Interference (MCI) Widely Tunable Laser Integrated with Semiconductor Optical Amplifier, Quanan Chen1,2, Xiang Ma1,2, Wei Sun1,2, Ye Lu1,2, Gonghui Liu1,2, Gongyuan Zhao1,2, Qiaoyin Lu1,2, Weihua Guo1,2; 1Huaqiao Univ. of science and technology, China; 2Wuhan National Laboratory for Optoelectronics, China. We demonstrate the MCI laser integrated with SOA through a two-port multi-mode interference reflector. A tuning range of more than 45 nm with SMSRs up to 47 dB is achieved.

W4H.4 • 16:30
MONET: An Early Demonstrator of National and Metro Reconfigurable, Wavelength Routed Optical Networks: A Historical Perspective, Rod C. Allermans1; 1Univ. of California Santa Barbara, USA. We provide a historical perspective of Multiple Wavelength Optical Networking (MONET) including its impact on commercially deployed WDM networks and offer a perspective to the future.

W4I.4 • 16:30
EML-based IM/DD 400G (4x112.5-Gbit/s) PAM-4 over 80 km SSMF: A Comparison of Linear Pre-equalization and Nonlinear Pre-distortion, Weiyang Zhang1,2,3,4; 1ZTE Tx Inc, USA. We experimentally demonstrated EML-based IM/DD 4x112.5-Gbit/s PAM-4 transmission over 80km SSMF for inter-DCI applications. Thanks to the transmitter-side DSP based on linear pre-equalization and nonlinear look-up-table pre-distortion, the performances are significantly improved.

W4J.3 • 16:30
Service Chaining in Multi-Layer Networks using Segment Routing and Extended BGP FlowSpec, Francesco Paolucci1, Alessio Giorgetti2,3, Filip Cugn2,4, Piero Castoldi2; 1Scuola Superiore Sant’Anna, Italy; 2CNIT, Italy. Effective service chaining enforcement along TE paths is proposed using Segment Routing and extended BGP Flowspec for micro-flows mapping. The proposed solution is experimentally evaluated with a deep packet inspection service supporting dynamic flow enforcement.

W4K.3 • 16:45
A Chip-Scale Heterodyne Optical Phase-locked Loop with Low-power Consumption, Arda Simsek1, Shamsul Arifin1, Seang-Kyun Kim1, Gordon Morrison2, Leif Johansson2, Milan Mashanovitch3, Larry A. Coldren3, Mark Rodwell4; 1UCSSB USA; 2Freedom Photonics LLC, USA. A chip-scale heterodyne optical phase-locked loop, consuming only 1.3 W of electrical power, with a maximum offset locking frequency of 17.4 GHz is demonstrated. The InP-based photonic integrated receiver circuit consumes only 166 mW.

W4J.4 • 16:45
Optical Network as a Service for Service Function Chaining across Datacenters, Victor Mehmen1,2, Xi Wang1, Qiong Zhang1, Paparo Palacharla1, Tadashi Ikeda1,2, Idelfonso Tafur Monroy1; 1Technical Univ. of Denmark, Denmark; 2Fujitsu Laboratories of America, Inc., USA. We present the SPN OS, a Network-as-a-Service orchestration platform for NFV/SDN integrated service provisioning across multiple datacenters over packet/optical networks. Our prototype showcases template-driven service function chaining and high-level network programming-based optical networking.

For more details, see page 45.

For more details, see page 41.

OFC 2017 • 19–23 March 2017
### Wednesday, 22 March

#### 17:00 W4.A.6
**A Generalized Pairwise Optimization for Designing Multi-dimensional Modulation Formats.** Shaoliang Zhang\(^1\), Fatih Yaman\(^2\), Eduardo Mateo\(^3\), Takanori Inoue\(^4\), Kohei Nakamura\(^5\), Yoshisasa Inada\(^6\), NEC Laboratories America Inc, USA; \(^1\)NEC Corporation, Japan. A modified pairwise optimization algorithm has been proposed to optimize N-dimensional constellation. The resulting optimized 2- and 4-dimensional 8QAM formats outperform star-8QAM by >0.4 dB at the SNR above the FEC limit in both simulation and experiments.

#### 17:15 W4.A.7
**Filtering Tolerant Digital Subcarrier Multiplexing System with Flexible Bit and Power Loading.** Xiang Meng\(^7\), Qunbi Zhuge\(^8\), Meng Qiu\(^9\), Fangyuan Zhang\(^9\), Thang M. Hoang\(^2\), Mohammed Solaimani\(^1\), Ming Tang\(^1\), Deming Liu\(^2\), Songnian Fu\(^2\), David Plant\(^1\), WNLO, China; \(^1\)Next generation Internet Access National Engineering Lab (NGIAl), Huazhong Univ. of SciTech (HUST), China; \(^2\)Department of Electrical and Computer Engineering, McGill Univ., Canada; \(^3\)Ciena Corporation, Canada. We propose to use adaptive bit and power loading in digital subcarrier-multiplexing (SCM) systems based on time-domain hybrid QAM to increase optical filtering tolerance. 17.5% capacity improvement is achieved in experimental demonstrations.

#### 17:15 W4.B.6
**Selective Grating Inscription in Multicore Fibers for Radiofrequency Signal Processing.** Ivan Gasulla Mestre\(^1\), David Barrera\(^1\), Javier Hervas\(^1\), Salvador Sales\(^2\), Universitat Politècnica de Valencia, Spain. We present and experimentally demonstrate the implementation of true time delay lines for microwave photonics signal processing based on the selective inscription of Fiber Bragg gratings along the individual cores of a multicore fiber.

### 19–23 March

#### OFC 2017

Follow @ofcconference on Twitter. Use hashtag #OFC2017.
**W4G • 17:00 • Invited**
DAC-free Generation of M-QAM Signals with InP Segmented Mach-Zehnder Modulators, Martin Schell¹, Gerrit Fiol¹, Alessandro Aimeone¹; ¹Fraunhofer Institut, Germany. The concept of DAC-less generation of multi-level optical signals is discussed together with its latest InP-based results. A flexible transmitter sub-assembly enabling 32 GBd M-QAM operation up to 256-QAM is shown.

**W4H • 17:00**
Multinational Submarine Networks, Lara D. Garrett¹; ¹TE SubCom, TE Connectivity, USA. We discuss system design issues introduced by different ownership models in undersea OADM cables, including the selection of OADM node architectures and the level of OADM reconfigurability.

**W4I • 17:00**
Broadband Plasmonic Modulator Enabling Single Carrier Operation Beyond 100 Gbit/s, Claudia Hoessbacher¹, Arne Josten¹, Benedikt Baeuerle¹, Yuriy Fedoryshyn¹, Horst Hettich¹, Yannick Salamin¹, Wolfgang Henn¹, Christian Haffner¹, Rolf Schmid², Delwin Elder³, David Hillekuss¹, Michael Moeller², Larry Dalton³; ¹ETH Zurich, Switzerland; ²Micram Microelectronic GmbH, Germany; ³Univ. of Washington, USA. We demonstrate a plasmonic Mach-Zehnder modulator with a flat frequency response exceeding 170 GHz. Modulation of the device is shown at 100 GBd NRZ and 60 GBd PAM-4.

**W4J • 17:00**
On Efficient Incentive-Driven VNF Service Chain Provisioning with Mixed-strategy Gaming in Broker-based EO-IDCNs, Xiaoliang Chen¹, Lu Sun², Zuqing Zhu³, Hongbo Lu³, S. J. Ben Yao¹; ¹Univ. of California, Davis, USA; ²Univ. Scien. Techn. China, China. We propose to realize incentive-driven virtual network function service chain provisioning in broker-based elastic optical inter-datacenter networks with mixed-strategy gaming and design a heuristic to find the near-equilibrium solutions. Simulation results verify both the effectiveness and stability of the proposed approach.

**W4K • Panel: Quantum Communication Programs Around the World—Continued**

**W4L • 17:15**
High Speed 160 Gb/s DMT VCSEL Transmission Using Pre-equalization, Christoph Kortke¹, Christoph Caspar², Volker Jungnickel³, Ronald Freund³, Mikel Agustin³; ¹Technische Universität Berlin, Germany; ²Fraunhofer Heinrich Hertz Inst., Germany; ³VI Systems, Germany. High speed single channel DMT operation of a directly modulated 850 nm VCSEL with 26 GHz bandwidth is presented. Successful transmission of 161, 152, 135 Gb/s over 10, 300, 550 m of OM4 MMF is demonstrated at the SD-FEC BER limit.
Subcarrier modulation is
We report an IC-driven silicon
1
1
A tunable optical
Infinera Canada
Tel
Inst. of Communications
Queen's Univ. at Kingston, Canada;
Univ. of Southern
Universite de Paris-Sud XI, France;
STMicroelectronics, France.
We present a con
Single-
Frederic Boeuf
Marris-Morini
Paul Crozat
C Alonso-Ramos
2
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Laurent Vivien
Douglas M. Gill
Tam Huynh
Christian W. Baks
Douglas M. Gill
William M. Green
IBM TJ Watson Research Center,
USA. We report an IC-driven silicon
photonic segmented electrode Mach
Zehnder modulator exploiting optical
domain feed-forward equalization
resulting in 56-Gb/s NRZ operation
with BER<10^-12. The result could en-
able FEC-free links for latency sensitive
datcenter applications.

Driver-integrated 56-Gb/s Segment-
ed Electrode Silicon Mach Zehnder Modulator using Optical-domain
Equalization, Benjamin G. Lee
Nicolas Dupuis
Renato Rimaldo-Donadio
Tam Huynh
Christian W. Baks
Douglas M. Gill
William M. Green
IBM TJ Watson Research Center,
USA. We report an IC-driven silicon
photonic segmented electrode Mach
Zehnder modulator exploiting optical
domain feed-forward equalization
resulting in 56-Gb/s NRZ operation
with BER<10^-12. The result could en-
able FEC-free links for latency sensitive
datcenter applications.

Design Considerations for a Digital
Subcarrier Coherent Optical Mo-
dem, David Krause
Ahmed Awadali
Abdullah Karar
Han Henry Sun
Kuang-Tsan Wu
Infinera Canada Inc, Canada. Subcarrier modulation is shown to provide a number of system
benefits including complexity savings
in dispersion compensation, Kerr
nonlinearity mitigation and flexibility
in spectral efficiency. Design consider-
ations are discussed.

Experimental Demonstration of Per-
formance-enhanced MIMO-OFDM
Visible Light Communications, Yang
Hong
Lian-Kuan Chen
Jian Zhao
The Chinese Univ. of Hong Kong,
Hong Kong; Tyndall National Inst.,
Ireland; Univ. College Cork, Ireland.
We experimentally demonstrate indi-
vidual OCT predecoding and SVD-based
adaptive loading to boost the capacity
of MIMO-OFDM VLC systems.
For 1.5-Gbit/s 1-m transmission, the aver-
age BER can be reduced from 1.7×10^-2
to 4.1×10^-2 and 4.7×10^-3, respectively.

Experimental Demonstration of Tunable
Optical Channel Slicing and Stitching to Enable Dynamic
Bandwidth Allocation, Yinwen Cao,
Ahmed Almaiman
Morteza Ziya-
di
Amirhossein Mohajerin Asrael
Changjing Bao
Peicheng Liao
Fatemeh Alisahi
Ahmad Fallahpour
Yoichi Akasaka
Martin Fejer
Joseph Touch
Moshe Tur
Abi Williner
Univ. of Southern
California, USA;
Fujitsu Laboratories of America,
USA;
Stanford Univ., USA;
Information Sciences Inst., USA;
Tel Aviv Univ., Israel. A tunable optical
channel slicing and stitching scheme
is experimentally demonstrated in
QPSK/16QAM systems. Its applica-
tion to dynamic bandwidth allocation
in WDM channels brings >6dB OSNR
improvement at 1e-3 BER comparing
to direct channel insertion.

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Experimental Demonstration of Per-
formance-enhanced MIMO-OFDM
Visible Light Communications, Yang
Hong
Lian-Kuan Chen
Jian Zhao
The Chinese Univ. of Hong Kong,
Hong Kong; Tyndall National Inst.,
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to 4.1×10^-2 and 4.7×10^-3, respectively.

Experimental Demonstration of Tunable
Optical Channel Slicing and Stitching to Enable Dynamic
Bandwidth Allocation, Yinwen Cao,
Ahmed Almaiman
Morteza Ziya-
di
Amirhossein Mohajerin Asrael
Changjing Bao
Peicheng Liao
Fatemeh Alisahi
Ahmad Fallahpour
Yoichi Akasaka
Martin Fejer
Joseph Touch
Moshe Tur
Abi Williner
Univ. of Southern
California, USA;
Fujitsu Laboratories of America,
USA;
Stanford Univ., USA;
Information Sciences Inst., USA;
Tel Aviv Univ., Israel. A tunable optical
channel slicing and stitching scheme
is experimentally demonstrated in
QPSK/16QAM systems. Its applica-
tion to dynamic bandwidth allocation
in WDM channels brings >6dB OSNR
improvement at 1e-3 BER comparing
to direct channel insertion.

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No text content provided.
We propose and transmit photodetectors reported. To the authors' knowledge, N-well and p-well Schottky diodes have been Schottky diodes in CMOS as 1310nm High-speed Optical Photodetectors—Continued

1310nm high-speed Optical Receivers, Wouter Diels1, Michiel Steyaert1, Filip Tavernier1; Katholieke Universiteit Leuven, Belgium. Schottky diodes in CMOS as 1310nm photodetectors are proposed. N-well and p-well Schottky diodes are fabricated and characterized in 40nm bulk CMOS. To the authors' knowledge, this is the first 1310nm CMOS photodetector reported.

200 Gbit/s 16QAM WDM Transmission over a Fully Integrated Cladding Pumped 7-Core MCF System, Carlos Castro1, Saurabh Jain1, Yongmin Jung1, Erik De Man1, Stefano Calabrò2, Klaus Pulverer1, Marc Bohn2, John Hayes2, Shaif-ul Alam2, David J. Richardson1, Katsuhisa Takenaga3, Takayuki Mizuno3, Yutaka Miyamoto3, Toshio Morikawa3, Werner Rosenkranz2, 1Univ. of Kiel, Germany; 2Conant R&D GmbH, Germany; 3Optoelectronics Research Centre, Univ. of Southampton, UK; 4Fujikura Ltd., Japan; 5NTT Network Innovation Laboratories, Japan; 6Technical Univ. of Denmark, Denmark. A complete, realistic integrated system is investigated, consisting of directly spliced 7-core MCF, cladding-pumped 7-core amplifiers, isolators, and couplers. The system is demonstrated in a 16QAM C-band WDM scenario over 720 km.
We demonstrated delta-integrated Bragg devices, Sophie Lafortune 1, Alexandre D'Smar 1,2, Universite Laval, Canada, 1,2. Integrated Bragg grating filters in silicon-on-insulator waveguides are evolving from simple broadband reflectors to filters with complex spectral responses and high-speed modulators. We review recent progress and applications of these devices.

**Room 408A**

**Th1G • Gratings and Filters—Continued**

**Th1G.3 • 08:30 Invited**

**Silicon Photonic Bragg Grating Devices**, Sophie Lafortune 1, Alexandre D'Smar 1,2, Universite Laval, Canada, 1,2.

**Th1H • Advances in Multicore Fiber Technology—Continued**

**Th1H.3 • 08:30**

**Time-dependent Crosstalk from Multiple Cores in a Homogeneous Multi-core Fiber**, Georg Rademacher 1, Benjamin J. Putnam 1, Ruben S. Luis 1, Y. Awaji 1, Naoya Wada 1, National Inst of Information & Comm Tech, Japan. We investigate the time-dependence of crosstalk in homogeneous multi-core fibers originating from multiple interfering cores. We observe that increasing the number of interacting cores increases the frequency of crosstalk fluctuations by an order of magnitude.

**Th1H.4 • 08:45**

**Bending Radius Dependence of Spatial Mode Dispersion in Randomly Coupled Multi-Core Fiber**, Shinichi Azazza 1, Taiji Sakamoto 1, Saki Nozoe 1, Yuto Sago 1, Masaki Wada 1, Takayoshi Moni 1, Kyoto Tsukijawa 1, Takashi Yamamoto 1, Kazuhide Nakajima 1, NTT Access Network Service Systems Laboratories, NTT Corporation, Japan. Randomly coupled multi-core fiber (MCF) with a uniform twist realized lower spatial mode dispersion (SMD) and bending radius dependence. The SMD-macrobending relationship was examined numerically and experimentally using MCFs fabricated with a preform rotation mechanism.

**Th1I • Network Architecture Evolution—Continued**

**Th1I • Data Analytics and Machine Learning—Continued**

**Th1J • Coherent Technologies for Access—Continued**

**Th1J.1 • 08:30 Top Scored**

**Experimental Assessment of Node and Control Architectures to Support the Observe-Analyze-Act Loop**, Luis Giffre 1, Alba P. Vela 1, Marc Ruiz 1, Jorge Lopez de Vergara 1, Luis Velasco 1, Universitat Politècnica de Catalunya, Spain; 2, Department of Electronics and Communication Technologies, Universidad Autónoma de Madrid (UAM), Spain. An architecture supporting the OAA loop is proposed. It consists on extending nodes and the domain controller with analytics capabilities for local and network-wide operation automation. The architecture is experimentally assessed through a use case.

**Th1J.2 • 08:45**

**Large-Capacity Optical Access Network Utilizing Multicore Fiber and Self-Homodyne Coherent Detection**, Zhenhua Feng 1, Ming Tang 1, Ming Wu 1. We demonstrate quality of transmission with Dynamically Configurable Optical Impairment Model, Martin Bouda 1, Shoucheng Oda 1, Olga Vassilieva 1, Masakata Miyabe 1, Setsuo Yoshida 1, Toru Katagiri 1, Yasuhiro Aoki 1, Takeshi Hoshida 1, Tadashi Ikeya 1, Fujitsu Laboratories of America Inc, USA; 2, Fujitsu Laboratories Ltd., Japan; 3, Fujitsu Limited, Japan. We propose a dynamically configurable optical impairment model for a physical layer abstraction enabling physical parameters learning in multi-vendor networks. We experimentally demonstrate quality of transmission prediction in mesh networks with 0.6 dB Q-factor accuracy.

**Th1J.3 • 08:45**

**Top Scored**

**Optical Coherent Transmission of 20x192-MHz DOCSIS 3.1 Channels with 16384QAM based on Delta-Sigma Digitization**, Jing Wang 1, Zhen-sheng Jia 1, L. Alberto Campus 1, Curtis Knittel 1, Gee-Kung Chang 1, Georgia Inst of Technology, USA; 2, Cable Television Laboratories (CableLabs), Inc., USA. We demonstrated delta-sigma digitization and 80-km coherent transmission of 20x192-MHz DOCSIS 3.1 channels via a low-cost single-wavelength DP-16QAM system. Modulation-error-ratio higher than 48 dB was achieved supporting 16384QAM on all 20 DOCSIS channels.

**Th1K • Access—Continued**

**Th1K.1 • 08:30 Top Scored**

**Optical Coherent Transmission of 20x192-MHz DOCSIS 3.1 Channels with 16384QAM based on Delta-Sigma Digitization**, Jing Wang 1, Zhen-sheng Jia 1, L. Alberto Campus 1, Curtis Knittel 1, Gee-Kung Chang 1, Georgia Inst of Technology, USA; 2, Cable Television Laboratories (CableLabs), Inc., USA. We demonstrated delta-sigma digitization and 80-km coherent transmission of 20x192-MHz DOCSIS 3.1 channels via a low-cost single-wavelength DP-16QAM system. Modulation-error-ratio higher than 48 dB was achieved supporting 16384QAM on all 20 DOCSIS channels.

**Th1K.2 • 08:45**

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**Th1K.3 • 08:45**

**Top Scored**

**Large-Capacity Optical Access Network Utilizing Multicore Fiber and Self-Homodyne Coherent Detection**, Zhenhua Feng 1, Ming Tang 1, Ming Wu 1. We propose a dynamically configurable optical impairment model for a physical layer abstraction enabling physical parameters learning in multi-vendor networks. We experimentally demonstrate quality of transmission prediction in mesh networks with 0.6 dB Q-factor accuracy.

**Room 408B**

**Room 409AB**

**Room 410**

**Room 411**

**Show Floor Programming**
Th1A • Detectors/Receivers—Continued

**Th1A.4 • 09:00**

Ge$_2$Sn$_{1-x}$, Multiple-quantum-well p-n Photodiodes for Optical Communications at 2 μm, Yuan Dong$^{1}$, Wei Wang$^{2}$, Shengqiang Xi$^{3}$, Dian Lei$^{1}$, Xiaogong$^{1}$, Shun Ying Lee$^{7}$, Nan Kang$^{5}$, Soon Fatt Yoon$^{7}$, and Gengchau Liu$^{1}$, National Univ. of Singapore, Singapore; Gerhard Schuettz$^{1}$, University of Arizona, and the MS Communication Engineers of Japan. He received the BS degree from Tottori University in 1979, the MS degree from the University of Arizona in 1987, and the PhD degree from the University of Arizona in 1989. He is a fellow of OSA and IEICE (Institute of Electronics, Information and Communication Engineers of Japan). He is currently engaged in pioneering research on spatial multiplexing and diversity. The average error-free spectral efficiency of 12 b/s/Hz is achieved over 12 Gbps channel bandwidth with 64QAM signal processing. This paper reviews key results of broadband optical signal processing using this platform.

**Th1A.5 • 09:15**

High-gain Phase Modulated Analog Photonic Link Using High-power Balanced Photodiodes, Zhanjing Yang$^{1}$, Andreas Beling$^{2}$, Nuno Andre$^{1}$, Shengqiang Xu$^{1}$, and Kresten Yvind$^{2}$, VPI Photonics, Germany. We experimentally demonstrated an ultra-compact 5-channel hybrid integrated III-V/Si transmitter enabling 100Gb/s transmission over 10 km at 21.4 Gbps/channel for 100Gb/s.

**Th1B • Silicon Photonics—Continued**

**Th1B.4 • 09:00**

Integrated 5-channel WDM hybrid III-V/Si transmitter enabling 100Gb/s and beyond, Guilhem de Valicourt$^{1}$, Xiuguang Zhang$^{1}$, Senthuradathan Chandrasekhar$^{1}$, Young-Kai Chen$^{1}$, Anaelle Maho$^{1}$, Romain Brenot$^{1}$, Pi Dong$^{1}$, HI-V Lab, France; Nokia Bell Labs, USA. We report the demonstration of an ultra-compact 5-channel hybrid integrated III-V/Si transmitter. We successfully achieved modulation up to 40 Gbps/channel providing a total aggregated capacity of 200 Gbit/s and transmission over 10 km at 21.4 Gbps/channel for 100Gb/s.

**Th1B.5 • 09:15**

69 Gb/s DMT Direct Modulation of a Heterogeneously Integrated InP-on-Si DFB Laser, Abdul Rahim$^{1}$, Amin Abbasi$^{1}$, Nuno Andre$^{1}$, Andrew Kumatiba$^{1}$, Hadrien Loucheti$^{1}$, Kasper van Gas$^{1}$, Roel Baets$^{1}$, Gunther Roelkens$^{1}$, and Ghent Univ., Belgium; VPI Photonics, Germany. A heterogeneous integrated InP-on-Si DFB laser, with direct modulation bandwidth of 21GHz has been used for the generation of a 69Gb/s discrete multi-tone signal. Transmission at 56Gb/s over 5 km SMF is demonstrated as well.

Toshio Morioka joined NTT Labs., in Yokosuka, Japan in 1985 and moved to Technical University of Denmark in 2011. Since 1985, he has been engaged in pioneering research on ultrafast and large-capacity transmission technologies based on multicore fibers and reviewed future perspectives on next generation Pbit/s.

**Th1C • SDM Transmission II—Continued**

**Th1C.3 • 09:00**

High-Capacity Transmission Using High-density Multicore Fiber, Toshio Morioka$^{1}$, DTU Fotonik, Denmark. Recent progress in large-capacity transmission technologies based on multicore fibers is reviewed in this tutorial. The key metrics of analog coherent interfaces for today’s 200G 16QAM and future 400-600G 64QAM pluggable systems. A cloud service provider perspective on next generation Pbit/s is also discussed.

**Th1C.4 • 09:00**

Invited Tutorial—Demos/Visits—Continued

**Th1D • Advances in Coherent Subsystems—Continued**

**Th1D.4 • 09:00**

Invited Lessons Learned from CFP2-ACO System Integrations, Interoperability Testing and Deployments, Harase Chao$^{1}$, Mark M. Filer$^{2}$, Andreas Bechtolsheim$^{1}$, Romain Brenot$^{2}$, Anaelle Maho$^{2}$, Arthur Networks, Inc., USA; Microsoft, USA. We discuss the quantum-well p-i-n photodiode on Si substrate with a cutoff wavelength beyond 2 μm. A record-low dark current density of 31 mA/cm$^2$ at $V_{th} = -1$ V is achieved.

**Th1E • Visible Light Communications—Continued**

**Th1E.4 • 09:00**

Adaptive Physical-layer Network Coding over Visible Light Communications, Yang Hong$^{1}$, Lian-Kuan Chen$^{1}$, Xun Guan$^{1}$; The Chinese Univ. of Hong Kong, Hong Kong. We propose and experimentally demonstrate the adaptive physical-layer network coding to boost throughput of VLC-based two-way relay networks. Experimental results show that the network capacity can be improved by 100% with ~2.5-dB SNR penalty.

**Th1E.5 • 09:15**

Ultra-Broadband Optical Signal Processing using AlGaAs-OI Devices, Michael Galili$^{1}$, Francesco Da Ros$^{1}$, Hao Hu$^{1}$, Minhao Pu$^{1}$, Kresten Yvind$^{2}$, Leif K. Oxenlowe$^{1}$, Nanyang Technological Univ., Singapore; DTU Fotonik, Denmark. Aluminum Gallium Arsenide on insulator (AlGaAs-OI) has recently been developed into a very attractive platform for optical signal processing. This paper reviews key results of broadband optical signal processing using this platform.
We describe a polarization rotator that alters the polarization direction of light. The TNLC functions as an achromatic filter and can be used as an optical resonator that reflects light at a specific wavelength. Our device incorporates a 90° twisted nematic liquid crystal (TNLC) for high performance and is fabricated using a slurry casting method with highly pure SiO2 powder as a starting material. The minimum loss was 0.25 dB/km and the crosstalk was -33.4 dB/100 km.

We realize a 125 μm-cladding four-core fiber with four air-holes using a novel fabrication technique without any drilling process. Core-to-core crosstalk is reduced to -63 dB/km at 1550 nm by intentionally remaining the air-holes during the fabrication process.
Thursday, 23 March

10:00–16:00 Exhibition and Show Floor, Exhibit Hall G-K (coffee service from 10:00–10:30)

10:00–16:00 OFC Career Zone Live, South Lobby
Ultra-broadband Fabrication-tolerant Polarization Splitter and Rotator, Kang Tan1, Ying Huang1, Guo-Qiang Lu1, Changyuan Yu1, Chengkuo Lee1; 1Inst. of Microelectronics, A*STAR, Singapore; 2Department of Electrical & Computer Engineering, National Univ. of Singapore, Singapore; 3National Univ. of Singapore (Suzhou) Research Inst., China. A polarization splitter and rotator that supports simultaneous O-, C-, and L-band operation is first experimentally demonstrated, with record 1-dB bandwidth over 360 nm, high fabrication tolerance, and high TE-TM conversion efficiency of ~0.33 dB.

Field Trial of a Novel SDN Enabled Network Restoration Utilizing In-depth Optical Performance Monitoring Assisted Re-planning, Fanchao Meng1, Yanni Ou1, Shuangyu Yan1, Reza Nejabati1, Dimitra Simeonidou1; 1Univ. of Bristol, UK. We experimentally demonstrate a monitoring scheme utilizing both intermediate node and receiver monitoring for network re-planning. Either modulation format switching or light-path re-routing is adopted for restoration. The recovered signal performs better compared with static planning.

Adaptive Stokes Space Based Polarization Demultiplexing for Flexible UDWDM Metro-Access Networks, Somayeh Ziaei1,2, Nelson J. Muga1,3, Ricardo Ferreira1,2, Fernando Guimaraes1, Ali Shahpari1,2, Somayeh Ziaei1,2, Armando Pinto1,2, 1Univ. of Aveiro, Portugal; 2Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino, Italy; 3Instituto de Telecomunicaciones, Portugal. We experimentally demonstrate a flexible coherent UDWDM system with support to optical-wireless links and adaptive DP-QPSK/DP-16QAM modulation, enabled by Stokes-based polarization demultiplexing. The system is shown to be resilient to dynamic power ranges of >12 dB.
Th2A.1 Double Slot Fiber-to-chip Coupler using Direct Strip-slot Mode Coupling, Kyung-hun Han1, Min Teng1, Ben Niu1, Yunjo Lee1, Sangsik Kim1, Minghao Qi1,2, Purdue Univ., USA. We present a fiber-to-chip coupler using asymmetric double slot waveguide and direct strip-slot mode coupling to shorten a transition while maintaining high coupling efficiency. Experimental result shows a 1.8 dB insertion loss with a broad bandwidth.

Th2A.2 Polymer Waveguide Based Spot-size Converter For Low-loss Coupling Between Si Photonics Chips And Single-mode Fibers, Kazuki Yashihara, Feng Yu3, Takaaki Ishigure1; 1Graduate School of Science and Technology, Keio Univ., Japan; 2Japan research center, Huawei technologies Japan K.K., Japan; 3Faculty of Science and Technology, Keio Univ., Japan. By applying the Mosquito method, we fabricated tapered polymer waveguides for on-wafer size converters (SSCs) enabling low-loss coupling between Si waveguides and standard single mode fibers. The fabricated SSCs exhibit remarkably low insertion loss as 2.7 dB.

Th2A.3 Stochastic Simulation and Sensitivity Analysis of Photonic Circuit through Morris and Sobol Method, Abi Waqas1, Daniele Melati1, Abishek Gopalan2, Steve Sanders2,1; 1Department of Electrical and Computer Engineering, University of Illinois at Chicago; 2School of Electrical and Computer Engineering, Georgia Institute of Technology. We design and characterize an optical chip for data compression based on Haar Wavelet Transform, Catinh Pinho1, Ana Tavares1, Guilherme Cabral1, Tiago Morgado2, Ali Shahpari1, Marco Lima1, Antonio L. Teixeira1,2; 1Department of Electronics, Telecommunications and Informatics (DEET), Univ. of Aveiro, Portugal; 2Instituto de Telecomunicações, Univ. of Aveiro, Portugal. A new optical chip for data compression based on Haar Transform (HT) was designed and tested. Asymmetric couplers and multimode interconnecters (1x2 and 2x2) are implemented in the chip to perform all-optical HT operations.

Th2A.4 A Polymer Waveguide Material Optimized for On-Board Optical Links and Si Photonic Interfaces, Shoto Takanobu1,2, Iymon. Barwicz1, Nobuhiko Imajyo1,2, Kenta Kobayashi1, Takashi Sayama1, Seiki Ohsara1, Paul Fortier1, Yoshie Taira1,2; 1Asahi Glass Co. Ltd., Japan; 2IBM T J Watson Research Center, USA; 3IBM Bromont, Canada. We report on a polymer optical waveguide material with 0.29 dB/cm loss at 1550nm, wide spectral window of transparency, environmental stability, and solder-rewow compatibility. Flexible ribbons are sufficiently robust for standard high-throughput microelectronics assembly.

Th2A.5 Low-loss and Polarization-insensitive Photonic Integrated Circuit Based on Micron-scale SOI Platform for High Density TDM PONs, Qiang Zhang1,2,1Huawei, China. We present a photonic integrated circuit of four-channel bidirectional optical sub-assembly on monolithic silicon. Experiment results with loss less than 1.5dB, PDL<0.5dB, and near 30dB isolation, allow for realization of Class C+ QSFP TDM-PON OLT module.

Th2A.6 MEMS Tunable Hybrid Plasmonic-Si Waveguide, Xu Sun1, Lars Thylen1, Lech Wosinski1, KTH, Sweden. A MEMS tunable hybrid plasmonic-Si (HF) waveguide is investigated, showing very large changes of both effective refractive index and propagation loss when applying bias voltage. Preliminary experimental results show that: with 15um MEMS structure in Si waveguide platform, the extinction ratio can be over 20DB between “on” and “off” states.

Th2A.7 Broadband, mode-selective 15-Mode Multiplexer Based on Multiplane Light Conversion, Nicolas Barré1, Bertrand Denolle1,2, Pu Jian1, Jean-François Morizur1, Guillaume Labrèolle1, CAilabs, France. We report a 15 spatial mode multiplexer based on Multi-Plane Light Conversion, with high mode selectivity across the full C+L band. The multiplexer shows average 4.4 dB insertion loss and 23 dB mode selectivity.

Th2A.8 Large Mode-field-diameter optical Surface Coupler Based on SiO2-capsuled Vertically Curved Si Waveguide, Yuki Atsumi1, Tomoya Yoshida1, Emiko Omoda1, Youchi Sakakibara1,2; AIST, Japan. We design surface optical couplers on vertically-curved Si waveguide for 5-μm MFD SMFs. The device shows high-efficient coupling of < 1 dB loss in wavelength range of 330 nm with high device-size and fiber-alignment robustness.

Th2A.9 Design and Characterization of an Optical Chip for Data Compression based on Haar Wavelet Transform, Catinh Pinho1, Ana Tavares1, Guilherme Cabral1, Tiago Morgado2, Ali Shahpari1, Marco Lima1, Antonio L. Teixeira1,2; 1Department of Electronics, Telecommunications and Informatics (DEET), Univ. of Aveiro, Portugal; 2Instituto de Telecomunicações, Univ. of Aveiro, Portugal. A new optical chip for data compression based on Haar Transform (HT) was designed and tested. Asymmetric couplers and multimode interconnecters (1x2 and 2x2) are implemented in the chip to perform all-optical HT operations.

Th2A.10 Rectangular Versus Circular Fiber Core Designs: New Opportunities for Mode Division Multiplexing, Lior Rechtman1, Dan M. Marom1; 1Hebrew Univ. of Jerusalem, Israel. The properties of rectangular core fiber are investigated for mode division multiplexing. Polazation degenerate mode groups, favorable mode profiles for device coupling, modal area uniformity, and good spicce performance suggest it’s a good candidate.

Th2A.11 Comparison of Multimode Fiber Modal Bandwidth Metrics, Petr Sterlingov1,3, ‘Corning SNG Ltd., Russia. We describe a multimode fiber bandwidth metric significantly more strongly correlated to link inter-symbol interference (ISI) penalties than conventional metrics. The improvement is demonstrated in plots of ISI vs. bandwidth for various link lengths.

Th2A.12 Mode-Dependent Gain Characterization of Erbium-doped Multimode Fiber Using C’ Imaging, Haoshuo Chen1, Bin Huang1, Nicolas K. Fontaine1, Roland Ryt1, Jose Antonio Lopez1, Li Guifang1, Rodrigo Amezcua Correa1, Pierre Sillard1, Cedric Gonnet1, Juan Carlos Alvarez Zacarias1, Zeinab Sanjabi Eznavabi1, Axel Schulz-Genz1, Nokia Bell Labs, USA; 2University of Central Florida, USA; 3Photonics Group, France. We characterize an erbiun-doped step-index multimode fiber using C’ imaging based on a swept-wavelength interferometer. Modal contents, delays and mode-dependent gains are fully characterized using space-to-time mapping.

Th2A.13 Performance Analysis of Flexible Regeneration and Modulation Conversion in Elastic Optical Networks, Miroslaw Klikowkski1, Krzysztof Walkowiak1,2, ‘Wroclaw Univ. of Science and Technology, Poland; 1National Inst. of Telecommunications, Poland. We study potential performance gains resulting from deliberate use of signal regeneration along with modulation conversion in transparent elastic optical networks (EONs) realizing super-channel transmission.

Th2A.14 Energy Saving in SBPP-Based IP over WDM Networks with Protection Router Card Sleeping, Lin Zhu1, Haomin Jiang1, Yongcheng Liu1, Sanjay K. Bose1, Gangxiang Shen1, Soochow Univ., China; 2IIT Guwahati, India. We develop an energy-saving scheme for the shared backup path protected (SBPP) IP over WDM network through sleeping protection router cards. Results show that the scheme is efficient in energy saving and redy to be adopted significantly compared to other conventional schemes.

Th2A.15 A Capacity Analysis for Space Division Multiplexing Optical Networks with MIMO Equalization, Yao Liu1, Nan Hua1,2, Xin Guo1, Nokia Bell Labs, USA; 2Department of Electronic Engineering, Tsinghua Univ., China. A Capacity Analysis for Space Division Multiplexing Optical Networks with MIMO Equalization, Yao Liu1, Nan Hua1,2, Xin Guo1, Nokia Bell Labs, USA; 2Department of Electronic Engineering, Tsinghua Univ., China. We analyze the capacity of SDM networks using limited DSP complexity. Results show that DSP complexity limitations can severely restrict the network capacity enhancement brought by adding spatial channels, especially for large-scale networks.

Th2A.16 Benefits of Higher Modulation in Flexible Grid Networks using Optical WDM and Digital OTN Switching, Onur Turkc1, Abishek Gopalan1, Biao Lu1, Steve Sanders1, Parthiban Kandappan1, Infineon, USA. We study the effects of higher modulation formats on the design of optical network architectures using Flexible Grid and Sliceable Bandwidth Variable Transponders. We show architectures with digital switching getting more benefit from higher modulation.

Th2A.17 Holding-Time Information (HTI): When to Use it?, Sandeep Kumar Singh1, Adelma Jukani1, TU Braunschweig, Germany. The known techniques of HTI-aware routing can be used for connection admission, or spectrum defragmentation. We show that HTI used for defragmentation is the most beneficial in reducing blocking in space-division multiplexed elastic optical networks.

Th2A.18 On the Power Consumption of MIMO Processing and its Impact on the Performance of SDM Networks, Nikolaos Panteleimon Damantopoulos1, Belnem Sharati2,3, Ioannis Tomkos1; 1Athens Information Technology (AIT), Greece; 2Universitat Politècnica de Catalunya (UPC), Spain. The power consumption of MIMO-OSD for SDM networks is investigated, emerging sub-20-nm CMOS technology. Significant limitations on the network performance are revealed when scaling to large MIMO multiplicity (6 x 12 x 12).
We propose a channel bonding design for 100 Gb/s PON based on FEC codeword alignment, Liang Zhang1, Yuanjue Luo1, Bo Gao1, Xiang Liu1, Frank Effkenberger1. A novel rank-based queue scheduling method for achieving low latency in a fronthaul bridged network. We confirm with computer simulations the proposed scheme increased the number of accommodated fronthaul steams by 40%.

Th2A.25
Demonstration of Performance of GDFMA and OFDMA for Spectrally Efficient 100 Gb/s Access Lightpath shimizu1, Hirotaka Nakamura1, Xin Yin1-2, Stefano Porto1, Xiaoping Zheng2,3. We experimentally demonstrate a flexible direct phase modulated DFB laser through a beat signal for UDWDM PON. Rx sensitivity of -43 dBm at BER=10^12 and channel spacing of 7.5 GHz is achieved for 5 Gb/s.

Th2A.26
Investigation of the Performance of GDFMA and OFDMA for Spectrally Efficient 100 Gb/s Access Lightpath shimizu1, Hirotaka Nakamura1, Xin Yin1-2, Stefano Porto1, Xiaoping Zheng2,3. We experimentally demonstrate a flexible direct phase modulated DFB laser through a beat signal for UDWDM PON. Rx sensitivity of -43 dBm at BER=10^12 and channel spacing of 7.5 GHz is achieved for 5 Gb/s.

Th2A.27
Real-time Demonstration of 28 Gbit/s Electrical Dublonary TDM-PON Extension Using Remote Nodes, Rene Borik1, Robert Borkowski1, Wolfgang Paehlmann1, Jonas Von Kerrebrouck1, Chris Chase1, Robert Lucas1, Timothy De Keulemans2, Jo-han Bawinkel2, Doutje Van Veen1, Vincent Hautsma1, Xin Yin1, Thomas Pfeiffer1,1, Nokai Bell Labs, Germany. An experimental real-time reach and split extension of a 28 Gbit/s electrical dublonary TDM-PON is demonstrated. 50 dB budget is achieved using either remote nodes based on SOA or based on a distributed OLT concept.

Th2A.28
Forward Error Correction Analysis for 10Gb/s Burst-mode Transmission in TDM/DWDM PONs, Nicola Brandonisio1, Stefano Porto1, Daniel Carey3, Peter Osseur2, Giuseppe Talli1, Nick Parsons1, Paul D. Townsend2, Th2A.29
Experimental Phase Noise Limitations in Directly-detected Single Sideband Optical OFDM Systems, Alberto Gatto1, Silvio Mandelli2, Jacobo Morosi1, Maurizio Magarini1, Paolo Martelli1, Pierpaolo Botti1, Politecnico di Milano - DEIB, Italy. 10Gb/s forward error correction for a PON upstream channel are analyzed experimentally by measuring true burst-mode pre- and post-error correction BER, frame loss rate and error spectrum in intensity modulated optical OFDM.

Th2A.29
Experimental Phase Noise Limitations in Directly-detected Single Sideband Optical OFDM Systems, Alberto Gatto1, Silvio Mandelli2, Jacobo Morosi1, Maurizio Magarini1, Paolo Martelli1, Pierpaolo Botti1, Politecnico di Milano - DEIB, Italy. 10Gb/s forward error correction for a PON upstream channel are analyzed experimentally by measuring true burst-mode pre- and post-error correction BER, frame loss rate and error spectrum in intensity modulated optical OFDM.
Exhibit Hall K

Th2A.34 VCSELs to Multicore Fiber Reconfigurable Optical Switch Based on Diffractive MEMS Mirrors, Mahmoud Gadalla, Véronique François, Bora Ung, 1 École de technologie supérieure (ETS), Canada; VCSELs light was coupled to any selected core(s) in a multicore fiber with average max crosstalk of -10.4 dB using diffractive MEMS. This is a step toward agile multicore fiber interconnects and ROADMs.

Th2A.35 Hardware Programmable Network Function Service Chain on Optical Rack-Scale Data Centers, Qianqiao Chen, Vaibhawa Mishra, Sebastian Engelmann, 1 Univ. of Bristol, UK; 2 Huber-Suhner Polatis, UK. A datacenter network that supports programmable optical and multi-layer service chaining by adopting miniaturized reconfigurable optical backplanes and FPAGs is demonstrated. The end-to-end testbed delivers hitless on-chip service chain switch-over, 9.8G service chaining by adopting miniaturized reconfigurable optical backplanes and FPAGs.

Th2A.36 Network Synthesis of a Topology Reconfigurable Disaggregated Rack Scale Datacentre for Multi-Tenancy, Ademir Soares, Georgios S. Zervas, 1 Univ. of Bristol, UK. A performance analysis of a hybrid reconfigurable disaggregated datacentre is presented. It offers substantial benefits in terms of network blocking, power consumption and cost when compared to pure circuit switched and statistical hybrid architectures.

Th2A.37 Co-design of a Low-latency Centralized Controller for Silicon Photonic Multistage MZI-based Switches, Yule Xiong, Felipe Gohring de Magalhães, 2 Gabriela Nicolaescu, Fabiano Hessel, 1 Odile Libarion-Ladouceur, 1 McGill Univ., Canada; 2 FPfG/PUCRS, Brazil; École Polytechnique de Montréal, Canada. An FPGA-based centralized controller architecture for silicon photonics switches is experimentally demonstrated achieving scheduling decision in one clock cycle. The FPGA simultaneously operates as the controller, and the traffic payload generator with error detection.

Th2A.38 Few-Mode 850-nm VCSEL Chip with Direct 16-QAM OFDM Encoding at 80-Gbit/s for 100-m OM4 MMF Link, Hsuan-Yun Kao, Cheng-Ting Tsai, 1 Chun-Yen Peng, 1 Shang-Fong Lin; 2 National Taiwan Univ., Taiwan; 3 National coatschung Univ. of Applied Sciences, Taiwan; 4 National Chung Hsing Univ., Taiwan; 5 National Chiao Tung Univ., Taiwan; 6 University of British Columbia, Canada; 7 National Chiao Tung Univ., Taiwan. Optical mode-lock loop using semiconductor optical amplifiers is experimentally demonstrated. By integrating the capacity expansion and implementation with photonics, the proposed scheme is compact, has a simple architecture, and has a wide operating frequency range.

Th2A.39 A Silicon Metamaterial Chip-to-Chip Converter for Photonic Flip-Chip Applications, Tymon Barwicz, 1 Swetha Kamlapurkar, 1 Yves Martin, 2 Robert L. Bruce, 1 Sebastian Engelmann, 1 IBM T.J. Watson Research Center, USA. We demonstrate a metamaterial converter with a highly elongated coupler mode optimized for direct optical chip-to-chip connections. We show a highly broadband converter response with <0.35dB penalty over the 120nm spectrum measured.

Th2A.40 4-mode MDM Transmission over MMF with Direct Detection Enabled by Cascaded Mode-Selective Couplers, Zhongying Wu, 1 Jiachen Li, 1 Yu Tian, 1 Dawei Ge, 1 Jinglong Zhu, 1 Qi Mo, 2 Fang Ren, 1 Jinyi Yu, 1 Zhengbin Li, 1 Zhangyuan Chen, 1 Yangge He, 1 Peiking Univ., China; 2 Univ. of Science and Technology Beijing, China. We propose and experimentally fabricate low modal-crosstalk mode multiplexer/demultiplexer consisting of cascaded mode-selective couplers (MSCs) for MDM transmission, based on which 4-mode MDM transmission with OOK modulation and direct detection over 500-m MMF is experimentally demonstrated.

Th2A.41 Bio-Inspired Optical Microwave Phase Lock Loop Based on Silicon Linear Effects in Semiconductor Optical Amplifier, Ruihe Lin, 1 Luis A. Perea, 2 The Phet D. To, 1 Jia Ge, 1 Li Xia, 1 Malec Fol, 1 Univ. of Georgia, USA. Optical microwave phase lock loop using semiconductor optical amplifiers is experimentally demonstrated. Experimental results and implementation with photonics, the proposed scheme is compact, has a simple architecture, and has a wide operating frequency range.

Th2A.42 Measurement of Optical Signal-to-noise ratio in Coherent Systems using Polarization Multiplexed Transmission, Wolfgang Moench, 1 Eberhard Loedl, 1 Viavi, Germany. A new method for measuring Optical Signal-to-Noise-Ratio (OSNR) in systems using polarization multiplexed transmission was investigated. The OSNR can be calculated from the correlation between spectral components in the optical spectrum of a transmission signal.

Th2A.43 Mode-Group Multiplexed Transmission using OAM Modes over 1 km Ring-Core Fiber without MIMO Processing, Feng Feng, 1 Xianqiong Ji, 1 Dominc O’Brien, 2 Frank Payne, 2 Timothy Wilkinson, 1 Univ. of Cambridge, UK; 2 Univ. of Science and Technology of China, China. We demonstrate mode-group multiplexed transmission over 1km ring-core fiber to transmit >210Gbit/s using OOK modulation and direct detection. SLM based spatial (de)multiplexers perform all-optical multiplexing and demultiplexing in an OAM mode basis.

Th2A.44 Dual Laser Switching for Dynamic Wavelength Operation in Amplified Optical Transmission, Shengkang Zhu, 1 Weyiang Mo, 1 Daniel C. Kilper, 1 Aravind P. Ananth, 1 Liam Barry, 1 Univ. of Arizona, USA; 2 Dublin City Univ., Ireland. Fast switching of a dual laser PM-QPSK transceiver is used to evaluate the complex direct modulation using polarization-multiplexed PAM-4 system by varying signal baud-rate with data-rate up to 120 Gbaud. Experiments show over 30-Gbaud degrades >4 dB OSNR sensitivity compared with 10-Gbaud.

Th2A.45 Comparison of CD(C) ROADM Architectures for Space Division Multiplexed Networks, Jose Manuel Ruiz-Medina, 1 Behnam Shariati, 1 Dan M. Marom, 1 Dimitrios Klonidis, 1 Ioannis Tomkos, 1 Universidade Lusófona de Humanidades e Tecnologias, Portugal; 2 Universitat Politècnica de Catalunya , Spain; 3 Athens Information Technology (AIT), Greece; 4 The Hebrew Univ. of Jerusalem, Israel. We compare different architectures of CD and CDC ROADMs supporting spatial superchannel routing in terms of required components, revealing the most cost-effective designs.

Th2A.46 Fast Reconfigurable SOA-based All-optical Wavelength Conversion of QPSK Data Employing Switching Tunable Pump Lasers, Y Lin, 1 Awarid P. Ananth, 2 Sean O’Duell, 2 Sepideh T. Naimi, 1 Yonglin Yu, 1 Liam Barry, 2 Dublin City Univ., Ireland; 3 Wuhan National Laboratory for Optoelectronics, Huazhong Univ. of Science and Technology, China. We demonstrate a dynamically reconfigurable SOA-based all-optical wavelength converter for QPSK data at 12.5 Gbaud using a fast switching tunable laser as one of the pump sources. The experimental results indicate that it is feasible to build fast reconfigurable wavelength converters with <30 ns switching time.

Th2A.47 Adiabatic Chip Impact on the OSNR Sensitivity of Complex Direct Modulation: An Experiment Investigation, Di Che, 1 Feng Yuan, 1 William Sheih, 1 Univ. of Melbourne, Australia. We study the adiabatic chip impact on the complex direct modulation using polarization-multiplexed PAM-4 system by varying signal baud-rate with data-rate up to 120 Gbaud. Experiments show over 30-Gbaud degrades >4 dB OSNR sensitivity compared with 10-Gbaud.

Th2A.48 • 10:00 Simultaneous Measurement of Chromatic and Modal Dispersion in FMMs Using Microwave Photonic Techniques, Ruizong Mi, 1 Ningbo Zhao, 1 Zhiqun Yang, 1 Cheng, 1 Tianjin Univ., China; 2 CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA. A microwave-photonic technique for measuring dispersion characteristics of few-mode fibers is proposed and experimentally demonstrated. This technique allows simultaneous high-precision measurement of chromatic dispersion and differential modal group delay, for the first time.

Th2A.49 Reproducible Broadband Optical Noise Generation Based on Phase Modulation to Intensity Modulation Conversion and a Nonlinear Trans- formation, Xingxing Jiang, 1 Mengfan Cheng, 1 Fengguang Luo, 1 Lei Deng, 1 Changjian Ke, 1 Songnian Fu, 1 Ming Tang, 2 Deming Liu, 1 Mingming Zhang, 1 Ping Shum, 1 Huazhong Univ. of Sci. & Tech., China; 2 Nanyang Technological Univ., Singapore. We experimentally demonstrate a reproducible broadband optical noise generation scheme. A flat spectrum and a symmetrical distribution can be obtained. The complexity of the analogue noise can be determined by the input binary sequence.

Th2A.50 Capacity Limits of Space-Division Multiplexed Submarine Links Subject to Nonlinearities and Power Feed Constraints, Omar Domingues, 1 Darli Mello, 1 Reginaldo Silva, 1 Sergio O. Arik, 1 Joseph M. Kahn, 1 School of Electrical and Computer Engineering, Unicamp, Brazil; 2 Department of Electrical Engineering, Stanford Univ., USA; 3 Padtec S/A, Brazil. We calculate the capacity limits of SDM submarine links. We demonstrate that limitations due to nonlinearities become negligible compared to power-feed limitations as the propagation distance and the total number of spatial channels increase.

Th2A.51 1.6Tb/s (4x400G) Unrepeated Transmission over 205-km SSMF using 65-Gbaud PDM-16QAM with Joint LUT Pre-distortion and Post DBP Nonlinearity Compensation, Junwen Zhang, 1 Jianjun Yu, 1 Hung Chang Chen, 2 ZTE Tx Inc, USA. Joint LUT-based pre-distortion and DBP-based post-compensation to mitigate the opto-electronic components and fiber nonlinearity impairments, we demonstrated the unrepeated transmission of 1.6Tb/s based on 4-lane 400G single-carrier PDM-16QAM over 205-km SSMF without distributed amplifier.
We report a... Aramais Zakharian... Laurent Schmalen... Toshi... Marianne Bigot... Ivan Aldaya... Masataka Nakazawa... Yoshihisa Inada... Andrew Ellis... Ko... Shun Ka Lo... Keisuke Kasai... Huawei... 10:15–10:45... For more details, see page 48... Open Packet DWDM TIP 10:15–11:45... For more details, see page 45... Market Watch Panel VI: Photonic Integration Business Case – Reality Check 10:30–12:00... For more details, see page 41... POF Symposium POF/TO 11:00–13:00... For more details, see page 48... ONF: The Path Forward ONF 12:00–13:30... For more details, see page 45... Market Watch Thursday, 23 March... Huawei... 10:15–10:45... For more details, see page 48... Market Watch Panel VI: SDN & Optics - What is the Business Case? 12:30–14:00... For more details, see page 42... Huawei... 10:15–10:45... For more details, see page 48... OFC 2017 • 19–23 March 2017
Th3A • 13:00
Architecture and Technologies for the Current and Future Radio Access Network
Erik Dahlman, Ericsson AB, Sweden.
This tutorial will provide an overview of the current status of 5G mobile communication including - The main 5G use cases with corresponding requirements and service characteristics - Key technologies pursued to address these use cases - Standardization activities and corresponding time line to reach the target of first 5G specifications targeting to be available in 2018.

Erik Dahlman is currently Senior Expert in Radio Access Technologies within Ericsson Research. He was deeply involved in the development and standardization of 3G radio access technologies (WCDMA and HSPA), first in Japan and later within the global 3GPP standardization body. Later on he was involved in the standardization/development of the 3GPP Long Term Evolution (LTE) and its continued evolution. His currently focuses on research and development of future 5G wireless access technologies.

Erik Dahlman is the co-author of the books 3G Evolution – HSPA and LTE for Mobile Broadband, 4G – LTE and LTE-Advanced for mobile broad-band communications, and has more than 150 refereed publications.

Cost-effective 25G APD TO-Can/RoSA for 100G Applications
Mengyuan Huang, Ericsson AB, Sweden.

This tutorial will provide an overview of the current status of 25G APD TO-Can/RoSA for 100G Applications including 100G-PON, 5G wireless, and data center applications with PAM4 and DMT modulations.

Mengyuan Huang is currently a Senior Product Manager in the line of 400G/200G/100G/50G/25G optical transmission product line in Ericsson, and has more than 15 years of experience in the field of optical communication industry.

Erik Dahlman is currently a Senior Expert in Radio Access Technologies within Ericsson Research. He was deeply involved in the development and standardization of 3G radio access technologies (WCDMA and HSPA), first in Japan and later within the global 3GPP standardization body. Later on he was involved in the standardization/development of the 3GPP Long Term Evolution (LTE) and its continued evolution. His currently focuses on research and development of future 5G wireless access technologies.

Erik Dahlman is the co-author of the books 3G Evolution – HSPA and LTE for Mobile Broadband, 4G – LTE and LTE-Advanced for mobile broad-band communications, and has more than 150 refereed publications.
This paper discusses trade-offs in real-world environments. The high fidelity aerospace test laboratory and devices were validated in a high-core multicore fibers (MCF). Our sensors based on strongly-coupled modulation order, increasing the optical channel rate and transceiver power when the bit rate of an optical channel reach and transceiver power is increased through the symbol rate when the bit rate of an optical channel.
band and, most recently, 4G – LTE-Advanced Pro and The Road to 5G.
He is a frequent invited speaker at different international conferences and holds more than 100 patents within the area of mobile communication. In 2009, Erik Dahlman received the Mayor Technical Award, an award handed out by the Swedish Government, for his contributions to the technical and commercial success of the 3G HSPA radio-access technology. In 2010, he was part of the Ericsson team receiving the LTE Award for "Best Contribution to LTE Standards”, handed out at the LTE World Summit. In 2014 he was nominated for the European Inventor Award, the most prestigious inventor award in Europe, for contributions to the development of 4G LTE.

**Th3A • Optical Technologies for Radio Access Network—Continued**

**Th3B • Practical Solutions to Transceiver Integration—Continued**

**Th3C • Optical Wireless Systems—Continued**

**Th3D • DSP for Direct-Detection Systems—Continued**

**Th3E • Waveguide Devices—Continued**

**Th3F • Transmission Experiments and Modeling—Continued**

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**Th3B.2 • 13:30**

Free Space to Few-mode Fiber Coupling Efficiency Improvement with Adaptive Optics under Atmospheric Turbulence, Donghao Zheng,1 Yan Li,1 Beibei Li,1 Wei Li,1 Erhu Chen,1 Jian Wu,1 Beijing Univ. of Posts & Telecom, China; 2Beijing Insitute of Tracking & Telecom Technology, China. Coupling efficiency between free-space-optical beam and few-mode-fibers with adaptive optics is investigated. The experimental results show that coupling efficiency of single-mode-fiber and few-mode-fiber is improved by over 10dB with adaptive optics under moderate turbulence.

**Th3C.2 • 13:30**

A 10m/10Gbps Underwater Wireless Laser Transmission System, Chun-Ming Ho2, Chang-Kai Lu1, Hsin-Ting Lee1, Sheng-Jhe Huang1, Ming-Te Cheng1, Zhin-Yi Yang1, Xin-Yao Lin1,1 National Taipei Univ. of Technology, Taiwan; 2Jinwei Univ. of Science and Technology, Taiwan. A 10Gbps/5GHz 16-QAM-OFDM underwater wireless laser transmission system based on light injection and optoelectronic feedback techniques is proposed and demonstrated. Good bit error rate performance and constellation map are achieved over a 10-m underwater link.

**Th3D.2 • 13:30**

1.55-µm EML-based DMT Transmission with Nonlinearity-aware Time Domain Super-Nyquist Image Induced Allaliasing, Xuezhi Hong1,2, Oskars Ozolins3, Changjian Guo1, Xiaodan Pang1, Junwei Zhang1, Jaime R. Navarro1, Aditya Kakkar1, Richard Schatz1, Urban Westergren1, Gunnar Jacobsen1, Sergei Popov1, Jiajia Wu1, Weijie Chang1, Jiang Tang2, Deming Lu1, Huaxiunfong Univ. of Sci. & Tech., China. Inverse-designed star-crossings with 8 and 10 ports are proposed, with ultra-short coupling lengths of 5.28µm and 5.4um respectively. Their measured ILs are less than 1.68dB and 2.4dB respectively over 60nm bandwidth centered 1550nm wavelength.

**Th3E.2 • 13:30**

Inverse-designed Ultra-compact Star-crossings Based on PhC-like Subwavelength Structures, Lili Li1, Minming Zhang1, Dongyu Li2, Feiyi Zhou1, Weijie Chang1, Jiang Tang2, Deming Lu1, Huaxiunfong Univ. of Sci. & Tech., China. Inverse-designed star-crossings with 8 and 10 ports are proposed, with ultra-short coupling lengths of 5.28µm and 5.4um respectively. Their measured ILs are less than 1.68dB and 2.4dB respectively over 60nm bandwidth centered 1550nm wavelength.

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**Th3B.1 • 13:45**

Multi-wavelength 1000Gb/s Silicon Photonics Based Transceiver with Silicon/mux/demux and MEMS-coupled InP Lasers, Lucas B. Soldano1, Jay Kubick1, Dinh Ton1, Karam Corporaion, Italy. A QSFP packaged 100Gb/s CWDMA4 transceiver is demonstrated by a hybrid assembly of a commercial silicon photonics chip containing modulators and electronics, a silica based mux/demux PLC, and a MEMS carrier with four InP lasers.
### Room 408A

**Th3G • Power Efficient Optics—Continued**

- **Th3G.2 • 13:30 Invited** Optimizing Power Consumption of a Coherent DSP for Metro and Data Center Interconnects, Theodor Kuptze¹, Andreas Bisplinghof¹, Thomas Duthel¹, Chris R. Fludger¹, Stefan Langenbach¹; 'Cisco Optical GmbH, Germany. We discuss several options for reducing power consumption of DSP used for coherent interfaces. These options are put in perspective with the needs of metro and data center interconnects for an overall optimized solution.

- **Th3G.3 • 13:45 Colloidal Quantum Dots Based Integrated Fiber-optic Detector**, Ao Yang¹, Xin Tran¹, Kecheng Yang¹, Junya Li¹, Xiaochao Tan¹, Huan Liu¹, Hasheng Song¹, Jiang Tang¹, Fei Yi¹; 'Huazhong Univ. of Science and Technology, China. We report an integrated fiber-optic power meter by dip coating PbS colloidal quantum dots onto a pretreated specialty fiber. We measured the readout current at 1550nm as a function of the optical power, the bias voltage and the distance between the contact electrodes.

### Room 408B

**Th3H • Sensors for Telecom and Biomedical Applications—Continued**

- **Th3H.2 • 13:30** 3-Dimensional Soft Shape Sensor based on Dual-layer Orthogonal Fiber Bragg Grating Mesh, Li Xu¹, Jia Ge¹, Jay H. Patel¹, Mable P. Fok¹; 'Univ. of Georgia, USA. We present a soft silicone shape sensor for 3D surface shape measurement. The sensor is based on dual-layer fiber Bragg grating arrays with orthogonal mesh structure, which enable 3D bi-directional shape sensing.

### Room 409AB

**Th3I • Novel Photonic Devices—Continued**

- **Th3I.3 • 13:30 Thin-film Lithium Niobate on Silicon Mach-Zehnder Electrooptic Modulators up to 50 GHz, Ashutosh Rao¹, Aniket Patil¹, Payam Rabiei¹, Anmamudi Honaroodost¹, Richard DeSalvo¹, Arthur Paoliella¹, Susan Fathpour¹; 'CREOL, Univ Central Florida, USA; 'Partow Technologies LLC, USA; 'Ham's Corporation, USA. Compact electro-optical modulators are demonstrated on thin-film lithium niobate on silicon with half-wavelength length product of 3.1 to 6.5 Vcm (from DC up to 50 GHz), 18 dB extinction ratio, and 33-GHz 3-dB electrical bandwidth.

- **Th3I.4 • 13:45 Power-efficient Electro-optical Single-tone Optical-frequency Shifter Using X-cut Y-Propagating Lithium Tantalate Waveguide Emulating a Rotating Half-wave-plate, Chuan Qin¹, Hongbo Lu¹, Andrea Pollick², Sn Sriram³, S. J. Ben Yoo³; 'Univ. of California Davis, USA; 'Srico Inc., USA. We demonstrate a single-tone electro-optical frequency shifter based on an X-cut, Y-propagating Zn-diffused lithium tantalate waveguide emulating a rotating half-wave plate achieving 10 dB reduction in power consumption compared to Z-propagating LiNbO3 counterparts.

### Room 410

**Th3J • Nonlinear Mitigation Techniques—Continued**

- **Th3J.3 • 13:30 Solitons and Nonlinear Fourier Transformation, Akhiro Maruta¹; 'Osaka Univ., Japan. The eigenvalue of the associated equation of the nonlinear Schrödinger equation which describes lightwave propagation in a nonlinear dispersive fiber, is invariable. This property can be applied to a nonlinearity-resilient modulation scheme and analysis of soliton collision induced rogue wave generation.

- **Th3J.4 • 13:45 Network Fault Protection Performance Enhancement by using Elastic Optical Path, Hitoshi Takeshita¹, Takefumi Oguma¹, Shinuke Fujisawa¹, Yuta Suzuki¹, Baku Yatabe¹, Akio Tajima¹; 'NEC, Japan. The challenges of enhancing protection performance by improving the spectral efficiency of elastic optical networks are studied. Novel optical filter configuration, signal equalization, and spectral bandwidth assignment technologies are shown to reduce the guard band.
Thursday, 23 March

Th3A • Optical Technologies for Radio Access Network—Continued

Th3B • Practical Solutions to Tranceiver Integration—Continued

Th3C • Optical Wireless Systems—Continued

Th3D • DSP for Direct-Detection Systems—Continued

Th3E • Waveguide Devices—Continued

Th3F • Transmission Experiments and Modeling—Continued

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A multimode, Paraskevas Bako, Johan Bauwelinck

We report a 40-Gb/s 1.5-μm VCSEL link with a low-power SiGe driver and TIA operated at 2.5 V. We demonstrate inherently robust and low-cost imaging scheme based on integrated optical phased array (OPA) driven by random control patterns. A proof-of-concept monolithic InP-based OPA is fabricated to demonstrate high-speed one-dimensional scanning without need for time-consuming calibration.

Ultra-low Power SiGe Driver—Continued

A 40-Gb/s 1.5-μm VCSEL link with a low-power SiGe VCSEL driver and TIA operated at 2.5 V: Wouter C. Soenen; Bart Moenciojay, Xin Yin, Silvia Spiga, Markus-Christian Amann, Christian Neumeyer, Markus Orthsieber, Elad Mentovich, Dimitris Apostolopoulos, Parakseas Bakepoulos, Johann Bauwelinck, IDlab Dep. INTEC, Ghent Univ.-imec, Belgium; Walter Schattky Inst., Technische Universitã¤t München, Germany; Vertilas GmbH, Germany; MeFanax Technologies, Israel; Dep. Electrical & Computer Engineering, NTUA, Greece. VCSEL links typically require multiple supply voltages for high-speed and low-power operation. We report a 40-Gb/s 1.5-μm VCSEL link achieving 8.7 pJ/bit of energy efficiency with a 0.13-μm SiGe VCSEL driver and TIA operated at 2.5 V.

Optical OFDM Transmission using Low-Noise Kerr Frequency Comb Generated in On-Chip Microresonator, Meng Zhao, Jing Zhang, Jie Xiang, Xingwen Yi, Shu-Wei Huang, Hao Liu, Mingbin Yu, D. L. Kwong, Kun Guo, Chee Wei Wong, UESTC, China; UCL, USA; IME, Singapore. We demonstrate high-bitrate coherent optical OFDM transmission utilizing low-noise Kerr frequency comb as multi-channel laser source. 4QAM-OFDM data with total bitrate of 136.0 Gb/s are successfully transmitted over a 100 km fiber link.

Correlation Properties of the Phase Noise Between Pairs of Lines in a Quantum-Dot Optical Frequency Comb Source, Kristian Zanette, John C. Cartledge, Maurice O’Sullivan, Queen’s Univ. at Kingston, Canada; Ciena Corp., Canada. The correlation properties of the phase noise between pairs of comb lines are determined for a quantum-dot frequency comb source laser through simultaneous measurements of the in-phase and quadrature components for each of the comb lines.

Demonstration of Tunable Mitigation of Interchannel Interference of Spectrally Overlapped 16-QAM/QPSK Data Channels using Wave Mixing of Delayed Copies, Amirhossein Mohajerian Araii, Morteza Ziyadi, Yinfen Cao, Ahmed Almairan, Fatemeh Alishahi, Ahmad Fallahpour, Changning Bao, Peicheng Liao, Bishara Shamee, Joseph Touch, Moshe Tur, Carsten Langrock, Martin Fejer, Alan Willner, Univ. of Southern California (USC), USA; Information Sciences Inst., USA; Tel Aviv Univ., Israel; Stanford Univ., USA. A tunable all-optical inter-channel interference mitigation method is proposed for an overlapped channel system that avoids the need for multi-channel detection. We experimentally demonstrate the system performance improvement for 16QAM and QPSK overlapped channels for both 20/25 Gbaud data and under different channel spacing conditions.

Highly Reliable Large-scale Optical Cross-connect Architecture Utilizing MxM Wavelength-selective Switches, Shuhei Yamakami, Masaki Niwa, Yojiro Mori, Hiroshi Hasegawa, Kenichi Sato, Nagaya Univ., Japan. We propose a highly reliable and large-scale OXC architecture that consists of MxM WSSs. The proposed scheme can drastically reduce the annual downtime of optical paths stemming from WSS failures while retaining excellent cost-effectiveness.
We experimentally demonstrated an efficient-mobile-fronthaul architecture, in which 48 20-MHz LTE-A mobile-fronthaul channels are aggregated via CDM in a single IM-DD channel with an average EVM of ~3.6% after 5-km transmission over SSMF. Signals are aggregated via CDM in a single IM-DD channel with an average EVM of ~3.6% after 5-km transmission over SSMF. The use of THP enables nearly two orders of magnitude BER performance improvement in a 30-Gbaud PAM4 transmission over a 20-km SSMF.
**Room 408A**

**Th3G • Power Efficient Optics—Continued**

**Th3G.5 • 14:30** 
**Invited**

Use of Embedded Optics to Decrease Power Consumption in IO Dense Systems, Rob Stone, Broadcom Corporation, USA. Use of embedded optical modules in highly IO dense systems such as network switches or routers has the potential to deliver solutions with overall lower power consumption. We consider this from a historical perspective and consider implications of these new architectures, with SerDes power savings of 50% possible by moving to embedded modules.

**Room 408B**

**Th3H • Sensors for Telecom and Biomedical Applications—Continued**

**Th3H.6 • 14:30** 
**Invited**

Applying Fiber Optic and Telecom Technologies for Multiphoton Biomedical Imaging, Chris Xu, Cornell Univ., USA. The main characteristics of the pulsed excitation source, such as wavelength, pulse energy, and repetition rate, for multiphoton biomedical imaging are discussed. Recent advances in these sources using fiber optic and telecom techniques are presented.

**Room 409AB**

**Th3I • Novel Photonic Devices—Continued**

**Th3I.7 • 14:30**

Quantum Dot Lasers Grown on (001) Si Substrate for Integration with Amorphous Si Waveguides, Youming Wan, Qiang Li, Alan Y. Liu, Yu Geng, Justin Norman, Weng Chou, Arthur C. Gossard, John E. Bowers, Evelyn Hu, Ken M. Leu, HKUST, Hong Kong; UCSB, USA; Sandia National Laboratories, USA; Harvard Univ., USA. Heteroepitaxially grown InAs quantum dot lasers were demonstrated on (001) Si under continuous-wave optical pumping with low thresholds (down to 35 µW). The feasibility of integrating active and passive devices through electrical injection was analyzed.

**Room 410**

**Th3K • Network Survivability—Continued**

**Th3K.6 • 14:30**

Correlated-failure-aware VON mapping, Jian Kong, Nannan Wang, Jason P. Aue, Inwoong Kim, Xi Wang, Qiong Zhang, Hakki C. Cankaya, Weisheng Xie, Tadashi Ikeuchi, The Univ. of Texas, Dallas, USA; Fujitsu Laboratories of America, USA; Fujitsu Network Communications, USA. We analyze the availability of virtual optical networks (VONs) mapped over a physical optical network with correlated failures, and we propose a correlated-failure-aware VON mapping algorithm to support high availability while reducing the penalty cost and total link cost.

**Room 411**

**Show Floor Programming**

**Transport SDN: Commercial Applications, Solutions & Innovation Areas**

Huawei 15:00–16:00
For more details, see page 45

**Thursday, 22 March**

15:00–15:30 Coffee Break, 400 Foyer; Exhibit Hall
Th4A • Optical Amplifiers
Presider: Maxim Bolshtyansky; TE SubCom, USA

15:30–17:30

Th4A.1 • 15:30
20dB Net-Gain Fiber Optical Parametric Amplification of 18x120Gb/s Polarization-Multiplexed Signals, Marc P. Stephens1, Vladimir Gordinenko2, Nick J. Doran3, ‘Aston Univ., UK. We report the amplification and characterization of 18x120Gb/s (2.16Tb/s) polarization-division multiplexed WDM signals using a polarization-insensitive single-pump FOPA, whilst achieving fiber-to-fiber net signal gains of 10-20dB over >2THz gain bandwidth.

Th4A.2 • 15:45
Experimental Demonstration of Raman-Assisted Phase Sensitive Amplifier with Reduced ASE Noise Level and More than 25dB Net Gain, Yinwen Cao1, Ahmed Almam1, Youichi Akasaka2, Fatemeh Alihashi3, Morteza Zyad1, Arminhossein Mohajerin Arase1, Changjing Bao1, Peicheng Liao1, ‘Tel Aviv Univ., Israel; ‘Information Sciences Inst., USA. The performance of a black-box Raman-assisted PSA amplifier is experimentally evaluated. In a 20-Gbaud QPSK system, more than 25dB net gain is demonstrated. Comparing to a 4dB-noise-figure EDFA, ~1.5dB ASE noise level reduction is observed.

Th4B • Optical Technologies for Radio Access Network II
Presider: Björn Skubic; Ericsson, Sweden

15:30–17:30

Th4B.1 • 15:30 Invited Mobile Fronthaul Architecture and Technologies: a RAN Equipment Assessment, Philippe Chanclo1, Luz Anet Neto2, Kamil Grybowski3, Zakaria Taqj4, Fabienne Salou5, Naveen Genay6, ‘Orange Labs, France. Optical fiber is the required technology for Radio Access Network (RAN) backhaul and fronthaul. We report the evolution of RAN equipment including the advent of virtualization and an investigation of the required architecture and optical access technologies.

Th4C • DSP for Coherent Systems
Presider: David Millar; Mitsubishi Electric Research Laboratories, USA

15:30–17:30

Th4C.1 • 15:30 Discrete Cosine Transform Based Pilot-aided Phase Noise Estimation for High-order QAM Coherent Optical Systems, Chen Zhu1, Norkiki Kaneda2, ‘Bell Laboratories, Nokia, USA. We present a low-complexity, feed-forward pilot-aided phase noise estimation based on discrete cosine transform low pass filter model for high-order QAM signals. The proposed scheme is experimentally demonstrated in 11-Gbaud PDM-128-QAM and PDM-256-QAM systems.

Th4C.2 • 15:45
Improved Linewidth Tolerant Carrier Phase Recovery Based on Polar MAP Metric Estimate, Murti Sales Llopis1, Md Shuhuddin Faruk1, Seb J. Savory1, ‘Univ. of Cambridge, UK. A new metric that analytically approximates the maximum a posteriori (MAP) solution is presented. Used with a decision-directed carrier phase estimation algorithm, the linewidth tolerance exceeds the limits achieved when using the conventional Euclidean distance.

Th4D • Submarine Transmission Systems
Presider: Dmitri Foursa; TE SubCom, USA

15:30–17:15

Th4D.1 • 15:30
Unrepeatered WDM Transmission of Single-carrier 400G (66-Gbd PDM-16QAM) over 403 km, João Januario1,2, Sandro Rossi3, José H. Junior3, Andrea Chuichierelli4, André Souza1, Alexandre Felipe1, Aldánio Bordonalli5, Serguei Makovey6, Juliano Oliveira7, Jacklyn Resi7; ‘Division of Optical Technologies, CPqD, Brazil; ‘School of Electrical and Computer Engineering, State Univ. of Campinas, Brazil; ‘Carnegie Incorporated, USA. This paper demonstrates a record single-carrier 400 Gb/s unrepeatered WDM transmission over 403 km with 64.7-dB span loss. Using optimized amplification map with 1st-order Raman amplifiers, ROPAs, and 112/150-um2 Aeff fibers, error-free transmission is demonstrated for 16 x 66 Gbd-16QAM.

Th4D.2 • 15:45
24 Tbd Unrepeatered C-Band Transmission of Real-Time Processed 200 Gbd PDM-16-QAM over 349 km, Hans Bisessour1, Christian Bastide1, Sophie Etienne1, Sebastien Dupont2, ‘Alcatel-Lucent Submarine Networks, France. We present a record unrepeated experiment with 120 PDM-16-QAM channels at 200 Gbd/s over 349.2 km, applying a high-power booster and a ROPA with third-order Raman pumping from the receiver end.

Th4E • Novel Applications of Microwave Photonics
Presider: Richard DeSalvo; Harris Corporation, USA

15:30–17:30

Th4E.1 • 15:30
LIGO Experiments, Eric Gustafsson1,2; ‘California Inst. of Technology, USA. This talk will be about the first two detections of Gravitational Waves by the LIGO Observatory detectors and will include a brief description of several of the Advanced LIGO detector optical and laser subsystems.

Th4E.2 • 15:45
Top-scoring
24 Tbd Unrepeatered C-Band Transmission of Real-Time Processed 200 Gbd PDM-16-QAM over 349 km, Hans Bisessour1, Christian Bastide1, Sophie Etienne1, Sebastien Dupont2, ‘Alcatel-Lucent Submarine Networks, France. We present a record unrepeated experiment with 120 PDM-16-QAM channels at 200 Gbd/s over 349.2 km, applying a high-power booster and a ROPA with third-order Raman pumping from the receiver end.
15:30–17:30  Th4F • Network Design
Presider: Qiong Zhang; Fujitsu Laboratories of America Inc, USA

15:30–17:30  Th4G • Laser Transmitters
Presider: Thomas Schrans; Rockley Photonics, USA

15:30–17:15  Th4H • Characterization of SDM Fibers
Presider: Axel Schulzgen; Univ. of Central Florida, USA

15:30–17:15  Th4I • Coherent Optical Signal Processing
Presider: Michael Vasilyev; Univ. of Texas at Arlington, USA

15:30–17:30  Th4F.1 • 15:30 Invited
Techniques for Agile Network Re-Optimization Following Traffic Fluctuations, Tomohiro Hashiguchi1, Kazuyuki Tajima1, Yutaka Takita1, Toru Kategiri1; Fujitsu Limited, Japan. We study the cost effectiveness of network re-optimization for both short-term traffic variations and long-term traffic growth. The presented re-optimization operation is effective in reducing equipment cost while curbing the increase of operational cost.

15:30–17:30  Th4G.1 • 15:30 Top Scored
4 x 56 Gb/s High Output Power Electro-absorption Modulated Laser Array, Michael A. Theurer1, Martin Möhrle1, Ute Troppenz1, Heinz-Gunter Bach1, Anane Sigmund1, Georges Przyrembel1, Martin Schell1; Fraunhofer Heinrich Hertz Inst., Germany. We demonstrate a high output power EML-array operating at 4 x 56 Gb/s NRZ. On chip RF transmission lines enable flexibility for packaging and driver integration. A common active layer structure allows for cost effective fabrication.

15:30–17:15  Th4H.1 • 15:30 Invited
Creation, Propagation and Detection of Vector Modes for Optical Communication, Andrew Forbes1; Univ. of Witwatersrand, South Africa. Vector modes are the natural modes of many fibre systems and have the capacity to be used as a modal set for optical communication. Here we outline recent progress in the creation and detection of these modes, and use the tools to study their propagation in free space and fibre.

15:30–17:15  Th4I.1 • 15:30
Bit-rate-transparent Optical RZ-to-NRZ Format Conversion Based on Linear Spectral Phase Filtering, Reza Maram1, Francesco Da Ros1, Pengyu Guan2, Kasper M. Røge2, Michael Galili2, Leif K. Oxenlowe2, Jose Azana3; 1INRS-Energie Matériaux et Télécom, Canada; 2Department of Photonics Engineering, Technical Univ. of Denmark, Denmark. We propose a novel and strikingly simple design for all-optical bit-rate-transparent RZ-to-NRZ conversion based on optical phase filtering. The proposed concept is experimentally validated through format conversion of a 640 Gbit/s coherent RZ signal to NRZ signal.

15:30–17:30  Th4G.2 • 15:45
56 Gb/s Electro-Absorption Modulation of a Heterogeneously Integrated InP-on-Si DFB Laser Diode, Amin Abbasi1, Bart Moeneclaey1, Jochem Verbrae1, Xin Yin1, Johan Bauwelinck1, Gunther Roelkens1, Geert Morthier1; INTEC, Ghent Univ. - imec, IDLab, Belgium; 2INTEC, Ghent Univ.-Imec, Belgium. Electro-absorption modulation of a heterogeneously integrated InP/Si DFB laser is demonstrated by reverse biasing the InP tapers, used to couple the light between the InP and the Si waveguides. Modulation at 56 Gb/s is demonstrated.

15:30–17:15  Th4I.2 • 15:45
Enhanced Self-coherent Optical OFDM using Stimulated Brillouin Scattering, Elias Giacoumidis1, Eric Magi1, Amal Choudary1, David Marpaung1, Bill Corcoran1, Mark D. Pelusi1, Benjamin Eggleton1; 1CUDOS, Univ. of Sydney, Australia; 2Monash Univ., Australia. We experimentally demonstrate the first self-coherent optical OFDM (SCO-OFDM) based on received optical carrier amplification by stimulated Brillouin scattering. Compared to the conventional CO-OFDM, SCO-OFDM has similar performance with 9.6-Gb/s (16-QAM) enhanced data rate.
The performance of a few-mode distributed Raman amplifier supporting 14 spatial modes. Using a first-order Raman amplification scheme, we have achieved an error-free transmission over a 10-km SSMF link with a round-trip processing latency of <20 μs.

The extended Kalman filter for carrier phase recovery in optical fiber bank multicarrier offset-QAM systems provides an improvement of the LP1 mode-equalized gain. The noise figure is evaluated over a range of SNRs. The optimal SNR regions for MQAM are compared to an error-free transmission over a 10-km SSMF link with a round-trip processing latency of <20 μs.

A few-mode distributed Raman amplifier with second-order few-mode dispersion and 2 dB mode-equalized gain has been achieved with a total throughput of 120 Gb/s using only four Xilinx Virtex-7 FPGAs. Error-free transmission across the C-band over a 10-km SSMF link has been achieved with a round-trip processing latency of <20 μs.

The novel application of few-mode distributed Raman amplifiers for fiber access network II is presented. The proposed method is of low complexity and its performance is comparable to the state-of-the-art BPS method.

We present a 7-core radiation fiber with a radiation-induced refractive index change of 10⁻⁴. The fiber is fabricated using a new fabrication process and characterized for use in telecommunication satellite purposes. We outline the important role of wide bandwidth bit error rate (BER) and round-trip processing latency in optical filter bank multicarrier offset-QAM systems.
Th4F.2 • 16:00  Demonstration of Reconfigurable WDM Multicast Supporting Content Replication and Protection Switching for Content Delivery Optical Network, Ze Li1, Min Zhang1, Dashi Wang1, Dequan Xie2, Yue Cui1, Qi Yang1, 1Beijing Univ of Posts & Telecom, China; 2Wuhan Research Inst. of Posts and Telecommunications, China. We propose a reconfigurable WDM multicast scheme supporting content replication and protection switching for CDN through SOA and our LCoS-based TB-WSS. One-to-six/seven/eight 25 Gb/s QPSK WDM multiscats also with protection switching function have been successfully demonstrated.

Th4F.3 • 16:15  Dynamic Control of Coarse/Fine Hybrid Granular Routing Optical Networks, Yusaku Ito1, Yojiro Mori1, Hiroshi Hassegawa1, Ken-ichi Sato1, 1Nagoya Univ., Japan. Dynamic control of coarse/fine granular routing optical networks is proposed. The routing scheme exploits virtual direct links, which enhances fiber frequency utilization and eliminates the need to control intermediate nodes. Its effectiveness is numerically verified.

Th4F.4 • 16:30  Routing and Regenerator Planning in a Carrier’s Core ROADM Network, Balagangadhar Bathula1, Angela Chiu1, Rakesh Sinha1, Sheryl L. Woodward1, 1AT&T, USA. Optimizing routing and regenerator planning in a carrier’s inter-city ROADM network provides significant savings. We describe how regenerator site planning and regenerator planning in a carrier’s inter-city ROADM network provides significant savings.

Th4G.3 • 16:00  Ultra-broadband EA-DFB Laser Module for 200-Gbit/s PAM4 Transmitter, Hiroshi Yamazaki1, Shigeru Kanazawa1, Yasuhiko Nakashizuka2, Yuta Uedai1, Wataru Kobayashi1, Yoshifumi Muramoto1, Hiroyuki Ishii1, Hiroaki Sanjo1, 1NTT Device Technology Laboratories, Japan; 2NTT Device Innovation Center, Japan. A lumped-electrode EA-DFB laser module with a modulation bandwidth of ~59 GHz was designed and fabricated based on a flip-chip interconnection technique. It enables 107-G baud PAM4 transmission.

Th4H.2 • 16:00  Nondestructive Characterization of Differential Mode Delay in Few-mode Fiber Link Using Rayleigh Backscattering Spectral Shifts, Shingo Ohno1, Daisuke Iida1, Toge Kunihiro1, Tetsuya Manabe1, 1NTT Access Service Systems Laboratories, Japan. We propose a nondestructive method for characterizing accumulated differential mode delay along a few-mode fiber link using Rayleigh backscattering spectral shifts caused by slight environmental disturbances, and achieve 20-ps accuracy and 40-nm resolution.

Th4H.3 • 16:15  Distributed Measurement of Single-way Inter-modal Crosstalk in Spliced FMFs Based on BOTDA, Hiroshi Takahashi1, Chihito Kito1, Kunhiro Toge1, Tetsuya Manabe1, Fumihiko Ito2, 1NTT, Japan; 2Shimane Univ., Japan. This paper focuses on the distributed measurement of inter-modal crosstalk for spliced FMFs, and reveals that single-way inter-modal crosstalk in spliced QI-FMIs, unlike round-trip crosstalk with reflectometric methods, can be characterized using a BOTDA-based method.

Th4H.4 • 16:30  Nearfield Complex Imaging, Yifei Wang1, Jian Fang1, An Li1, Qi Yang1, William Shehi1, 1The Univ. of Melbourne, Australia; 2Victoria research laboratory, NICTA Ltd., Australia; 3Wuhan Research Inst. of Post and Telecommunications, China. Complex imaging via coherent detection is proposed for acquiring two-dimensional nearfield optical image recovering amplitude and phase simultaneously. We experimentally demonstrate the technique using few-mode-fiber (FMF) modes with high extinction ratio, and characterize the FMF differential-group delay.
Millimeter-wave RoF technology is proven to flatten and broaden the emission spectrum in the range 950-1600 nm with dual pumping. Dual pumping scheme achieves differential mode-core gain of less than 4-dB and a 6.5-dB average noise figure are successfully achieved in the C-band.

Spectra of Bi/Er Co-doped Silicate Fiber Broadband Near Infrared (NIR) Luminescence confirms to flatten and broaden the emission spectrum in the range 950-1600 nm and dual pumping. Dual pumping scheme proves to flatten and broaden the emission spectrum in the range 950-1600 nm with multiple active centers.

Optical Transport Network Architecture Enabling Ultra-Low Latency for Communications among Base Stations, Jun Li1, Jaja Chen1, ‘KTH-Royal Inst. of Technology, Sweden. We propose a novel transport network architecture for mobile backhauling along with its tailored communication protocol to offer ultra-low latency. Results show that less than 0.5 milliseconds packet delay can be achieved for inter-base-station communications.

Flex-Frame Timing-Critical Passive Optical Networks for Delay Sensitive Mobile and Fixed Access Services, Mu Xu1,2, Xiang Liu1, Naresh Chand1, Frank Effenberger1, Gee-Kung Chang2,1, KTH-Royal Inst. of Technology, Sweden. The problem of correlated phase noise in spatial-divison multiplexed transmission is studied. To compensate for the phase noise, an algorithm for joint-core phase-noise compensation with subcarrier multiplexing, estimated total capacity with variable spectral efficiency is 66.8 Tb/s.

Phase-Noise Compensation for Spatial-Division Multiplexed Transmission, Amr F. Alfredsson1, Erik Agrall1, Henk Wymeersch1, Magnus Karlsson2,1, Chalmers Univ. of Technol., Sweden. The problem of correlated phase noise in spatial division multiplexed transmission is studied. To compensate for the phase noise, an algorithm for joint-core phase-noise estimation and symbol detection is proposed, which outperforms conventional methods.

Nonlinearity Compensation and Subcarrier Multiplexing, Matt Mazurczyk1, Jin-Xing Cai2, Hussam G. Batahan1, Yu Sun1, Oleg V. Sink1, Maxim A. Bolshiatynskiy1, Dmitri Foursta1, Alexei Pilipetski1,1, TE SubCom, USA. We achieve transoceanic distance transmission with 350-390 Gb/s 64APSK coded modulation channels and explore the benefit of nonlinearity compensation with subcarrier multiplexing. Estimated total capacity with variable spectral efficiency is 66.8 Tb/s.

500Gb/s 64APSK Coded Modulation Transmission over Long Haul Submarine Distance with Nonlinearity Compensation and Subcarrier Multiplexing, Alireza Hadjizadeh1,2,3, Shinichi Aozasa1,2, Xiang Liu1, Lin Cheng1, Masafumi Koga1, Takashi Yamamoto1, Sakamoto1,2,3, ‘NTT Corporation, USA. We demonstrate a cladding-pumped 2-LP mode coupled 6-core EDFA with a 125-μm cladding diameter. A differential mode-core gain of less than 4-dB and a 6.5-dB average noise figure are successfully achieved in the C-band.

Performance Comparison of Advanced Modulation Formats for Transoceanic Coherent Systems, Ivan Fernandez de JaureguiaRuz1, Amirhossein Ghazaei1, Rafael Rios-Muller1, Patrice Tran1,2, ‘Nokia Bell Labs, France. We experimentally compare the performance of probabilistically-shaped 64QAM (PS64QAM), 64APSK, 64QAM and 32QAM in terms of SNR and GMI in B2B and after 6600km transmission. We show that PS64QAM outperforms all formats by 0.4 bits/symbol.

Millimeter-wave Fiber-wireless Integrated Systems. Non-telecommunication applications are discussed for application to high bitrate wireless communication in fiber-wireless bridge configuration and railway communication systems. Non-telecommunication application such as a millimeter-wave radar system is also shown in the paper.
Network Utilization Improvement using Format-agnostic Multi-channel Wavelength Converters

Low-power E1-class 10-Gb/s Directly Modulated Laser in TO-can Package with Optical Filtering for XG-PON Application, Enyu Zhou, Ning Cheng, Sulin Yang, Liqiang Yu, Xiang Liu, Cong Chen, Jingjie Wang, 'Huawei Technology Co. Ltd, China. A low-cost E1-class 1577nm 10Gb/s directly modulated DFB laser in TO-can package is demonstrated with 7.3dBm output power and 8.9dB extinction ratio using optical filtering. 37.6dBm output power is achieved after 20km single-mode fiber transmission. 

Flexible Scheme for Measuring Chromatic Dispersion Based on Interference of Frequency Tones, Kyle Bortzill, Mohamed A. Ettabib, James C. Gates, Cosimo Lacava, Francesca Parmigiani, David J. Richardson, Periklis Petropoulos, 'Univ. of Southampton, UK. We propose and demonstrate a flexible new scheme for measuring chromatic dispersion profiles of optical devices. This is achieved by measuring the phase difference between two mutually coherent tones that are mixed together through a modulator.

Investigation of Inter-core Crosstalk and Raman Nonlinearity in Wideband MCF Transmission, Ruben S. Luis, Benjamin J. Puttnam, Georg Rademacher, Werner Klaus, Y. Awaji, Naoya Wada, 'National Inst Information & Comm Tech, Japan. We address the interplay between Raman nonlinearity and crosstalk on a multicore fiber transmitting a 80 nm WDM signal spanning across C+L bands. We show a 0.1 dB/THz increase of crosstalk tilt due to Raman fiber nonlinearity.

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SC359, Datacenter Networking 101, Cedric Lam, Hong Liu; Oracle, USA. Sunday, 08:00-10:00. Page 22
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  - Sunday, 09:00-12:00
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- SC261, **ROADM Technologies and Network Applications**
  - Thomas Strasser; Nistica Inc., USA
  - Monday, 13:30-16:30
  - Page 23

- SC372, **Building Green Networks: New Concepts for Energy Reduction**
  - Rod S. Tucker; Univ. Melbourne, Australia
  - Sunday, 17:00-20:00
  - Page 22

- SC442, **Free Space Switching Systems: PXC and WSS**
  - David Neilson; Nokia Bell Labs, USA
  - Monday, 09:00-12:00
  - Page 22

- SC443, **Optical Amplifiers: From Fundamental Principles to Technology Trends**
  - Michael Vasilyev1, Shu Namiki2
  - 1National Institute of Advanced Industrial Science and Technology (AIST), Japan
  - Sunday, 09:00-12:00
  - Page 22

- SC446, **Hands-on: Characterization of Coherent Opto-electronic Subsystems**
  - Harald Rohde and Robert Palmer; Coriant, Germany
  - Monday, 08:30-12:30
  - Page 23

**S3: Radio-over-Fiber, Free-Space and Non-telecom Systems**

**Technical Sessions**

- M3E, **Radio-over-Fiber Systems**
  - Monday, 16:00-18:00
  - Page 70

- Th1E, **Visible Light Communications**
  - Thursday, 08:00-09:45
  - Page 126

- Th3C, **Optical Wireless Systems**
  - Thursday, 13:00-14:45
  - Page 138

- Th4E, **Novel Applications of Microwave Photonics**
  - Thursday, 15:30-17:30
  - Page 146

- Tu2F, **Microwave Photonics Enabling Devices**
  - Tuesday, 16:30-18:30
  - Page 78

- W1C, **Novel Fronthauling Techniques**
  - Wednesday, 08:00-10:00
  - Page 98

- W3F, **Low Cost Systems for Wireless and Non-telecom Applications**
  - Tuesday, 16:30-17:30
  - Page 110

**Tutorial Speaker**

- Tu3B.1, **THz Communication Systems**
  - Tadao Nagatsuma; Osaka University, Japan
  - Tuesday, 16:30-17:30
  - Page 88

**Invited Speakers**

- M3E.1, **Techniques for Highly Linear Radio-over-Fiber Links**
  - Thomas Clark; JHU/APL, USA
  - Monday, 16:00-16:30
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- Th1E.3, **Enabling Technologies for High Speed Visible Light Communication**
  - Nan Chi; Fudan University, China
  - Thursday, 08:30-09:00
  - Page 128

- Th3C.1, **UAV Aerial Network and Free Space Communication**
  - Hamid Hemmati; Facebook Inc., USA
  - Thursday, 13:00-13:30
  - Page 138

- Th3C.4, **Trends and Progress in Optical Wireless Communications**
  - Steve Hranilovic; McMaster University, Canada
  - Thursday, 14:00-14:30
  - Page 142

- Th4E.1, **LIGO Experiments**
  - Eric Gustafsson; California Institute of Technology, USA
  - Thursday, 15:30-16:00
  - Page 146

- Th4E.6, **High Bitrate Mm-Wave Links Using RoF Technologies and Its Non-Telecom Application**
  - Atsushi Kanno; National Institute of Information and Communications Technology, Japan
  - Thursday, 17:00-17:30
  - Page 150

- Tu2F.5, **Towards Programmable Microwave Photonics Processors**
  - Jose Capmany; Universidad Politecnica de Valencia, Spain
  - Tuesday, 15:00-15:30
  - Page 82

- W1C.7, **RAN Revolution with NGFI (xHaul) for 5G**
  - Chih-Lin I; China Mobile, China
  - Wednesday, 09:30-10:00
  - Page 104
S4: Digital and Electronic Subsystems

Technical Sessions
M3D, High-Speed Subsystems, Monday, 16:00-17:45. Page 70
Th3D, DSP for Direct-Detection Systems, Thursday, 13:00-15:00. Page 138
Th4C, DSP for Coherent Systems, Thursday, 15:30-17:30. Page 146
Tu2D, Modulation, Detection and DSP for PAM-4 Systems, Tuesday, 14:00-16:00. Page 78
Tu3D, Linear and Nonlinear Multicarrier Systems, Tuesday, 16:30-18:30. Page 88
W1J, Forward Error Correction and Coding, Wednesday, 08:30-10:00. Page 99
W3B, Direct-Detection Transceivers, Wednesday, 13:00-15:00. Page 110
W4A, Coded Modulation, Wednesday, 15:30-17:30. Page 118

Tutorial Speakers
W3B.1, Optical Communications Systems for Data Center Networking, David Plant; McGill University, Canada. Wednesday, 13:00-14:00. Page 110

Invited Speakers
M3D.1, Advanced Algorithm for High-baud Rate Signal Generation and Detection, Zhang Junwen; ZTE (Tx), USA. Monday, 16:00-16:30. Page 70

M3D.4, Extreme Speed Power-DAC: Leveraging InP DHBT for Ultimate Capacity Single-Carrier Optical Transmissions, Agnieszka Konczykowska; III-V Lab, joint laboratory of Nokia Bell Labs, TRT and CE/LETI, France. Monday, 17:00-17:30. Page 74

Th3D.5, IM/DD Transmission Techniques for Emerging 5G Fronthaul, DCI and Metro Applications, Gordon Liu; Huawei Technologies Co Ltd, China. Thursday, 14:00-14:30. Page 142

Th4C.5, Signal Processing for Spectrally Efficient Systems, Gabriel CHARLET; Nokia Bell Labs, France. Thursday, 16:30-17:00. Page 148

Tu2D.7, Recent Advances in Short Reach Systems, Kang Ping Zhong; The Hong Kong Polytechnic University, Hong Kong. Tuesday, 15:30-16:00. Page 84

Tu3D.1, Nonlinear Frequency-Division Multiplexing in the Focusing Regime, Mansoor Yousefi; Telecom ParisTech, France. Tuesday, 16:30-17:00. Page 88

W4A.1, Advances in coded modulation for optical communications, Gerhard Kramer; Technical University of Munich, Germany. Wednesday, 15:30-16:00. Page 118

Panel
Tu2A, Panel: Coherent Interoperability Beyond QPSK - Is it Needed and What Will it Take?, Tuesday, 14:00-16:00. Page 14

Short Courses
SC105, Modulation Formats and Receiver Concepts for Optical Transmission Systems, Peter Winzer, S. Chandrasekhar; Nokia Bell Labs, USA. Sunday, 09:00-13:00. Page 22

SC205, Integrated Electronic Circuits for Fiber Optics, Y. K. Chen; Nokia Bell Labs, USA. Sunday, 17:00-20:00. Page 22


SC341, Multi-carrier modulation: DMT, OFDM and Superchannels, Sander L. Jansen1; Dirk van den Borne2; ADVANCE Optical Networking, Germany. Tuesday, 08:30-12:30. Page 23

SC390, Introduction to Forward Error Correction, Frank Kschischang; Univ. of Toronto, Canada. Monday, 08:30-12:30. Page 23


S5: Digital Transmission Systems

Technical Sessions
M2D, SDM Transmission I, Monday, 14:00-15:30. Page 62
M3C, Probabilistic Shaping and Advanced Modulation Formats, Monday, 16:00-18:00. Page 70

Th1C, SDM Transmission II, Thursday, 08:30-10:00. Page 126

Th3F, Transmission Experiments and Modeling, Thursday, 13:00-14:45. Page 138
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Sorin, Wayne V. - Tu2B.4
Soumplis, Polizois - W4.F1
Souza, Andre - Th4D.1
Sowailem, Mohammed - Tu2H.5, W3B.4, W4.A7
Spadaro, Salvatore - Tu3L.3, W4.F8
Spaelter, Stefan - Th4F.5
Spencer, Daryl T. - M3J.3, Tu3F.5
Subrahmaniam, Ramesh - Th1I.3
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