

OFC Postdeadline Papers

Thursday, 23 March 2017

Room 403A

18:00 -- 19:45

Th5A • Postdeadline Session I

Presider: Sheryl Woodward; AT&T Labs, USA

Th5A.1 • 18:00

SDN-Controlled 400GbE end-to-end service using a CFP8 client over a deployed, commercial flexible ROADM system, Lynn E. Nelson¹, Guodong Zhang¹, Narayan Padi¹, Craig Skolnick¹, Kathleen Benson¹, Troy Kaylor¹, Satoshi Iwamatsu², Robert Inderst², Fabio Marques³, Daniel Fonseca³, Mei Du⁴, Terry Downs⁴, Thor Scherer⁴, Christopher Cole⁵, Y Zhou⁵, Paul Brooks⁶, Andreas Schubert⁶; ¹AT&T Labs, USA; ²Coriant, R&D GmbH, Germany; ³Coriant, Portugal; ⁴Coriant USA, USA; ⁵Finisar Corp, USA; ⁶Viavi Solutions, Germany. We demonstrated a 400Gb/s Ethernet end-to-end circuit, inclusive of 400GbE client card with CFP8 interface and dual-carrier 16QAM line-side, on a production 100G core network segment between New York City and Washington DC. During the field trial, we demonstrated the feasibility of SDN-enabled creation, deletion, and re-routing of the 400G service.

Th5A.2 • 18:15

Transparent Software-Defined Exchange (tSDX) with Real-Time OSNR-Based Impairment-Aware Wavelength Path Provisioning across Multi-Domain Optical Networks, Yao Li¹, Weiyang Mo¹, Shengxiang Zhu¹, Yiwen Shen², Jiakai Yu¹, Payman Samadi², Keren Bergman², Daniel C. Kilper¹; ¹College of Optical Sciences, Univ. of Arizona, USA; ²Department of Electrical Engineering, Columbia Univ., USA. End-to-end, impairment-aware wavelength path provisioning is experimentally realized in a multi-domain network using a transparent software-defined exchange (tSDX) with real-time OSNR monitoring as an SLA guarantee for 100Gbps PM-QPSK DWDM transmission.

Th5A.3 • 18:30

First Experimental Demonstration of Autonomic Slice Networking, Luis Velasco¹, Lluís Gifre⁴, Francesco Paolucci³, Filippo Cugini²; ¹Universitat Politècnica de Catalunya, Spain; ²Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Italy; ³Scuola Superiore Sant'Anna, Italy; ⁴Universidad Autónoma de Madrid, Spain. An architecture to enable autonomic slice networking is presented. Extended nodes make local decisions, whereas domain systems collate and export metered data transparently to customer controllers. Discovered knowledge is experimentally used for network slice reconfiguration.

Th5A.4 • 18:45

Bi-directional 25G/50G TDM-PON with Extended Power Budget using 25G APD and Coherent Amplification, Dora van Veen¹, Vincent Houtsma¹; ¹Nokia Corporation, USA. We demonstrate 50G duobinary PON transmission using a commercial 25G APD-based receiver. To extend the power budget we used simplified coherent amplification achieving -35 dBm sensitivity at 25G, enabling 40 dB optical power budget.

Th5A.5 • 19:00

Quasi frequency drift suppression for burst mode operation in low-cost thermally-tuned TWDM-PON, helene debregeas², Romain Brenot², jean-guy provost², sophie barbet², Wolfgang Poehlmann¹, Robert Borkowski¹, Rene Bonk¹, thomas pfeiffer¹; ¹Nokia Bell Labs, France; ²III-V Lab, France. To solve the problem of thermally-induced frequency drift in burst-mode transmitters for TWDM access networks,

we propose a laser with reduced self-heating, and a simple counter-heating method that demonstrates clear improvement in burst-mode BER measurements.

Th5A.6 • 19:15

200 Gbps OOK Transmission over an Indoor Optical Wireless Link Enabled by an Integrated Cascaded

Aperture Optical Receiver, Zizheng Cao¹, Longfei Shen¹, Yuqing Jiao¹, Xinran Zhao¹, A. Koonen¹; ¹*Eindhoven Univ. of Technology, Netherlands*. Enabled by an integrated InP membrane cascaded aperture optical receiver with flexibly-designed light collection aperture and >67 GHz bandwidth, the record-breaking 200 Gbps (5λ×40 Gbps) OOK data transmission is achieved over a 2 meter indoor optical wireless link.

Th5A.7 • 19:30

Bidirectional Delivery of 54-Gbps 8QAM W-Band Signal and 32-Gbps 16QAM K-Band Signal over 20-km

SMF-28 and 2500-m Wireless Distance, Xinying Li^{1,2}, Jianjun Yu^{1,2}, Kaihui Wang¹, Yuming Xu¹, Long Chen¹, Li Zhao¹, Wen Zhou¹; ¹*Key Laboratory for Information Science of Electromagnetic Waves (MoE), Fudan Univ., China*; ²*ZTE (TX) Inc., USA*. We experimentally demonstrate photonics-aided bidirectional delivery of 54-Gbps 8QAM W-band signal and 32-Gbps 16QAM K-band signal over 20-km SMF-28 and 2500-m wireless distance with BER under 3.8×10^{-3} , employing antenna MIMO and advanced DSPs.

Room 403B

18:00 -- 19:45

Th5B • Postdeadline Session II

Presider: Leif Oxenlowe; DTU Fotonik, Denmark

Th5B.1 • 18:00

1-Pb/s (32 SDM/46 WDM/768 Gb/s) C-band Dense SDM Transmission over 205.6-km of Single-mode

Heterogeneous Multi-core Fiber using 96-Gbaud PDM-16QAM Channels, Takayuki Kobayashi¹, Masanori Nakamura¹, Fukutaro Hamaoka¹, Kohki Shibahara¹, Takayuki Mizuno¹, akihide sano¹, Hiroto Kawakami¹, Akira Isoda¹, munehiko nagatani⁷, Hiroshi Yamazaki⁷, Yutaka Miyamoto¹, Yoshimichi Amma², Yusuke Sasaki², Katsuhiro Takenaga², Kazuhiko Aikawa², Kunimasa Saitoh³, Yong-min Jung⁴, David J. Richardson⁴, Klaus Pulverer⁵, Marc Bohn⁵, Md. Nooruzzaman⁶, Toshio Morioka⁶; ¹*NTT Network Innovation Laboratories, Japan*; ²*Fujikura Ltd., Japan*; ³*Hokkaido Univeristy, Japan*; ⁴*Univ. of Southampton, UK*; ⁵*Coriant R&D GmbH, Germany*; ⁶*Technical Univ. of Denmark, Denmark*; ⁷*NTT Device Technology Laboratories, Japan*. We demonstrate the first 1-Pb/s unidirectional inline-amplified transmission over 205.6-km of single-mode 32-core fiber within C-band only. 96-Gbaud LDPC-coded PDM-16QAM channels with FEC redundancy of 12.75% realize high-aggregate spectral efficiency of 217.6 b/s/Hz.

Th5B.2 • 18:15

70.4 Tb/s Capacity over 7,600 km in C+L Band Using Coded Modulation with Hybrid Constellation

Shaping and Nonlinearity Compensation, Jin-Xing Cai¹, Hussam G. Batshon¹, Matt Mazurczyk¹, Oleg V. Sinkin¹, Ding Wang¹, Milen Paskov¹, Will Patterson¹, Carl Davidson¹, Pat Corbett¹, Greg wolter¹, Tim Hammon¹, Maxim A. Bolshtyansky¹, Dmitri Foursa¹, Alexei Pilipetskii¹; ¹*TE SubCom, USA*. We demonstrate 70.4 Tb/s transmission over 7,600 km with C+L band EDFAs using coded modulation with hybrid probabilistic and geometrical constellation shaping. We employ multi-stage nonlinearity compensation including DBP, fast LMS equalizer and generalized filter.

Th5B.3 • 18:30

Trans-Atlantic Field Trial Using Probabilistically Shaped 64-QAM at High Spectral Efficiencies and Single-Carrier Real-Time 250-Gb/s 16-QAM, Junho Cho¹, Xi Chen¹, Sethumadhavan Chandrasekhar¹, Gregory Raybon¹, Ronen Dar¹, Laurent Schmalen⁴, ELLS Burrows¹, Andrew Adamiecki¹, Steve Corteselli¹, Yan Pan³, Diego Correa³, Brad McKay³, Szilard Zsigmond³, Peter Winzer¹, Stephen Grubb²; ¹Nokia Bell Labs, USA; ²Facebook, USA; ³Nokia, USA; ⁴Nokia Bell Labs, Germany. We transmitted probabilistically shaped 64-QAM at 7.46 b/s/Hz over a 5,523-km in-service EDFA-only amplified trans-Atlantic cable (5.68 b/s/Hz over a looped-back 11,046 km). Using real-time processing we achieve single-carrier 250-Gb/s 16-QAM at 4 b/s/Hz.

Th5B.4 • 18:45

Entropy-Loading: The Multi-Carrier Constellation-Shaping for Colored-SNR Optical Channels, Di Che¹, William Shieh¹; ¹Univ. of Melbourne, Australia. We propose the multi-carrier entropy-loading as a capacity-approaching modulation for colored-SNR optical channels. A 400-Gb/s constellation-shaped 64-QAM experiment reveals >0.3 bits/symbol mutual information or >2 dB OSNR sensitivity advantage over single-carrier systems.

Th5B.5 • 19:00

Single Carrier 1.2 Tbit/s Transmission over 300 km with PM-64 QAM at 100 GBaud, Karsten Schuh¹, Fred Buchali¹, Wilfried Idler¹, Tobias A. Eriksson¹, Laurent Schmalen¹, Wolfgang Templ¹, Rolf Schmid², Lars Altenhain², Michael Moeller², Klaus Engenhardt³; ¹Nokia Bell Labs, Germany; ²MICRAM Microelectronic GmbH, Germany; ³Tektronix, Germany.

We experimentally demonstrate Dual Polarization 64 QAM at 100 GBaud performing below the 20% soft FEC threshold of 4×10^{-2} over 300 km of ultra large effective area fiber at a record line rate of 1.2-Tbit/s.

Th5B.6 • 19:15

218-Gb/s Single-Wavelength, Single-Polarization, Single-Photodiode Transmission Over 125-km of Standard Singlemode Fiber Using Kramers-Kronig Detection, Xi Chen¹, Cristian Antonelli², Sethumadhavan Chandrasekhar¹, Gregory Raybon¹, Jeffrey Sinsky¹, Antonio Mecozzi², Mark Shtaf³, Peter Winzer¹; ¹Nokia Bell Labs, USA; ²Univ. of L'Aquila, Italy; ³Tel Aviv Univ., Israel. We demonstrate a 218-Gb/s direct detection receiver using Kramers-Kronig optical phase reconstruction and chromatic dispersion compensation based on a single photodiode and achieve single-span transmission over 125 km of standard singlemode fiber at 1550 nm.

Th5B.7 • 19:30

First 400GBASE-LR8 interoperability using CFP8 modules, Martin Birk¹, Lynn E. Nelson¹, Guodong Zhang¹, Christopher Cole², Chengpin Yu², Mitsuo Akashi³, Kiyohisa Hiramoto³, X Fu³, Paul Brooks⁴, Andreas Schubert⁴, Thananya Baldwin⁵, Robert Luking⁵, G Pepper⁵; ¹AT&T Labs, USA; ²Finisar, USA; ³Oclaro, USA; ⁴Viavi, Germany; ⁵Ixia, USA. We demonstrate interoperability of 400GBASE-LR8 for the first time between different modules suppliers and test sets using CFP8 alpha production pluggable modules. Error-free operation was measured with 10km of fiber and additional attenuation.

Th5B.8 • 19:45

Record High Capacity (6.8 Tbit/s) WDM Coherent Transmission in Hollow-Core Antiresonant Fiber, Zhixin Liu¹, Lidia Galdino¹, John R. Hayes², Domanic Lavery¹, Boris Karanov¹, Daniel Elson¹, Kai Shi¹, Benn C. Thomsen¹, Marco Petrovich², David J. Richardson², Francesco Poletti², Radan Slavik², Polina Bayvel¹; ¹Dept. of Electronic and Electrical Engineering, UCL, United Kingdom; ²ORC, University of Southampton, United Kingdom. The first multi-terabit/s WDM data transmission through anti-resonant

hollow-core fiber is demonstrated. 16×32-GBd dual-polarization Nyquist-shaped 256QAM channels propagated through a 270-m long fiber. No non-linearity penalty was observed for powers up to 1W.

Room 408A

18:00 -- 19:45

Th5C • Postdeadline Session III

Presider: Benjamin Lee; IBM TJ Watson Research Center, USA

Th5C.1 • 18:00

Silicon-Organic Hybrid (SOH) IQ Modulator for 100 GBd 16QAM Operation, Stefan Wolf¹, Heiner Zwickel¹, Clemens Kieninger¹, Yasar Kutuvantavida¹, Matthias Lauer¹, Joachim Lutz², Lars Altenhain², Rolf Schmid², Wolfgang Freude¹, Christian Koos¹, Sebastian Randel¹; ¹*Karlsruher Institut für Technologie, Germany*; ²*Micram Microelectronic GmbH, Germany*. We generate record-high line rates of 400 Gbit/s (100 GBd 16QAM) using a silicon-based IQ modulator. With a BER=1.9×10⁻² we transmit a net data rate of 333 Gbit/s, the highest value for a semiconductor-based modulator.

Th5C.2 • 18:15

Multi-Channel, Widely-Tunable Coherent Transmitter and Receiver PICs Operating at 88Gbaud/16-QAM, Matthias Lauer¹, Ryan Going¹, Robert Maher¹, Mingzhi Lu¹, Wilson ko¹, Pavel Studenkov¹, James Ferrara¹, Amir Hosseini¹, Scott Corzine¹, Jeff Rahn¹, Matthias Kuntz¹, Huan-Shang Tsai¹, Andy Karanicolas¹, Peter Evans¹, Vikrant Lal¹, David Welch¹, Frederick A. Kish¹; ¹*Infinera Corporation, USA*. We demonstrate 2-channel Tx and Rx PICs capable of delivering >700Gbps per channel (via 88Gbaud, 16-QAM dual-polarization modulation) over an 80km unamplified link with per channel extended C-band tunability.

Th5C.3 • 18:30

32QAM WDM Transmission Using a Quantum-Dash Passively Mode-Locked Laser with Resonant Feedback, Juned N. Kemal¹, Pablo Marin-Palomo¹, Kamel Merghem², Aubin Guy², Cosimo Calo³, Romain Brenot³, Francois Lelarge³, Abderrahim Ramdane², Sebastian Randel¹, Wolfgang Freude^{1,4}, Christian Koos^{1,4}; ¹*Inst. of Photonics and Quantum Electronics (IPQ), Karlsruher Institut für Technologie, Germany*; ²*Center for Nanosciences and Nanotechnologies (CNRS - C2N), France*; ³*III-V Lab, France*; ⁴*Inst. of Microstructure Technology (IMT), Karlsruher Institut für Technologie, Germany*. We demonstrate coherent WDM transmission using a quantum-dash mode-locked laser diode with resonant feedback. We report a line rate of 12 Tbit/s (32QAM 60×20 GBd PDM) over 75 km SMF. The spectral efficiency is 7.5 bit/s/Hz.

Th5C.4 • 18:45

First Real-Time 100-Gb/s NRZ-OOK Transmission over 2 km with a Silicon Photonic Electro-Absorption Modulator, Jochem Verbist¹, Michiel Verplaetse¹, Ashwyn Srinivasan², Peter De Heyn², Timothy De Keulenaer^{3,1}, Ramses Pierco^{3,1}, Renato Vaernewyck^{3,1}, Arno Vyncke^{3,1}, Philippe Absil², Guy Torfs¹, Xin Yin¹, Gunther Roelkens¹, Joris Van Campenhout², Johan Bauwelinck¹; ¹*Ghent Univ., Belgium*; ²*imec, Belgium*; ³*BiFast, Belgium*. We demonstrate the first real-time, serial 100 Gb/s NRZ-OOK transmission with an integrated GeSi EAM implemented on a silicon photonics platform. Transmission over 500m of SSMF and 2 km of dispersion shifted fiber is presented.

Th5C.5 • 19:00

100 GBd Intensity Modulation and Direct Detection with an InP-based Monolithic DFB Laser Mach-

Zehnder Modulator, Sophie Lange¹, Stefan Wolf², Joachim Lutz³, Lars Altenhain³, Rolf Schmid³, Ronald Kaiser¹, Christian Koos², Sebastian Randel², Martin Schell¹; ¹*Fraunhofer Heinrich Hertz Inst., Germany*; ²*Karlsruhe Inst. of Technology, Germany*; ³*Micram Microelectronic GmbH, Germany*. We demonstrate, for the first time with a DFB-MZM at 1550 nm, 100-GBd NRZ and PAM4 transmission over up to 1.2 km due to close-to-zero chirp. At 100-GBd PAM4, the DFB-MZM consumed only 0.85 pJ/bit.

Th5C.6 • 19:15

Integrated ultra-wide band wavelength-tunable hybrid external cavity silicon-based laser, Guilhem de Valicourt¹, Agnes Verdier², Romain Brenot², Young-Kai Chen¹, Po Dong¹; ¹*Nokia Bell-Labs, USA*; ²*III-V Lab, France*. We demonstrate a novel hybrid III-V/Si laser, which exhibits high fiber-coupled output power without booster SOA (up to +13 dBm at certain wavelengths) and a record tuning range (95nm) over the C and L band with side mode suppression ratio greater than 35 dB.

Th5C.7 • 19:30

Integrated Ferroelectric Plasmonic Optical Modulator, Andreas Messner¹, Felix Eltes², Ping Ma¹, Stefan Abel², Benedikt Baeuerle¹, Arne Josten¹, Wolfgang Heni¹, Daniele Caimi², Jean Fompeyrine², Juerg Leuthold¹; ¹*ETH Zurich, Switzerland*; ²*IBM Zurich, Switzerland*. An integrated ferroelectric plasmonic Mach-Zehnder modulator is demonstrated to work in a direct-detection setup with a 72 Gbit/s NRZ modulation format. The device works reliably beyond 130°C with an extinction ratio beyond 15 dB.

Room 408B

18:00 -- 19:45

Th5D • Postdeadline Session IV

Presider: Francesco Poletti; Univ. of Southampton, UK

Th5D.1 • 18:00

Lowest-Ever 0.1419-dB/km Loss Optical Fiber, Yoshiaki Tamura¹, Hirotaka Sakuma¹, Keisei Morita¹, Masato Suzuki¹, Yoshinori Yamamoto¹, Kensaku Shimada¹, Yuya Honma¹, Kazuyuki Sohma¹, Takashi Fujii¹, Takemi Hasegawa¹; ¹*Sumitomo Electric Industries Ltd, Japan*. Lowest-ever 0.1419-dB/km loss at 1560-nm wavelength was realized in a silica-core fiber with 1290-°C low fictive temperature, 147- μm^2 large effective area and low microbending loss due to soft primary coating.

Th5D.2 • 18:15

Endlessly adiabatic fibre, Kerriane Harrington¹, Stephanos Yerolatsitis¹, Dennis Van Ras², Tim A. Birks¹; ¹*Univ. of Bath, UK*; ²*Specialty Department, Draka Comteq Fiber BV, Netherlands*. An optical fibre with a logarithmic index profile can be adiabatically tapered over any length, no matter how short. We report an experimental approximation to such a fibre.

Th5D.3 • 18:30

Coupled-Core Optical Amplifier, Nicolas K. Fontaine¹, Jose Antonio-Lopez², Haoshuo Chen¹, roland ryf¹, David T. Neilson¹, Axel Schulzgen², Juan Carlos Alvarado Zacarias², Rene-Jean J. Essiambre¹, Hirotaka Sakuma³, Takemi Hasegawa³, Testuya Nakanishi³, Tetsuya Hayashi³, Rodrigo Amezcua Correa²; ¹*Nokia Corporation, USA*; ²*CREOL, UCF, USA*; ³*Sumitomo Electric Industries, Ltd., Japan*. We demonstrate a 4-core fiber amplifier that has strongly coupled cores at both the pump and signal wavelengths. Strong mode-coupling minimizes the mode dependent loss and simplifies requirements on the spatial uniformity of the pump.

Th5D.4 • 18:45

MCF-enabled Ultra-High-Density 256-core MT Connector and 96-core Physical-Contact MPO Connector, Tetsu Morishima¹, Jun Ito¹, Takayuki Shimazu¹, Hajime Arao¹, Osamu Shimakawa¹, Toshihisa Yokochi¹, Fumiya Uehara¹, Masaki Ohmura¹, Tetsuya Nakanishi¹, Tomomi Sano¹, Tetsuya Hayashi¹; ¹*Optical Communications Laboratory, Sumitomo Electric Industries, Ltd., Japan*. Ultra-high-density multi-MCF connectors were realized with the insertion loss of <1 dB by 125- μ m-cladding single-mode 8-core fibers and a newly developed simple rotational alignment method using MT-insertable V-groove array with the MT-standard 250- μ m fiber pitch.

Th5D.5 • 19:00

Silicon Photonics Coherent Transceiver in a Ball-Grid Array Package, Christopher R. Doerr¹, John Heanue¹, Long Chen¹, Ricardo Aroca¹, Saeid Azemati¹, Gaz Ali¹, Greg McBrien¹, Li Chen¹, Binbin Guan¹, Hongbin Zhang¹, Xingyu Zhang¹, Torben Nielsen¹, Habib Mezghani¹, Momchil Mihnev¹, Chiwai Yung¹, Michelle Xu¹; ¹*Acacia Communications, Inc., USA*. We demonstrate a silicon photonics coherent transceiver in a ball-grid-array package. It can be handled like a conventional surface-mount-technology component, surviving pick-and-place and 260C reflow. It saves cost, size and provides enhanced thermals and bandwidth.

Th5D.6 • 19:15

8-channel 448 Gbit/s Hybrid Silicon Photonic Multi-Chip PSM Transmitter Enabled by Photonic Wire Bonding, Muhammad Rodlin Billah¹, Matthias Blaicher¹, Juned N. Kemal¹, Tobias Hoose¹, Heiner Zwickel¹, Phillip-Immanuel Dietrich¹, Ute Troppenz², Martin Möhrle², Florian Merget³, Andreas Hofmann¹, Jeremy Witzens³, Sebastian Randel¹, Wolfgang Freude¹, Christian Koos¹; ¹*Karlsruher Institut für Technologie, Germany*; ²*Fraunhofer Inst. for Telecommunications, Germany*; ³*Integrated Photonics Laboratory, RWTH Aachen, Germany*. We demonstrate an eight-channel hybrid multi-chip module comprising hybrid-integrated 8ch-PSM transmitter comprising InP lasers, connected to Si silicon photonic pn-modulators, and parallel single-mode fibers, all connected via photonic wire bonds (PWB). We transmit 28 GBd PAM-4 signals at a total data rate of 448 Gbit/s over 2 km.

Th5D.7 • 19:30

High Density Optical Packaging of High Radix Silicon Photonic Switches, Tae Joon Seok^{1,2}, Victor I. Kopp³, Dan Neugroschl³, Johannes Henriksson², Jianheng Luo², Ming C. Wu²; ¹*Gwangju Inst. of Science and Technol, Korea (the Republic of)*; ²*EECS, Univ. of California, Berkeley, USA*; ³*Chiral Photonics, Inc., USA*. We report on high density optical packaging of high radix (64x64) silicon photonic MEMS switches using pitch-reducing optical fiber array. The footprint of 61-channel optical I/O is as small as 330 μ m x 280 μ m.

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