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Th.3.A Post Deadline Paper Session I

Th.3.A.1	32-core Inline Multicore Fiber Amplifier for Dense Space Division Multiplexed Transmission Systems1
	<i>Saurabh Jain (University of Southampton, United Kingdom); Takayuki Mizuno (NTT, Japan); Yongmin Jung (Optoelectronics Research Centre, University of Southampton, Southampton, United Kingdom); John Hayes (University of Southampton, United Kingdom); Guocai Bai (Optoelectronics Research Centre, United Kingdom); Hirotaka Ono (NTT Photonics Laboratories, Japan); Kohki Shibahara (NTT Innovation Laboratories, Japan); Qiongyue Kang (ORC, UNiversity of Southampton, United Kingdom); Marco Petrovich (University of Southampton, United Kingdom); Akihide Sano, Akira Isoda and Yutaka Miyamoto (NTT Network Innovation Laboratories, Japan); Yusuke Sasaki, Yoshimichi Amma, Katsuhiro Takenaga and Kazuhiko Aikawa (Fujikura Ltd., Japan); Carlos Castro (Christian-Albrecht Universität zu Kiel & Coriant GmbH, Germany); Klaus Pulverer (Coriant R&D GmbH, Germany); Md Nooruzzaman and Toshio Morioka (Technical University of Denmark, Denmark); Shaif-ul Alam and David J Richardson (University of Southampton, United Kingdom)</i>
	◆ We present a high-core-count SDM amplifier, i.e. 32-core multicore-fiber amplifier, in a cladding-pumped configuration. An average gain of 17dB and NF of 7dB is obtained for -5dBm input signal power in the wavelength range 1544nm-1564nm.
Th.3.A.2	1.3-μm Directly Modulated Membrane Laser Array Employing Epitaxial Growth of InGaAlAs MQW on InP/SiO₂/Si Substrate4
	<i>Takuro Fujii, Hidetaka Nishi, Koji Takeda, Erina Kanno and Koichi Hasebe (NTT Corporation, Japan); Takaaki Kakitsuka (NTT Corporation); Tsuyoshi Yamamoto (NTT Corporation, Japan); Hiroshi Fukuda (NTT Corporation); Tai Tsuchizawa and Shinji Matsuo (NTT Corporation, Japan)</i>
	◆ We have developed the first 1.3-μm directly modulated membrane laser array on Si. An InGaAlAs active layer with tensile residual strain is successfully grown on an InP/SiO ₂ /Si substrate. 8-channel, 25.8-Gbit/s modulation is demonstrated with an energy cost of ~200 fJ/bit.
Th.3.A.3	Chirp-Free Modulator using Injection Locked VCSEL Phase Array.....7
	<i>Nicolas K Fontaine and Xian Xiao (Bell Labs/Alcatel-Lucent, USA); Haoshuo Chen and Bin Huang (Nokia Bell Labs, USA); David Neilson (Bell Labs, USA); Kwangwoong Kim (Nokia Bell Labs, USA); Jeffrey H Sinsky (Alcatel-Lucent, USA); Roland Ryf (Bell Labs, Nokia, USA); Gregory Raybon (Nokia Bell Labs, USA); Peter Winzer (Lucent Technologies, USA); Aidan Daly (VERTILAS GmbH, Germany); Christian Neumeyr (VERTILAS, GmbH, Germany); Markus Ortsiefer (VERTILAS GmbH, c/o GATE Garching, Germany)</i>
	◆ We demonstrate a chirp-free modulator using two injection locked VCSELs placed inside a reflective Mach-Zehnder interferometer and produce Nyquist pulse-shaped waveforms with modulation voltages below 500-mV.
Th.3.A.4	Full C-Band Tunable Coherent Transmitter and Receiver InP Photonic Integrated Circuits10
	<i>Vikrant Lal, Joseph Summers, Amir Hosseini, Scott Corzine, Peter Evans, Matthias Lauermann, Ryan Going, An Nguyen, Mohammad Chitgarha, John Osenbach, Naksup Kim, Mingzhi Lu, Thomas Vallaitis, Parmijit Samra, Chul Park, Matthias Kuntz, David Gold, Jiaming Zhang, Jie Tang and Huan-Shang Tsai (Infinera, USA); Han Sun (Infinera Canada,</i>

Canada); Rene Schmogrow, Jeff Rahn, Don Pavinski and Pierre Mertz (Infinera, USA); Tim Butrie (Infinera.com, USA); Kuang-Tsan Wu, Matthew Mitchell, Mehrdad Ziari, Fred Kish and Dave Welch (Infinera, USA)

◆ We introduce a scalable PIC and module platform with full C-band tunability per-channel operating at 33 and 44 Gbaud per channel under 16-QAM dual-polarization mode and demonstrate transmitter and receiver integration up to 14-channels enabling multi-Tb/s total PIC capacities.

Th.3.A.5 50x50 Polarization-Insensitive Silicon Photonic MEMS Switches: Design and Experiment 13

Sangyoon Han and Tae Seok (University of California, Berkeley, USA); Kyoungsik Yu (KAIST, Korea); Niels Quack, Richard Muller and Ming Wu (University of California, Berkeley, USA)

◆ We report on a polarization-insensitive silicon photonic MEMS switch with 50x50 ports. The switch employs a two-level waveguide-crossbar with MEMS-actuated polarization-insensitive couplers. The simulated and measured polarization-dependent losses are 1 dB and 8.5 dB, respectively.

Th.3.B Post Deadline Paper Session II

Th.3.B.1 Wavelength Selective Switch for Dynamic VCSEL-Based Data Center 16

Haoshuo Chen (Nokia Bell Labs, USA); Nicolas K Fontaine (Bell Labs/Alcatel-Lucent, USA); Bin Huang (Nokia Bell Labs, USA); Xian Xiao (Bell Labs/Alcatel-Lucent, USA); Roland Ryf (Bell Labs, Nokia, USA); David Neilson (Bell Labs, USA)

◆ We demonstrate a 1X7 wavelength selective switch (WSS) for multimode fiber covering more than 100 THz of spectrum (780 nm to 1080 nm). WDM VCSEL transmission over the WSS is demonstrated

Th.3.B.2 Demonstration of Fully Nonlinear Spectrum Modulated System in the Highly Nonlinear Optical Transmission Regime 19

Vahid Aref (Nokia Bell Labs, Germany); Son Thai Le (Nokia-Bell-Labs, Germany); Henning Buelow (Nokia Bell Labs, Germany)

◆ We report a 3 dB increase in the nonlinear threshold of a 64 $\times$ 0.5Gbaud 16-QAM continuous-nonlinear-spectrum modulated signal by nonlinear multiplexing with QPSK modulated multi-solitons, showing the first ever fully nonlinear-spectrum modulated system in the highly nonlinear regime.

Th.3.B.3 16 Channel WDM Regeneration in a Single Phase-Sensitive Amplifier through Optical Fourier Transformation 22

Pengyu Guan and Francesco Da Ros (Technical University of Denmark, Denmark); Mads Lillieholm (DTU Fotonik, Denmark); Hao Hu (Technical University of Denmark, Denmark); Kasper Røge (DTU Fotonik, Denmark); Michael Galili, Toshio Morioka and Leif Oxenløwe (Technical University of Denmark, Denmark)

◆ We demonstrate simultaneous phase regeneration of 16-WDM DPSK channels using optical Fourier transformation and a single phase-sensitive amplifier. The BERs of 16-WDM $\times$ 10-Gbit/s phase noise degraded DPSK signals are improved by 0.4-1.3 orders of magnitude.

Th.3.B.4	300-Gbps Discrete Multi-tone Transmission Using Digital-Preprocessed Analog-Multiplexed DAC with Halved Clock Frequency and Suppressed Image 25 <i>Hiroshi Yamazaki, Munehiko Nagatani and Fukutaro Hamaoka (NTT Corporation, Japan); Shigeru Kanazawa (NTT Corporation); Hideyuki Nosaka (NTT Corporation, Japan); Toshikazu Hashimoto and Yutaka Miyamoto (NTT Corporation)</i> ♦ We demonstrated DMT optical transmission at a net data rate of 250 (gross 300) Gbps with a single EML and a single PD. We used a new DP-AM-DAC, which relaxes the clock frequency requirement and suppresses high-frequency image signal.
Th.3.B.5	First Demonstration of Real-Time 100 Gbit/s 3-Level Duobinary Transmission for Optical Interconnects 28 <i>Xin Yin (Ghent University - IMEC, Belgium); Michiel Verplaetse (Ghent University, Belgium); Rui Lin (KTH Royal Institute of Technology & Huazhong University of Science and Technology, P.R. China); Joris Van Kerrebrouck (Ghent University, Belgium); Oskars Ozolins (Acreo Swedish ICT, Sweden); Timothy De Keulenaer (Ghent University-UGent, Belgium); Xiaodan Pang (Acreo Swedish ICT, Sweden); Ramses Pierco, Renato Vaernewyck and Arno Vyncke (Ghent University, Belgium); Richard Schatz and Urban Westergren (Kista Photonic Research Centre (KPRC), Royal Institute of Technology (KTH), Sweden); Gunnar Jacobsen (Acreo AB, Sweden); Sergei Popov (Royal Institute of Technology, Sweden); Jiajia Chen (KTH Royal Institute of Technology, Sweden); Guy Torfs (Ghent University & Imec, Belgium); Johan Bauwelinck (Ghent University - iMinds, Belgium)</i> ♦ We report on the first experimental demonstration of 100Gbit/s 3-level duobinary optical transmission enabled by in-house newly developed SiGe BiCMOS transmitter/receiver ICs. Operated in real-time, we demonstrated a 100Gbit/s data-rate over 2km SSMF without DSP.
Th.3.B.6	First Demonstration of an Automatic Multilayer Intent-Based Secure Service Creation by an Open Source SDN Orchestrator 31 <i>Thomas Szyrkowiec (ADVA Optical Networking & Technische Universität München, Germany); Michele Santuari (CREATE-NET, Italy); Mohit Chamania (ADVA Optical Networking, Germany); Domenico Siracusa (CREATE-NET, Italy); Achim Autenrieth (ADVA Optical Networking, Germany); Victor Lopez (Telefonica, Spain)</i> ♦ In this work we demonstrate an automatic intent-based encryption layer selection and configuration for a multilayer network covering IP and optical utilizing an open source SDN orchestrator. Results indicate that the processing impact of a secure channel creation is negligible.
Th.3.C	Post Deadline Paper Session III
Th.3.C.1	High-spectral-efficiency transmission of PDM 256-QAM with Parallel Probabilistic Shaping at Record Rate-Reach Trade-offs 34 <i>Sethumadhavan Chandrasekhar and Borui Li (Nokia Bell Labs, USA); Junho Cho (Nokia Bell labs, USA); Xi Chen (Nokia Bell Labs, USA); Ellsworth Burrows (Bell Labs, Nokia, USA); Gregory Raybon (Nokia Bell Labs, USA); Peter Winzer (Lucent Technologies, USA)</i> ♦ We demonstrate the transmission of near-optimal low-complexity probabilistically shaped PDM 256-QAM over multiple low-loss all-Raman amplified 50-km large effective area fiber spans, with spectral efficiencies from 14.1 b/s/Hz to 8.9 b/s/Hz at reaches from 500 km to 4000 km.

- Th.3.C.2 665 and 947b/s/Hz Ultra-highly Aggregate-Spectral-Efficient SDM/WDM Transmission over 6-Mode 19-Core Fibre Using DP-16QAM/64QAM Signals 37**
Daiki Soma (KDDI R&D Laboratories Inc., Japan); Yuta Wakayama (KDDI R&D, Japan); Shohei Beppu (KDDI R&D Laboratories, Japan); Koji Igarashi (Osaka University, Japan); Takehiro Tsuritani (KDDI R&D Laboratories, Inc., Japan); Hidenori Taga (KDDI R&D Laboratories Inc., Japan); Itsuro Morita and Masatoshi Suzuki (KDDI R&D Laboratories, Japan)
 ♦ 665 and 947b/s/Hz ultra-highly aggregate spectral-efficient SDM transmission over 9.8 km 6-mode 19-core fibre has been successfully demonstrated using 5.7-GHz-spaced 5-Gbaud DP-16QAM/64QAM Nyquist WDM signals with pre-emphasis-based MDL compensation and cladding-pumped 6-mode pre-amplification.
- Th.3.C.3 Long-Distance Transmission over Coupled-Core Multicore Fiber 40**
Roland Ryf (Bell Labs, Nokia, USA); Juan Alvarado-Zacarias (CREOL, USA); Bin Huang (Nokia Bell Labs, USA); Jose Antonio-Lopez (CREOL, USA); Sun Hyok Chang (ETRI, Korea); Nicolas K Fontaine (Bell Labs/Alcatel-Lucent, USA); Haoshuo Chen (Nokia Bell Labs, USA); Rene Essiambre (Nokia, USA); Ellsworth C. Burrows (Bell Labs, Alcatel-Lucent, USA); Rodrigo Anezcu-Correa (CREOL, USA); Tetsuya Hayashi and Yoshiaki Tamura (Sumitomo Electric Industries, Ltd., Japan); Takemi Hasegawa and Toshiki Taru (Sumitomo Electric Industries, Ltd.)
 ♦ We demonstrate combined wavelength- and space-multiplexed long-distance transmission over a coupled-core fiber with 4 cores. The fiber shows a very small impulse response spread, achieves performance that can exceed single-mode fiber, while providing 4 times the capacity.
- Th.3.C.4 65Tb/s Transoceanic Transmission Using Probabilistically- Shaped PDM-64QAM 43**
Amirhossein Ghazisaeidi, Ivan Fernandez de Jauregui Ruiz and Rafael Rios-Müller (Nokia Bell Labs, France); Laurent Schmalen (Nokia Bell Labs, Germany); Patrice Tran, Patrick Brindel and Alexis Carbo Meseguer (Nokia Bell Labs, France); Qian Hu (Bell Labs, Nokia, Germany); Fred Buchali (Nokia Bell Labs, Germany); Gabriel Charlet and Jeremie Renaudier (Bell Labs Nokia, France)
 ♦ We report on a C+L-band transoceanic transmission using capacity-approaching probabilistically-shaped 64QAM. Digital nonlinear compensation and adaptive-rate spatially-coupled LDPC decoding enable transmission of 65 Tb/s over 6600km, with spectral efficiency of 7.3 b/s/Hz.
- Th.3.C.5 Demonstration of a Partially Integrated Silicon Photonics ONU in a Self-Coherent Reflective FDMA PON 46**
Stefano Straulli, Paolo Savio and Giuseppe Franco (Istituto Superiore Mario Boella, Italy); Roberto Gaudino (Politecnico di Torino, Italy); Stephane Bernabé, Maryse Fournier, Viviane Muffato, Sylvie Menezo and Benoit Charbonnier (CEA-LETI, France); Enrico Temporiti, Daniele Baldi, Gabriele Minoia and Matteo Repossi (STMicroelectronics, Italy); Lee Carroll, Junsu Lee and Peter O'Brien (Tyndall National Institute, Ireland); Riccardo Marchetti (Università degli Studi di Pavia, Italy); Guang-Hua Duan (III-V Lab, France); Fabienne Saliou (Orange, France); Silvio Abrate (Istituto Superiore Mario Boella, Italy)
 ♦ We report about the transmission experiments of a self-coherent reflective PON using a partially integrated silicon-photonics ONU, demonstrating 500 Mbps per user with a power budget of 24 dB in off-line processing and 21 dB in real-time.

- Th.3.C.6 High-Split Intelligent TWDM PON Enabled by Distributed Raman Amplification49**
Patrick Iannone and Alan Gnauck (Nokia Bell Labs, USA); Michael Straub, Jörg Hehmann, Lothar Jentsch and Thomas Pfeiffer (Nokia Bell Labs, Germany); Mark Earnshaw (Nokia Bell Labs, USA)
- ◆ We demonstrate a symmetric-rate, 8 x 10-Gb/s, bi-directional TWDM-PON with 42-km reach, and 1:256 split. Distributed Raman amplification provides gain for the upstream channels (allowing low-cost low-power transmitters) and powering for an intelligent splitter module for supervision of mission-critical services.