

POST-DEADLINE PAPERS

PROCEEDINGS

THURSDAY 14:00 – 15:30

ROOM SALER

PDP.1

Chair: Peter Krummrich, Technische Universität Dortmund, Germany

PDP.1.1 • 14:00 – 14:15

Elephant Coupler: Vertically Curved Si Waveguide with Wide and Flat Wavelength Window Insensitive to Coupling Angle

T. Yoshida, E. Omoda, Y. Atsumi, M. Mori, Y. Sakakibara
Electronics and Photonics Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1, Umezono, Tsukuba, Ibaraki, 305-8568, JAPAN
Few-micron-scale vertical silicon coupler that has high coupling efficiency, weak wavelength dependence, and weak incident angle dependence of wavelength window was achieved with vertically curved silicon waveguide "elephant coupler" formed by ion implantation method compatible with LSI manufacturing technology.

PDP.1.2 • 14:15 – 14:30

Ultra-Compact Plasmonic IQ-Modulator

C. Haffner¹, W. Heni^{1*}, Y. Fedoryshyn¹, B. Baeuerle¹, A. Josten¹, Y. Salamin¹, R. Bonjour¹, C. Hoessbacher¹, A. Emboras¹, D. L. Elder², P. Leuchtmann¹, D. Hillerkuss¹, L. R. Dalton², C. Hafner¹, and J. Leuthold¹

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²University of Washington, Department of Chemistry, Seattle, WA 98195-1700, United States
Plasmonic IQ-modulators with a record small footprint are demonstrated to operate up to 72 GbD. The devices have shown the ability to encode QPSK and 16-QAM modulation formats with power consumption as low as 27 fJ/bit at 18 GbD-16QAM.

PDP.1.3 • 14:30 – 14:45

Error-free 56 Gb/s NRZ Modulation of a 1530 nm VCSEL Link

Daniel M. Kuchta¹, Fuad E. Doany¹, Laurent Schares¹, Christian Neumeyer², Aidan Daly², Benjamin Kögel², Jürgen Roskopf², and Markus Ortsiefer²
¹IBM – T. J. Watson Research Center, 1101 Kitchawan Road, Yorktown Heights, NY 10598
²Vertilas GmbH, Daimlerstrasse 11d, 85748 Garching, Germany
We demonstrate a 1530 nm VCSEL that can operate error-free without DSP or FEC to 56 Gb/s. At 50 Gb/s, error-free operation is attained up to 2 km of SMF. A 2-tap FFE driver is used to precompensate the VCSEL.

PDP.1.4 • 14:45 – 15:00

100 Gbit/s OOK Using a Silicon-Organic Hybrid (SOH) Modulator

W. Hartmann^{1,2}, M. Lauer¹, S. Wolf¹, H. Zwicker¹, Y. Kutuvantavida^{1,2}, J. Luo³, A. K.-Y. Jen³, W. Freude¹, C. Koos^{1,2}
¹Karlsruhe Institute of Technology, Institute of Photonics and Quantum Electronics, Karlsruhe, Germany
²Karlsruhe Institute of Technology, Institute of Microstructure Technology (IMT), Karlsruhe, Germany
³Department of Materials Science and Engineering, University of Washington, Seattle, Washington, USA
We demonstrate a silicon-organic hybrid (SOH) Mach-Zehnder modulator suitable for 100 Gbit/s on-off keying (OOK) with peak-to-peak drive voltages of 1.4 V and energy consumption below 100 fJ/bit. Devices were fabricated using standard processes on a commercial silicon photonic platform.

PDP.1.5 • 15:15 – 15:30

Low cost 112 Gb/s InP DFB-EAM for PAM-4 2 km Transmission

C. Caillaud¹, M. A. Mestre Adrover², F. Blache¹, F. Pommereau¹, J. Decobert¹, F. Jorge¹, P. Charbonnier¹, A. Konczykowska¹, J.-Y. Dupuy², H. Mardoyan², K. Mekhazni¹, J.-F. Paret¹, M. Faugeron¹, F. Mallecot¹ and M. Achouche¹
(1) III-V lab, a joint laboratory between ALBLF, TRT and CEA Leti
(2) Alcatel-Lucent Bell Labs France
A 112-Gb/s PAM4 transmitter module which integrates InP DFB and EAM demonstrated for the first time 2 km transmission with only 3-taps equalizer due to 50 GHz bandwidth, >13 dB extinction ratio and 1.5 mW output power.

THURSDAY 14:00 – 15:30

ROOM PERELLO

PDP.2

Chair: Ton Koonen, COBRA TU Eindhoven, The Netherlands

PDP.2.1 • 14:00 – 14:15

Efficient Annular Cladding Amplifier with Six, Three-Core Cores

Cang Jin^{1,2}, Bin Huang^{1,3}, Kuanping Shang¹, Haoshuo Chen¹, Roland Ryt¹, R. J. Essiambre¹, Nicolas K. Fontaine¹, Guifang Li¹, L. Wang², Y. Messaddeq², S. LaRochelle²
¹Bell Laboratories/Alcatel-Lucent, 791 Holmdel Rd., Holmdel, NJ 07733, USA
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³CREOL, the University of Central Florida, Orlando, Florida 32816, USA
We demonstrate a multi-core, multi-mode optical amplifier with 18 spatial channels pumped by a single 15-W multi-mode pump diode. The amplifier has >20-dB gain per mode, <3-dB mode and core dependent gain, and >31 mW per spatial channel.

PDP.2.2 • 14:15 – 14:30

160-Gbps Nyquist PAM4 Transmitter Using a Digital-Preprocessed Analog-Multiplexed DAC

Hiroshi Yamazaki^{1,2}, Munehiko Nagatani^{1,2}, Shigeru Kanazawa³, Hideyuki Nosaka², Toshikazu Hashimoto², Akihide Sano¹, and Yutaka Miyamoto¹
¹NTT Network Innovation Labs., NTT Corporation, 1-1 Hikari-no-oka, Yokosuka, Kanagawa, Japan
²NTT Device Technology Labs., NTT Corporation, 3-1 Morinosato-Wakamiya, Atsugi, Kanagawa, Japan
³NTT Device Innovation Center, NTT Corporation, 3-1 Morinosato-Wakamiya, Atsugi, Kanagawa, Japan
We proposed an ultra-wide-band DAC configuration consisting of a digital preprocessor, two sub-DACs, and an analog multiplexer. The output bandwidth is nearly doubled from that of the sub-DACs. The idea was verified by a 160-Gbps Nyquist PAM4 transmission.

PDP.2.3 • 14:30 – 14:45

Polarization Division Multiplexed Intensity, Inter Polarization Phase and Inter Polarization Differential Phase Modulation with Stokes Space Direct Detection for 1λ×320 Gb/s 10 km Transmission at 8 bits/symbol

M. Morsy-Osman¹, M. Chagnon¹, D. V. Plant¹
¹ECE dept., McGill University, Montréal, Qc, H3A 2A7, Canada,
We propose modulation and Stokes space direct-detection of four orthogonal degrees of freedom of one laser; the intensity on two polarizations, inter-polarization phase and inter-polarization differential phase, to achieve 320 Gb/s 10 km transmission <HD-FEC at 8 bits/symbol.

PDP.2.4 • 14:45 – 15:00

Direct Detection Transceiver at 150-Gbit/s Net Data Rate Using PAM 8 for Optical Interconnects

M. A. Mestre¹, H. Mardoyan¹, A. Konczykowska², R. Rios-Müller¹, J. Renaudier¹, F. Jorge¹, B. Duval², J.-Y. Dupuy², A. Ghazisaeidi¹, P. Jenneve¹, S. Bigo¹
¹Alcatel-Lucent Bell Labs, Cité de l'Innovation, Route de Villejust, 91620 Nozay, France,
²III-V Lab-Common laboratory of Alcatel-Lucent Bell Labs France', 'Thales Research and Technology' and 'CEA Leti', Route de Nozay, 91460 Marcoussis, France
We demonstrate a single-polarization driver-free, direct-detection 56-Gbaud PAM-8 transceiver enabled by a high-speed selector power DAC fabricated in InP DHBT, and successfully transmit 168 Gbit/s line-rate over 2 km distance without optical amplification.

PDP.2.5 • 15:00 – 15:15

Distributed 1-Tb/s All-Optical Aggregation Capacity in 125-GHz Optical Bandwidth by Frequency Conversion in Fiber

Thomas Richter¹, Carsten Schmidt-Langhorst¹, Robert Elschner¹, Lutz Molle¹, Saleem Alreesh¹, Tomoyuki Kato², Takahito Tanimura², Shigeki Watanabe², Johannes Karl Fischer¹, Colja Schubert¹
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²Fujitsu Laboratories Ltd., 4-1-1 Kamikodanaka, Nakahara-ku, Kawasaki 211-8588, Japan
We demonstrate the spatially distributed aggregation of four 31.1-GbD PDM-32QAM sub-carriers into a 1-Tb/s net data rate superchannel occupying only 125-GHz optical bandwidth, and its subsequent transmission over 160-km SSMF with broadband reception in a single coherent receiver.

THURSDAY 14:00 – 15:30

ROOM MALVARROSA

PDP.3

Chair: Ronald Freund, Fraunhofer Heinrich Hertz Institute, Germany

PDP.3.1 • 14:00 – 14:15

2.15 Pb/s Transmission Using a 22 Core Homogeneous SingleMode Multi-Core Fiber and Wideband Optical Comb

B. J. Puttnam¹, R. S. Luís¹, W. Klaus, J. Sakaguchi, J.-M. Delgado Mendinueta¹, Y. Awaji¹, N. Wada¹, Yoshiaki Tamura², Tetsuya Hayashi², Masaaki Hirano² and J. Marcianti³
¹Photonic Network System Laboratory, National Institute of Information and Communications Technology (NICT), 4-2-1 Nukui-Kitamachi, Koganei, Tokyo 184-8759, Japan. ²Sumitomo Electric Industries, Ltd., 1, Taya-cho, Sakae-ku, Yokohama, 244-8588. Japan ³RAM Photonics, 4901 Morena Blvd., Suite 128, San Diego, CA 92117, USA.
We use a wideband optical comb source with 10THz bandwidth for 2.15 Pb/s transmission over 31km of a new, homogeneous 22-core single-mode multi-core fiber using 399 x 25GHz spaced, 6.468 Tb/s spatial-super-channels comprising 24.5GBaud PDM-64QAM modulation in each core.

PDP.3.2 • 14:15 – 14:30

2.05 Peta-bit/s Super-Nyquist-WDM SDM Transmission Using 9.8-km 6-mode 19-core Fiber in Full C band

D. Soma¹, K. Igarashi^{1,2}, Y. Wakayama¹, K. Takeshima¹, Y. Kawaguchi¹, N. Yoshikane¹, T. Tsuritani¹, I. Morita¹, and M. Suzuki¹
¹KDDI R&D Laboratories Inc., 2-1-15 Ohara, Fujimino-shi, Saitama, 356-8502 Japan, da-souma@kddilabs.jp ²Osaka University, 2-1 Yamadaoka, Suita-shi, Osaka, 565-0871 Japan
We demonstrate ultra-dense SDM transmission of 360-channel Super-Nyquist-WDM DPQPSK signals over 9.8-km 6-mode 19-core fiber, achieving the record fiber capacity of 2.05 Pbit/s (360WDMx114SDMx50Gbit/s) with the highest aggregate spectral efficiency of 456 bit/s/Hz.

PDP.3.3 • 14:30 – 14:45

10-Mode Mode-Multiplexed Transmission over 125-km Single-Span Multimode Fiber

R. Ryf¹, H. Chen¹, N. K. Fontaine¹, A. M. Velazquez-Benitez^{1,2,3}, Jose Antonio-Lopez³, C. Jin^{1,4}, B. Huang^{1,3}, M. Bigot-Astruc⁵, D. Molin⁵, F. Achten⁵, P. Sillard⁵, R. Amezcua-Correa³
¹Bell Laboratories, Alcatel-Lucent, 791 Holmdel-Keypoint Rd, Holmdel, NJ, 07733, USA ²Instituto de Investigaciones en Materiales, UNAM, Cd Universitaria, D.F., 04510, Mexico ³CREOL, the University of Central Florida, Orlando, Florida 32816, USA ⁴COPL, Université Laval, Quebec QC, Canada G1V0A6 ⁵Prysmian Group, Parc des Industries Artois Flandres, 62092 Haisnes Cedex, France.
We demonstrate combined wavelength- and mode-multiplexed transmission over a 125-km multimode single span composed of 10- and 15-mode fibers with a spectral efficiency of 29 b/s/Hz. A transmission capacity of 115.2 Tb/s is achieved over a distance of 87 km.

PDP.3.4 • 14:45 – 15:00

Experimental Demonstration of Capacity Increase and Rate-Adaptation by Probabilistically Shaped 64-QAM

F. Buchali¹, G. Bocherer², W. Idler¹, L. Schmalen¹, P. Schulte², and F. Steiner²
¹Alcatel-Lucent Bell Labs, Stuttgart, Germany, ²Technische Universität Munchen, Germany
We implemented a flexible transmission system operating at adjustable data rate and fixed bandwidth, baudrate, constellation and overhead using probabilistic shaping. We demonstrated in a transmission experiment up to 15% capacity and 43% reach increase versus 200 Gbit/s 16-QAM.

THURSDAY 14:00 – 15:30

ROOM PINEDO

PDP.4

Chair: Andreas Kirstaedter, University of Stuttgart, Germany

PDP.4.1 • 14:00 – 14:15

First Demonstration of Multi-vendor and Multi-domain EON with S-BVT and Control Interoperability over Pan-European Testbed

O. Gonzalez de Dios¹, R. Casellas², F. Paolucci³, A. Napoli⁴, Ll. Gifre⁵, S. Annoni⁶, S. Belotti⁶, U. Feiste⁴, D. Rafique⁴, M. Bohn⁴, S. Bigo⁷, A. Dupas⁷, E. Duttisseuil⁷, F. Fresi³, B. Guo⁸, E. Hugues⁸, P. Layec⁷, V. López¹, G. Meloni³, S. Misto⁶, R. Morro⁹, T. Rahman¹⁰, G. Khanna¹¹, R. Martínez², R. Vilalta², F. Cugini³, L. Poti³, A. D'Errico¹², R. Muñoz¹², Y. Shu⁸, S. Yan⁶, Y. Yan⁶, G. Zervas⁸, R. Nejabati⁶, D. Simeonidou⁸, L. Velasco⁸ and J. Fernández-Palacios¹
¹Telefónica I+D, Spain, ²CTTC, Spain, ³CNITScuola Superiore Sant' Anna, Italy, ⁴Coriant R&D, Germany, ⁵UPC GCO, Spain, ⁶Alcatel-Lucent, Italy, ⁷Alcatel-Lucent, France, ⁸University of Bristol, UK, ⁹Telecom Italia, Italy, ¹⁰TU/e Eindhoven, Netherlands, ¹¹Technische Universität München, Germany, ¹²Ericsson Research, Italy.
The operation of multi-domain and multi-vendor EONs can be achieved by interoperable Sliceable Bandwidth Variable Transponders, a GMPLS / BGP-LS-based control plane and a planning tool. This paper reports the first full demonstration and validation this end-to-end architecture.

PDP.4.2 • 14:15 – 14:30

LIGHTNESS: A Deeply-Programmable SDN-enabled Data Centre Network with OCS/OPS Multicast/Unicast Switch-over

G. M. Saridis¹, S. Peng¹, Y. Yan¹, A. Aguado¹, B. Guo¹, M. Arslan¹, C. Jackson¹, W. Miao², N. Calabretta², F. Agraz³, S. Spadaro³, G. Bernini⁴, N. Ciulli⁴, G. Zervas⁵, R. Nejabati¹, D. Simeonidou¹
¹HPN, University of Bristol, U.K., ²COBRA, Eindhoven University of Technology, the Netherland, ³Universitat Politècnica de Catalunya, Spain, ⁴Nextworks, Pisa, Italy.
We demonstrate an all-optical dynamic DCN utilizing a fully SDN-enabled data-plane including programmable FPGA-based NICs, offering Network Function Virtualization OCS/OPS driven multicasting for Virtual DC applications enabling link recovery and VM migration.

PDP.4.3 • 14:30 – 14:45

Demonstration of symmetrical 25 Gbps TDM-PON with 31.5 dB optical power budget using only 10 Gbps optical components

Vincent Houtsmas and Douthe van Veen
Bell-Labs/Alcatel Lucent, Murray Hill, New Jersey, USA,
First demonstration of symmetrical 25-Gbps TDM-PON with 31.5-dB class N2 power-budget over 0-20 km at 1556-nm using only 10-Gbps optical components. EDFAs are used as booster and preamplifier at the OLT. Low-cost dispersion compensating schemes are applied to increase reach.

PDP.4.4 • 14:45 – 15:00

First Demonstration of Real-Time End-to-End 40 Gb/s PAM-4 System using 10-G Transmitter for Next Generation Access Applications

Jinlong Wei¹, Nicklas Eiselt^{1, 2}, Helmut Griesser³, Klaus Grobe³, Michael Eiselt¹, Juan José Vegas-Olmos², Idelfonso Tafur Monroy², and Jörg-Peter Elbers³
¹ADVA Optical Networking SE, Märzenquelle 1-3, 98617 Meiningen, Germany
JWei@advaoptical.com ²Technical University of Denmark, DTU Photonik, Ørstedts Plads, Build. 343, DK-2800 ³ADVA Optical Networking SE, Fraunhoferstr. 9a, 82152 Martinsried/Munich, Germany.
We demonstrate the first known experiment of a real-time end-to-end 40-Gb/s PAM-4 system for next generation access applications using 10G class transmitters only. Up to 25-dB upstream link budget for 20 km SMF is achieved.

PDP.4.5 • 15:00 – 15:15

Field-Trial of a Real-Time Bidirectional UDWDM-PON Coexisting with GPON, RF Video Overlay and NG-PON2 Systems

Ricardo M. Ferreira¹, Ali Shahpari¹, Fernando P. Guiomar¹, Sofia B. Amado¹, Cláudio Rodrigues², Jacklyn D. Reis³, Armando N. Pinto³ and António L. Teixeira¹
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We report a field-trial of bidirectional coherent Nyquist UDWDM-PON using off-the-shelf real-time FPGA-based transceivers, coexisting with GPON, RF Video and NG-PON2. A sensitivity of -44.5 dBm is achieved for 64x2.5 Gb/s DQPSK, with a 17 dB dynamic power range for US channels.