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Final Program

WEDNESDAY, 23 AUGUST 2017

Page:

8:00 am–8:15 am **Grand Ballroom A**

Session WA **Welcome Remarks**

8:15 am–9:00 am **Grand Ballroom A**

Session WA **Plenary I**

Session Chair Lars Zimmermann, *Leibniz Institute for Innovation in High-Performance Microelectronics (IHP)*

8:15 am–9:00 am ***(Plenary)***

1 **WA1** **Enabling Chip-Scale Trace-Gas Sensing Systems with Silicon Photonics,** W. Green, *IBM T. J. Watson Research Center*

Tunable laser trace-gas spectroscopy has been effectively used in both environmental and medical applications, for its sensitivity and specificity. We'll describe how contemporary silicon photonics manufacturing and assembly are leveraged for a cost-effective miniaturized spectroscopic sensor platform, and outline uses in fugitive methane emissions monitoring.

9:00 am–10:00 am **Grand Ballroom A**

Session WB **Mid-Infrared Integrated Photonics**

Session Chair Goran Mashanovich, *University of Southampton*

9:00 am–9:15 am

3 **WB1** **Mid-Infrared n-Ge on Si Plasmonic Based Microbolometer Sensors,** K. Gallacher, R. W. Millar, *University of Glasgow, Glasgow, United Kingdom,* V. Giliberti, E. Calandrini, L. Baldassarre, *Sapienza Universitá di Roma, Rome, Italy,* J. Frigerio, A. Ballabio, *Politecnico di Milano, Como, Italy,* E. Sakat, G. Pellegrini, *Politecnico di Milano, Milano, Italy,* G. Isella, *Politecnico di Milano, Como, Italy,* M. Ortolani, *Sapienza Universitá di Roma, Rome, Italy,* P. Biagioni, *Politecnico di Milano, Milano, Italy* and D. J. Paul, *University of Glasgow, Glasgow, United Kingdom*

The detection and amplification of molecular ab- sorption lines from a chemical weapons simulant is demonstrated using plasmonic antennas fabricated from n-Ge epitaxially grown on Si. A free-standing $Si_{0.25}Ge_{0.75}$ microbolometer detector with n-Ge plasmonic antenna is demonstrated as an integrated mid- infrared plasmonic sensor.

9:15 am–9:30 am

5 **WB2** **Broadband Mid Infrared Photonic Integrated Components Using a Ge-Rich SiGe Platform,** V. Vakarin, J. M. Ramirez, Q. Liu, X. Le Roux, *Université Paris-Sud, Orsay, France,* J. Frigerio, A. Ballabio, *Politecnico di Milano, Como, Italy,* L. Vivien, *Université Paris-Sud, Orsay, France,* G. Isella, *Politecnico di Milano, Como, Italy,* and D. Marris-Morini, *Université Paris-Sud, Orsay, France*

We demonstrate low-loss mid infrared photonic integrated components fabricated on a Ge-rich $Si_{1-x}Ge_x$ platform. These devices show broadband operation over a wavelength range of at least from $\lambda \approx 5.1$ μm to $\lambda \approx 8.6$ μm, and comprise waveguides, multimode interference couplers and Mach-Zehnder interferometers.

9:30 am–9:45 am

7 **WB3** **Mid-Infrared Ge-on-Si Electro-Absorption Modulator,** T. Li, *University of Southampton, Southampton, United Kingdom and Peking University, Beijing, China,* M. Nedeljkovic, N. Hattasan, A. Z. Khokhar, S. A. Reynolds, S. Stanković, M. Banakar, W. Cao, Z. Qu, C. G. Littlejohns, J. Soler Penades, K. Grabska, L. Mastronardi, D. J. Thomson, F. Y. Gardes, G. T. Reed, *University of Southampton, Southampton, United Kingdom,* H. Wu, Z. Zhou, *Peking University, Beijing, China,* and G. Z. Mashanovich, *University of Southampton, Southampton, United Kingdom*

We present the first waveguide electro-absorption modulator in germanium-on-silicon material platform at 3.8 μm wavelength, based on free-carrier injection into a straight waveguide. The fabricated 1 mm long device has modulation depth of >35 dB at 7 V.

9:45 am–10:00 am

9 **WB4** **Heavily-Doped Germanium on Silicon with Activated Doping Exceeding 10^{20} cm^{-3} as an Alternative to Gold for Mid-Infrared Plasmonics,** J. Frigerio, A. Ballabio, *Politecnico di Milano, Como, Italy,* G. Pellegrini, *Politecnico di Milano, Milan, Italy,* K. Gallacher, *University of Glasgow, Glasgow, United Kingdom,* V. Gilberti, L. Baldassarre, *Sapienza Università di Roma, Rome, Italy,* R. Milazzo, *Università di Padova, Padova, Italy,* K. Huet, F. Mazzamuto, *Laser System and Solutions of Europe, Grennevilliers, France,* P. Biagioni, *Politecnico di Milano, Milan, Italy,* D. J. Paul, *University of Glasgow, Glasgow, United Kingdom,* M. Ortolani, *Sapienza Università di Roma, Rome, Italy,* E. Napolitani, *Università di Padova and CNR-IMM Matis, Padova, Italy,* and G. Isella, *Politecnico di Milano, Como, Italy*

Ge-on-Si has been demonstrated as a platform for Si foundry compatible plasmonics. We use laser thermal annealing to demonstrate activated doping levels $>10^{20}$ cm^{-3} which allows most of the 3 to 20 μm mid-infrared sensing window to be covered with enhancements comparable to gold plasmonics.

10:00 am–10:30 am **Grand Ballroom B**

Exhibits / Coffee Break

10:30 am–12:00 pm **Grand Ballroom A**

Session WC **Group IV Light Sources / GeSn Devices**

Session Chair Dan Buca, *Forschungszentrum Jülich*

10:30 am–11:00 am ***(Invited)***

11 **WC1** **Zener Tunnel-Injection for Ge Optical Amplifiers, Lasers and Modulators,**
R. Koerner, I. A. Fischer, M. Oehme, C. Clausen, and J. Schulze, *University of Stuttgart, Stuttgart, Germany*

We present the Ge Zener-Emitter injection mechanism for synthesis of an indirect semiconductor optical amplifier (ISOA), featuring gain characteristics and electro-absorption modulation with extinction ratios >14 dB by sufficient Moss-Burstein shift, for generic Ge-on-Si Photonics platform.

11:00 am–11:15 am

13 **WC2** **Lasing of Optically Pumped GeSn Micro-Structures Grown on Step-Graded GeSn Buffers,** V. Reboud, *Univ. Grenoble Alpes, CEA LETI, Grenoble, France,* A. Gassenq, N. Pauc, *Univ. Grenoble Alpes, CEA INAC, Grenoble, France,* J. Aubin, *Univ. Grenoble Alpes, CEA LETI, Grenoble, France,* Q. M. Thai, *Univ. Grenoble Alpes, CEA INAC, Grenoble, France,* M. Bertrand, L. Milord, E. Martinez, C. Licitra, D. Rouchon, J. Rothman, *Univ. Grenoble Alpes, CEA LETI, Grenoble, France,* F. Armand Pilon, T. Zabel, H. Sigg, *Paul Scherrer Institut, Villigen, Switzerland,* A. Chelnokov, J. M. Hartmann, *Univ. Grenoble Alpes, CEA LETI, Grenoble, France,* and V. Calvo, *Paul Scherrer Institut, Villigen, Switzerland,*

We report optically pumped lasing from GeSn micro-disks with high Sn content active GeSn layers. Buffer layers made by a step-growth show enhanced performances compared to conventional Ge strain relaxed buffers.

11:15 am–11:30 am

15 **WC3** **Reduced Threshold Microdisk Lasers from GeSn/SiGeSn Heterostructures,**
D. Stange, N. von den Driesch, *Forschungszentrum Juelich GmbH, Juelich, Germany,* T. Zabel, F. Armand-Pilon, *Paul Scherrer Institut, Villigen, Switzerland,* B. Marzban, *RWTH Aachen IPH, Aachen, Germany,* D. Rainko, *Forschungszentrum Juelich GmbH, Juelich, Germany,* J.-M. Hartmann, *Univ. Grenoble Alpes, Grenoble, France,* G. Capellini, T. Schroeder, *IHP, Frankfurt (Oder), Germany,* H. Sigg, *Paul Scherrer Institut, Villigen, Switzerland,* J. Witzens, *RWTH Aachen IPH, Aachen, Germany,* D. Grützmacher, and D. Buca, *Forschungszentrum Juelich GmbH, Juelich, Germany*

We present optically pumped lasing from group IV GeSn/SiGeSn heterostructures. A comparison between double heterostructure and multi-quantum-well microdisk cavities reveals advantages of the multi-well design. Strongly reduced lasing thresholds compared to values from bulk devices are observed.

11:30 am–11:45 am

17 **WC4** **Cavity Mode Analysis of Highly Strained Direct Bandgap Germanium Micro-Bridge Cavities,** F. Armand-Pilon, T. Zabel, E. Marin, *Paul Scherrer Institute, Villigen, Switzerland,* C. Bonzon, *ETH Zürich, Zürich, Switzerland,* S. Tardif, A. Gassenq, N. Pauc, *University Grenoble Alpes and CEA-INAC, Grenoble, France,* V. Reboud, *University Grenoble Alpes and CEA-LETI, Grenoble, France,* V. Calvo, *University Grenoble Alpes and CEA-INAC, Grenoble, France,* J. M. Hartmann, J. Widiez, A. Chelnokov, *University Grenoble Alpes and CEA-LETI, Grenoble, France,* J. Faist, *ETH Zürich, Zürich, Switzerland,* and H. Sigg, *Paul Scherrer Institute, Villigen, Switzerland*

Enhanced photoluminescence at a wavelength as high as 5 μm is obtained in uniaxial tensile strained GeOI micro-bridges cavities. We present, using excitation power dependent photoluminescence spectroscopy, a clear cavity mode pattern which indicates a loss reduction with increasing free carrier density.

11:45 am–12:00 pm

19 **WC5** **Design of a High-Speed Germanium-Tin Absorption Modulator at Mid-Infrared Wavelengths,** R. Ponce, *RWTH Aachen University, Aachen, Germany and Forschungszentrum Juelich GmbH, Juelich, Germany and Jülich Aachen Research Alliance, Fundamentals of Future Information Technology (JARA-FIT),* S. Sharif Azadeh, *RWTH Aachen University, Aachen, Germany and Jülich Aachen Research Alliance, Fundamentals of Future Information Technology (JARA-FIT),* D. Stange, *Forschungszentrum Juelich GmbH, Juelich, Germany and Jülich Aachen Research Alliance, Fundamentals of Future Information Technology (JARA-FIT),* F. Merget, B. Marzban, *RWTH Aachen University, Aachen, Germany and Jülich Aachen Research Alliance, Fundamentals of Future Information Technology (JARA-FIT),* Z. Ikonic, *University of Leeds, Leeds, England,* D. Buca, *Forschungszentrum Juelich GmbH, Juelich, Germany and Jülich Aachen Research Alliance, Fundamentals of Future Information Technology (JARA-FIT),* and J. Witzens, *RWTH Aachen University, Aachen, Germany and Jülich Aachen Research Alliance, Fundamentals of Future Information Technology (JARA-FIT)*

We propose a high-speed electro-absorption modulator based on a direct bandgap $Ge_{0.875}Sn_{0.125}$ alloy operating at mid-infrared wavelengths. Enhancement of Franz-Keldysh-effect by field confinement to GeSn in a reverse-biased junction results in 3.2 dB insertion losses, 35 GHz bandwidth and 6 dB extinction ratio for 2 Vpp applied voltage.

12:00 pm–1:30 pm

Lunch Break (on own)

1:30 pm–3:00 pm **Grand Ballroom A**

Session WD **Optical Transmitter and Filter Technology**

Session Chair Zhiping Zhou, *Peking University*

1:30 pm–1:45 pm

21 **WD1** **High-Efficiency Silicon Mach-Zehnder Modulator with Vertical PN Junction Based on Fabrication-Friendly Strip-Loaded Waveguide,** Y. Maegami, G. Cong, M. Ohno, M. Okano, *National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan,* K. Itoh, N. Nishiyama, S. Arai, *Tokyo Institute of Technology, Tokyo, Japan,* and K. Yamada, *National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan*

We demonstrate a vertical p-n junction silicon Mach-Zehnder modulator constructed with hydrogenated amorphous silicon strip-loaded waveguides on a flat SOI platform. A 3-mm-long phase shifter shows 0.80- to 1.86-Vcm modulation efficiency, 7.3- to 16.9-dBV loss-efficiency product, 3-dB bandwidth of 17 GHz, and 25-Gb/s operation.

WD2 **WITHDRAWN**

2:00 pm–2:15 pm

25 **WD3** **High-Performance Si Optical Modulator with Strained p-SiGe Layer and Its Application to 25 Gbps Optical Transceiver,** J. Fujikata, K. Kinoshita, *Photonics Electronics Technology Research Association (PETRA), Tsukuba, Japan,* J. Han, *The University of Tokyo, Tokyo, Japan,* T. Horikawa, S. Takahashi, K. Yashiki, M. Kurihara, Y. Hagihara, *Photonics Electronics Technology Research Association (PETRA), Tsukuba, Japan,* M. Takenaka, *The University of Tokyo, Tokyo, Japan,* T. Nakamura, K. Kurata, and T. Mogami, *Photonics Electronics Technology Research Association (PETRA), Tsukuba, Japan*

We developed a high performance Si optical modulator by applying a p-type-doped strained SiGe layer, which was integrated with high-performance Ge photodetector at around 1.3 μm wavelength. We demonstrated a high modulation efficiency of 1.0 Vcm and 25 Gbps operation with CMOS-driver.

2:15 pm–2:30 pm

27 **WD4** **A Novel Approach to Create a Tunable Fanoresonance with an Extinction Ratio over 40 dB,** A. Li and W. Bogaerts, *Ghent University-IMEC, Ghent, Belgium*

We experimentally demonstrate a novel method tomake a tunable Fano resonance. Based on a silicon microringwith two tunable reflectors inside, we are able to generate atunable Fano resonance with maximum extinction ratio over 40 dB and a slope rate over 700 dB/nm.

2:30 pm–2:45 pm

29 **WD5** **Electrical Trimming of the Resonance of a Silicon Micro-Ring Resonator,** A. P. Knights, Z. Wang, D. Paez, and L. Dow, *McMaster University, Hamilton, ON, Canada*

Post-fabrication trimming of a silicon micro-ring resonator is demonstrated using an electrically mediated process. The resonance of a fully fabricated ring is permanently blue-shifted by 240 pm after diffusion from local reservoirs of boron dopant. Thermal energy is supplied by an integrated heater.

2:45 pm–3:00 pm

31 **WD6** **High-Performance Sub-Wavelength Engineered Silicon Bragg-Rejection Filters,** D. Pérez-Galacho, D. Oser, C. Alonso-Ramos, F. Mazeas, X. Le Roux, W. Zhang, D. Marris-Morini, *Université Paris-Saclay, Orsay, France,* L. Labonté, S. Tanzilli, *Université Côte d'Azur, Nice, France,* E. Cassan, and L. Vivien, *Université Paris-Saclay, Orsay, France*

We present high-performance Bragg filters based on Si sub-wavelength engineering. We demonstrated a novel differential configuration approach that relaxes fabrication constraints. Single-etch filters with corrugation widths of 150 nm allowed measured wavelength rejection exceeding 40 dB with narrow bandwidths as low as 1.1 nm.

3:00 pm–3:30 pm **Grand Ballroom B**

Exhibits / Coffee Break

3:30 pm–4:30 pm **Grand Ballroom A**
Session WE **Control and Tuning Technology**
Session Chair Yu Yu, *Huazhong University of Science and Technology*

3:30 pm–4:00 pm ***(Invited)***

N/A **WE1** **Active/Passive Photonic Components and Circuits on Silicon,** T. Chu, *Zhejiang University*

4:00 pm–4:15 pm

33 **WE2** **Novel Adaptive Driving Method Enabling Better High-Frequency Performance for Silicon Mach-Zehnder Modulator,** G. Cong, M. Ohno, Y. Maegami, M. Okano, and K. Yamada, *National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan*

We propose an adaptive distributed-bias driving method for silicon travelling-wave Mach-Zehnder modulators and achieved ~25% modulation efficiency enhancement at both 10 and 25 Gb/s with <3.5 V_{pp}, without optimizing horizontal PN-diodes. This method also suggests a new modulator scheme allowing efficiency improvement and design flexibilities.

4:15 pm–4:30 pm

35 **WE3** **Intrinsic Resonance Stabilization in Depletion-Type Silicon Micro-Ring Modulators,** Z. Wang, D. J. Paez, L. Dow, and A. P. Knights, *McMaster University, Hamilton, ON, Canada*

A method is proposed for locking the resonance of a high-bandwidth, silicon micro-ring modulator using intrinsic-defect-mediated-photon-absorption. The photo-signal is generated by the modulator, and thus the need for a waveguide tap is negated. A digital PID loop is used for stabilization.

4:30 pm–5:30 pm

Industry Forum

4:15 pm–5:45 pm **Grand Ballroom B**
Session WP **Welcome Reception / Poster I**
Session Chair TBD

4:15 pm–5:45 pm

37 **WP1** **Fabrication of Silicon Slot Waveguides with 10nm Wide Oxide Slot,** K. Debnath, A. Z. Khokhar, G. T. Reed, and S. Saito, *University of Southampton, Southampton, United Kingdom*

We propose and demonstrate a fabrication technique to realize extremely narrow dielectric slots in silicon waveguides. Using this method, we have demonstrated a silicon slot waveguide with 10 nm dielectric slot with a measured propagation loss of 13.6 dB/cm.

39 **WP2** **Phase Trimming of Mach-Zehnder Interferometers by Laser Annealing of Germanium Implanted Waveguides,** X. Chen, M. M. Milosevic, D. J. Thomson, A. Z. Khokhar, Y. Franz, A. F. J. Runge, S. Mailis, A. C. Peacock, and G. T. Reed, *University of Southampton, Southampton, United Kingdom*

We demonstrate a new post-fabrication trimming technique to fine-tune the phase of integrated Mach-Zehnder Interferometers (MZIs), enabling permanent correction of typical fabrication based phase errors. Preliminary results demonstrate a phase trimming accuracy of 0.146 π.

41 **WP3** **Thermo-Optical Switching in Hybrid VO_2/Si Waveguides by Lateral Displaced Microheaters,** L. Sanchez, A. Rosa, A. Griol, *Univ. Pol. de València, Valencia, Spain,* M. Menghini, P. Homm, B. Van Bilzen, J.-P. Locquet, *KU Leuven, Leuven, Belgium,* C. Mai, L. Zimmermann, *IHP, Frankfurt, Germany* and P. Sanchis, *Univ. Pol. de València, Valencia, Spain*

A lateral displaced microheater is demonstrated for switching across the VO_2 phase transition in ultra-short hybrid VO_2/Si waveguides for both TE and TM light polarizations. Simulation and experimental results are obtained showing a very good agreement with a switching electrical power of around 10mW.

43 **WP4** **A NIR-LED Based on Tensile Strained, Heavily Doped Ge/Si µ-Strips Fabricated in a BiCMOS Pilot Line,** G. Capellini, S. Lischke, L.-W. Nien, *IHP, Frankfurt (Oder), Germany,* J. Kreissl, *IHP, Frankfurt (Oder), Germany and Technische Universität Berlin, Berlin, Germany,* Y. Yamamoto, *IHP, Frankfurt (Oder), Germany,* M. Virgilio, *IHP, Frankfurt (Oder), Germany and Università di Pisa, Pisa, Italy,* J. Schäffner, W. M. Klesse, D. Wolansky, *IHP, Frankfurt (Oder), Germany,* K. Voigt, *Technische Universität Berlin, Berlin, Germany,* L. Zimmermann, A. Mai, B. Tillack, and T. Schroeder, *IHP, Frankfurt (Oder), Germany*

We present an edge-light emitting diode based on highly doped Ge/Si µ-strips starined by a SiN top stressor. The device, manufactured in a BiCMOS pilot line, shows RT NIR electroluminescence in a spectral region extending from the C- to the U- telecom bands and beyond

45 **WP5** **Optical Proximity Correction in Geometry Sensitive Silicon Photonics Waveguide Crossings,** D. Celo, P. Dumais, *Huawei Technologies Canada Co., Ltd., Ottawa, ON, Canada,* W. Liu, *Huawei Technologies Co., Ltd., Shenzhen, China,* C. Zhang, D. J. Goodwill, J. Jiang, and E. Bernier, *Huawei Technologies Canada Co., Ltd., Ottawa, ON, Canada*

Silicon waveguide crossings using multi-mode interferometers are highly sensitive to geometry at the internal corners. Optical proximity correction was developed using design-of-experiments without sophisticated foundry modeling. This simple technique improved loss by a factor of 2, to <30 mdB, while maintaining flatness over C-band.

47 **WP6** **HWCVD a-Si:H Interlayer Slope Waveguide Coupler for Multilayer Silicon Photonics Platform,** R. Petra, S. Z. Oo, A. Tarazona, R. Cernansky, S. Reynolds, D. J. Thomson, A. Z. Khokhar, A. Politi, G. Z. Mashanovich, G. T. Reed, and H. M. H. Chong, *University of Southampton, Southampton, United Kingdom*

We present an interlayer slope waveguide, designed to guide light from one level to another in multilayer silicon photonics platform. The waveguide is fabricated using HWCVD a-Si:H at 350°C. Measured loss of 0.5 dB/slope was obtained at wavelength of 1550 nm for TE mode polarization.

49 **WP7** **Tensile Strained GeSn Mid-Infrared Light Emitters,** R. W. Millar, D. C. S. Dumas, K. Gallacher, *University of Glasgow, Glasgow, United Kingdom,* P. Jahandar, M. Myronov, *University of Warwick, Coventry, United Kingdom,* and D. J. Paul, *University of Glasgow, Glasgow, United Kingdom*

Compressively strained GeSn alloys grown on Ge buffers on Si (001) substrates were fabricated into microdisks and strained using silicon nitride stressors. The strained disks are measured to be tensile by Raman spectroscopy, and demonstrate direct bandgap emission in the 3–5 µm gas sensing window.

51 **WP8** **The Electronic Band Structure of $Ge_{1-x}Sn_x$ in the Full Composition Range: Indirect, Direct, and Inverted Gaps Regimes, Band Offsets, and the Burstein-Moss Effect,** P. Scharoch, M. P. Polak, and R. Kudrawiec, *Wroclaw Univ. of Science and Technology, Wroclaw, Poland*

A comprehensive study of the $Ge_{1-x}Sn_x$ alloy in the full composition range using state-of-the-art density functional theory methods has been performed. Various conclusions shedding new light on its properties, in relation to experiment, like gaps regimes, band offsets, and the Burstein-Moss effect, has been drawn.

53 **WP9** **Reduction of Optical Bleaching in Phosphorus Doped Ge Layer on Si,** S. A. Srinivasan, *IMEC, Heverlee, Belgium and Ghent University, Ghent, Belgium,* C. Porret, M. Pantouvaki, *IMEC, Heverlee, Belgium,* Y. Shimura, *IMEC, Heverlee, Belgium and Shizuoka University, Hamamatsu, Japan,* P. Geiregat, *Ghent University, Ghent, Belgium,* R. Loo, J. Van Campenhout, *IMEC, Heverlee, Belgium,* D. Van Thourhout, *Ghent University, Ghent, Belgium*

Optical bleaching is studied on undoped and highly doped Ge layer on Si using Transient Absorption Spectroscopy. Upon optical pumping, doped Ge showed a reduction in optical bleaching as compared to undoped Ge due to the homogeneous broadening effect in doped Ge.

55 **WP10** **Integration of Carbon Nanotubes on Silicon Photonics Resonators,** E. Durán-Valdeiglesias, W. Zhang, T.-H.-C. Hoang, C. Alonso-Ramos, X. Le Roux, S. Serna, *Université Paris-Saclay, Orsay, France,* M. Balestrieri, *Université Paris-Saclay, Gif-sur-Yvette, France,* D. Marris-Morini, *Université Paris-Saclay, Orsay, France,* F. Intonti, F. Sarti, N. Caselli, F. La China, F. Biccari, M. Gurioli, *University of Florence European Laboratory for Non-Linear Spectroscopy, Sesto Fiorentino (FI), Italy,* A. Filoramo, *Université Paris-Saclay, Gif-sur-Yvette, France,* E. Cassan, and L. Vivien, *Université Paris-Saclay, Orsay, France*

We report on the integration of carbon nanotubes in silicon micro-cavities to develop cost-effective light sources. Strong light coupling from carbon nanotubes was demonstrated into silicon photonics resonators, nanobeam cavities and photonic crystals.

57 **WP11** **Strained Silicon Photonics for Pockels Effect Based Modulation,** M. Berciano, P. Damas, G. Marcaud, X. Le Roux, P. Crozat, C. Alonso-Ramos, D. Benedikovic, D. Morini, E. Cassan, and L. Vivien, *Université Paris-Saclay, Orsay, France*

We present on experimental results of strain-induced Pockels effect in silicon based on Mach-Zehnder interferometer modulators. We theoretically studied both Pockels effect and carrier parasitic effect in silicon under an electric field. We demonstrated high speed Pockels-based optical modulation up to 25 GHz.

59 **WP12** **Broad Wavelength Generation and Conversion with Multi Modal Four Wave Mixing in Silicon Waveguides,** S. Signorini, M. Mancinelli, *University of Trento, Trento, Italy,* M. Bernard, *University of Trento, Trento, Italy and Bruno Kessler Foundation, Trento, Italy,* M. Ghulinyan, G. Pucker, *Bruno Kessler Foundation, Trento, Italy,* and L. Pavesi, *University of Trento, Trento, Italy*

We demonstrate spontaneous and stimulated Four Wave Mixing (FWM) in silicon waveguides with multi modal phase matching as a mean for tunable and large wavelength conversion and generation. We obtained a distance between the generated idler and signal of more than 750 nm.

61 **WP13** **High-Speed, High-Responsivity Ge Photodiode with NiSi Contacts for an Advanced Photonic BiCMOS Technology,** S. Lischke, D. Knoll, D. Wolansky, M. Kroh, A. Peczek, and L. Zimmermann, *IHP, Frankfurt (Oder), Germany*

We will show that contacting a high-performance Ge photodiode with NiSi instead of $CoSi_2$ has no negative effect. This result strongly supports the development of an advanced photonic BiCMOS process where the RF performance of SiGe HBTs can take strong benefit from the “cold” NiSi.

63 **WP14 Germanium-on-Silicon Waveguides for Mid-Infrared Photonic Sensing Chips,** K. Gallacher, *University of Glasgow, Glasgow, United Kingdom,* L. Baldassarre, *Sapienza University of Rome, Rome, Italy,* R. W. Millar, *University of Glasgow, Glasgow, United Kingdom,* A. Sorgi, *Sapienza University of Rome, Rome, Italy,* V. Giliberti, *Istituto Italiano di Tecnologia, Rome, Italy,* J. Frigerio, G. Isella, *Politecnico di Milano, Como, Italy,* I. Figliolia, P. Biagioni, *Politecnico di Milano, Milano, Italy,* M. Michele, *Sapienza University of Rome, Rome, Italy,* and D. J. Paul, *University of Glasgow, Glasgow, United Kingdom*

Germanium-on-silicon rib waveguides are modelled, fabricated and characterized with a novel near-field infrared spectroscopy technique that allows on-chip investigation of the waveguide losses at 5.8 um wavelength.

65 **WP15 Manufacturing Variability Estimations for Deposited Silicon Photonic Circuits,** T. Lipka and H. k. Trieu, *Hamburg University of Technology, Hamburg, Germany*

We present a comprehensive study of deposited silicon microring resonators for photonic-integrated circuitry. Refractive index, thickness, and widths variations are estimated. The statistical deviations are sufficiently low to realize photonic circuits of high quality for instance deposited on various substrates and integrated with heterogeneous materials.

N/A **WP16 Tensile-Strained GeSn/SiGeSn Multiple Quantum Wells Laser Wrapped in Si_3N_4 Liner Stressor,** Y. Liu, S. Zhang, X. Gao, Y. Wang, J. Zhang, G. Han and Y. Hao, *Xidian University, Xi'an, China*

A tensile-strained GeSn/SiGeSn multiple quantum well (MQW) laser wrapped in Si_3N_4 liner stressor is designed and characterized theoretically. The boosting effects of tensile strain introduced into the GeSn/SiGeSn MQW laser by Si_3N_4 liner stressor on the threshold current density and optical gain are demonstrated.

N/A **WP17 Hybrid NIR/MIR Beam Splitter (De)Multiplexer on SOI Platform,** M.-S. Rouifed, *Nanyang Technological University, Singapore,* C. G. Littlejohns, *Nanyang Technological University, Singapore and University of Southampton, Southampton, United Kingdom,* G. X. Tina, H. Qiu, *Nanyang Technological University, Singapore,* J. Soler Penades, M. Nedeljkovic, *University of Southampton, Southampton, United Kingdom,* Z. Zhang, C. Liu, D. J. Thomson, G. Z. Mashanovich, G. T. Reed, *University of Southampton, Southampton, United Kingdom,* and H. Wang, *Nanyang Technological University, Singapore,*

We present an ultra-compact MMI-based beam splitter (de)multiplexer for the NIR/MIR wavelength of 1.55 μm and 2 μm based on silicon-on-insulator (SOI) substrate. Simulations and fabrication of such device are performed and exhibits extremely low insertion losses, high contrasts and cross-talk for both wavelengths.

73 **WP18 Carrier Dynamics Analysis in Metal-Semiconductor-Metal Device for Mid-IR Silicon Photonics,** A. T. L. Hui, Y. Ding, H. Hu, and M. Galili, *Technical University of Denmark, Lyngby, Denmark*

A modelling platform for active carrier removal based on metal-semiconductor-metal structure is reported on analysis of carrier dynamics. The analysis reveals electric current hot spots exist in geometric singularities and curly trajectory of carriers should be considered when accurately estimating the effective carrier lifetime.

75 **WP19 Cross-Slot Waveguide and Compact Straight Slotted Resonator Based Bio-Chemical Sensors,** S. Ghosh, *City, University of London, London, United Kingdom,* C. Pan, *Southeast University, Nanjing, China,* and B. M. A. Rahman, *City, University of London, London, United Kingdom*

Two novel designs of integrated bio-chemical sensor incorporating an integrated cross-slot waveguide and a compact straight vertical slotted resonator with high sensitivity and small physical footprint are reported.

77 **WP20 Plasmonic Germanium Resonators for CMOS Compatible Terahertz Chem-Bio Sensing Platform,** S. Guha, M. Kazmierczak, *Leibniz Institute for Innovative Microelectronics, Berlin, Germany,* M. Betthenhausen, *University of Kassel, Kassel, Germany,* O. Skibitzki, *Leibniz Institute for Innovative Microelectronics, Berlin, Germany,* C. You, *University of Osnabrück, Osnabrück, Germany,* J. Mitzloff, *Leibniz Institute for Innovative Microelectronics, Berlin, Germany,* J. Flesch, C. You J. Piehler, *University of Osnabrück, Osnabrück, Germany,* B. Witzigmann, *University of Kassel, Kassel, Germany,* and T. Schroeder, *Leibniz Institute for Innovative Microelectronics, Berlin, Germany*

This work demonstrates plasmon based Germanium (Ge) resonators fabricated on standard BiCMOS technology operating at THz frequency range for chem-bio sensing. The Ge resonators operate at 0.55 THz and is shown to sense chem bio adlayers on top of them.

THURSDAY, 24 AUGUST 2017

8:00 am–9:45 am **Grand Ballroom A**

Session ThA **Silicon Nitride Photonics for Sensing**

Session Chair Christian Koos, *Karlsruhe Institute of Technology (KIT)*

8:00 am–8:30 am ***(Invited)***

79 **ThA1** **EU Pilot Lines for Integrated Photonics,** J.-M. Fedeli, S. Nicoletti, *CEA-LETI, Grenoble, France,* L. Lagae, *IMEC, Leuven, Belgium,* I. Artundo, *VLC Photonics S.L., Valencia, Spain,* and P. O'Brien, *Tyndall, Cork, Ireland*

Three EU pilot lines dealing with integrated optics have been set up. PIX4life is focused on SiN PICs, MIRPHAB on optical sensors for chemical sensing, PIXAPP on photonics packaging.

8:30 am–9:00 am ***(Invited)***

81 **ThA2** **Spectroscopic Sensing and Applications in Silicon Photonics,** E. Ryckeboer, X. Nie, A. Dhakal, D. Martens, P. Bienstman, G. Roelkens, and R. Baets, *Ghent University-IMEC, Ghent, Belgium*

We report on miniaturized spectroscopic sensors that are realized using Silicon Photonics technology. This technology relies on CMOS compatible processes to fabricate both Silicon and Silicon-Nitride based photonics integrated circuits. Various spectroscopic sensor designs and applications are discussed.

9:00 am–9:15 am

83 **ThA3** **Ultra-wide Band (400–1700 nm) Integrated Spectrometer Based on Arrayed Waveguide Gratings for Spectral Tissue Sensing,** D. Geuzebroek, A. van Rees, E. Klein, *LioniX International B.V., Enschede, The Netherlands,* and K. Lawniczuk, *Bright Photonics B.V., Eindhoven, The Netherlands*

We describe the use of photonic integrated circuits as a ultra-wide band spectrometer for spectral tissue sensing in the wavelength range of 400 to 1700nm. Measurements show that all individual arrayed waveguide gratings, fabricated in TriPleX™ technology, work as expected and demonstrate the broadband operation.

9:15 am–9:30 am

85 **ThA4 Tunable Index Back End of Line Platform for Enhanced Integrated Photonics,** F. Y. Gardes, C. Lacava, K. Debnath, T. D. Bucio, M. Banakar, S. Stankovic, A. Alattili, A. Z. Khokhar, S. Saito, P. Petropoulos, *University of Southampton, Southampton, United Kingdom,* I. Molina-Fernández, R. Alir, A. Ortega-Moñux, J. G. Wangüemert-Pérez, *Universidad de Málaga, Málaga, Spain,* Y. Chen, J.-J. He, *Zhejiang University, Hangzhou, China,* P. Cheben, and J. H. Schmid, *National Research Council Canada, Ottawa, ON, Canada*

We demonstrate a back end of line compatible SiN based material with tunable refractive index enabling low optical loss, high non-linear Kerr response, low index photonic crystals, high efficiency couplers, low loss waveguides and temperature tolerant MUX for DWDM.

9:30 am–9:45 am

87 **ThA5 Waveguide Optical Tweezers for Selective Cell Lysis,** S. A. Kahn, A. C. Ceballos, A. K. Ellerbee Bowden, and O. Solgaard, *Stanford University, Stanford, CA, USA*

Waveguide evanescent fields enable lysing of selected red blood cells. Cells are trapped on waveguides and are lysed by rapidly reducing the trapping forces. Red blood cells of different age require different levels of lysing power, allowing selective lysing of crenate cells.

9:45 am–10:15 am **Grand Ballroom B**

Exhibits / Coffee Break

10:15 am–12:00 pm **Grand Ballroom A**
Session ThB **Nanofabrication of Novel Passive Devices**
Session Chair Kei May Lau, *Hong Kong University of Science and Technology*

10:15 am–10:45 am ***(Invited)***

N/A **ThB1 A Heterogeneous III-V/Si_3N_4 Platform for Integrated Quantum and Nonlinear Photonics,** K. Srinivasan and M. Davanco, *National Institute of Standards and Technology, Gaithersburg, MD, USA*

We use heterogeneous integration to develop a platform capable of combining the deterministic single-photon generation and single-photon-level nonlinearities possible in single InAs quantum dot devices with the low-loss waveguiding and Kerr nonlinear frequency conversion available in stoichiometric silicon nitride photonics.

10:45 am–11:00 am

89 **ThB2 Sub-Wavelength Silicon Grating Metamaterial Ring Resonators,** D. Benedikovic, M. Berciano, X. Le Roux, V. Vakarin, G. Marcaud, C. Alonso-Ramos, E. Cassan, D. Marris-Morini, and L. Vivien, *Université Paris-Saclay, Orsay, France*

We report on experimental results of silicon micro-ring resonators based on non-resonant photonic metamaterial waveguides. High extinction ratio up to 30 dB and loaded Q-factors in a range of 1500 to 6000 were achieved at a wavelength of 1550 nm.

11:00 am–11:15 am

91 **ThB3 Bragg Grating Filter for Suspended Silicon Waveguides,** C. Alonso-Ramos, X. Le Roux, D. Benedikovic, V. Vakarin, E. Durán-Valdeiglesias, D. Oser, D. Pérez-Galacho, E. Cassan, D. Marris-Morini, *Université Paris-Saclay, Orsay, France,* P. Cheben, *National Research Council Canada, Ottawa, ON, Canada,* and L. Vivien, *Université Paris-Saclay, Orsay, France*

We present a novel suspended Si waveguide approach for hybrid near-infrared and mid-infrared operation. Large waveguide cross-sections allow mid-infrared propagation, while an original corrugation yields effective single-mode near-infrared operation. Exploiting this concept, we demonstrated Bragg filters with 4 nm bandwidth and 40 dB rejection.

11:15 am–11:30 am

93 **ThB4 Fully Suspended Mid-Infrared Racetrack Resonator with Subwavelength Grating Cladding,** W. Zhou, *The Chinese University of Hong Kong, Shatin, Hong Kong,* Z. Cheng, *The University of Tokyo, Tokyo, Japan,* X. Wu, B. Zheng, X. Sun, and H. K. Tsang, *The Chinese University of Hong Kong, Shatin, Hong Kong*

A fully suspended mid-infrared racetrack resonator is experimentally demonstrated. It has good mechanical stability and broad spectral range of transparency. The measured loaded optical Q factor is 16,440 at 2402.38 nm, with an extinction ratio of 11.83 dB.

11:30 am–11:45 am

95 **ThB5 Fabrication of Vertically Curved Si Surface Optical Coupler Coupling with 5-µm-Mode-Field-Diameter Optical Fiber,** Y. Atsumi, T. Yoshida, E. Omoda, and Y. Sakakibara, *National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan*

A vertically curved Si surface optical coupler for high-numerical-aperture optical fibers with 5-µm-mode-field-diameter was fabricated. The dome-like SiO_2 coupler-top could be successfully formed, and the coupler showed optical coupling with loss of 5.2 dB and the 0.5-dB bandwidth of 110 nm.

11:45 am–12:00 pm

97 **ThB6 Three-Mode Synthesis of Slab Gaussian Beam in Ultra-Low-Loss In-Plane Nanophotonic Silicon Waveguide Crossing,** P. Dumais, D. J. Goodwill, D. Celo, J. Jiang, and E. Bernier, *Huawei Technologies Canada Co., Ltd, Ottawa, ON, Canada*

We demonstrate experimentally a fundamentally new low-loss silicon nanophotonic in-plane crossing. The crossing operation uses a three-mode synthesis of a 1-D Gaussian beam. The measured loss is 0.007 dB ± 0.004 dB, which is the lowest reported loss for silicon waveguide crossings.

12:00 pm–1:30 pm

Lunch Break (on own)

1:30 pm–3:00 pm **Grand Ballroom A**

Session ThC **Data Transmission Modules**

Session Chair Koji Yamada, *National Institute of Advanced Industrial Science and Technology (AIST)*

1:30 pm–2:00 pm ***(Invited)***

N/A **ThC1** **Industrial Installation of Optical I/O Cores Based on Si Photonics,** K. Kurata, *Photonics Electronics Technology Research Association, Tsukuba, Japan*

2:00 pm–2:15 pm

99 **ThC2** **25 Gb/s Error-Free Transmission with a Packaged Chipset Integrating a III-V/SOI DFB Laser, an Electro-Absorption Modulator and a Semiconductor Optical Amplifier,** I. Ghorbel, A. Gallet, A. Shen, D. Carrara, D. Make, G. Levaufre, G.-H. Duan, *III-V Lab, a joint lab of Nokia, Thales and CEA, Palaiseau, France,* S. Olivier, C. Jany, S. Malhouitre, C. Kopp, *CEA LETI, Grenoble, France,* C. Eason and P. O'Brien, *Tyndall National Institute, Cork, Ireland*

We report on the first hybrid III-V on silicon integration of a DFB laser, an electro-absorption modulator and a semiconductor optical amplifier. We packaged the fabricated chipset and validated the module through 25 Gb/s error-free transmissions for short reach communication applications.

2:15 pm–2:30 pm

101 **ThC3** **Co-Integration of a Temperature Tolerant Low Impedance Resonantly Enhanced Silicon Photonics Modulator,** A. Moscoso-Mártir, J. Nojic, S. Romero-García, S. Sharif Azadeh, B. Shen, *RWTH Aachen University, Aachen, Germany,* D. E. Rasmussen, M. Nielsen, *Mellanox Technologies, Roskilde, Denmark,* A. Sandomirsky, A. Badihi, S. Rockman, *Mellanox Technologies, Yokneam, Israel,* F. Merget, *RWTH Aachen University, Aachen, Germany,* R. Setter, E. Mentovich, *Mellanox Technologies, Yokneam, Israel,* and J. Witzens, *RWTH Aachen University, Aachen, Germany,*

We report on an optically wideband, resonantly enhanced Mach-Zehnder modulator co-integrated with a 4Ω output impedance, 28 Gbd driver from Mellanox Technologies. Error free transmission is demonstrated, at 14 Gbps (25 Gbps), in 4 nm (3 nm) wide optical wavelength range at a 10 mW (20 mW) laser output power level.

2:30 pm–2:45 pm

103 **ThC4** **1.5-µm Directly Modulated Transmission Over 66 km of SSMF with an Integrated Hybrid III-V/SOI DFB Laser,** V. Cristofori, F. Da Ros, *Technical University of Denmark, Lyngby, Denmark,* M. E. Chaibi, *University of Rennes, Lannion, France,* Y. Ding, *Technical University of Denmark, Lyngby, Denmark,* L. Bramerie, *University of Rennes, Lannion, France,* A. Shen, A. Gallet, G.-H. Duan, *III-V Lab, a joint lab of Nokia, Thales and CEA, Palaiseau, France,* K. Hassan, S. Olivier, *CEA-LETI, Grenoble, France,* L. K. Oxenløwe, *Technical University of Denmark, Lyngby, Denmark,* and C. Peucheret, *University of Rennes, Lannion, France*

A hybrid III-V/SOI directly modulated DFB laser operating at 1.5 µm is fabricated, showing a side mode suppression ratio above 50 dB and a 3-dB bandwidth of 12 GHz. Error-free transmission (BER<10^{-9}) at 10 Gb/s over 66-km SSMF is demonstrated without dispersion compensation and FEC.

2:45 pm–3:00 pm

105 **ThC5** **High Reflection Tolerance of Quantum Dot Distributed Feedback Lasers for Silicon Photonics Transmitters,** N. Hatori, K. Mizutani, S.-H. Jeong, Y. Tanaka, and K. Kurata, *Photonics Electronics Technology Research Association (PETRA), Tsukuba, Japan*

We demonstrated high reflection tolerance of a quantum dot distributed feedback laser. Laser characteristics of single mode operation of 40 dB SMSR and high power operation over 15mW were obtained, and significant improvements of tolerance up to –30 dB near end reflection were successfully achieved.

3:00 pm–3:30 pm **Grand Ballroom B**

Exhibits / Coffee Break

3:30 pm–4:15 pm **Grand Ballroom A**
Session ThD **Nonlinear Photonics**
Session Chair Li Yang, *Huawei*

3:30 pm–3:45 pm

107 **ThD1** **CMOS Compatible USRN:Si_7N_3 for Supercontinuum Generation, Parametric Amplification and Four-wave Mixing,** T. Wang, *Singapore University of Technology and Design, Singapore and Chinese Academy of Sciences, Beijing, China,* K. J. A. Ooi, *Singapore University of Technology and Design, Singapore,* D. K. T. Ng, *Agency for Science, Technology and Research (A*STAR), Singapore,* A. K. L. Chee, *Massachusetts Institute of Technology, Cambridge, MA, USA*, and D. T. H. Tan, *Singapore University of Technology and Design, Singapore*

We experimentally demonstrate a CMOS compatible optical parametric amplifier based on Si_7N_3 waveguides which are compositionally tailored that the 1550 nm wavelength resides within the multi–photon regime, while possessing large nonlinear parameter of 550 W^{-1}/m, 500 times larger than that in Si_3N_4.

3:45 pm–4:00 pm

109 **ThD2** **Linear and Third Order Nonlinear Optical Properties of GeSbS Chalcogenide Integrated Waveguides,** S. Serna, *Université Paris-Saclay, Orsay, France and Université Paris Saclay, Palaiseau, France,* H. Lin, *Massachusetts Institute of Technology-MIT, Cambridge, MA, USA,* C. Alonso-Ramos, *Université Paris-Saclay, Orsay, France,* A. Yadav, *University of Central Florida, Orlando, FL, USA,* X. Le Roux, *Université Paris-Saclay, Orsay, France,* K. Richardson, *University of Central Florida, Orlando, FL, USA,* E. Cassan, *Université Paris-Saclay, Orsay, France,* N. Dubreuil, *Université Paris Saclay, Palaiseau, France,* J. Hu, *Massachusetts Institute of Technology-MIT, Cambridge, MA, USA,* and L. Vivien, *Université Paris-Saclay, Orsay, France*

We report on the linear and nonlinear measurements of GeSbS chalcogenide glasses in waveguide configuration. Single-mode waveguides and ring resonators have been characterized in linear and nonlinear optical regimes around 1.58 μm wavelength demonstrating the interest of using this material for ultrahigh-bandwidth optical communications systems.

4:00 pm–4:15 pm

111 **ThD3** **Third Order Nonlinear Optical Properties of Ge-Rich SiGe Waveguides,** S. Serna, *Université Paris-Saclay, Orsay, France and Université Paris Saclay, Palaiseau, France,* V. Vakarin, J. M. Ramirez, X. Le Roux, *Université Paris-Saclay, Orsay, France,* J. Frigerio, A. Ballabio, *Politecnico di Milano, Como, Italy,* L. Vivien, *Université Paris-Saclay, Orsay, France,* G. Isella, *Politecnico di Milano, Como, Italy,* E. Cassan, *Université Paris-Saclay, Orsay, France,* N. Dubreuil, *Université Paris Saclay, Palaiseau, France,* and D. Marris-Morini, *Université Paris-Saclay, Orsay, France*

We report on the first third order nonlinear experimental characterization of Ge-rich $Si_{1-x}Ge_x$ waveguides, with Germanium concentrations x ranging from 0.7 to 0.9. These results will provide helpful insights to assist the design of nonlinear integrated optical devices in the near- and mid-IR wavelength ranges.

4:15 pm–5:45 pm **Grand Ballroom B**
Session ThP **Poster II**
Session Chair TBD

4:15 pm–5:45 pm

113 **ThP1** **WDM-compatible 2×2 Optical Switch for Mode-Division Multiplexing on a Silicon Chip,** H. Jia, T. Zhou, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,* L. Zhang, J. Ding, *Chinese Academy of Sciences, Beijing, China,* and L. Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We propose a WDM and MDM compatible 2×2 switch on a silicon chip. It is composed of mode multiplexers, 2×2 single mode optical switch elements, and mode de-multiplexers. We demonstrate a prototype which can manipulate four spatial modes with broad wavelength span.

115 **ThP2** **Long Delay Optical Feedback Sensitivity of Hybrid III-V/SOI Directly Modulated DFB Lasers,** A. Gallet, *Université Paris-Saclay, Orsay, France and III-V Lab, a joint lab of Alcatel-Lucent, Thales and CEA, Palaiseau, France,* K. Schires, H. Huang, M. Song, *III-V Lab, a joint lab of Alcatel-Lucent, Thales and CEA, Palaiseau, France,* A. Accard, D. Make, *Université Paris-Saclay, Orsay, France,* S. Olivier, *CEA LETI, Grenoble, France,* G.-H. Duan, *III-V Lab, a joint lab of Alcatel-Lucent, Thales and CEA, Palaiseau, France,* and F. Grillot, *III-V Lab, a joint lab of Alcatel-Lucent, Thales and CEA, Palaiseau, France and University of New Mexico, Albuquerque, NM, USA*

Hybrid III-V/SOI DFB lasers subjected to external optical feedback is analyzed. Its impact on optical spectrum, eye diagram and bit error rate (BER) is discussed.

117 **ThP3** **A PAM-4 Optical Receiver Based on a Silicon Photonic Quantizer,** W. Xu, *Shanghai Jiao Tong University, Shanghai, China,* J. Gao, *University of Rochester, Rochester, NY, USA,* P. Ji, Y. Sun, W. He, *Shanghai Jiao Tong University, Shanghai, China,* and H. Wu, *University of Rochester, Rochester, NY, USA*

We propose a new PAM4 receiver architecture based on a silicon photonic quantizer that converts a PAM-4 optical signal into multiple weighted electrical signals. Circuit simulation of this receiver at 50-Gbps demonstrates its feasibility and advantages.

119 **ThP4** **Passive and Active Wavelength Trimming of Temperature-Insensitive Silicon MZI,** J.-M. Lee, M.-S. Kim, J. T. Ahn, *ETRI, Daejeon, Korea,* L. Adelmini, D. Fowler, C. Kopp, *CEA LETI, Grenoble, France,* C. J Oton, *Scuola Superiore Sant'Anna, Pisa, Italy and CNIT, Pisa, Italy,* and F. Testa, *Ericsson Telecomunicazioni S.p.A., Pisa, Italy*

Temperature-insensitive silicon MZI with local heaters is fabricated by DUV lithography. Temperature dependence is less than 5 pm/C but the wavelength can be tuned by the local heater at the efficiency of 24 mW/FSR. The results are discussed in comparison with permanent wavelength trimming by thermal annealing.

121 **ThP5** **Silicon PAM-4 Optical Modulator Driven by Two Binary Electrical Signals with Different Peak-to-Peak Voltages,** L. Zheng, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,* J. Ding, *Chinese Academy of Sciences, Beijing, China,* S. Shao, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,* L. Zhang, *Chinese Academy of Sciences, Beijing, China,* and L. Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We demonstrate a silicon PAM-4 optical modulator which is driven by two uncorrelated binary electrical signals with different peak-to-peak voltages. The device can work at 32 Gbaud in the wavelength range from 1525 nm to 1565 nm.

123 **ThP6** **A Method to Optimizing Optical Switch Topology for Photonic Network-on-Chip,** T. Zhou, H. Jia, Y. Xia, and L. Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,*

We propose a method to optimize the optical switch by substituting some of the switch elements with crossings so that the topology can be simplified and the insertion loss can also be effective minimized. A six-port optical switch prototype is designed and fabricated on silicon.

125 **ThP7 Silicon Photonic Wavelength Tunable Laser Diode with Low Loss Direct Heating Phase Shifter,** T. Kita, Y. Chiba, and H. Yamada, *Tohoku University, Sendai-shi, Japan*

We proposed and demonstrated a compact and low propagation loss thermo-optical phase shifter using a multi-mode interference for wavelength tunable laser diode.

127 **ThP8 Demonstration of Low Polarization Dependent Loss of 1.3 µm Two Dimensional Grating Coupler,** Y. Sobu, S.-H. Jeong, and Y. Tanaka, *Photonics Electronics Technology Research Association (PETRA), Tsukuba, Japan*

Reduction of the polarization dependent loss (PDL) of 1.3 µm two dimensional grating coupler (2D-GC) was demonstrated by using slanted arrays and cross shaped scatterers. The PDL of 2D-GC was measured to be <0.5 dB over a 40 nm range at 1.3 µm.

129 **ThP9 Broadband Sub-Wavelength Grating Coupler for O-Band Application,** Y. Wang, L. Xu, A. Kumar, D. Patel, Z. Xing, R. Li, M. G. Saber, Y. D'Mello, E. El-Fiky, and D. V. Plant, *McGill University, Montreal, QC, Canada*

We demonstrate a broadband sub-wavelength grating coupler for the O-band application, which has a simulated coupling efficiency of –3.3 dB with 3-dB bandwidth of 78 nm and a measured coupling efficiency of –4.5 dB with a 3-dB bandwidth of 65 nm for fundamental TE mode.

131 **ThP10 2D Integrating Cell Waveguide Platform Employing Ultra-Long Optical Path Lengths,** L. S. Fohrmann, G. Sommer, *Hamburg University of Technology, Hamburg, Germany,* G. Pitruzzello, T. F. Krauss, *University of York, York, United Kingdom,* A. Y. Petrov, *Hamburg University of Technology, Hamburg, Germany and ITMO University, St. Petersburg, Russia,* and M. Eich, *Hamburg University of Technology, Hamburg, Germany and Helmholtz-Zentrum Geesthacht, Geesthacht, Germany*

A 2D integrating cell waveguide platform is presented where ultra-long optical path lengths in a small area are realized by multiple reflections of a guided signal at PhC boundaries. In experiments, path lengths of 25 cm are demonstrated in integrating cells with 1.8 mm radius.

133 **ThP11 Design and Integration of an O-Band Silicon Nitride AWG for CWDM Applications,** S. Guerber, *STMicroelectronics SAS, Crolles, France and Université Paris-Saclay, Orsay, France,* C. Alonso-Ramos, D. Perez-Galacho, X. Le Roux, *Université Paris-Saclay, Orsay, France,* N. Vulliet, S. Crémer, *STMicroelectronics SAS, Crolles, France,* D. Marris-Morini, *Université Paris-Saclay, Orsay, France,* F. Boeuf, *STMicroelectronics SAS, Crolles, France,* L. Vivien, *Université Paris-Saclay, Orsay, France,* and C. Baudot, *STMicroelectronics SAS, Crolles, France*

Experimental demonstration of an O-band four channel CWDM silicon nitride AWG is reported. Specificity of low order array has been explored through multiple devices among which insertion loss below 2.3dB, crosstalk level as high as 37dB and polarization insensitive spectral response flattening is obtained.

135 **ThP12 Optimized 32-Channel Silicon Hybrid Demultiplexer Fabricated with CMOS Technology,** J. Wang, S. Deng, C. Y. Wong, Y. Wen, W. Wei, T. Wang, G. N. Liu, E. Zhou, and L. Liu, *Huawei Technologies Co., Ltd., Shenzhen, China*

We presented a 32-channel silicon hybrid demultiplexer fabricated with CMOS technology. Double-etched mode converter and wide arrayed waveguide are used to improve AWG performances while the counter-tapered coupler is optimized for broadband mode multiplexing.

137 **ThP13 A Novel Scheme to Excite SOI Slot Waveguide Mode,** V. Mere, R. Kallega, and S. K. Selvaraja, *Indian Institute of Science, Bangalore, India*

This paper presents a novel robust method to excite a slot waveguide mode. We experimentally demonstrate the fundamental slot-mode excitation in a Si slot-waveguide ring resonator. Furthermore, we also demonstrate nearly athermal (12 pm/°C) behaviour of PMMA filled slotted ring resonator

139 **ThP14 Sealed and Compact Fiber Links to Integrated Photonics Using Grating Couplers,** N. Hoppe, M. Haug, T. Polder, M. Félix Rosa, W. Vogel, P. Scheck, L. Rathgeber, D. Widmann, and M. Berroth, *University of Stuttgart, Stuttgart, Germany*

We present a sealed, permanent, compact and efficient optical fiber-to-chip interface utilizing the wide-spread grating coupler. The easily produced fiber link is based on the reflection in an angle-polished fiber with a reflective metal coating. Efficiencies for different coupling methods to grating couplers are compared.

141 **ThP15 Faraday Rotation in Silicon Waveguides,** D. Jalas, N. Hakemi, *Hamburg University of Technology, Hamburg, Germany,* M. Cherchi, M. Harjanne, *VTT Technical Research Centre of Finland, Espoo, Finland,* A. Y. Petrov, *Hamburg University of Technology, Hamburg, Germany and ITMO University, St. Petersburg, Russia,* and M. Eich, *Hamburg University of Technology, Hamburg, Germany and Helmholtz-Zentrum Geesthacht, Geesthacht, Germany*

We investigate the possibility of using silicon waveguides as Faraday rotators for optical isolators. We employ multimode waveguides with a square cross-section. This approach offers the opportunity to introduce integrated nonreciprocal components into the silicon-on-insulator platform without complication of an additional magneto-optical material.

143 **ThP16 Study of Backend Waveguide Arrays for Adiabatic Coupling to Si Waveguides,** K. Voigt, *Technische Universität Berlin, Berlin, Germany and IHP, Frankfurt (Oder), Germany*, V. Brulis, *Photon Design, Oxford, United Kingdom,* K. Petermann, *Technische Universität Berlin, Berlin, Germany* and L. Zimmermann, *Technische Universität Berlin, Berlin, Germany and IHP, Frankfurt (Oder), Germany*

We compare the performances of different spot size converter (SSC) designs consisting of backend waveguide arrays ("dot-like", "cross-like, "stripes", "box") at the facet, adiabatically coupled to tapered Si waveguides. For the study, we use SiON waveguides and a low index step "box" waveguide.

145 **ThP17 Spectral Variation Analysis for Silicon Grating Couplers Fabricated on a 300-mm SOI Wafer,** T. Horikawa, *Photonics Electronics Technology Research Association (PETRA), Tsukuba, Japan and National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan,* D. Shimura, J. Ushida, Y. Sobu, A. Shiina, M. Tokushima, S.-H. Jeong, K. Kinoshita, and T. Mogami, *Photonics Electronics Technology Research Association (PETRA), Tsukuba, Japan*

Spectral variation behavior for many grating couplers is experimentally investigated. It was found that the coupling wavelength is shifted by fabrication deviations in grating structure, and grating depth variation in 300-mm wafer processes is precisely derived by numerical analysis for coupling wavelength variation.

147 **ThP18 Electro-Optic Phase Modulators Based on Transparent-Conducting-Oxide Loaded Silicon Waveguides,** G. Sinatkas, I. Skandalos, T. Christopoulos, and E. E. Kriezis, *Aristotle University of Thessaloniki, Thessaloniki, Greece*

Electro-optic phase modulation schemes are investigated by inducing carrier-concentration changes in transparent conducting oxide semiconductors, integrated in well-established silicon-photonic platforms. By exploiting the epsilon-near-zero effect, binary phase-shift keying modulation is manifested, resulting in high-speed modulation solutions of reduced footprint, compared to the conventional all-silicon designs.

149 **ThP19 Advanced High Speed Slow-Light Silicon Modulators in the O-Band for Low Power Optical Interconnects in Data Centers,** A. Zanzi, A. Rosa, A. Griol, P. Sanchis, J. Marti, and A. Brimont, *Universitat Politècnica València, Valencia, Spain*

This paper presents the design and preliminary results of a low power, compact and high-speed modulator in the O-band featuring apodized slow-light structures and a slow-wave RF design. The device is a candidate for future single mode optical interconnects in large-scale data centers

N/A **ThP20 An Ultra-Compact MMI-Based Wavelength Diplexer Employing Subwavelength Grating,** L. Liu, Q. Deng, and Z. Zhou, *Peking University, Beijing, China*

Through the refractive index engineering of the subwavelength grating, an ultra-compact multimode interference based diplexer is proposed and demonstrated. It is 43.4 μm in length, only ~30% of its conventional counterpart and displays a wide 1dB bandwidth >120nm.

151 **ThP21 Tunable Mode Hybridisation in Compact SOI Coupled Ring Cavity,** A. Pandey and S. K. Selvaraja, *Indian Institute of Science, Bengaluru, India*

We propose and experimentally demonstrate a coupled micro-ring cavity system. The cavity enables tunable resonance mode spacing, with mode spacing as low as 27.5 GHz is demonstrated in a footprint that is 87% less than a conventional single cavity system.

153 **ThP22 A S-Bend Multimode Interference with Optical Delay and Power Divider for Broadband WDM Filtering,** S.-H. Hsu, Y.-C. Chung, and Y.-C. Yang, *National Taiwan University of Science and Technology, Taipei, Taiwan, R.O.C.*

A s-bend multimode interference (MMI) on 5-micron thick silicon-on-insulator experimentally demonstrated the relative optical delay and coupling power coefficient as 18.3-micron and 0.95, respectively. This s-bend MMI based Mach-Zehnder interferometer wavelength filter could illustrate process-insensitive performance on the flat top response and isolation.

155 **ThP23 Guard-Ring Dependence of Noise Characteristics for Single-Photon Avalanche Diodes in a Standard CMOS Technology,** J. Rhim, *Hewlett Packard Enterprise, Palo Alto, CA, USA,* K. Yu, P.-H. Chang, S. Palermo, *Texas A&M University, College Station, TX, USA,* C. Li, M. Fiorentino, R. Beausoleil, *Hewlett Packard Enterprise, Palo Alto, CA, USA,* and M.-J. Lee, *Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland*

We investigate the effects of guard-ring structure on noise characteristics for CMOS-compatible single-photon avalanche diodes (SPADs). SPADs with different guard-ring structures are fabricated in standard 0.18-μm CMOS technology and the noise characteristics as dark current, dark-count rate and afterpulsing probability are measured and analyzed.

157 **ThP24 Realization of Counter-Doped Silicon Modulators for Efficient Silicon Optical Interposers,** V. Reboud, M. Fournier, B. Szelag, B. Blampey, P. Gindre, T. Ferrotti, O. Dubray, D. Fowler, E. Grellier, O. Lemonnier, Y. Thonnart, and S. Bernabé, *Univ. Grenoble Alpes, Grenoble, France*

We fabricated counter-doped ring resonator modulators that guarantee the absence of unexpected p-i-n junctions in the ring waveguide due to overlay misalignments inherent to successive lithographic steps. Fabricated ring resonator modulators showed good efficiency ($V_{\pi}L$ at 1.55 V.cm at –1V) and transmission at 10 $Gb.s^{-1}$.

Time / Location TBD
Gala Dinner

FRIDAY, 25 AUGUST 2017

8:00 am–8:45 am **Grand Ballroom A**
Session FA **Plenary II**
Session Chair Jeremy Witzens, *RWTH Aachen University*

8:00 am–8:45 am ***(Plenary)***

N/A **FA1** **Physics of High-Q Microresonators: Optomechanics & Frequency Combs,**
T. Kippenberg, *EPFL – Ecole Polytechnique de Lausanne, Switzerland*

8:45 am–10:00 am **Grand Ballroom A**
Session FB **Silicon Photonics for Sensing**
Session Chair Andrew Poon, *Hong Kong University of Science and Technology*

8:45 am–9:15 am ***(Invited)***

N/A **FB1** **Silicon-Based Cascaded Microring for Optical Sensing,** J. He, *Zhejiang Universtiy*

9:15 am–9:45 am ***(Invited)***

159 **FB2** **Free-Space Coupled Silicon Photonic Crystal Refractometric Membrane Sensors,**
Y. Sun, Y. Liu, and W. Zhou, *University of Texas at Arlington, Arlington, TX, USA*

We report free-space coupled single-layer and coupled bi-layer silicon photonic crystal refractive index sensing schemes. High quality factor and low detection limit sensor cavities were designed and demonstrated experimentally based on mode engineering.

9:45 am–10:00 am

161 **FB3** **Ge PIN Photodetectors with Nanohole Arrays for Refractive Index Sensing,**
L. Augul, R. Körner, S. Bechler, J. Schulze, and I. A. Fischer, *University of Stuttgart, Stuttgart, Germany*

We present an experimental realization of an integrated biosensor consisting of a Ge PIN photodetector with an Al nanohole array in its contact metal layer. The device responsivity strongly depends on the surrounding refractive index, making the device suitable for integrated sensing at reduced size.

10:00 am–10:30 am **Grand Ballroom B**

Exhibits / Coffee Break

10:30 am–12:00 pm **Grand Ballroom A**

Session FC **Towards Novel Applications**

Session Chair Wim Bogaerts, *Ghent University*

10:30 am–11:00 am ***(Invited)***

163 **FC1** **Silicon Photonics for Applications in Quantum Technologies,** M. G. Thompson, *University of Bristol*

Quantum photonic technologies have the potential to revolutionise our information and communication systems, enabling ultra-secure communication and advanced computation with applications in quantum simulation and machine learning. Here we overview the potential of silicon photonics to realise such a technology platform.

11:00 am–11:15 am

165 **FC2** **A Monolithically Integrated Si Optical Single-Sideband Modulator,** B.-M. Yu, J.-M. Lee, *Yonsei University, Seoul, Korea,* C. Mai, S. Lischke, L. Zimmermann, *IHP, Frankfurt (Oder), Germany,* and W.-Y. Choi, *Yonsei University, Seoul, Korea*

We demonstrate a monolithically integrated Si optical single-sideband modulator that contains a ring-assisted Mach-Zehnder modulator, two MMI optical couplers, and an electrical quadrature hybrid coupler. The modulator successfully produces 30-GHz single sideband with 15 dB suppression of the undesired sideband.

11:15 am–11:30 am

167 **FC3** **Integrated All-Optical Phase-Sensitive Amplifier Using the Thermal Nonlinearity,** T. Van Vaerenbergh, G. J. Mendoza, D. Kielpinski, J. S. Pelc, N. Tezak, R. Bose, C. Santori, and R. G. Beausoleil, *Hewlett Packard Labs, Palo Alto, CA, USA*

We demonstrate an all-optical phase-sensitive amplifier, a critical component in integrated circuits for all-optical computing. The amplifier is fabricated in amorphous silicon-on-insulator and relies on thermo-optic self-heating in a ring-loaded Mach-Zehnder interferometer. changing the power and phase of the bias input tunes the gain.

11:30 am–12:00 pm ***(Invited)***

169 **FC4** **Laser Integration on Silicon,** P. Doussiere, *Intel Corporation, Santa Clara, CA, USA*

In this presentation we will review the progress of silicon III-V semiconductor hybrid near-infrared lasers and show that they can meet the performance and reliability required for commercial datacom transceivers at 100 Gbit/s and beyond.

12:00 pm–1:30 pm

Lunch Break (on own)

1:30 pm–3:15 pm **Grand Ballroom A**
Session FD **Si/III-V Lasers**
Session Chair Heisheng Rong, *INTEL*

1:30 pm–1:45 pm

171 **FD1** **Integration of III-V Light Sources on a Silicon Photonics Circuit by Transfer Printing,** J. Juvert, *Ghent University, Ghent, Belgium,* T. Cassese, *Scuola Superiore Sant'Anna, Pisa, Italy,* S. Uvin, A. De Groote, *Ghent University, Ghent, Belgium,* B. Snyder, P. De Heyn, P. Verheyen, *IMEC, Leuven, Belgium,* A. J. Trindade, C. Bower, *X-Celeprint Limited, Cork, Ireland,* M. Romagnoli, *Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Pisa, Italy,* G. Roelkens, and D. Van Thourhout, *Ghent University, Ghent, Belgium*

We report on the integration by transfer printing of III-V Fabry-Pérot cavities on a silicon photonic circuit. We pre-process the III-V coupons on their native substrate, transfer print onto the target SOI, and post-process the printed coupons. We report light coupling into the photonic circuit.

1:45 pm–2:15 pm ***(Invited)***

N/A **FD2** **III-V Quantum Dot Lasers Grown on Si Emitting at 1.5 um,** K. Lau, *Hong Kong University of Science and Technology*

Directly grown high performance InAs/GaAs QD lasers on silicon substrates emitting at 1.3 um have been reported. We demonstrate by MOCVD the first room-temperature InAs/InAlGaAs quantum-dot microdisk lasers epitaxially grown on on-axis (001) Si, with a lasing wavelength of 1.56 um and low pump power.

2:15 pm–2:30 pm

173 **FD3** **Monolithic Integration of InAlAs/InGaAs Quantum-Well on InP-OI Micro-Substrates on Si for Infrared Light Sources,** Y. Baumgartner, B. Mayer, M. Sousa, D. Caimi, K. Moselund, and L. Czornomaz, *IBM Research GmbH, Rüschlikon, Switzerland*

We demonstrate for the first time that InAlAs/InGaAs QW can be selectively grown on micron-sized InP-OI substrates, obtained by selective epitaxy in empty oxide cavities on Si. The concept, material and optical characterizations are presented, paving the way towards integrated light sources for infrared applications.

2:30 pm–2:45 pm

175 **FD4** **Epitaxy of Direct Bandgap Group IV Heterostructure Lasers,** N. von den Driesch, D. Stange, D. Rainko, *Forschungszentrum Jülich GmbH, Jülich, Germany,* P. Zaumseil, G. Capellini, *IHP, Frankfurt (Oder), Germany,* J.-M. Hartmann, *Univ. Grenoble Alpes, Grenoble, France,* T. Schroeder, *IHP, Frankfurt (Oder), Germany,* S. Mantl, D. Grützmacher, and D. Buca, *Forschungszentrum Jülich GmbH, Jülich, Germany*

We demonstrate epitaxial growth of direct bandgap group IV GeSn/SiGeSn double heterostructures and multi quantum wells. While both designs offer high structural quality and strong light emission, multi quantum wells benefit from a smaller number of defects at the active region.

2:45 pm–3:15 pm ***(Invited)***

N/A **FD5** **Direct Growth of III-V Quantum-Dot Lasers on Silicon,** H. Liu, *University College London, London, United Kingdom*

Direct growth of III-V lasers on Si is the most promising solution to overcome the lack of efficient light sources on Si platform. We demonstrated the first practical silicon-based telecommunications wavelength III-V lasers with low threshold current density, high output power, and long lifetime.

3:15 pm–3:45 pm **Grand Ballroom B**

Exhibits / Coffee Break

3:45 pm–5:00 pm **Grand Ballroom A**
Session FE **Optoelectronic Devices**
Session Chair Kartik Srinivasan, *National Institute of Standards and Technology (NIST)*

3:45 pm–4:15 pm ***(Invited)***

N/A **FE1** **Black Phosphorus Infrared Optoelectronics,** M. Li, *University of Minnesota*

4:15 pm–4:30 pm

177 **FE2** **Design and Performance of High-Speed Ge-on-Si Waveguide Photodiodes,** N. K. Hon, S. Sahni, A. Mekis, and G. Masini, *Luxtera, Inc., Carlsbad, CA, USA*

Three Ge-on-Si photodetector architectures with different contacting schemes are compared, with emphasis on their bandwidth. The study shows that bandwidth >50 GHz and responsivity >1 A/W at 1490 nm can be achieved using a commercial silicon photonics process.

4:30 pm–4:45 pm

179 **FE3** **Operation and Analysis of Low-Voltage Three-Terminal Avalanche Photodiodes,** Z. Huang, X. Zeng, D. Liang, M. Fiorentino, and R. G. Beausoleil, *Hewlett Packard Labs, Palo Alto, CA, USA*

We demonstrate a three-terminal waveguide avalanche photodiode detector (3TAPD) with –6V breakdown voltage, 18.6GHz 3dB bandwidth. Design, simulation of the device is discussed.

4:45 pm–5:00 pm

181 **FE4** **Electrically Tunable Absorption in Graphene-Integrated Silicon Photonic Crystal Cavity,** L. Abdollahi Shiramin, W. Xie, *Gent University-IMEC, Ghent, Belgium,* B. Snyder, P. De Heyn, P. Verheyen, *IMEC, Leuven, Belgium,* G. Roelkens, and D. Van Thourhout, *Gent University-IMEC, Ghent, Belgium*

We demonstrate 17 dB extinction ratio in an electrically gated graphene-integrated silicon photonic crystal cavity by applying –1.2 V gate voltage. The shift of resonance wavelength for the same voltage range is 0.75 nm. The size of the graphene layer is only 5 μm^2.

Additional Papers: