2017 IEEE 14th International Conference on Group IV Photonics (GFP 2017)

Berlin, Germany
23-25 August 2017
Final Program

WEDNESDAY, 23 AUGUST 2017

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

The detection and amplification of molecular absorption 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.
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 $\lambda \approx 5.1 \, \mu m$ to $\lambda \approx 8.6 \, \mu m$, and comprise waveguides, multimode interference couplers and Mach-Zehnder interferometers.

We present the first waveguide electro-absorption modulator in germanium-on-silicon material platform at 3.8 $\mu m$ 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.

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 $\mu m$ mid-infrared sensing window to be covered with enhancements comparable to gold plasmonics.
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)

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


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

WC3  Reduced Threshold Microdisk Lasers from GeSn/SiGeSn Heterostructures,

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

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


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–1:45 pm

**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

**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 V cm and 25 Gbps operation with CMOS-driver.

2:15 pm–2:30 pm

**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 to make a tunable Fano resonance. Based on a silicon microring with two tunable reflectors inside, we are able to generate a tunable Fano resonance with maximum extinction ratio over 40 dB and a slope rate over 700 dB/nm.
2:30 pm–2:45 pm

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

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–4:00 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

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 Vpp, without optimizing horizontal PN-diodes. This method also suggests a new modulator scheme allowing efficiency improvement and design flexibilities.
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.

Industry Forum

4:15 pm–5:45 pm

Session WP Welcome Reception / Poster I

Session Chair TBD

Grand Ballroom B

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.


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.


A lateral displaced microheater is demonstrated for switching across the VO₂ phase transition in ultra-short hybrid VO₂/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.
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 strained 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.


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.


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.

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.

WP8  The Electronic Band Structure of Ge₁₋ₓSnₓ 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, Wrocław Univ. of Science and Technology, Wrocław, Poland

A comprehensive study of the Ge₁₋ₓSnₓ 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.
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.

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.

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.

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.

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, 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.
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 μm wavelength.

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.

WP16  Tensile-Strained GeSn/SiGeSn Multiple Quantum Wells Laser Wrapped in Si₃N₄ 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 Si₃N₄ liner stressor is designed and characterized theoretically. The boosting effects of tensile strain introduced into the GeSn/SiGeSn MQW laser by Si₃N₄ liner stressor on the threshold current density and optical gain are demonstrated.

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, Southampoton, United Kingdom, G. X. Tina, H. Qiu, Nanyang Technological University, Singapore, J. Soler Penades, M. Nedeljkovic, University of Southampoton, Southampoton, United Kingdom, Z. Zhang, C. Liu, D. J. Thomson, G. Z. Mashanovich, G. T. Reed, University of Southampoton, Southampoton, 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.

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.
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.


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)


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)

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


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

**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

**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  
Exhibits / Coffee Break

**10:15 am–12:00 pm**

Grand Ballroom B

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)

**ThB1**   A Heterogeneous III-V/Si₃N₄ 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

**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

**ThB3**  Bragg Grating Filter for Suspended Silicon Waveguides, C. Alonso-Ramos, X. Le Roux, D. Benedikovíc, 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.

**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.

**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 SiO₂ 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.

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

### 1:30 pm–2:00 pm  
**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  
**ThC2**  

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  
**ThC3**  

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.
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.

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.

We experimentally demonstrate a CMOS compatible optical parametric amplifier based on Si₃N₃ 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 Si₃N₄.
3:45 pm–4:00 pm

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

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

Session ThP Poster II
Session Chair TBD

Grand Ballroom B

4:15 pm–5:45 pm

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.
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.

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.

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.

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.

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.
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.

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.

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.

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.
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.


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.

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.

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.

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.
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.

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.

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.

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.

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.
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.

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.


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.


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 ($V_{πL}$ at 1.55 V.cm at –1V) and transmission at 10 Gb.s$^{-1}$.

Time / Location TBD

Gala Dinner
### FRIDAY, 25 AUGUST 2017

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Session</th>
<th>Chair</th>
<th>Details</th>
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| 8:00 am–8:45 am | Grand Ballroom A | Plenary II  | Jeremy Witzens, RWTH Aachen University | 8:00 am–8:45 am (Plenary)  
FA1 Physics of High-Q Microresonators: Optomechanics & Frequency Combs, T. Kippenberg, EPFL – Ecole Polytechnique de Lausanne, Switzerland |
| 8:00 am–10:00 am| Grand Ballroom A | Silicon Photonics for Sensing | Andrew Poon, Hong Kong University of Science and Technology | 8:45 am–9:15 am (Invited)  
FB1 Silicon-Based Cascaded Microring for Optical Sensing, J. He, Zhejiang University |
| 8:45 am–9:15 am |                  |             |                        | 9:15 am–9:45 am (Invited)  
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. |
<p>| 10:00 am–10:30 am| Grand Ballroom B | Exhibits / Coffee Break |                        |                                                            |</p>
<table>
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<tr>
<th>Time</th>
<th>Session FC</th>
<th>Title</th>
<th>Authors</th>
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<tbody>
<tr>
<td>10:30 am–11:00 am</td>
<td>FC1</td>
<td>Silicon Photonics for Applications in Quantum Technologies</td>
<td>M. G. Thompson, University of Bristol</td>
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<td><strong>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.</strong></td>
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<tr>
<td>11:00 am–11:15 am</td>
<td>FC2</td>
<td>A Monolithically Integrated Si Optical Single-Sideband Modulator</td>
<td>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</td>
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<td>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.</td>
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<tr>
<td>11:15 am–11:30 am</td>
<td>FC3</td>
<td>Integrated All-Optical Phase-Sensitive Amplifier Using the Thermal Nonlinearity</td>
<td>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</td>
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<td>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.</td>
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<tr>
<td>11:30 am–12:00 pm</td>
<td>FC4</td>
<td>Laser Integration on Silicon</td>
<td>P. Doussiere, Intel Corporation, Santa Clara, CA, USA</td>
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<td>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.</td>
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<td>12:00 pm–1:30 pm</td>
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<td>Lunch Break (on own)</td>
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### 1:30 pm–1:45 pm

**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)

**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

**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


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


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 µm².
Additional Papers:

23  **Resonantly Enhanced Silicon Photonics Mach-Zehnder Modulator**  
    *Kasper Van Gasse, Gunther Roelkens, Qiangsheng Huang*

67  **Ge n+/p Shallow Junctions for Light Emission and Detection Applications**  
    *Cheng Li, chen Wang, Guangyang Lin, Songyan Chen, Hongkai Lai*