Cavity modulator assisted nonreciprocal light transmission on Silicon

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Nonreciprocal light transmission is indispensable in many photonic circuits. It forms the basis of optical isolators, which allow the propagation of light in a specific direction while blocking the propagation in the opposite direction [1]. When placed after a laser, an optical isolator inhibits back-reflections in the laser and also alleviates multi-path interference [2]. There are three major methods to achieve non-reciprocal optical transmission i.e. modulation, depositing magneto-optic materials, and non-linear effects. The modulation based approach has the potential to deliver high isolation and offers seamless integration with existing silicon photonic integrated circuit components [3].

We propose and experimentally demonstrate cascaded cavity modulator based nonreciprocal light transmission. The proposed design is shown in Fig. 1(a) and a microscope image of the fabricated device is shown in Fig. 1(b). The device was fabricated on the iSiPP50G silicon platform of IMEC [4]. When the two ring modulators are driven by the microwave signals $V_1(t)$ and $V_2(t)$ respectively, the transmission in forward and backward direction is given by; $T^{Forward}(t) = T_t^1(V_1(t)) \times T_t^2(V_2(t - \tau_0))$ and $T^{Backward}(t) = T_t^2(V_2(t)) \times T_t^1(V_1(t - \tau_0))$ where τ_0 is the optical delay between the cavity modulators. The equations clearly depict that in case of a non-zero optical delay and distinct driving microwave signals, non-reciprocal transmission can be achieved in our device. The measured spectrum for the device with τ_0 = 1.6 ps, and driving signals $V_1(t) = V_{pp}\mathrm{Sin}(\Omega t)$ and $V_2(t) = V_{pp}\mathrm{Cos}(\Omega t)$ (V_{pp} = 8 V, Ω = 6 GHz) is shown in Fig. 1(c). In the forward direction, the carrier component peaks whereas it is suppressed by 16 dB in the backward direction. The relative suppression is denoted as the Asymmetric Transmission Ratio (ATR). The asymmetric transmission arises from the direction dependent distribution of optical power between the carrier and the sidebands. In the forward direction, the carrier component is stronger than the sidebands whereas in the backward direction, the carrier power is distributed to the sidebands. This leads to stronger sidebands in the backward direction and a weak carrier. The variation of ATR as a function of drive voltage (V_{pp}) is shown in Fig. 1(d). The ATR peaks at 16 dB when the V_{pp} is 8V and it reduces to zero when the driving signal is weak (5 V and lower). Excellent agreement with a theoretical model is found. Simulations show both ATR and insertion loss can still be improved through optimizing the optical delay.

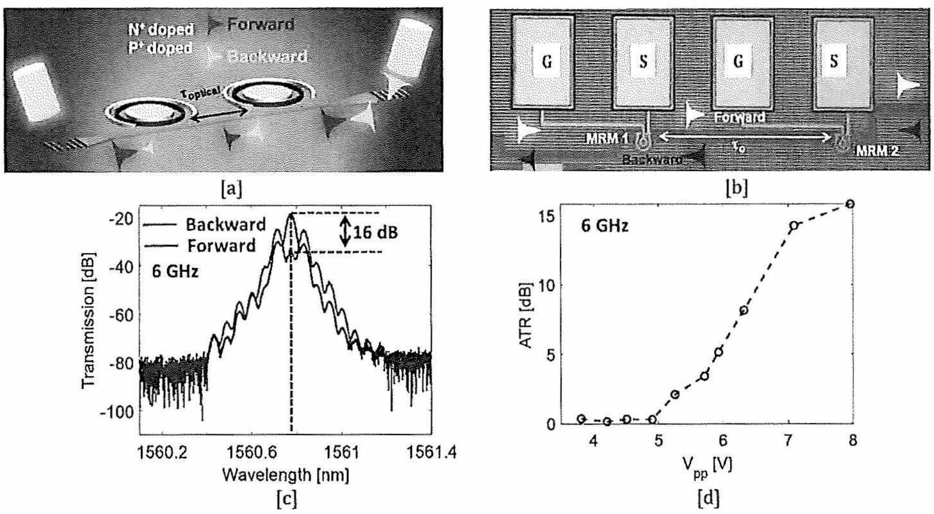

Fig. 1 (a) Schematics of the cascaded cavity modulators, (b) microscope image of the fabricated device, (c) measured transmission spectra at 6 GHz modulation frequency in forward and backward direction, and (d) variation of ATR as a function of the applied microwave V_{pp}.

Example References

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Uni-travelling-carrier photodiodes (UTC PDs) are heterogeneously integrated on a silicon-nitride (SiN) platform using micro-transfer-printing (μTP). These waveguide-coupled photodiodes feature a high responsivity for a very small footprint and promise high-speed operation into the THz domain.

CK-4.4 THU 9:30

Exploration of the optical behavior of phase-change materials integrated in silicon photonics platforms

•C. Zrounba[1], S. Cueff[1], S. Le Beux[2], I. O'Connor[1], and F. Pavanello[1]; [1]Lyon Institute of Nanotechnologies, Écully, France; [2]Concordia University, Montréal, Canada

We demonstrate that, contrary to common assumptions, the absorption profile within waveguide-integrated phase-change material devices may not be exponential and that a non-negligible power fraction may be lost rather than absorbed.

CK-4.5 THU 9:45

Cavity modulator assisted nonreciprocal light transmission on Silicon

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We experimentally demonstrate op-

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EE-2.4 THU 9:30

Transition dipole moment structure revealed by high harmonic generation spectroscopy in thin layer black phosphorus

•K. Uchida[1], V. Pareek[2], K. Nagai[1], K. Dani[2], and K. Tanaka[1]; [1]Kyoto University, Kyoto, Japan; [2]Okinawa Institute of Science and Technology Graduate University, Okinawa, Japan

We observed high harmonic generation in thin layer black phosphorus. By measuring crystal orientation dependence with the resonant excitation condition, we succeeded in reconstructing the transition dipole moment structure in two-dimensional momentum space.

EE-2.5 THU 9:45

Ultrafast Single-Photon Detection based on Optical Kerr Gates

•A.M. Flatae[1], A.-H. Fattah[1], A. Farrag[1], and M. Agio[1,2]; [1]University of Siegen, Laboratory of Nano-Optics and Cμ, Siegen, Germany; [2]National Institute of Optics (INO), National Research Council (CNR), Florence,

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EF-5.4 THU 9:30

Features of spontaneous symmetry breaking of dissipative cavity solitons in passive Kerr resonators

•G. Xu[1], A. Nielsen[1], B. Garbin[1,2], L. Hill[3], G.-L. Oppo[3], J. Fatome[1,4], S. Murdoch[1], S. Coen[1], and M. Erkintalo[1]; [1]The University of Auckland, Auckland, New Zealand; [2]Université Paris-Saclay, Palaiseau, France; [3]University of Strathclyde, Glasgow, United Kingdom; [4]Laboratoire Interdisciplinaire Carnot de Bourgogne, Dijon, France

We report on theoretical and experimental investigations of spontaneous polarization symmetry breaking of temporal cavity solitons. Our findings represent the first observation of these dynamics for dissipative solitons in any two-component physical system.

EF-5.5 THU 9:45

Self-Stabilized Soliton Generation in a Microresonator Through Mode-Pulled Brillouin Lasing

•I.H. Do[1], D. Kim[2], D. Jeong[1], D. Suk[1], D. Kwon[3], J. Kim[3], J.H. Lee[4], and H. Lee[1,2]; [1]Graduated School of Nanoscience and Technology, Korea Advanced Institute of Science and

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damental importance for emerging photonic applications. We demonstrate 260-folds of photoluminescence enhancement along with tunable lifetime of fluorescent dye by integrating with MIM nanocavity

EH-4.5 THU 9:30

Near-field and far-field studies of single and double sub-wavelength sized infrared plasmonic nano-antennas

L. Abou Hamdan[1], L. Abou Hamdan[2], V. Krachmalnicoff[1], R. Haidar[2], P. Bouchon[2], and •Y. De Wilde[1]; [1]ESPCI Paris, Université PSL, CNRS, Institut Langevin, Paris, France; [2]DOTA, ONERA, Université Paris-Saclay, Palaiseau, France

The thermal radiation from single or double metal-insulator-metal nanoantennas is measured. The fundamental spatial mode can be excited at different wavelengths on single MIMs, and we observe the simultaneous thermal excitation of various hybrid modes on double MIMs.

EH-4.6 THU 9:45

Sensitive Determination of the Size and Dielectric Function of Plasmonic Nanoparticles using the Extinction-to-Absorption Ratio

•A. Djorović[1], S.J. Oldenburg[2], J. Grand[1,3], and E.C. Le Ru[1]; [1]The MacDiarmid Institute for Advanced

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I. Kinski[4], D. Dorosz[5], and M. Kochanowicz[6]; [1]Leibniz Institute of Photonic Technology, Jena, Germany; [2]University of Cantabria, Santander, Spain; [3]Fraunhofer Institute of Ceramic Technologies and Systems, Dresden, Germany; [4]Fraunhofer Institute of Ceramic Technologies and Systems, Hermsdorf, Germany; [5]AGH University of Science and Technology, Krakow, Poland; [6]Bialystok University of Technology, Bialystok, Poland

We investigate the introduction of laser-active nanocrystals (Ti:sapphire and Pr:yttria) into optical fibres using glass powder doping. The survival of crystalline material during fibre drawing is confirmed by fluorescence and nanostructure analysis.

CE-8.5 THU (Invited) 9:30

Novel concepts for fabrication and applications of fibers using high-index heavy metal oxide glasses

•H. Ebendorff-Heidepriem; Institute for Photonics and Advanced Sensing, The University of Adelaide, Adelaide, Australia; ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP), Adelaide, Australia

This talk will review our recent advances in the fabrication of heavy metal oxide glass fibers and waveguides and our recent research on using these fibers to demonstrate new lasing, imaging, sensing and mode propagation concepts.

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Cavendish Laboratory, University of Cambridge, Cambridge, CB3 0HE, United Kingdom; [2]Department of Chemistry, King's College London, 7 Trinity Street, London, SE1 1DB, United Kingdom; [3]Department of Physics and Astronomy, University College London, London, WC1E 6BT, United Kingdom

Molecule-metal transient bonds underpin catalysis. Here we confine light to atomic scales for single-molecule probes utilising surface-enhanced Raman scattering. Our analysis of >800,000 spectra shows light-induced local polarization reduces energy barriers for molecule-metal bindings.

EG-5.4 THU 9:30

Thermal effects - an alternative mechanism for plasmon-assisted photocatalysis

Y. Dubi[1], J.H. Baraban[1], •I.W. Un[2], and Y. Sivan[2]; [1]Department of Chemistry, Ben Gurion University, Beer Sheva, Israel; [2]School of Electrical and Computer Engineering, Ben-Gurion University of the Negev, Beer Sheva, Israel

We show that the claims in some of the most famous papers on the topic of plasmon-assisted photocatalysis are extremely unlikely to be correct and that the faster reactions are likely the result of heating.

EG-5.5 THU 9:45

Super-Resolution Mapping of Light-Driven Reactions on Metal Nanostructures

•S. Ezendam[1], J. Gargiulo[1], A. Sousa-Castillo[1,2], L. Nan[1], M. Maier[1], S.A. Maier[1,3], and E. Cortés[1]; [1]Chair in Hybrid Nanosystems, Nanoinstitut, Fakultät für

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