Tuesday Morning, August 8, 2023

Mid-IR Optoelectronics: Materials and Devices
Room Lecture Hall, Nielsen Hall - Session MIOMD-TuM1

Plenary Lecture & Integrated Photonics

Moderator: Fisher Yu, University of Arkansas

8:30am **MIOMD-TuM1-2 Plenary Lecture: Hybrid Passive Photonics in the Longwave-Infrared*, David Burghoff,*** University of Texas at Austin **INVITED**

The development of passive low-loss material platforms is vital for advancing quantum and nonlinear photonics. Recently, mature nanophotonic platforms like Si3N4 and Si-on-insulator have emerged in the near- and midwave-infrared. These platforms have enabled the creation of a wide range of devices that exploit nonlinear effects, including frequency comb generation, supercontinuum generation, quantum frequency conversion, and generation of entangled biphotons. However, none of these platforms are suitable for the longwave-infrared (6 to 14 µm), as most optical materials become too lossy.

Recent advances in low-loss longwave-infrared photonic platforms, such as diamond, chalcogenide glasses, and germanium, have now made it possible to explore novel applications of nonlinear photonics. In this talk, we will discuss our recent work on the development of low-loss platforms based on hybrid photonic integration and will outline a roadmap for novel nonlinear photonic devices using similar schemes. Hybrid approaches could enable novel sensing modalities using supercontinuum and frequency comb technology, with significant implications for chemical and biological sensing, healthcare, and environmental monitoring.

In particular, we will highlight our work demonstrating ultra-high-quality factor microresonators based on Ge-on-glass. By coupling the output of a quantum cascade laser (QCL) into a partially suspended Ge-on-glass waveguide and coupling it into a waveguide, we demonstrate resonators with an intrinsic quality factor of 2.5×105, approximately two orders of magnitude better than the prior state-of-the-art. In addition, we will discuss our more recent results demonstrating that the same approach can be used to create fully-integrated Ge-on-ZnSe waveguides with losses nearly as low. Our results demonstrate the importance and potential of using high-quality native materials for passive photonics in the longwave infrared range and will allow for a number of new device topologies.

9:10am **MIOMD-TuM1-6 Modeling of GaSb-Based Monolithically Integrated Passive Photonic Devices at $\lambda > 2$ µm*, Md Saiful Islam Sumon,*** The Ohio State University*; S. Sankar, S. Nikor,* Ohio State University*; I. Faruque,* university of Bristol, UK*; S. Dwivedi,* Rockley Photonics*; S. Arafin,* Ohio State University

Photonic integrated circuits for the extended short and mid-wave infrared (eS-MWIR) wavelength regime are crucial for potential applications including on-chip chemical and biological sensing and non-invasive medical diagnosis. The lack of high-performance lasers on an SOI wafer and material limitations in InP necessitate an alternative material system. A monolithic platform based on GaSb addresses these concerns through the tight integration of both passive and active components since it is an optimal material system for realizing long-wavelength lasers and photodetectors. In this work, we modeled and optimized various fabrication-compatible passive components including 1×2 power splitters/combiners based on directional coupler (DC), multimode interferometer (MMI), and Y-branch as well as a grating coupler on GaSb substrates at 2.56 µm.

Surface ridge waveguides designed on GaSb-based epitaxial layers are schematically shown in Figure 1(a). Figure 1(b) shows the effective refractive indices n_{eff}, of a few lowest-order guided modes as a function of the ridge width W, and the inset shows the mode profile of TE_0 at $W = 4$ µm. Figure 1(c) shows the transmission through the two output ports of DC-, MMI-, and Y-branch- splitters with 1-dB bandwidth, $\Delta\lambda \sim 1$ µm at a center wavelength of 2.56 µm. For all the splitters, we achieve 50:50 power splitting with an excess loss lower than 0.12 dB. For the grating coupler, a coupling efficiency of -5.4 dB and a 3-dB bandwidth of 80 nm are achieved at 2.56 µm. Details of the design and simulation results of all these passive photonic devices will be presented at the conference.

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