Hybrid passive photonics in the longwave-infrared

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The development of passive low-loss material platforms is vital for advancing quantum and nonlinear photonics. Recently, mature nanophotonic platforms like Si_3N_4 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[1], chalcogenide glasses[2], and germanium[3], 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[3] 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 2.5×10^5, 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.

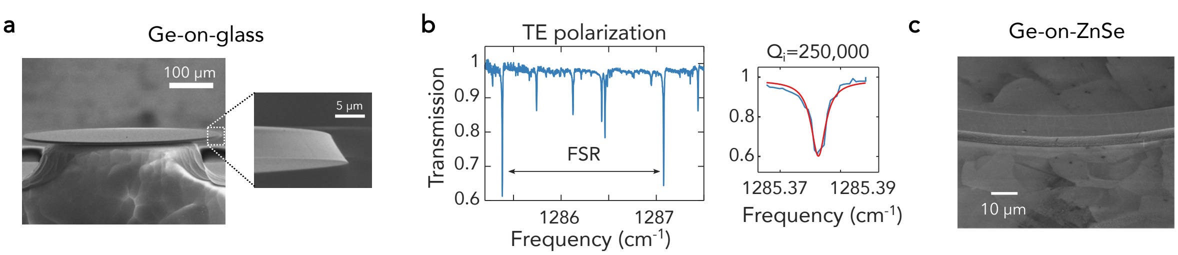

Figure 1. a. Ultra-low-loss microdisks based on a Ge-on-glass platform. By relying on native materials and mechanical processing rather than material growth, microresonators can be fabricated with losses lower than epitaxially-grown Ge and III-V materials. b. Transmission scan of a resonance, demonstrating the first clear resonances in the LWIR. c. Fully integrated hybrid Ge-on-ZnSe platform.

[1] Y.-J. Lee et al., Opt. Express **28**, 5448 (2020).

[2] B. Gholipour et al., J. Phys. Photonics **5**, 012501 (2023).

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