All-Epitaxial Nanophotonic Architectures for Mid-Infrared Optoelectronics

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The mid-infrared (mid-IR) provides a design space where a wide range of engineered and intrinsic light matter interactions can be harnessed to develop a new generation of optical materials and devices. In particular, the highly-doped semiconductor class of materials offers an intriguing opportunity to control the permittivity of epitaxially-grown semiconductors, and can serve as low-index dielectrics, epsilon-near-zero materials, or even as plasmonic materials. Because these materials can be directly integrated with epitaxially-grown optoelectronic device active regions, there exists an opportunity to develop new mid-IR device architectures leveraging co-design of optical and electronic properties, all in a monolithic material system.

In this presentation I will discuss recent results showing strongly enhanced performance of mid-IR structures and devices leveraging all-epitaxial photonic enhancement of response, including distributed Bragg reflectors, leaky cavity LEDs and detectors, guided mode LEDs and detectors, and plasmonic infrared detectors, operating across the mid-infrared. I will present the opportunities and challenges for these new device architectures, and discuss potential future approaches for further enhancement and systems integration.

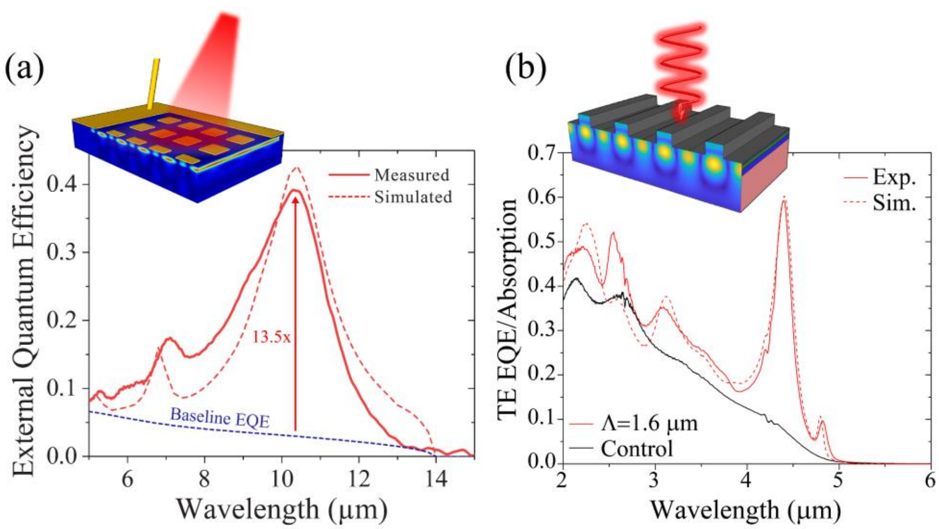

Figure 1: (a) Measured (solid) and simulated (dashed) T=195K external quantum efficiency (EQE) for a long-wave infrared plasmonic nBn detector with simulated EQE of the same detector without the plasmonic enhancement. (b) Measured (solid) and simulated (dashed) room temperature EQE for a mid-wave infrared guided mode resonance detector, compared to same detector structure without grating.

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