Light-Matter Interaction in Nanophotonic Devices

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Abstract. Miniaturization and high-density integration of optical devices can enable fast, low-loss, compact photonic systems that operate at reduced power levels. These systems are of great practical interest for applications in telecommunication, bio-chemical sensing and quantum communication/ information processing. I will review the design, fabrication and characterization of photonic crystal cavities and lasers, which are capable of confining photons to ultra-small volumes for long periods of time. The porous nature of photonic crystal lasers (Fig. A) allows for efficient interaction between light and matter introduced in the laser cavity and enables the realization of compact chemical sensors based on intra-cavity laser spectroscopy [1]. Quantum cascade lasers (QCL), are ideally suited for this application due to their operation in the mid-IR range [$\lambda \in (5\mu m, 20\mu m)$]. Novel photonic crystal QCL design [2], that takes advantage of both electronic and photonic band-gap engineering, will be presented (Fig. B). The application of semiconductor nanowires as light sources in nanophotonic systems will also be presented (Fig. C) [3]. Finally, I will discuss opto-mechanical interaction (e.g. optical binding and repulsion, radiation pressure) between nanoscale waveguides and resonators [4]. Strong light localization in these systems gives rise to attractive and repulsive forces between that are large enough to cause observable displacements of the optical components. These nano-scale opto-mechanical systems illustrate the potential for a broader class of optically-tunable nanophotonic devices and nano-structured artificial materials.

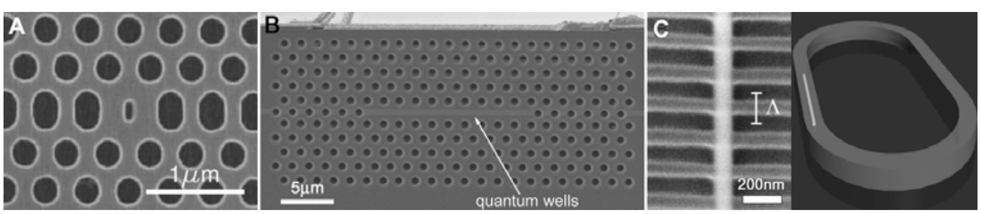

FIGURE 1. A) Photonic crystal cavity and B) QCL. C) CdS nanowire embedded in optical cavities.

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