STRONG LIGHT-MATTER INTERACTIONS IN SEMICONDUCTOR QUANTUM DOTS COUPLED TO PHOTONIC CRYSTALS

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Abstract

Two dimensional photonic crystals have been recognized as a highly promising scalable platform for compact integrated photonics. Another important aspect of photonic crystals is their ability to localize and trap light to spatial volumes on the order of a cubic wavelength, resulting in extremely high electromagnetic intensities. Recently, it has been shown that by embedding a single quantum dot (QD) in the high field region of photonic crystal cavities it becomes possible to achieve strong light-matter interactions at the single photon/single atom level. These unprecedented interaction strengths open up the possibility for creating nonlinear optical effects approaching the single photon level. In addition, they can be exploited to engineer unique quantum mechanically entangled states of light and matter that enable scalable quantum networks. I will discuss our work on coupling indium arsenide (InAs) QDs to photonic crystal structures for creating nonlinear optical interactions at low photon numbers, and for storing and transferring quantum information from QD spin to photons. I will describe an experimental demonstration of giant optical Stark shifts with only 10 photons of energy using a strongly coupled cavity-QD system, and a more recent demonstration of all-optical switching with only 150 photons of control energy. I will then discuss our work on coupling QD spin to light in order to realize a *quantum transistor* that can exhibit the quantum mechanical property of entanglement. The quantum transistor could enable a novel class of opto-electronic devices that serve as a fundamental building block for quantum computers and quantum networks.

Key words: Quantum dots, photonic crystals, optical switching, nanophotonics