Magnetic control of light-matter coupling for a single quantum dot embedded in a microcavity

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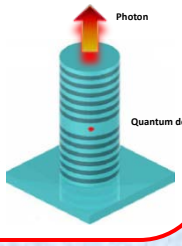
We report the design, fabrication and optical investigation of the magnetically tunable single quantum dot – micropillar cavity system. Unlike other studies where cavity-quantum dot spectral resonance was achieved by temperature tuning, we demonstrate that Zeeman effect of excitons confined in a single quantum dot is an efficient method to tune the quantum dot-cavity coupling simply by varying the magnetic field. The tuning range of single quantum dot exciton transitions can be as large as ~0.7 meV, which is much larger than the cavity mode linewidth (~0.3 meV). This enables us to tune the quantum dot emission into resonance with the fundamental cavity mode easily. An enhancement of the quantum dot emission due to the Purcell effect was also observed. Our results provide an alternative for realizing cavity-quantum dot based single photon devices.

Motivation

- quantum dot – microcavity system with high-Q and small-modal-volume cavities for the realization of strong coupling between single quantum emitter and optical mode
- Generation of polarized single photon emission in the strong coupling regime

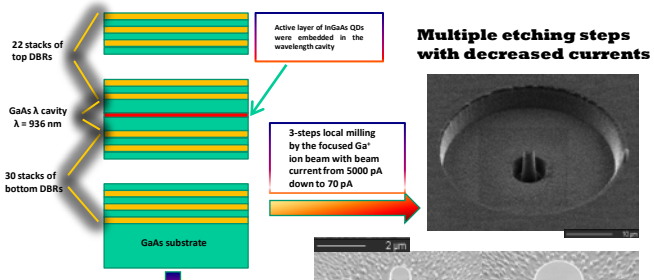


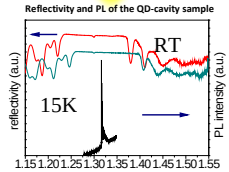
Here:

- A systematic study of the quantum dot micropillar cavity fabricated by focused-ion-beam (FIB) is presented
- Spectral tuning of quantum dot emission on resonance with the cavity mode by exciton zeeman effect was realized

Growth and Fabrication of GaAs/AlAs MCs

- Monolithic epitaxial growth by MOCVD (550 ^{0}C for QDs)
- Alternating GaAs/AlAs DBR layers were grown at 650 ^{0}C
- FIB milling of micropillars down to 1-4 μm in diameter



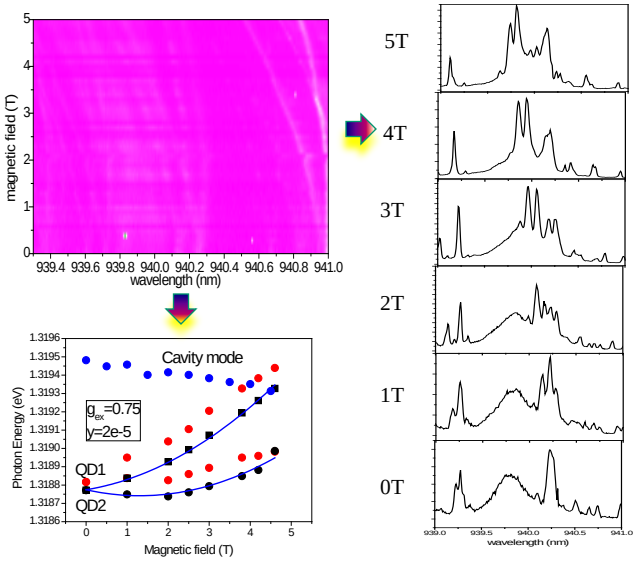


- Smooth side walls and surface
- Possibility of milling arbitary shapes and lateral sizes
- High quality pillars comparable to traditional EBL-RIE technique

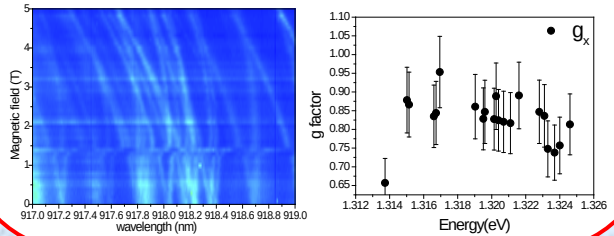
Magnetic tuning of coupled QD-cavity resonance

- Single quantum dot emissions showed Zeeman splittings in magnetic field
- The transition energy of single dot exciton can be tuned as high as ~0.7 meV, that the coupled resonance with cavity mode was observed
- The intensity of single dot emission was enhanced on resonance due to Purcell effect.

Magnetic mapping on different pillars



g-factors of excitonic transitions from different dots



Conclusion

- High quality quantum dots embedded in micropillars are grown and fabricated by MOCVD and FIB post milling processes
- Coupling of single quantum dot to the fundamental cavity mode is tuned by varying magnetic field, and the enhancement of single dot's emission is observed on coupled resonance
- g factors of exciton complexes from different dots are measured