Single quantum dots and single photons - light matter interaction effects in micropillar cavities

Stephan Reitzenstein, Carolin Hofmann, Micha Strauss,

Sven Höfling, Martin Kamp, Lukas Worschech, Karl Brunner, Alfred Forchel Physikalisches Institut, Universität Würzburg

Abstract :

Using high Q factor semiconductor microcavities with a small number of quantum dots populated by individual photons it has become possible to observe light matter interaction effects originating from coupling of single photons and single quantum dot excitons. The talk summarizes our results on quantum dot (QD) micropillar cavities and micro disks and rings containing dots with strongly varying oscillator strengths and different Q- factors in III-V and II-VI systems, respectively. Due to the three dimensional electronic confinement the quantum dot excitons act as the solid state equivalent of atom - like emitters. The three dimensional optical confinement in the cavities results in discrete photon modes. The energies of the QD excitons are tuned in and out of resonance with the optical modes by temperature tuning.

We have recently realized very high quality factor active micropillar cavities with Q factors as high as 160.000 for 4 µm diameter GaAs/AlAs micropillars with InGaAs dots. In these structures the photon lifetime approaches 100 ps. As simultaneously the spontaneous emission life time of emitters on resonance is shortened, these structures will allow one to study effects in a regime where the photon lifetime is similar or even larger than the dot recombination time. In the III-V material system we have investigated strong coupling effects using InGaAs quantum dots of widely varying oscillator strengths in high quality cavities of various diameters. The values for the vacuum Rabi splittings vary from about 140 µeV to about 20 µeV, when the oscillator strength of the InGaAs dots decreases from 50 to 10. Much larger values of the vacuum Rabi splitting are observed in II-VI microrings with embedded dots, where the strongly increased oscillator strength (~ 400) of the II-VI dots results in splittings of about 0.7 meV.