Single photon emission and cavity-coupling in semiconductor quantum dots

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Quantum dots (QD) coupled to optical microcavities behave as single photon emitters where the emission linear polarization and antibunching time are continuously controlled by the energy detuning between the quantum dot and the cavity mode. The case of InAs/GaAs QDs coupled to a photonic crystal microcavity is described in some detail and compared to InP/InGaP uncoupled QDs. The polarization rotation spans over 160º and is interpreted in terms of hybridization between the QD and the cavity states. The observed reduction of the antibunching time for decreasing detuning demonstrates that the enhancement of the spontaneous emission rate, originated by Purcell effect, acts in the same way as increasing the pumping rate on the antibunching time.

By photoluminescence excitation (PLE) measurements we observe the effective coupling between two QDs located near the cavity center and separated by 1,4 μm. The inter-dot coupling is mediated by the photonic crystal cavity mode. The two dots are simultaneously coupled to the cavity for detuning range in the order of 1 meV, as shown by Purcell effect. In this range, quasi-resonant excitation at the “p-states” of each of the QDs results in an emission intensity increase of the other one. Coherent coupling between the two QDs is believed to be the most probable inter-dot interaction mechanism due to the similar saturation behaviour in both emission processes (intra- and inter-dot excitation) upon increasing the excitation intensity. The strength of the effective inter-QD coupling is estimated around 30 μeV.

The present results open the possibility to obtain single photon emitters with continuous control of their emission properties and to use distant solid state qubits in quantum logic operations.

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