Coupling and wavelength tuning of GaAs quantum dots

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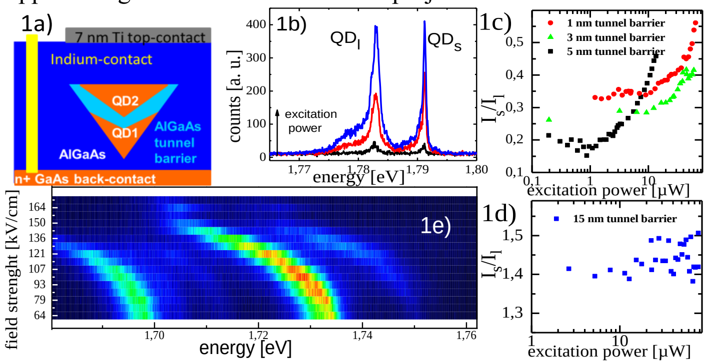
We study a novel type of GaAs quantum dot molecules (QDM) fabricated by filling of nano-holes with a modulated material sequence. The samples were fabricated using molecular beam epitaxy (MBE) and the local droplet etching technique (LDE).[1] We have established the fabrication of highly uniform GaAs quantum dots (QD) by filling of LDE holes [2,3]. The fabrication of the present QDMs bases on the recently demonstrated drilling of ultra-low density nanoholes [3]. The nanoholes are etched in AlGaAs surfaces using Al droplets. The material sequence filled into the holes consists of GaAs to form a bottom QD, AlGaAs as tunnel barrier, and, again, GaAs to form an upper QD. Finally, the QDM is capped by an AlGaAs layer. Important parameters of the QDM such as individual quantum dot size and tunneling barrier thickness are adjusted by the respective filling amounts. In order to apply a vertical electric field, the QDMs were embedded in a gate structure as shown in Fig. 1a.
We investigate QDMs with varied tunnel barrier thickness to study coupling effects with excitation power dependent measurements. Fig. 1b presents typical power dependent photo-luminescence (PL) spectra of a QDM. Two PL peaks are observed that we associate to emission from the individual QDs. The ratio of the integrated intensities of the ground state emission from the higher energetic QD_s and the lower energetic QD_l is presented in Fig. 1c as a function of the excitation power. The power dependence of the ratio clearly indicates non-resonant coupling within the QDM. [4] A reference sample with thicker tunnel barrier shows a constant ration indicating negelegible coupling (Fig. 1d). Furthermore, we studied the influence of a vertical electric field on the photoluminescence emission of our QDMs. We obtain Stark-shifts up to 25 meV, as shown in Fig. 1e.

The authors would like to thank the "Deutsche Forschungsgemeinschaft" for financial support via grant GrK 1286 and DFG-project HA2042/6-1



(a) Schematic sample structure of the QDM samples (b) PL spectra of a GaAs QDM at different excitation powers. (c) Intensity ratios I_s/I_l of the two QD's peaks of QDMs with different tunnel barrier thicknesses (d) I_s/I_l for a DQM with a 15 nm thick tunnel barrier (e) Electric field dependence of the ground-state emission depicted in color-encoded intensity

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