Energy transfer processes in InAs/GaAs quantum dot bilayer structure

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Semiconductor Quantum Dots (QDs) made of InAs and grown epitaxially on GaAs are typical nanostructures known from more than a decade that have found applications in laser, single and entangled photon sources, and as spin-based qubits. Nevertheless, there are still some features that are interesting from the point of view of fundamental studies as well as the development of advanced and novel QD-based devices or improvement of the performances of the existing ones.

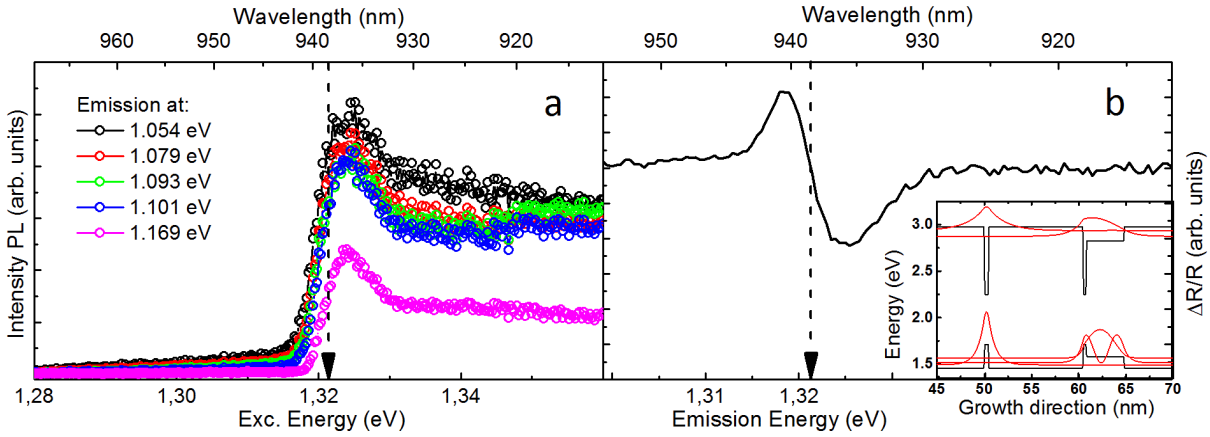

Figure 1 1a) PLE spectra at different emission energies, 1b) Photoreflectance spectrum with resonant related to ground state of InGaAs capping layer

In this work we focus on double layer QDs grown in the Stransky-Krastanov mode by molecular beam epitaxy. InAs/GaAs Quantum Dots emitting below 1 μm have been extensively investigated in recent years. In contrast, structures with double layer QDs have allowed the extension of the dots' emission to longer wavelengths of approx. 1.15 - 1.20 μm. They are consisting of two layers of highly homogeneous InAs QDs separated by 10-nm thick GaAs layer. The lower layer (seeding layer), determines the position of the QDs in the second layer thanks to the strain induced by the dots. The second layer is capped with an InGaAs layer to extend the dot emission to longer wavelengths. By means of micro-photoluminescence excitation spectroscopy we probe states predominantly confined in InGaAs capping layer, being a part of a double quantum well system composed of the two wetting layers – see the inset in Fig. 1b. We could observe emission from quantum dots in the single dot regime with excitation energy at the InGaAs layer. Efficiency of the carrier injection from this layer to QDs is decreasing with the energy difference between the QD emission and the injection layer ground state. Figure 1a shows intensity versus excitation energy with a characteristic step at about 1.32 eV. This energy agrees with InGaAs capping layer ground state which is shown in Fig. 1b (photoreflectance spectrum). There have also been detected fingerprints of the higher energy confined states within the QDs, which will be discussed and confronted with the results of eigth-band **k·p** calculations.

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