Investigation of the energy transfer in structures with large InGaAs/GaAs quantum dots

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Abstract

In this work we present optical studies of large $In_{0.3}Ga_{0.7}As$ quantum dots (QDs) grown on GaAs substrate. These nanostructures have already shown unique features, including the first demonstration of the strong coupling between quantum-dot-confined excitons and optical microcavity electromagnetic field, as well as the unexpectedly low fine structure splitting (about 5 μeV).

In the Stranski-Krastanov mode, the growth conditions, QD morphology and the presence of the wetting layer (WL) define the electronic properties of QDs. The carrier transfer to quantum-dot-confined states is mediated by WL. This report is focused on the energy transfer from WL states to the states confined in single large, elongated $In_{0.3}Ga_{0.7}As$/GaAs quantum dots. To determine the mechanism of the transfer, photoluminescence excitation spectroscopy on the single dot level has been performed. Evidence of the energy transfer from the WL to single quantum dot confined states is evidenced. The signal intensity is well correlated with the energetic separation between QD and the WL ground states, indicating on the efficiency change of feeding of quantum dot states. For this kind of quantum dots lower emission energy lines correspond to smaller dots but with higher In content. Efficacy of the energy transfer from the WL is explained in terms of the larger energy dissipation during the relaxation to the In-richer QDs, resulting in the decreased signal intensity at the excitation in the WL region. The other explanation can be the decreased oscillator strength of these dots, which is investigated in the multi-band $\mathbf{k}\cdot\mathbf{p}$ model. Two types of sharp emission features in excitation spectra are also observed. They are attributed to the dot excited states and to the localization centers within the 2D WL, where the latter has already been suggested in these structures. This kind of carrier localization within the WL states is investigated in temperature-dependent photoluminescence excitation experiment.