Emission studies of large and elongated InGaAs/GaAs quantum dots with the excitation energy control

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Low-indium content $In_{0.3}Ga_{0.7}As/GaAs$ self-assembled quantum dots (QDs) [1] constitute an unique kind of quasi-zero-dimensional nanostructures with an atypically large volume, beneficial for cavity QED [2], and in-plane shape asymmetry in comparison to well-studied epitaxial self-assembled InAs/GaAs QDs. The complexity and peculiar properties of this system have already been signalized, both theoretically and experimentally, indicating, e.g., the weak confinement regime [3] and low degree of linear polarization, of the order of few percent, observed in the surface emission (despite the distinct nanostructure in-plane asymmetry – lateral aspect ratio exceeding 2). There has also been reported the importance of quasi-zero-dimensional traps in the wetting layer for the dynamics of the entire system and its emission properties [4,5].

Regardless of the theoretical and experimental effort, there is still very limited knowledge on the detailed energy structure of such $In_{0.3}Ga_{0.7}As/GaAs$ self-assembled elongated QDs and the possible energy transfer processes between different parts of the system at the single nanoobject level. We present the emission study of low-density and low-strain $In_{0.3}Ga_{0.7}As/GaAs$ QDs. The structure is pumped with a tunable continuous wave semiconductor laser with an external cavity (Littrow configuration) providing a very narrow excitation linewidth ($\ll 1$ μeV). Taking the advantage of the precise excitation energy control we investigate the importance of the wetting layer states on the radiative recombination in $In_{0.3}Ga_{0.7}As/GaAs$ QDs and we trace the energy transfer between the wetting layer and QD-confined states. The excited states in these large QDs could also be probed, which have not been investigated till now. The experimental results are of the high importance as an input parameters for numerical modelling of the $In_{0.3}Ga_{0.7}As/GaAs$ QDs states within the multi-band $\mathbf{k}\cdot\mathbf{p}$ theory, eventually giving deeper understaning of the real QD energetic structure crucial for all the nanophotonic applications.

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