Experimental and Theoretical Determination of Exciton Fine Structure Splitting and Excitonic Complexes Binding Energy in InP-based Quantum Dashes

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We investigate optical properties of single quantum dashes (QDashes) in the InAs-InP material system in order to reveal their potential as an active region for non-classical light sources at the 2nd and 3rd telecommunication windows [1], [2]. This work is motivated by a lack of comprehensive study on fundamental and crucial physical parameters such as fine structure splitting of a neutral exciton ground state (FSS) or binding energies of various excitonic complexes. Unique feature of the system under study is its geometry with relatively small cross-sectional sizes providing strong vertical confinement and large lateral aspect ratio exceeding 5, which affects the wave function extension, Coulomb as well as exchange interactions differently.

We report on both experimentally and theoretically determined FSS and binding energies of biexciton and negatively charged exciton for molecular-beam-epitaxy-grown InAs/InGaAlAs/InP QDashes of various cross-sectional size emitting between 1.2 and 1.6 μm. We carried out single dash spectroscopy via microphotoluminescence on processed samples which facilitates identification of excitonic complexes. The FSS exhibits typically values above 100 μeV with no clear dependence on the dash size, in the range of available geometries. Rather large biexciton binding energy of approx. 3.5 meV was detected, which proves important role of correlation interactions prevailing the Coulomb repulsion of carriers of the same type and as a result shifting the biexciton to the binding state. This is additionally weakly sensitive to the cross-sectional dash size due to its negligible influence on the correlation energy. Furthermore, we analyzed negatively charged exciton complexes with the binding energy in the range of 4.2 meV to 5.2 meV.

The interpretation of all the experimental data was supported by calculations performed for realistic system parameters within an atomistic many-body approach, verified previously for less anisotropic nanostructures [3]. It allowed, for instance, associating the charged complexes to negative trion, and its binding energy changes to piezoelectric field influence on the Coulomb interactions in the system of two electrons and one hole. Eventually, large FSS values could be attributed to significant in-plane anisotropy of the dashes.

[1] P. Mrowiński, A. Musiał, G. Sęk, J. Misiewicz, S. Höfling, A. Somers, S. Hein, and A. Forchel, *Acta Physica Polonica A*, **124**, 5, 2013.
[2] Ł. Dusanowski, M. Syperek, W. Rudno-Rudziński, P. Mrowiński, G. Sęk, J. Misiewicz, A. Somers, J. P. Reithmaier, S. Höfling, and A. Forchel, *Applied Physics Letters*, **103**, 25, 2013.
[3] M. Zieliński, *Physical Review B*, **88**, 15, 2013.