Excitonic complexes in single InGaAs/GaAs quantum dots emitting at the telecommunication O-band

P. Mrowiński[1], K. Gawarecki[2], P. Machnikowski[2], A. Musiał[1], J. Misiewicz[1], N. Srocka[3], T. Heuser[3], D. Quandt[3], A. Strittmatter[3,*], S. Rodt[3], S. Reitzenstein[3], G. Sęk[1]

[1] *Laboratory for Optical Spectroscopy of Nanostructures, Department of Experimental Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, Wrocław, Poland*
[2] *Department of Theoretical Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, Wrocław, Poland*
[3] *Institute of Solid State Physics, Technische Universität Berlin, Berlin, Germany*
[*] *Currently: Institute of Experimental Physics, University Magdeburg, Magdeburg, Germany*

Direct coulomb and exchange interactions studied by accessing to excitonic complexes in low-dimensional structures are interesting for understanding their fundamental electronic and optical properties and likewise for applications relevant in nanophotonics, quantum optics and quantum information processing. We studied MOCVD-grown $In_{0.75}Ga_{0.25}As$/GaAs quantum dots redshifted to the telecom O-band by using the approach with an InGaAs strain reducing cap layer [1]. The influence of morphological details, such as size, shape and composition profile, on the electronic and optical properties has been addressed both experimentally and theoretically focusing on the basic excitonic complexes. Characterization of single quantum dots' emission by excitation power and polarization resolved microphotoluminescence resulted in determination of typical binding energies of the biexciton and charged excitons of: $\Delta E_{XX} = -3.7\,meV$, $\Delta E_{X+} = -1.8\,meV$, $\Delta E_{X-} = -3.6\,meV$. In addition, the bright exciton fine structure splitting distribution of $30 \div 80\,\mu eV$ has been observed (Fig. 1a). Applying the in-plane external magnetic field allowed also to evaluate the bright-dark exciton fine structure splitting to be of the order of $430\,\mu eV$.

These data have been compared to the results of theoretical calculations performed within the eight-band k·p model [2] utilizing realistic quantum dot morphology and composition parameters based on the structural data – see Fig. 1b (courtesy of Prof. Dr. M. Lehmann). The excitonic states are calculated using Hartree-Fock, or configuration-interaction method (40 electron and 40 hole states) showing high-impact of the correlation effects on the binding energies and on the spectral pattern of the excitonic complexes.

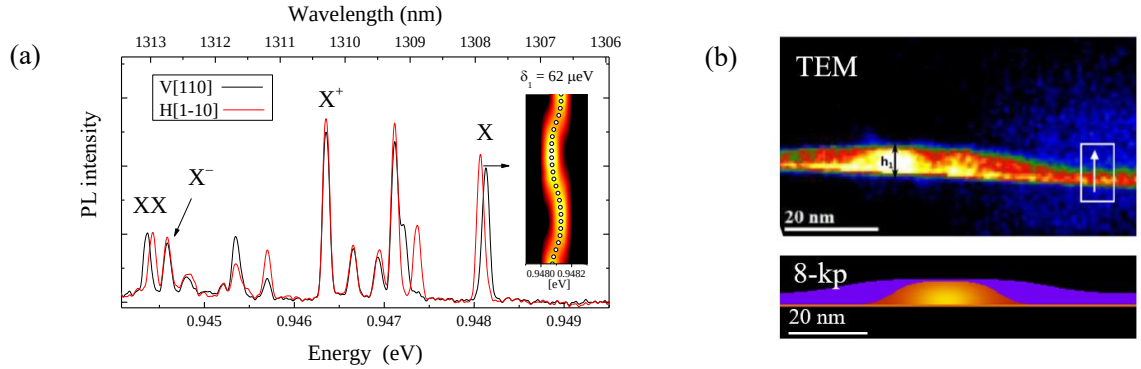

Figure 1 a) Polarization resolved μPL spectra from a single InAs quantum dot and b) structural TEM data used later on in theoretical analysis performed by eight-band kp model.

[1] F. Guffarth et al Phys. Rev. B **64**, 085305 (2001), J. Tatebayashi et al Appl. Phys. Lett. **78**, 3469 (2001)
[2] K. Gawarecki et al Phys. Rev. B **90**, 085437 (2014)