Optimizing the InGaAs/GaAs quantum dots for 1.3 μm emission

A. Maryński[1], P. Mrowiński[1], P. Podemski[1], K. Gawarecki[2], P. Machnikowski[2], A. Musiał[1], J. Misiewicz[1], D. Quandt[3], A. Strittmatter[3,*], S. Rodt[3], S. Reitzenstein[3] and G. Sęk[1]

[1] *Laboratory for Optical Spectroscopy of Nanostructures, Department of Experimental Physics, Faculty of Fundamental Problems of Technology, Wroclaw University of Science and Technology, Wroclaw, Poland*

[2] *Department of Theoretical Physics, Faculty of Fundamental Problems of Technology, Wroclaw University of Science and Technology, Wroclaw, Poland*

[3] *Institute of Solid State Physics, Technische Universität Berlin, Berlin, Germany*

In this contribution we determine experimentally and describe theoretically fundamental optical properties and electronic structure of GaAs-based QDs emitting at 1.3 μm grown using Metalorganic Chemical Vapour Deposition (MOCVD) technique. To redshift the QDs emission to telecommunication wavelengths In content of the capping strain reducing layer (SRL) was tuned to final composition of $In_{0.2}Ga_{0.8}As$ [1].

Photoreflectance (PR) experiments allowed for determination of 3 optical transitions in the range of the accompanying wetting layer (WL) and SRL which could not be clearly resolved in high-excitation photoluminescence (PL). Theoretical calculations within single-band and single particle kp approach using realistic structural parameters explained observed transitions as originating from hybrid WL-SRL quantum well in which 1 electron state and 3 holes states are confined. The 2D character of these states were further confirmed in PLE experiment together with determination of spectral range in which QDs can be efficiently quasi-resonantly excited to be (835-905) nm. This is crucial for the QD material to be further used as an active region of an on demand plug & play fiber-coupled single photon source suitable e.g., for quantum key distribution within local quantum networks.

Optical characterization of the QD material was performed in terms of PL, PR and photoluminescence excitation spectroscopy (PLE) in which the effective response of the whole QD ensemble was studied. The QD emission band was as designed centered at 1.3 μm at low temperature (10 K) with an inhomogeneous broadening of 35 meV. This shows relatively high homogeneity of investigated structures, comparable to results for state-of-the-art samples grown in Molecular Beam Epitaxy and ensures many single QD lines in the vicinity of 1.3 μm emission wavelength. High excitation PL study revealed two higher QD states well-isolated from the ground state with s-p splitting in the range of 67 meV. Experimental findings are in agreement with theoretical calculations indicating additionally 2 times larger contribution of electron energy (in comparison to the hole state) to this splitting. QD spectrum was calculated from single particle states determined within 8 band kp model with realistic structure parameters as well as In composition gradient within the QD and including influence of the strain distribution (calculated within the continuous elasticity approach) on the band structure and piezoelectricity up to the second order. Excitonic complexes were further calculated using configuration-interaction method. Theoretically obtained excitonic spectrum corresponds well to the results of high excitation PL measurements.

The work has been supported by the European Regional Development Fund (EFRE) of the European Union in the framework of the programme to promote research, innovation and technologies (Pro FIT). and grant No. 2/POLBER-2/2016 of the National Centre for Research and Development.and the National Science Centre (Poland) within the project 2014/15/D/ST3/00813.

[1] F. Guffarth et al., *Phys Rev B* **64**, 085305 (2001).

---

* Present: Institute of Experimental Physics, Otto von Guericke University Magdeburg, Germany