Temperature dependent emission linewidth and the exciton dephasing in large and asymmetric III-V semiconductor quantum nanostructures

Anna Musiał[1], Grzegorz Sęk[1], Aleksander Maryński[1], Michał Kozub[1], Jan Misiewicz[1], Andreas Löffler[2], Sebastian Hein[2], Sven Höfling[2], Stephan Reitzenstein[2,3], Johann P. Reithmaier[2,4], Martin Kamp[2] and Alfred Forchel[2]

[1] *Institute of Physics, Wrocław University of Technology, Poland*
[2] *W. C. Röntgen-Center for Complex Material Systems, University of Würzburg, Germany*
[3] *Institute for Solid State Physics, Technische Universität Berlin, Germany*
[4] *Institute of Nanostructure Technology and Analytics, University of Kassel, Germany*

Optical properties of epitaxially grown burried semiconductor nanostructures can be strongly influenced by the surrounding solid state matrix and the interaction with it reduces the coherence of the carrier excitations. The dephasing of an exciton becomes a crucial issue whenever applications are considered and this is why the identification of the dephasing mechanisms and ways to control and minimize them are of high importance. On the search for quantum systems being more robust against decoherence, large nano-objects have been predicted to be advantageous due to their weakened confining potential and resulting larger wave function extension [1-3].

To probe the exciton dephasing in two groups of large and asymmetric nanostructures microphotoluminescence has been measured on patterned samples, and the thermal evolution of the full width at half maximum (FWHM) of single emission lines has been analyzed, which has not been carried out for this kind of structures so far.

At first, lowly strained $In_{0.3}Ga_{0.7}As/GaAs$ and slightly elongated QDs (lateral aspect ratio - LAR ~ 2) with typical geometry of (20 x 50 x 5 nm^3) and shallow confining potential (approx. 30 meV) have been investigated. Low temperature FWHM varies in the range of 200 - 500 μeV, and is limited by spectral diffusion while no phonon-related spectral features can be resolved. Strong influence of Coulomb interactions with carriers/excitons in the wetting layer on emission from those dots has already been proven [4] and can lead to large values of FWHM at 5 K. Spectral diffusion effects originate mostly from the fluctuating charges trapped on the mesa sidewalls what has been evidenced by studying the emission for different mesa sizes. With increasing temperature the FWHM of single emission line is almost constant up to 30-40 K and then increases strongly, which we relate to the thermally enhanced interaction with the acoustic phonons and the increased contribution of the so called phonon sidebands to the emission spectral line. In the case of smaller mesas, the FWHM increase starts at lower temperatures and is faster.

An analogical study has been carried out for strongly elongated (LAR exceeding 5) exhibiting deeper confinement quantum dashes (approx. 20 x 150 x 3 nm^3) in the InAs/InP system. The initial FWHM value for those structures is lower (50 - 200 μeV) and the abrupt increase starts at higher temperatures around 60 K in agreement with expected size-related trends. Results for QDs with different height show that enhanced size in the strongest confinement direction causes lower sensitivity of FWHM to temperature changes in the high temperature limit.

[1] L. Besombes et. al., Phys. Rev. B **63**, 155307 (2001).
[2] E. Peter et. al., Phys. Rev. B **69**, 041307 (2004).
[3] P. Borri et. al., Phys. Rev. B **71**, 115328 (2005).
[4] Ł. Dusanowski et. al., J. Appl. Phys. **111**, 063522 (2012).

Monday
Tuesday
Wednesday
Thursday
Friday