Carrier dynamics of InAs/InP quantum dots ensemble embedded in various barrier layers.

A. Maryński[1], M. Syperek[1], M. Pieczarka[1], J. Misiewicz[1], V. Liverini[2,*], M. Beck[2], J. Faist[2], G. Sęk[1]

[1] *Laboratory for Optical Spectroscopy of Nanostructures, Division of Experimental Physics, Wrocław University of Science and Technology, Wrocław, Poland*
[2] *Institute of Quantum Electronics, ETH Zürich, Zürich, Switzerland*
[*] *currently at: Albis Optoelectronics AG, Rüschlikon, Switzerland*

In certain realization of photonic devices based on quantum dots (QDs) e.g. photon detectors, one need to assure lateral electronic coupling between ground states among ensemble of confined states. However, such coupling must be avoided in other type of devices e.g. lasers or amplifiers and can lead to deteriorate strongly their efficiency. In the following work we have focused on self-assembled QDs with their ground state emission centered around 1.55 mm. These dots can be well suited for optoelectronic devices (lasers, amplifiers, or detectors) operating in the C-band window of silica fibers. As we demonstrate, properties of a ground state of an entire system can be efficiently tuned by manipulating the chemical composition of the barrier and thus influencing the overall electron-hole confinement conditions.

We consider two kinds of QDs made of InAs submerged into different barriers lattice matched to InP: (i) InAlAs, and (ii) InGaAlAs. While in the former case one to expect a strong e-h confinement condition, in the latter case the confinement is slightly weaker (for electrons/or holes?). Both structure where examined in temperature-dependent photoluminescence (PL) and time-resolved photoluminescence (TRPL) experiments at T=5K where structure are excited in quasi-resonant conditions (Laser = 0.855eV).

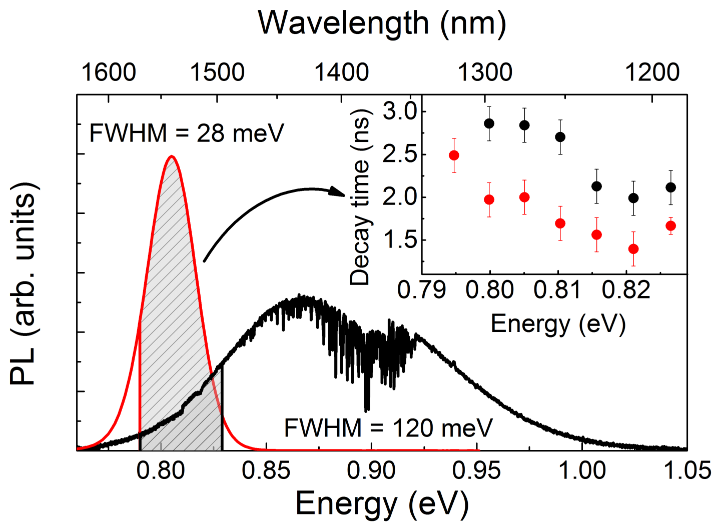

Figure 1 Photoluminescence at 5K. Red line corresponds to InGaAlAs sample, black one corresponds to InAlAs sample. Inset shows decay times for the up mentioned samples.

First, a strong difference between both structures is observed as considering the PL quench that is much slower for the InAs/InAlAs QDs structure than for the InAs/InAlGaAs one. In the latter case, the PL quench starts just above T = 5K. As far as we assume that the barrier is fully relaxed without any defect states, and the wetting layer density of states is not extended down to the QD ground state thus the PL quench process can be related to the in-plain coupling among QDs ensemble. This property can be additionally confirmed in the TRPL experiment. While for the QD structure with a strong e-h confinement the PL decay time lies in the range of ~2-2.8 ns, for the structure with lower confinement the PL decay time is 0.4-0.6 ns shorter that suggests existence of e-h transfer process between adjacent QDs influencing the overall PL decay.