Resonantly excited emission of individual CdSe QDs with single Mn^{2+} ions embedded in (Zn,Cd)Se barrier

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The Quantum Dots (QDs) emitting in yellow (2.1 eV – 2.16 eV) spectral band would be useful as the quantum light sources serving as building blocks of a laser operating in so far not covered spectral range. Incorporation of magnetic ions, like Mn, would further enhance their functionalities. Operation of such magnetooptical devices requires, however, QDs emitting below the energy of Mn internal transition at 2.1 eV, competing with excitonic transitions.

We demonstrate a growth and properties of micro-Photoluminescence (μ-PL) of CdSe QDs with single Mn^{2+} ions emitting in a yellow spectral range. Thanks to implementation of (Zn,Cd)Se barrier, the QD emission is shifted to energies smaller than as for a typical selenium based system of CdSe/ZnSe QDs (2.3-2.5 eV).[1]

A series of samples are grown by MBE technique with varying content of cadmium (Cd) in (Zn,Cd)Se barrier. The QDs are formed out of few monolayers of CdSe. The μ-PL is cw excited non-resonantly at 3.06 eV. Photoluminescence excitation (PLE) is performed using a cw tunable dye laser operating between 2.05-2.20 eV. A spatial resolution of the measurement is 0.5 μm or 3 μm, depending on the microscope objective used. The magnetic field is applied in Faraday configuration, at temperature between 1.7 K and 300 K. The reflectivity measurements are carried at T = 10 K with a halogen lamp serving as the light source.

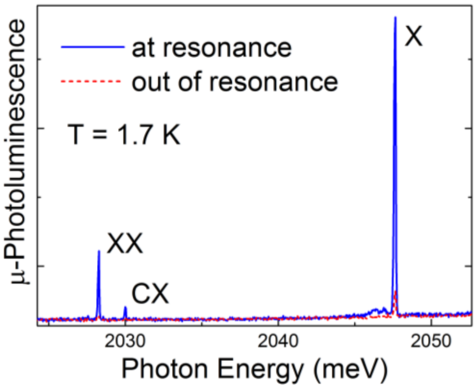

Figure 1. The μ-PL spectra of a single CdSe/ZnCdSe QD excited at resonance and out of resonance.

Above the barrier excited μ-PL shows a set of sharp emission lines corresponding to the QDs at energy between 1.8-2.3 eV, depending on the sample. A transition related to the barrier is observed between 2.45 - 2.65 eV, in consistency with the reflectivity results. The decrease of the barrier energy and corresponding decrease of QD energy is correlated with increasing Cd content in the barrier layer. A typical μ-PL spectrum of a single QD consists of a neutral (X), charged exciton (CX), as well as biexciton (XX) transitions (see Fig. 1), identified through measurements of linear polarization of emission anisotropy. The XX binding energy is around 20 meV. A characteristic six-fold splitting of the excitonic lines enabled identification of QDs containing single Mn^{2+} ions.

PLE spectra of individual QDs revealed sharp (FWHM down to 200 μeV) resonances, similar to the ones observed in a self-organized CdTe/ZnTe system, [2] attributed to a transfer of exciton through tunnelling between an absorbing state and the emitting QD state. The energy difference between the absorbing and emitting states remains in a range between 45 and 100 meV. The PLE carried out with a circularly polarized excitation and detection revealed a non-negligible degree of circular polarization conserved during the excitation transfer to both: QDs with and without Mn^{2+} ions, also in the absence of magnetic field.

[1] E. Kurtz *et al., J. Crys. Growth.* **184/185**, 242 (1998).
[2] T. Kazimierczuk *et al.*, *Phys. Rev. B* **79**, 153301 (2009).