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Properties of excitonic states in MOCVD-grown Zn(Cd)Se/ZnMgSSe quantum wells with spreaded heterointerfaces

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ZnSe is considered as a promising material for achieving Bose-Einstein condensate of exciton polaritons in microcavities with embedded quantum wells (QWs). This material allows to reach strong coupling mode at room temperatures [1] and exhibits several mechanisms of polariton relaxation. Particularly, polariton-phonon scattering can be further enhanced due to low LO phonon energy. The influence of a real heterointerface on these processes may be of crucial importance for an efficient control of polariton relaxation and thus deserves a detailed study.

Structures with 1 and 2 Zn(Cd)Se/ZnMgSSe QWs were grown by MOCVD on GaAs substrates in a hydrogen atmosphere at 85 Torr and 450–460 °C. Due to high growth temperature spreading of the QW heterointerfaces was observed, however, their lateral homogeneity remained high. In the samples with two QWs, the bottom QW was held at the high growth temperature longer than the top one, resulting in different degree of interface blurring for these QWs. This allows us to study the optical properties of two QWs with different interface spreading in the same sample.

The structure of exciton states in all QWs is well described in the framework of a strained Zn(Cd)Se layer thicker than the exciton Bohr radius. The different extent of QWs blurring leads to the energy shift between emission spectra of two QWs. The doublet structure dominating in the PL spectra is determined by the radiative recombination of free excitons (X) and excitons localized on neutral donors (D^0X). The spectral distance between maxima of X and D^0X lines is higher for QWs with blurred interfaces. This is related to the change in the decay of the wavefunction near interfaces for localized and delocalized exciton states [2].

The exciton-phonon coupling is enhanced for the QWs with spreaded interfaces. The most likely reason for this is the different degree of localization of electrons and holes near the interface, which enhances the exciton–phonon interaction via the Fröhlich mechanism.

A bi-exponential PL decay with the quenching times ~ 40 ps and ~ 400 ps is observed for each QW. The short time is caused by trapping of excitons by charged donors D^+. The slowly decreasing part is related to the radiative recombination of X and D^0X with no charged centers nearby. The interface spreading apparently leads to the increase of concentration of charged defects, which results in the decrease of the PL quenching time in blurred QWs.

Under additional below-barrier illumination with photon energy 1.9 eV the following phenomena in PL spectra are observed: (1) drastic decrease of PL quantum yield; (2) D^0X line disappearance; (3) change of X line width. Absorption of this illumination causes electrons to escape from QWs, leading to the growth of the number of ionized donors D^+ and to the decrease of the number of neutral donors D^0. A huge time constant (~1 s) of the phenomena points to charge redistribution between QWs and the substrate, which is considered to be a primary reason of PL lines narrowing due to lowering of the contribution of electron-exciton scattering. Other mechanisms that could affect PL line widths may be an increase in level of fluctuations of QW potential or a change of exciton-phonon interaction constant, both induced by a raise of the number of charged impurities.

[1] K. Sebald et al., Appl. Phys. Lett. **100**, 161104 (2012).
[2] A. F. Adiyatullin et al., J. Exp. Theor. Phys. **115**, 885 (2012).