Origin of luminescence quenching in structures containing CdSe/ZnSe quantum dots with a few Mn^{2+} ion

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Diluted Magnetic Semiconductors (DMS) exhibit giant Zeeman effect and related extraordinary magneto-optical properties [1] due to exchange interaction between magnetic ions and band carriers. Particullary interesting are low dimensional structures constructed of Mn-doped wide-gap II-VI semiconductors. Large binding energy and oscillator strength result in high efficiency of photon sources and in strong coupling with photonic modes. This is particullary important for future spintronic applications. However, the doping with Mn^{2+} ions at both bulk material and low dimensional structures results in suppression of excitonic luminescence [2]. This is due to the opening of the new channels of nonradiative rcombination of excitons [3]. The results obtained recently on individual self-organized CdSe/ZnSe QDs containing single Mn^{2+} ions indicate that in such structures a suppression of the luminescence does not occur effectively [4, 5]. In this work we investigate in detail the properties of structures containing CdSe/ZnSe quantum dots with a few Mn^{2+} ions in order to understand new aspects of the photoluminescence quenching mechanism.

Sample used in our experiments contains MBE-grown, self-assembled CdSe/ZnSe QDs doped with low concentration of Mn^{2+} ions. Our time-resolved and time-integrated experiments reveal the origin of the quenching observed in macro-photoluminescence studies of ensembles of such dots. We show that incorporation of even a few ions to an individual dot has little influence on its luminescence. At the same time, the presence of Mn^{2+} ions in the sample significantly affects the luminescence intensity of the whole structure. Also, we do not see any impact on the luminescence decay time. We interpret our observations in terms of model in which the quenching is not related to the non-radiative recombination channels of the exciton states in QDs, but it appears earlier, for the excited photocreated carriers in wetting layer or smaller, defective quantum dots.

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