In-plane radiative recombination channel of a dark exciton in self-assembled quantum dots

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Neutral exciton in a self-assembled quantum dot (QD) usually consists of the electron and the heavy hole with total angular momentum projections on the growth axis equal respectively to $\pm 1/2$ and $\pm 3/2$. Due to the isotropic electron-hole exchange interaction, the excitonic states are split in energy into two pairs: *bright excitons* (X_b) and *dark excitons* (X_d). Typically, the dark excitons are considered optically inactive as the spin of the electron and the heavy hole are combined into total spin 2. Thus, the dark exciton persists in QD relatively long time and might affect the performance of QD devices. The decay rate of the dark exciton is widely believed to be determined by a spin-flip process turning a dark exciton into a bright one [1, 2]. However, such a process is inefficient for the low temperatures as it requires absorption of energy from the phonon bath equal to (isotropic) electron-hole exchange constant δ_0.

In this study we demonstrate a clear evidence for a different, *radiative recombination channel* of dark excitons in self-assembled QDs. This channel is due to a light hole admixture in the excitonic ground state. The dipole moment of this transition is oriented along the growth axis. Therefore, X_d photoluminescence (PL) is emitted only in the direction perpendicular to the growth axis. We have confirmed this prediction by a direct measurement of a CdTe/ZnTe QD PL spectra from a cleaved edge of the sample. In such a geometry emission at the energy corresponding to the dark exciton was indeed observed for a sufficiently low excitation power (Fig. 1(a)). We emphasize that X_d emission line is almost fully linearly polarized along the growth axis (Fig. 1(b)), which shows that X_d PL *cannot be detected using typical setup geometry* (i.e., when detection is perpendicular to the sample surface). Importantly, a strong correlation between the dark exciton lifetime and the in-plane hole g-factor enabled us to show that the radiative recombination is the dominant decay channel of the dark excitons in CdTe/ZnTe QDs [3].

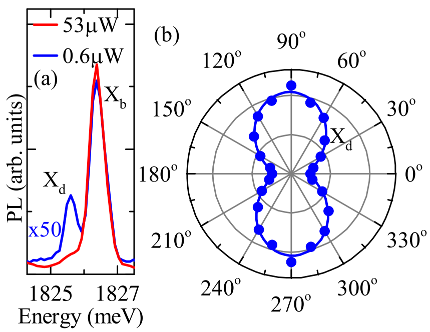

Figure 1: (a) PL spectra of a neutral exciton measured from the cleaved edge of the sample under CW excitation. (b) Polar plot presenting the polarization of the dark exciton emission (the 90° and 270° directions are along the QD growth axis).

We underline that X_d radiative recombination demonstrated in our work is not specific for CdTe/ZnTe QDs and should be present in all QDs exhibiting heavy-light hole mixing. Moreover, the dominance of this recombination channel over other X_d decay mechanisms opens a new possibility of a direct optical control of the dark exciton state.

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