# Photoluminescence dynamic of Copper-doped CdSe colloidal quantum dots and (Zn,Cd)Se/ZnSe quantum well

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Copper-doped semiconductor nanocrystals (NCs) are attractive for a variety of applications, such as light emitting diodes, biolabels and spintronics devices. From an application point of view, the understanding of the photoluminescence (PL) effects in such systems is essential. The aim of this work was to investigate the PL dynamics in two systems: Cu-doped CdSe colloidal quantum dots (QDs) and (Zn,Cd)Se/ZnSe quantum well (QW).

Colloidal QDs were synthesized according to a procedure from Ref. [1]. QW was grown by molecular beam epitaxy. The Cu content in both samples was ~1%. For time-resolved photoluminescence (TRPL) measurements the samples were mounted on a coldfinger cryostat and excited by picosecond laser pulses at 400 nm. The overall temporal resolution was 1 ns. The measurements were performed at 10-20 K.

In the case of QDs, due to the doping of copper atoms, excitonic luminescence disappears and broad band luminescence appears at 1.55 eV, with full width at half maximum of 260 meV. In the case of Cu-doped QW the exciton PL intensity decreases and three PL broad bands appear centered at about 1.65 eV, 1.91 eV and 2.25 eV. By comparison to the emission from an undoped QW, it is found that the emission line at 1.65 eV is related to the presence of copper ions. The PL line at 2.25 eV appears only in case of non-resonant excitation and its origin is associated with deep level defects present in ZnSe barrier. The PL line at 1.91 eV is associated with the excitons bound to impurities.

In both systems, the additional PL peak originates from recombination of a delocalized conduction-band electron with a hole localized at a copper dopant. The obtained PL decay times for this Cu-related transitions are orders of magnitude longer than for exciton transition, namely the decay time is 60 μs for QW and 600 ns for QDs. These long PL decay times indicate that the Cu-related transition is spin forbidden. In order to determine the origin of this transition, the decay time as a function of photon energy is investigated. With increasing energy a shortening of the PL lifetime is observed. Namely, within the investigated energy range the decay time decreases by a factor of 3 for QDs and by a factor of 2 for QW. One of the possible interpretation is hole hopping.

[1] L. Yang, K. E. Knowles, A. Gopalan, K. E. Hughes, M. C. James, and D. R. Gamelin, *Chem. Mater*. **28**, 7375−7384 (2016).

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