Tuning the emission energy from CdTe and CdSe quantum dots by copper doping

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Doping II-VI semiconductors with copper attracts a great interest because of a recent observation of a strong spin-exchange interaction between paramagnetic Cu^{2+} dopants and the band carriers in copper-doped chalcogenide nanocrystals [1]. This finding gives raise to explore diluted magnetic systems based on Cu^{2+} magnetic ions.

In this work, we report on the fabrication of copper doped self assembled CdTe/ZnTe and CdSe/ZnSe quantum dots (QDs) by molecular beam epitaxy containing various Cu concentrations. The samples are investigated by means of low-temperature photoluminescence and micro-photoluminescence. The most important result is that we observe a pronounced spectral blue shift of the excitonic emission from CdTe and CdSe QDs as result of incorporation of copper inside of them.

The growth of the samples is performed in the following way. First, a ZnSe barrier layer is grown on 100-GaAs substrate and is followed by 3 monolayers of CdSe grown by alternating opening of Cd and Se effusion cells for 5 seconds at 280^{o}C. Simultaneously to the Cd flux the copper effusion cell has been opened for 5 seconds. Its flux is characterized by the beam equivalent pressure being of the order of 10^{-9} – 10^{-8} torr depending on the sample. The estimated Cu content is, therefore, relatively low - of the order of maximum a few percent. QDs formation process is induced by the Se-covering at low temperature and its subsequent thermal desorption. QDs are finally covered with 50 nm ZnSe barrier layer.

In the case of Te-based structures, CdTe QDs are formed on a ZnTe barrier layer from 6 monolayers CdTe grown by alternating exposing to Cd and Te fluxes for 5 seconds. After the 3rd Cd-layer the sample is moved to another MBE chamber equipped with Cu effusion cell without breaking the high vacuum conditions. Cu is deposited for 5 seconds. Subsequently, the sample is moved back to the main growth chamber for the deposition of further 3 CdTe monolayer. The QDs formation process is induced by the Te covering method [2]. The growth is accomplished by a 50 nm thick ZnTe cap layer.

The samples are characterized by low temperature (5 K) photoluminescence and micro-photoluminescence measurements. We observe that the copper doping has a significant impact on the emission energy from CeSe and CdTe quantum dots despite of a relatively low Cu concentrations being of the order of only a few percent. The energy shift is as large as 250meV for CdTe quantum dots and 220 meV for CdSe quantum dots. The micro-photoluminescence technique confirms that the observed emission is originating indeed from QDs excitonic emission for all Cu compositions. When the excitation spot is reduced to 3μm the relatively broad emission from the QDs-ensemble splits into several emission lines origination from individual dots. Interestingly, the isolating of individual emission lines is much easier in the case of quantum dots containing copper which suggests a decrease of the density of optically active QDs.

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[1] Pandey, A. *et al.*, Nature Nanotechnology **2012**, 7, 792
[2] Tinjod, F. *et al.*, Journal of Alloys and Compounds **2004**, 371: 63