Self-assembled quantum dots containing magnetic ions

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Self assembled CdMnTe quantum dots (QDs) embedded in ZnCdTe matrix were prepared in a molecular beam epitaxy processes, where when depositing the layers from which the dots were finally formed, the Mn effusion cell was kept opened for the duration corresponding to deposition of 1-2 monolayers of CdMnTe (approx. 1 at. % of Mn). We estimate that the amount of Mn introduced in this way into the dots was about 5-20. The method used gives hope to achieve at least a degree of control of Mn introduced into the dots. We investigate our structures by means of spatially resolved photoluminescence in an external magnetic field up to 7 T, with the excitation spot size in the range of 1 µm. The excitonic emission from the QDs-ensemble is observed as a broad spectral feature extending from 1.72 eV to 1.9 eV and whose width is connected to fluctuation of chemical composistion and sizes of the quantum dots in the entire ensemble. The macro-luminescence becomes circularly polarized even in relatively weak magnetic fields evidencing a giant Zeeman splitting sude to the sp-d interaction of the excitons with Mn ions within the dots. On the other hand, we observed many sharp lines within the spectrum with the spectral width of about 3meV, which are associated to the excitonic emission from individual QDs. The widths of the lines from individual dots is relatively wide and reflects the fluctuations of the spin degree of freedom.

We performed detailed studies on these lines, in particular we observed the giant Zeeman splitting, narrowing of lines in an external magnetic field and circular polarization of these lines. In particular, we found that the value of the Zeeman splitting is extremely depends on the spectral position of the PL line from individual QD and consequently on its size. One possible explanation of this effect is the formation of magnetic polaron, *i.e.* spontaneous ferromagnetic alignment of Mn-ion within a QD due to their strong exchange interaction with the spin of carriers. According to several theoretical descriptions [1,2], the resulting non-zero magnetization should also strongly depend on the size of the QD. The smaller the QD, the stronger should be the polaron effect, which is consistent with our experimental finding.

In order to confirm our interpretation, we performed calculation in terms of the muffin tin model, which was already successfully used for the description of the magnetic polarons in bulk diluted magnetic semiconductors. From these calculations we obtained the information about the sizes, Mn-amount and, as an effect, the number of Mn ions which find themselves inside of the QDs.

This work was partly supported by the Foundation for Polish Science (Subsidy 8/2003).

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