

## CdS AND CdS:Mn NANOCRYSTALS FABRICATED BY ION-BEAM SYNTHESIS

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Recently, there have been many extensive studies for the fabrication and optical characterization of semiconductor nanocrystals. One of the most versatile techniques for compound nanocrystal fabrication is high-dose ion implantation followed by thermal annealing, because compound nanocrystals can be simply fabricated by sequential ion implantation of the elements forming the compound. In this work, we have fabricated CdS and Mn-doped CdS (CdS:Mn) nanocrystals by means of Cd<sup>+</sup>, S<sup>+</sup> and Mn<sup>+</sup> implantation into Al<sub>2</sub>O<sub>3</sub> and studied photoluminescence (PL) properties of CdS and CdS:Mn nanocrystals.

CdS samples were synthesized by equal doses ( $2.2 \times 10^{16}/\text{cm}^2$  or  $4.3 \times 10^{16}/\text{cm}^2$ ) of Cd<sup>+</sup> (450 keV) and S<sup>+</sup> (164 keV) into Al<sub>2</sub>O<sub>3</sub> at 600°C [1]. Samples annealed at 1000°C show efficient PL. The transmission electron microscopy and x-ray diffraction examinations show that the average diameter of CdS nanocrystals in Al<sub>2</sub>O<sub>3</sub> was ~17 nm and the CdS nanocrystals have the wurtzite structure. CdS:Mn nanocrystals were fabricated by implantation of Mn<sup>+</sup> ( $2 \times 10^{15}/\text{cm}^2$ , 250 keV) into CdS nanocrystals at 400°C. The Mn doped samples were annealed at 1000°C for 60 min.

In CdS nanocrystals, the absorption spectrum shows two excitonic peaks at 2.62 and 2.68 eV at 5 K. These peaks are due to the splitting of the excitonic states in wurtzite CdS nanocrystals. Under picosecond laser excitation, the PL spectrum appears near the optical absorption edge. The PL spectrum shows two peaks at 2.58 and 2.50 eV at 10 K. The PL lifetimes at 2.58 and 2.50 eV are 100 ps and 1 ns, respectively. The fast component at the higher energy and the slow component at the lower energy are attributed to the free-exciton emission and the bound-exciton emission, respectively.

CdS:Mn nanocrystals show efficient and broad luminescence around 2.1 eV. Similar PL is observed in bulk CdS:Mn. This is attributed to the intra-3d transition of Mn<sup>2+</sup> ions. Moreover, the PL excitation spectrum of CdS:Mn nanocrystals is similar to the absorption spectrum of CdS nanocrystals. These observations suggest that efficient energy transfer of carriers occurs from CdS nanocrystals to Mn<sup>2+</sup> ions. We will discuss radiative recombination processes of excitons in CdS nanocrystals and energy-transfer processes in CdS:Mn nanocrystals. Spectroscopic analysis shows that high-quality compound nanocrystals are formed by sequential ion implantation.

Oak Ridge National Laboratory is managed by UT-Battelle, LLC for the U.S. Department of Energy under contract DE-AC05-00OR22725.

[1] D. Matsuura, Y. Kanemitsu, T. Kushida, C. W. White, J. D. Budai, and A. Meldrum, Appl. Phys. Lett. **77** (2000) 2289.

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