Photoluminescence and Photoacoustic Characterization of Mn-Doped ZnS Nanoparticles: Varying Mn Concentration

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In recent years, considerable interest has been generated in the study of compound semiconductor in the nanometer range. Among the materials of interest is ZnS owing to its various opto-electronic application [1]. Of particular interest is the effect of doping ZnS with Mn^{2+} ion. Prior researches [2-4] have indicated that due to the high quantum efficiency exhibited by ZnS:Mn, they may form a new class of luminescent material with applications to displays, lighting and laser.

In this study, we investigated the effect of varying the amount of Mn^{2+} dopant on the photoluminescent property of ZnS:Mn. The PL intensities with the varying concentration of Mn will be observed as well as the its effect on the measured time decay constants of the samples.

Nanocrystalline ZnS:Mn with varying Mn^{2+} concentrations was synthesized using an inorganic synthesis method [5]. The resulting sample had a calculated particle diameter of 2 nm (from XRD pattern). The optical absorption spectra were obtained using a PA technique (Fig. 1) PA spectroscopy is a photothermal technique that enables us to obtain the optical absorption characteristics and information on the nonradiative processes even with opaque and powdered samples. The obtained PA spectra for all samples showed peaks at around 3.8 eV, attributed to the lowest transition energy due to quantum confinement effects [6]. It can be observed that there is a slight difference in the PA intensity as the photon energy decreases. This difference in intensity could be accounted for by the Mn dopant in the system. Taking the spectral difference between ZnS:Mn samples and the ZnS only samples, we find a peak at approximately 3.2 eV.

Figure 2 shows the photoluminescence spectra of the samples with varying Mn concentrations. It was found that as the concentration of the dopant was increased, the PL intensity also increased. On the other hand, if too much Mn^{2+} was added, a decrease in the PL intensity was observed (concentration quenching). Figure 3 shows the Mn^{2+} concentration dependence of maximum PL intensity. The optimal concentration determined for this batch of samples was at 8 mM.

Figure 4 shows the preliminary studies on the effect of Mn^{2+} concentration on the photoluminescent time decay. It was found that increasing the dopant concentration resulted in faster time decay constants (smaller value).

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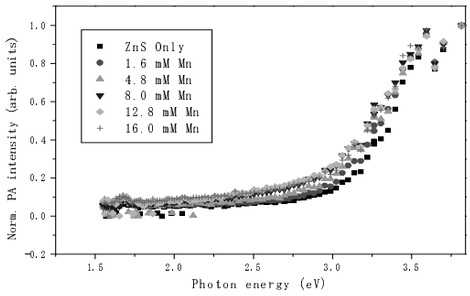

Figure 1: PA spectra for the different ZnS:Mn samples with varying Mn^{2+} concentration (from 0-16 mM).

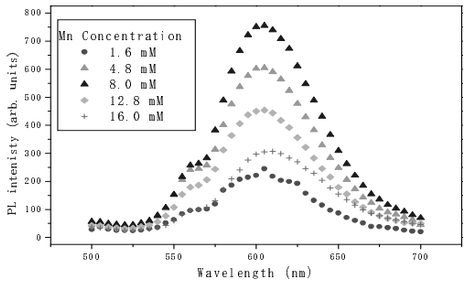

Figure 2: PL spectra for the different ZnS:Mn samples with varying Mn^{2+} concentration (from 1.6 -16 mM).

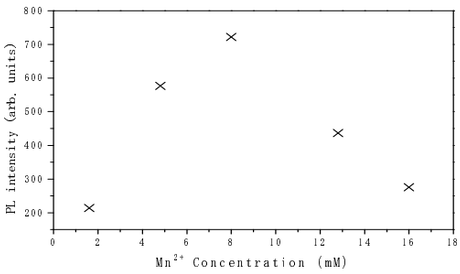

Figure 3: PL intensity plotted against the Mn^{2+} concentration.

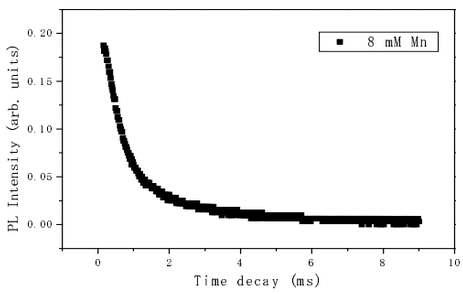

Figure 4: PL time decay curve for the sample with 8 mM Mn.