Luminescence of Nanocrystalline ZnSe:Mn

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The synthesis of semiconductors showing quantum size effects (e.g. the size dependence of the bandgap as well as other electronic parameters of the material) has been well established for several years [1,2]. The syntheses published can be divided into two types: "easy" – water soluble chemicals and the synthesis is performed in a normal fume cupboard; or "hard" – precursors that react strongly with water and oxygen and implies that the synthesis needs to be performed in a glovebox (dry nitrogen atmosphere).

Nanocrystalline ZnS is a material that has been studied extensively and its synthesis falls in the "easy" category. However, for device applications (such as electroluminescent materials) the ZnS band structure is unfavorable: the valence band is located too far down to allow easy injection of holes from a conducting polymer. Therefore, this presentation describes a more promising material: nanocrystalline ZnSe doped with Mn.

The synthesis for nanocrystalline ZnSe (category "hard") has been published recently [3], but incorporation of a luminescent dopant was not described that paper. In this presentation, the synthesis of nanocrystalline ZnSe:Mn^{2+} is described in detail [4], followed by a survey of the photoluminescent properties of nanocrystal powders.

The most important data, also shown in the Figures on the right, include the photoluminescence as a function of Mn^{2+} concentration (Figure 1), the lifetime of the Mn^{2+} (Figure 2) and ZnSe luminescence emissions and the temperature dependence of the luminescence. Figures 1 and 2 hint at the (preferential) formation of Mn^{2+}-Mn^{2+} pair states in the nanocrystal. Using Figure 3 a comparison will be made between the temperature dependence of the emission energy (Figure 3) of nanocrystalline and bulk ZnSe and an explanation of the observed similarities and differences will be presented.

[1] L. Brus, *Pergamon* **59**, 459 (1998) and the references therein.
[2] A. P. Alivisatos, *J. Phys. Chem.* **100**, 13226 (1996).
[3] M. A. Hines and P. Guyot-Sionnest, *J. Phys. Chem. B* **102**, 3655 (1998).
[4] J. F. Suyver, S. F. Wuister, J. J. Kelly and A. Meijerink. *Phys. Chem. Chem. Phys.* **2**, 5445 (2000).

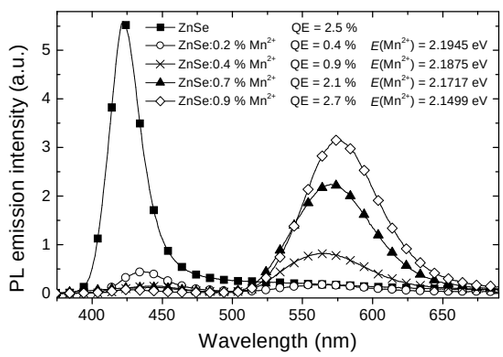

Figure 1: Luminescence spectra (excitation 330 nm, room temperature) of nanocrystalline ZnSe with various concentrations of Mn. Indicated are incorporated Mn concentrations, quantum efficiencies and the spectral position of the maximum of the Mn^{2+} related emission.

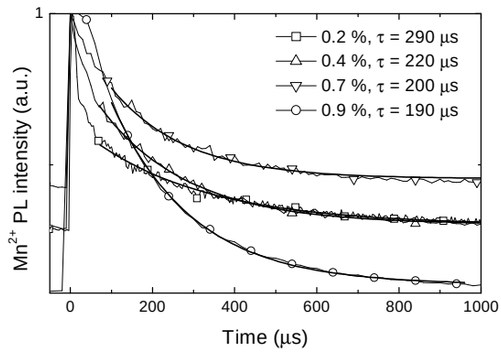

Figure 2: Time dependence of the Mn^{2+} related emission (λ_{ex} = 355 nm, λ_{em} = 550 nm, 300 K) of ZnSe:Mn^{2+} nanocrystals. The lines through the data are single exponential fits using the lifetimes indicated.

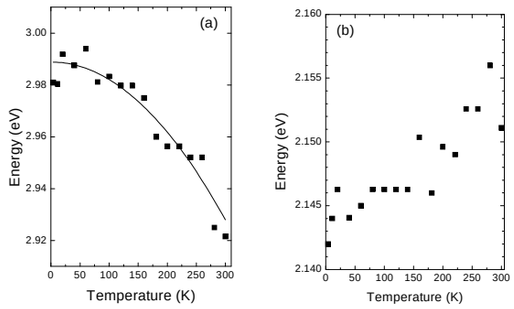

Figure 3: Temperature dependence of the **(a)** ZnSe related and **(b)** Mn^{2+} related luminescence for a ZnSe:0.7 % Mn^{2+} sample. Excitation at 330 nm. The fit in Figure **3(a)** is based on bulk ZnSe.