Luminescence Characteristics of Solutions, Powders, and Layers of ZnSe:Cu Nanocrystals

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The unique optical and electrical properties of semiconductor nanocrystals have attracted significant attention over the last few years [1]. Through the understanding of the origin of the quantum size effects, a new level of control of the properties of semiconductor systems has been obtained. Chemical synthesis allows one a large degree of control to prepare nanocrystals with various properties. Doping of the nanocrystals with an optically active ion is also possible, adding to the flexibility of these materials for device applications.

In order to use semiconductor nanocrystals as the optically active component in an electroluminescent device, high quality nanocrystals need to be synthesized. The research presented here deals with ZnSe nanocrystals doped with Cu, because the bulk material is known for its good electroluminescent properties. The samples are made in a glovebox (dry nitrogen atmosphere) using a chemical synthesis [2] based on the TOP/TOPO synthesis, well known for the CdSe nanocrystal synthesis. This method allows for a size selectivity through the synthesis time, as is shown in Figure 1. The spectra show two peaks: the first one, at 390 – 420 nm, is the ZnSe near bandgap luminescence [3] (which shifts to lower energy for larger particle sizes as expected) and the second one, at ~460 nm, is the Cu^{2+} luminescence. The dependence of the spectral position of these peaks on the synthesis time will be discussed.

In the low temperature photoluminescence measurements, shown in Figure 2, it is clear that the Cu^{2+} emission has become the dominant spectral feature. At low temperature, the luminescence quantum efficiency, dominated by the Cu^{2+} luminescence, reaches values of around 30 % [4]. This effect, together with the temperature dependent spectral position of these emission bands, will be discussed in detail and compared to bulk ZnSe:Cu. In addition, the assignment of the Cu^{2+} luminescence process will be presented.

Finally, layers of these nanocrystals on a conducting substrate (TFO) have been fabricated through dip-coating from a suspension. Preliminary electrochemical results (layer stability in relation to the dark current / photocurrent measurements and Mott-Schottky measurements) will be discussed and potential device application will be considered.

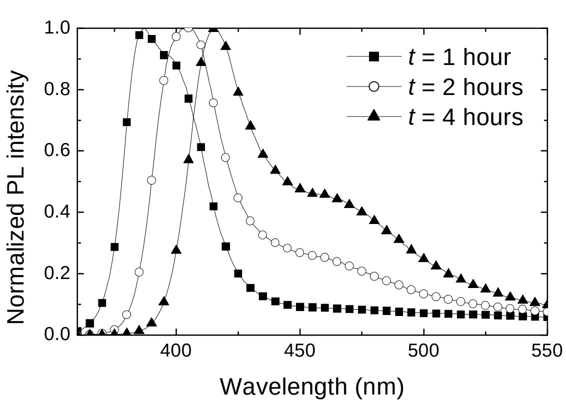

Figure 1: Normalized photoluminescence measu-rements (excitation was at 330 nm, room temperature) of ZnSe:Cu samples at different synthesis times. The growth of the nanocrystals and incorporation of copper is clearly reflected in the luminescence spectrum.

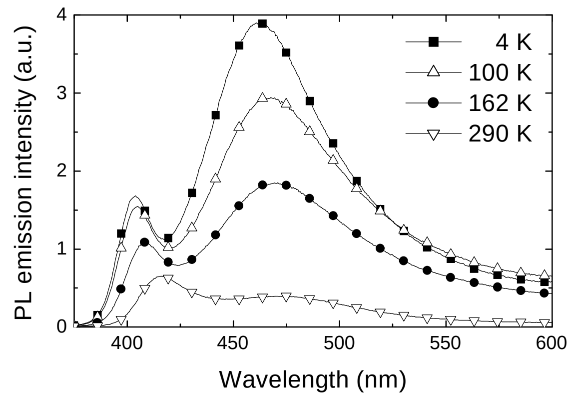

Figure 2: Temperature dependent photoluminescence measurements (excitation was at 330 nm) of 3.4 nm ZnSe:Cu nanocrystals. The relative intensities can be compared.

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[4] J. F. Suyver, S. F. Wuister, T. van der Beek, J. J. Kelly and A. Meijerink. *Appl. Phys. Lett.* **79**, 4222 (2001).