

PHOTOLUMINESCENCE OF ZnSe NANOCRYSTALS OBTAINED BY SPIN-COATING METHOD

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Abstract

Synthesis of the nanoparticles has made great strides in the field of nanotechnologies particularly in optoelectronics. Reading information by lasers on solid supports, as example, is performed by wide gap semiconductor thin films. From fundamental research, several theories were proposed to explain the physical properties of this new class of materials.

ZnSe nanoparticles incorporated in polystyrene films were deposited by spin-coating method on glass substrates. X-rays diffraction measurement confirms the incorporation of ZnSe with a cubic structure and nanometer size, in the polystyrene matrix. Optical characterization by UV - visible spectroscopy shows a shift of the edge of absorption toward great energies compared to the bulk crystal and the presence of broad peak witch is due to the creation of excitons in ZnSe nanocrystals. This displacement of the edge is due to quantum confinement induced by the low size of ZnSe crystallites. The width of the peaks enables us to estimate the distribution of crystallite size. Photoluminescence spectrum of films is formed by four (04) bands. The band in 432 nm (2.867 eV) is attributed to the transition band to band. The second in 471 nm (2.633 eV) is due to the transition between defect levels in the gap. The last, at 624 nm (2.366 eV), is assigned to the transition between levels in the gap created by the vacant Zn sites while the shoulder located at 408 nm (3.040 eV) is probably due to the polystyrene.

Introduction

During the last decade, notable progress has been made in both fundamental and applied research on semiconductor nanocrystals (NCs) [1-3]. These NCs exhibit unusual optical properties, which make them attractive as materials for nonlinear optical elements and luminescent devices [4-8]. Generally, the physical properties of the semiconductors change considerably when their sizes approach the Bohr radius scale of the bulk crystal exciton [9]. The size-dependent spectral characteristics of PL due to the size quantization effect allow control of the color of emitted light simply by adjusting the size of nanocrystals during synthesis [10]. The development of synthesis techniques for a variety of NCs led to investigations of opto-electronic properties [11]. The NCs are characterized by a dominant surface effect [12]. The embedding of NCs of semiconductors in wide-gap matrices like glass [5, 13], alkali halide matrices [14, 15], ZrO₂ [16], etc., has allowed huge nonlinear-properties devices.

Our interest to ZnSe quantum dots has been motivated by the inherent interest in quantum confined systems and extrapolation for intense UV-blue luminescent material for techno-

logical application. The room temperature band gap of 2.7 eV for bulk ZnSe ideally suits these applications. Several media has been employed to disperse semiconductor nanoparticles including the sol-gel process [5, 13, 17], solid state reaction and colloidal methods [18]. But some difficulties still accompany the synthesis and processing of semiconductor nano-particles, especially reactivity and agglomeration related problems.

In this work, we have elaborated ZnSe NCs embedded in polystyrene matrices and studied their photoluminescence responses. The polystyrene has a wide energy-band which makes it a transparent matrix in the UV-visible region.

Experimental Part

The nanocomposites ZnSe/polystyrene are obtained by direct inclusion of the ZnSe nanocrystallites in the polystyrene matrix. The introduction of these nanocrystallites in the matrix was realized in the liquid state by dissolving basic polymer and maintaining simultaneously under magnetic stirring. Once the polymer completely dissolved, layers were prepared (Fig. 1) by the spin - coating method on a glass substrate. The obtained samples of the order of centimetre square, were then left in the ambient air for drying. The X-ray diffraction (XRD) of ZnSe embedded in polystyrene was performed by using the K_{α} of copper $\lambda = 1.54 \text{ \AA}$ of a D8 Advanced Siemens Diffractometer. The optical density was measured at room temperature by a double beam UV-visible 3001 Shimadzu spectrophotometer and the photoluminescence measurements were carried out at room temperature with a 350 nm UV argon-ion laser.

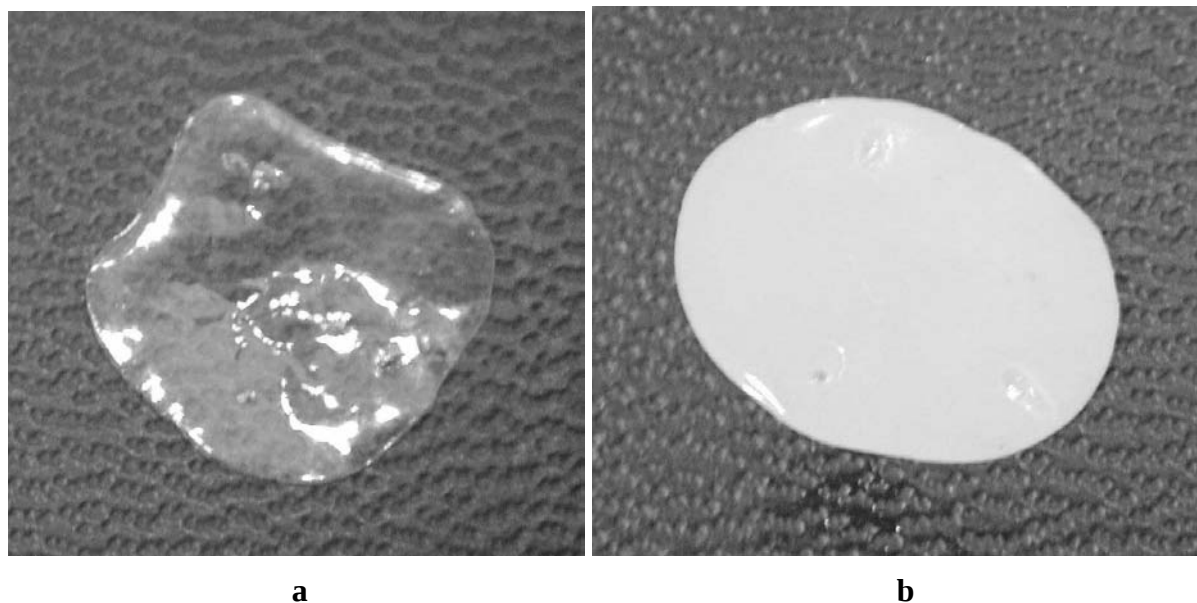


Figure 1: Polystyrene (PS) samples of pure (a) and nanocomposites ZnSe/PS (b).

Characterization and Discussion

DRX characterization shows the presence of crystallites of ZnSe with cubic structure in the polystyrene matrix which is an amorphous material (Fig. 2).

Optical characterization by UV-Visible spectroscopy (Fig. 3. a) shows the presence of excitonic peaks characteristic of ZnSe nanocrystals.

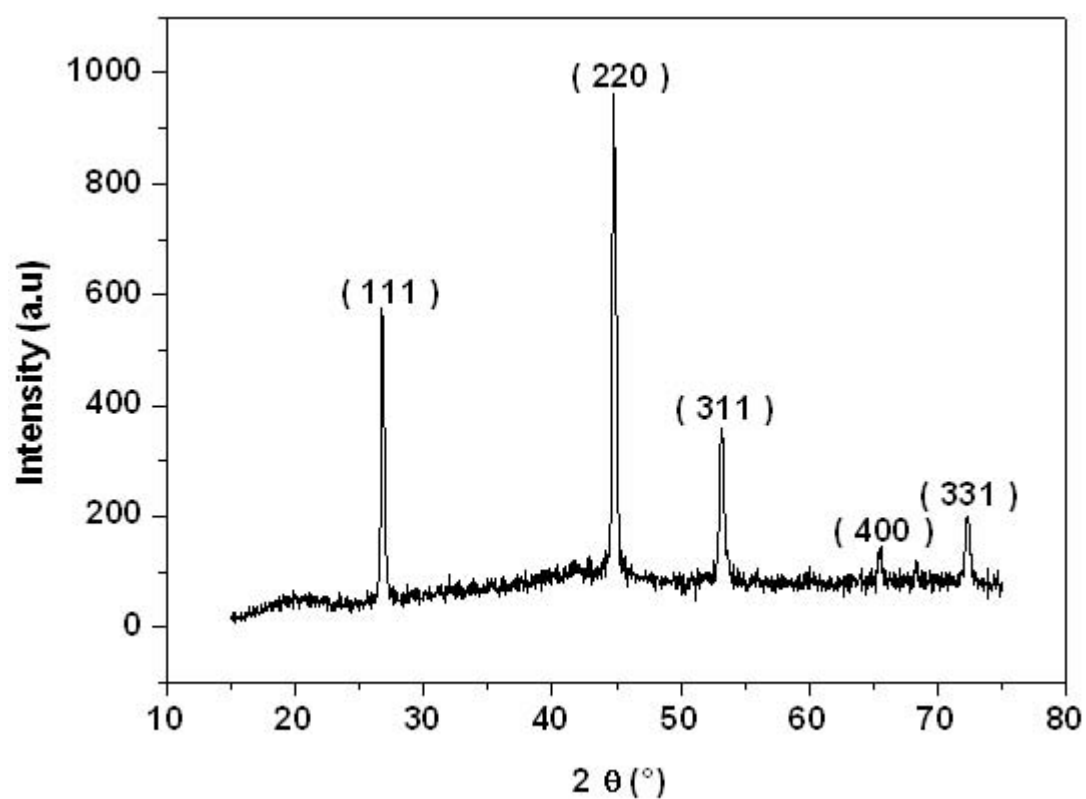
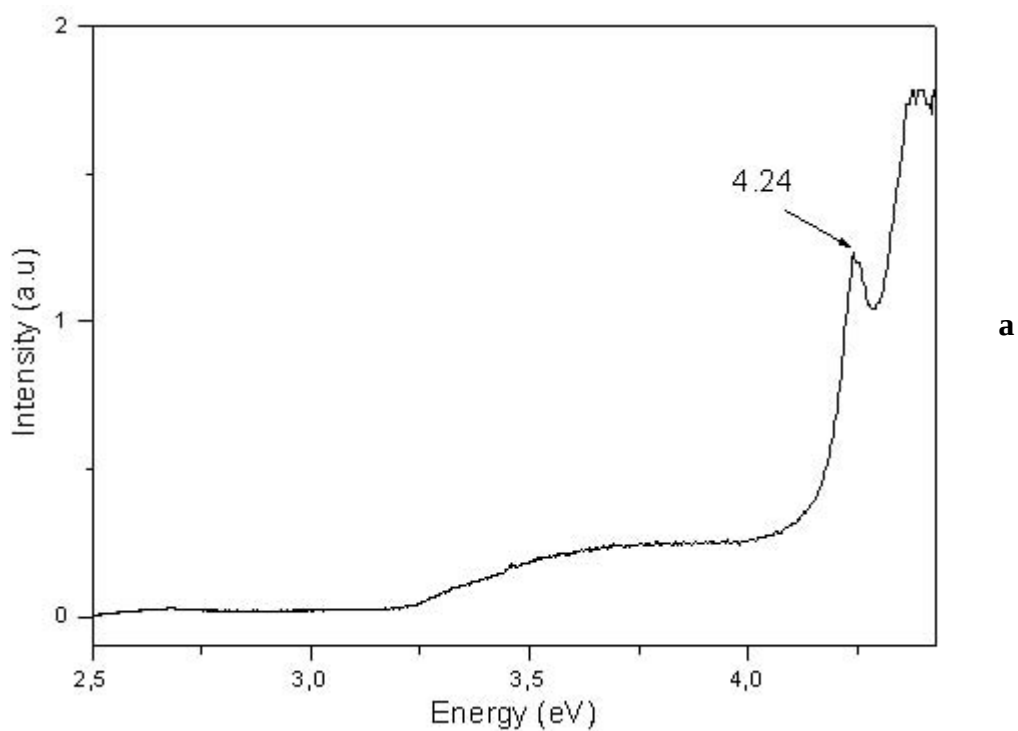


Figure 2: DRX spectrum of nanocomposites ZnSe/PS.

The photoluminescence spectrum of ZnSe crystallites dispersed in the matrix polystyrene is represented in Figure 3. (b).



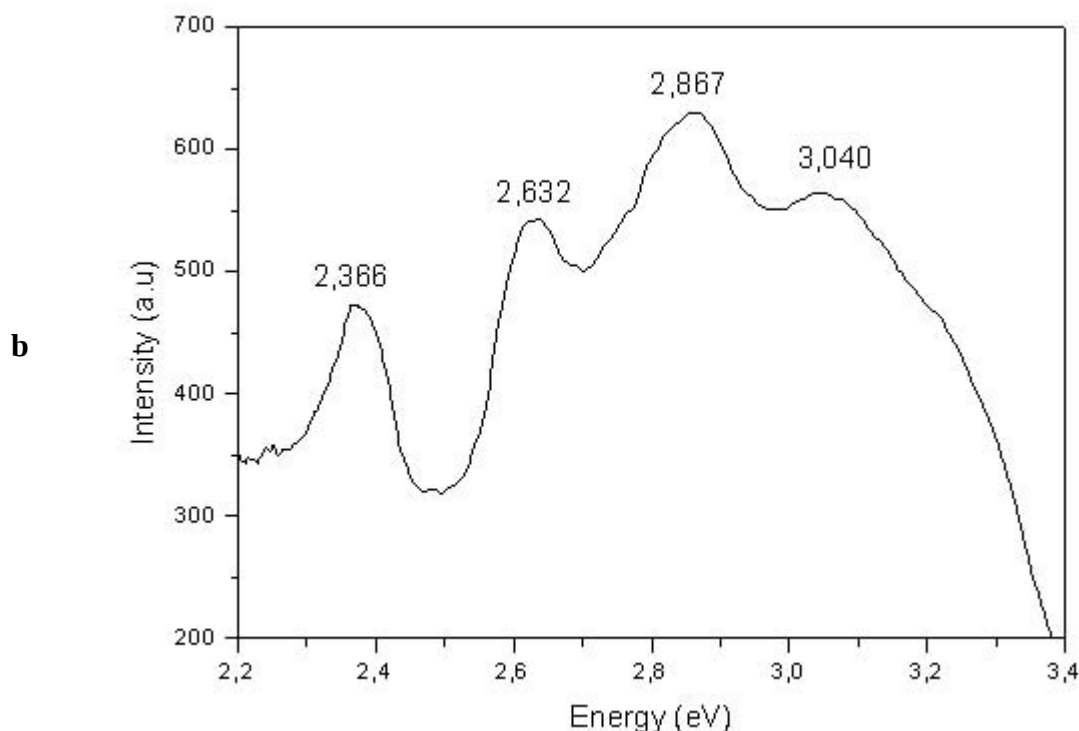


Figure 3: Optical absorption spectrum (a) and photoluminescence (b) of ZnSe/PS nanocomposites.

Photoluminescence spectrum of ZnSe/PS nanocomposites at room temperature reveals the presence of four emission bands located in the vicinity of the gap of bulk ZnSe crystal ($E_g = 2.7\text{eV}$) [9]. These bands are centred around 2.366, 2.632, 2.867 and 3.040 eV. The energy values of these bands are identical to those obtained by *Leppert and Al.* on ZnSe synthesized in the polymer [19].

The band located at 2.867 eV, near the absorption edge, is assigned to the band-to-band transition in ZnSe crystallites. This value, which is higher than the room temperature gap of ZnSe bulk crystal, indicates the increase of the gap of the ZnSe nanocrystallites. This redshift of 0.167 eV is attributed to the quantum size effect. The particle size-dependent redshift in the PL spectrum exhibited by ZnSe nanocrystals has been observed by many authors [20, 21]. The second band located at 2.633 eV could be possibly due to a defect level in ZnSe [9].

We assigned the band located around 2.366 eV to zinc vacancies [19, 22] and the intensity of this band testifies to the relatively important density of these defects. The last band (shoulder) located at 3.040 eV is probably allotted to polystyrene matrix. By examining the profile of the obtained lines one can deduce that the polystyrene constitutes a suitable medium to the incorporation of the ZnSe nanocrystallites.

Conclusion

The sample preparation method was selected for its simplicity, its moderate cost and the obtained product quality. It is possible to synthesize a great number of nanocomposites at room temperature by this method. Also, it allows a homogeneous and varied doping.

Quality of the pastilles obtained by the spin-coating method testifies that the good preparation conditions adopted.

The photoluminescence characterization showed that the studied nanocomposites present luminescence bands in the visible where optical consideration of these samples as active media is possible.

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