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Morphological and Optical Properties of Wet-chemically Synthesized ZnS Nanoparticles

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Abstract

A simple wet chemical method has been successfully deployed to synthesize ZnS nanostructures. Scanning electron microscope images revealed the formation of disc-like nanostructures. The nanoparticles have average diameter ~ 50 nm. The synthesized ZnS nanoparticles exhibit strong absorption peak at 350 nm. The band gap of the material was calculated to be 3.54 eV. The synthesized ZnS nanoparticles exhibit strong photoluminescence emission peak at 435 nm owing to sulfur vacancies in the lattice.

Keywords: Nanoparticles; Photoluminescence; Absorption; Quantum-confinement

1. Introduction

Semiconductor nanostructured materials are of keen interests to the researchers over the past two decades because of their potential optoelectronic and biomedical applications [1, 2]. Due to the small size of the nanocrystals, strong quantum confinement is observed in such nanostructures that give rise to various size dependent properties [3]. Amongst the widely studied high and direct band gap semiconductor materials the most remarkable are: ZnO, CdS, CdSe, ZnS and PbS [4-8]. Zinc Sulphide (ZnS) is gaining popularity because of high and direct band gap and its size tunability. ZnS is very popularly used as blue phosphor. In the colloidal solution blue shift of the emission is observed owing to strong quantum confinement effect. However, the specific origin of the blue PL emission from ZnS needs more investigations.

Amongst the various established methods of nanostructure synthesis, chemical synthesis method is very popular. It is a simple table top experiment and very cost effective that can be adopted in ambient laboratory environment without the maintenance of rigorous experimental conditions such as high temperature, low pressure and floe of different carrier gases. Here, in this paper, we report a simple cost-effective chemical synthesis of ZnS nanoparticles followed by typical morphological and optical characterizations.

2. Experimental

In a typical synthesis process zinc acetate aquash solution (0.2 M) was taken in a conical flask. 0.5 g of acetic acid was added to it. Sodium sulfide aquash solution (1.0 M) was then added drop-wise for 5 minutes under constant stirring. The stirring was continued for 2 hr at room temperature (31 ̂C). At the end of the reaction the precipitate was filtered using a filter

paper and washed thrice using de-ionized water for removal of any unreacted salts. The precipitate was then dried in an ordinary furnace for further characterization.
The surface morphology of the synthesized ZnS nanostructure was investigated in a ZEISS field emission scanning electron microscope (FESEM) operated at 5 kV. The UV-visible (UV-VIS) spectroscopic data were collected in a Perkin Elmer LS-55 spectrophotometer in the wavelength range 200-800 nm. The room temperature photoluminescence (PL) data were recorded in a Perkin Elmer LS-45 spectrophotometer that uses a xenon lamp as a source of excitation.

3. Results and discussions

The FESEM is a useful technique to study the surface morphology of materials. Typical FESEM image of the synthesized ZnS nanostructures is shown in Fig. 1. From the FESEM image the formation of ZnS disk-like nanoparticles is clearly observed. The nanoparticles have different sizes in the range of 20-100 nm. From the study of various FESEM images, the average particle size was estimated to be 50 nm.

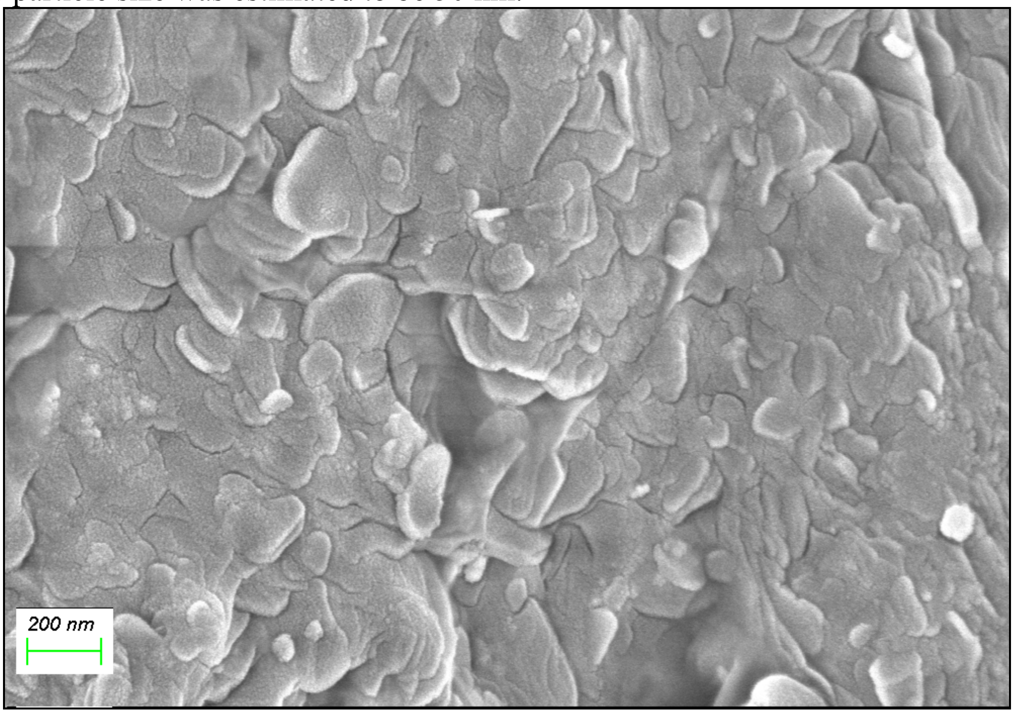

Figure 1: Typical FESEM image of synthesized ZnS nanostructures

UV-visible spectroscopy is a very useful technique to study the absorption spectrum of materials. Typical UV-VIS absorption spectrum of the synthesized ZnS nanoparticles is shown in Fig. 2. An onset absorption was observed at ~ 350 nm. This absorption onset corresponds to a direct band gap of 3.54 eV. This high and direct band gap makes ZnS a very potential candidate for optical absorber and detector applications.
Optical emission properties of materials can be investigated through photoluminescence spectroscopic study. Typical PL spectrum of the synthesized ZnS nanoparticles is shown in Fig. 3. The synthesized ZnS nanoparticles exhibit strong PL emission peak at ~ 435 nm. This blue PL emission is usually known as "self-activated". It usually happens due to vacancies of sulfur in the ZnS lattice [9]. This vacancy generated various donor sites in the crystal which has ionic character at room temperature. As a result, the conduction band is populated ta room temperature.

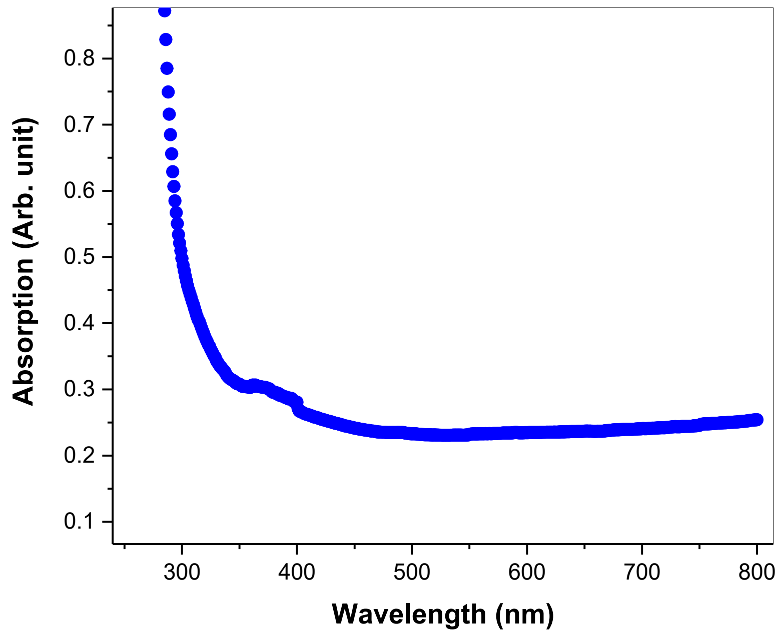

Figure 2: Typical UV-visible absorption spectrum of synthesized ZnS nanoparticles

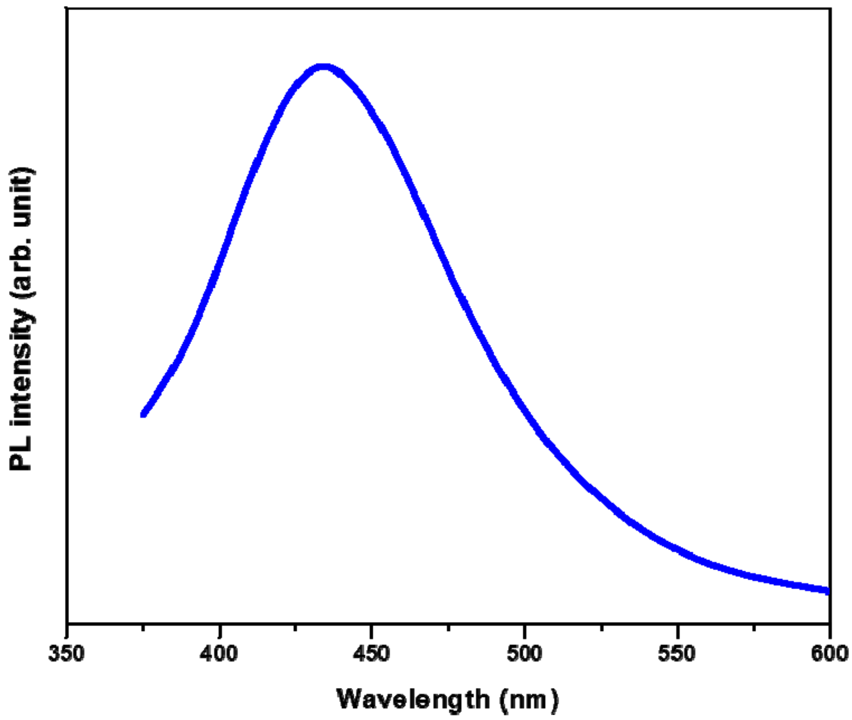

Figure 3: Typical room temperature PL spectrum of synthesized ZnS nanoparticles

4. Conclusions

In conclusion, we have successfully synthesized disk-like ZnS nanoparticles. The nanoparticles have average diameter of 50 nm. The nanoparticles have string absorption corresponding to a high and direct band gap of 3.54 eV. The ZnS nanoparticles show blue emission owing to sulfur vacancies in the lattice.

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