Photoluminescence Studies of CdS Nanoparticles

Kirti Vishwakarma, O. P. Vishwakarma and S. K. Pandey

Abstract II–VI semiconductor nanoparticles are presently of great interest for their practical applications such as zero-dimensional quantum confined materials and for their applications in optoelectronics and photonics. The optical properties get modified dramatically due to the confinement of charge carriers within the nanoparticles. Similar to the effects of charge carriers on optical properties, confinement of optical and acoustic phonon leads to interesting changes in the phonon spectra. In the present work, we have synthesized nanoparticles of cadmium sulfide (CdS) using chemical precipitation technique. A detailed study on CdS sample is done by characterizing photoluminescence (PL) spectra. Photoluminescence studies of CdS nanoparticle samples show a red shift. The intensity of red luminescence decreases and its peak position shifts to the lower energy with increasing size of the particles.

Keywords Cadmium sulfide · Nanoparticles · Photoluminescence spectra · Optical properties

Introduction

There is presently widespread interest in the physical and optical properties of nanometer-sized semiconductor particles, the so-called nanoparticles or quantum dots. It is known that the optical properties of such particles depend on their size

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[1–6]. Such particles display optical and physical properties which are intermediate between those of the bulk materials and those of the isolated molecules. For example, the optical absorption of bulk cadmium sulfide (CdS) typically extends to 690 nm. When CdS is made into 40 Å nanoparticles the longest absorption band shifts to 530 nm. In nanoparticles a large percentage of the atoms are on the surface, rather than in the bulk phase. Consequently, the chemical and physical properties of the material, such as the melting point or phase transition temperature, depend on the particle size. Nanoparticles can be made from a wide variety of materials, including CdS, ZnS, Cd_3P_2, and PbS, to name a few. The nanoparticles frequently display photoluminescence and sometimes display electroluminescence [7–12]. Additionally, some nanoparticles can form self-assembled arrays. Because of such favorable properties, nanoparticles are being extensively studied for use in optoelectronic displays. The CdS nanocrystalline has become a subject of both scientific and industrial importance in the past one decade.

Nanomaterials can be characterized using different techniques like X-ray diffraction, Ultra-violets spectroscopy, Scanning electron microscopy, Atomic force microscopy, and Tunneling electron microscopy. Many features of nanocrystals differ from those of their bulk counterparts and are dependent on their individual sizes. It has always been a prime goal, since the beginning of research in this field, to prepare samples of nanocrystals as identical as possible.

As the crystalline size decreases the band gap values increase. In principle, the band gap can be varied by changing the crystalline size. Thus, for low band gap material, one has to control the crystalline size to obtain the required band gap. Light emission from these nanocrystals is possible through a radiative recombination process of charge carriers generated by higher energy photon absorption. The color of the emission can be layered by changing the crystalline size and appropriate doping. The efficiency changes from 3 % in bulk to 18 % in nanocrystallites, leading to a tremendous improvement in the brightness of emitted light; because of the small size, the intensity of emitted light increases [13].

Experimental Support

It is a great challenge to synthesize particles of nanometer dimension with narrow size distribution without any impurity. Various methods have been attempted for the synthesis. Nanoparticles of CdS are synthesized in aqueous medium through chemical precipitation technique starting from cadmium salt and sodium sulfide, and using tri-ethanolamine as capping agent. These compounds are weighted in a microbalance. The stoichiometric solution was taken in a burette and was added in drops with continuous sitting to precipitate of CdS was formed. After complete precipitation, the solution in conical flask was constantly stirred for about 20 h. Then the precipitates were filtered out. The nanoparticles are separated from the reaction medium by centrifugation, washing, and drying. Photoluminescence

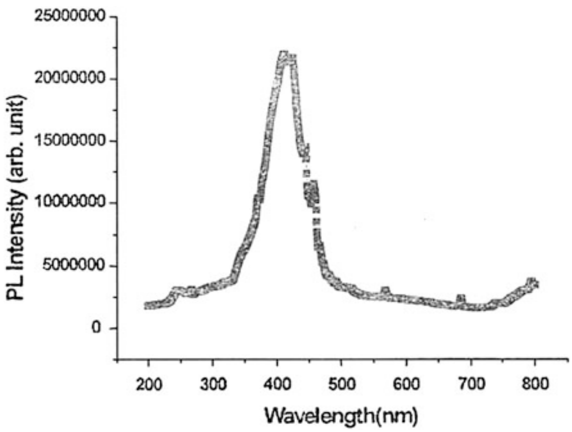

Fig. 1 Photoluminescence spectra of Cds

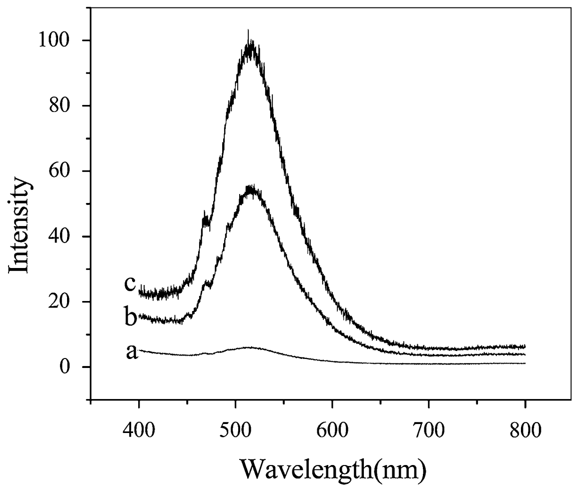

Fig. 2 Photoluminescence spectra of nanoparticles of CdS for different excitation wavelengths: **a** 300 nm, **b** 240 nm, and **c** 230 nm

of the sample is recorded using spectrofluorometer or different excitation wavelengths.

For the measurement of photoluminescence (PL) intensity, the particle was placed on a bare glass slide by using toluene and the glass slide was fixed onto the entrance slit of the monochromator. A filter was used between the sodium mercury lamp and the nanoparticles so that photoluminescence excitation can take place. By rotating the drum of the monochromator, the wavelength can be varied and thus relative PL intensity can be measured, and subsequently the PL spectra can be recorded.

Results and Discussions

Figure 1 shows the photoluminescence spectra of nanoparticles of CdS for different excitation wavelengths of 328 nm and the PL peak is about 410 nm. The luminescence from the surface states has also been observed. The peak of eigen-transition is strong and steep; the emission peak of surface states is flat and weak. The PL full-width half-maximum is only about 30 nm, it reveals the narrow size distribution of nanoparticles. Photoluminescence analysis in 400–650 nm emission wavelengths shows the well-known green emission band in CdS nanoparticles.

We have seen that the intensity peaks and its full-width half-maximum increases with increasing the crystalline size. Our result is similar to the work done [14] in 2005 by Prabhu et al. Figure 2 shows the PL spectra of CdS nanocrystal obtained [14].

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