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Photoluminescence studies on lead selenide thin films from thermal evaporation

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ABSTRACT

Thin films of PbSe are prepared by vacuum deposition technique on to well cleaned glass substrates. The film thicknesses are measured by quartz crystal monitor method. There is a blue shift in the PL Spectrum of PbSe thin films of different thicknesses were observed. A strong emission peak is observed at 606 nm. The excitation wavelength was 441 nm. This effect may be related to the quantum effects. PL emission intensity increases with thickness. The emission peak occurs at a higher wavelength than that of the absorption peaks. In fact the peak emission wavelength is invariably shifted towards red end of the spectrum compared to the peak of the absorption spectrum. This phenomenon is known as the Stokes shift.

Keywords: PbSe, Vacuum deposition, Photoluminescence Studies, Substrate, Thin films.

INTRODUCTION

PbSe has been subject to considerable research due to its technological importance in crystalline and polycrystalline forms as infrared radiation detectors, infrared emitters and solar control coatings [1-3]. Various methods employed for depositing PbSe thin films are electrochemical deposition [4, 5], chemical bath deposition (CBD) [6,7] molecular beam epitaxial growth method (MBE) [8-15] and vacuum evaporation method [16-23]. Of the various methods, vacuum evaporation method is the most widely used technique for the deposition of metals, alloys and also many compounds. This involves the evaporation for sublimation of the material in vacuum by thermal energy and allowing the vapor stream of the charge to condense on a substrate so as to form a continuous and adherent deposit of desired thickness [24]. This method is simple when

compared to the earlier methods because in proper experimental conditions it provides films of extreme purity. The present study reveals the Photoluminescence properties of PbSe thin films.

Materials and methods

The film preparation was previously described in our previous papers [25-27]. PbSe thin films are prepared by melting high purity lead selenide in a vacuum of 10^{-6} torr. Thin film samples are prepared on to well cleaned glass substrates kept to room temperature by thermal evaporation, using 12A4 Hind Hivac coating unit under a vacuum of 10^{-6} torr. Thicknesses of the films are measured using quartz crystal monitor method. A Photoluminescence (PL) spectrum of the films was recorded using a Cary Eclipse instrument in fluorescence emission scan mode with excitation Wavelength of 400nm.

RESULTS AND DISCUSSION

There is a blue shift in the PL Spectrum of PbSe thin films of different thickness shows in Fig 1, 2 & 3 which is corresponding to defect related luminescence emissions. A strong emission peak is observed at 606 nm. The excitation wavelength was 441 nm. This effect may be related to the quantum effects. As demonstrated in Fig.1, 2 and 3 that PL emission intensity increases with thickness. However, the whole PL emission spectrum covers the 555-695nm of the visible region of electromagnetic spectrum. In this experiment, several factors were found to affect the quality of the product. Light intensity can affect the particle size and morphology. The experiment results are listed in Table 1. These results are obtained by comparing present experimental route and previous experimental route [28, 29]. When the 300W high pressure indium lamp was used as light source, close to spherical PbSe particles were observed and the size of the particles is about 68, 94 and 151 nm. When 500W high pressure mercury lamp was used, about $80 \times 30 \text{ nm}^2$, $120 \times 30 \text{ nm}^2$ and $165 \times 30 \text{ nm}^2$ rectangular shape of the particles was obtained.

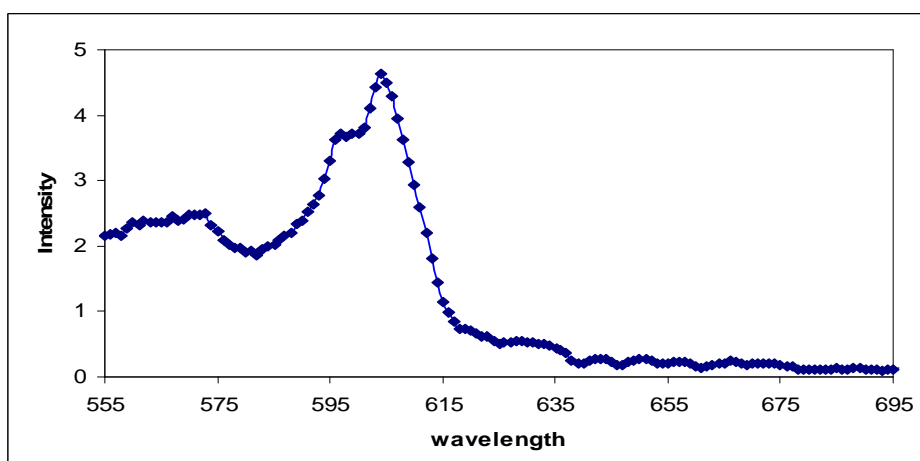


Fig.1. Photoluminescence Spectra of PbSe thin film (Emission Wavelength 606nm and Thickness 500Å)

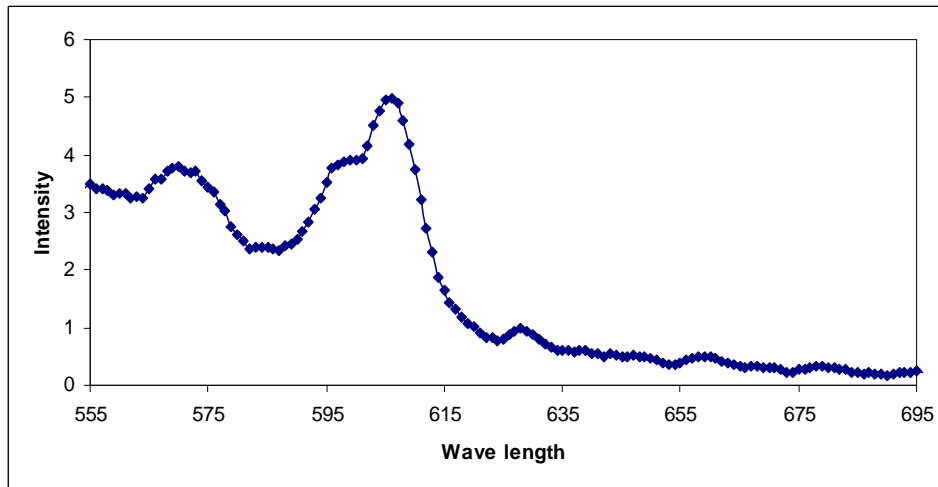


Fig.2. Photoluminescence Spectra of PbSe thin film (Emission Wavelength 606nm and Thickness 1000Å)

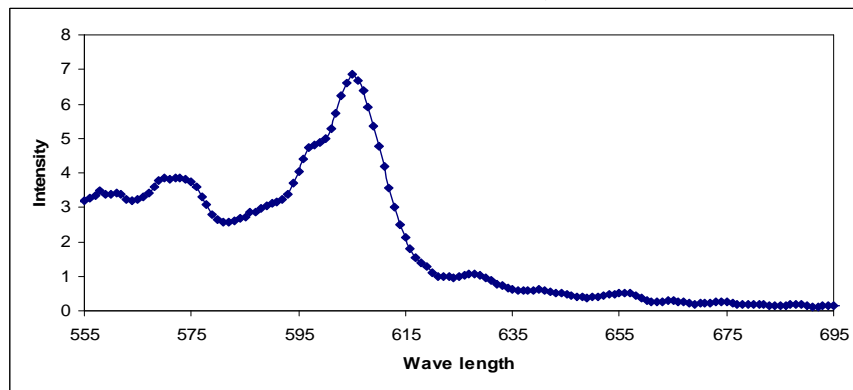


Fig.3. Photoluminescence Spectra of PbSe thin film (Emission Wavelength 606nm and Thickness 2000Å)

Table 1. Results of Characterizations different light Source

Lamp	Power (W)	Thickness (Å)	Size of PbSe (nm)	Morphology of PbSe	Time (hr)
High-pressure indium lam	300	500	68	Irregular spherical	2
		1000	94		
		2000	151		
High – pressure mercury lamp	500	500	80x30 nm ²	Rectangular	1.5
		1000	120X30nm ²		
		2000	165X30nm ²		

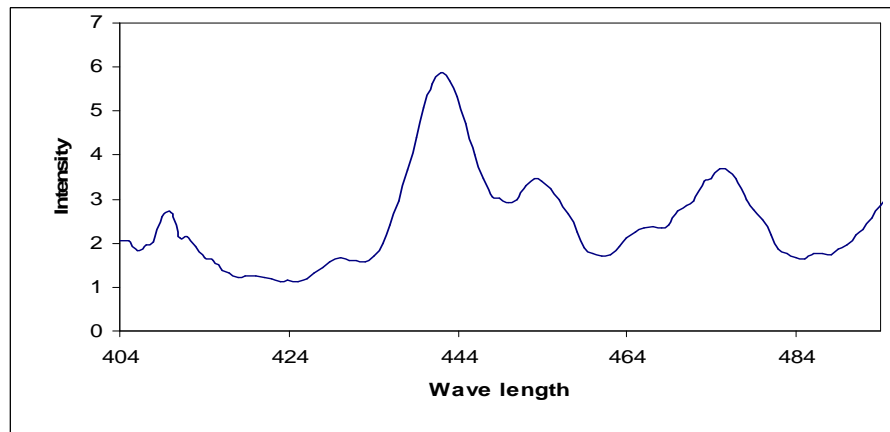


Fig.4. Photoluminescence Spectra of PbSe thin film (Excitation Wavelength 443nm and Thickness 500Å)

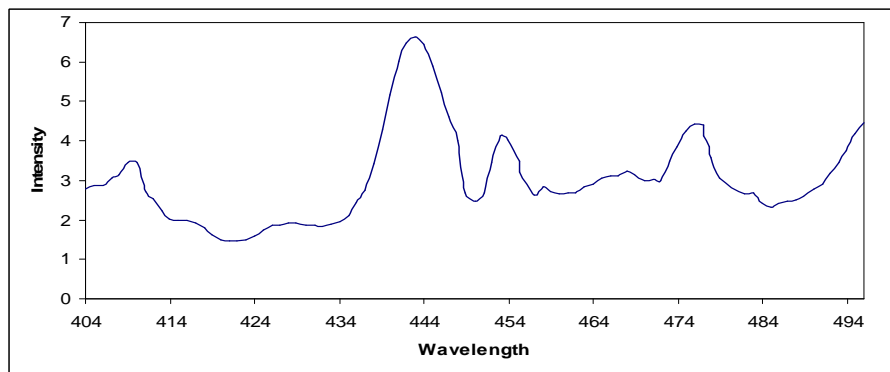


Fig.5. Photoluminescence Spectra of PbSe thin film (Excitation Wavelength 443nm and Thickness 1000Å)

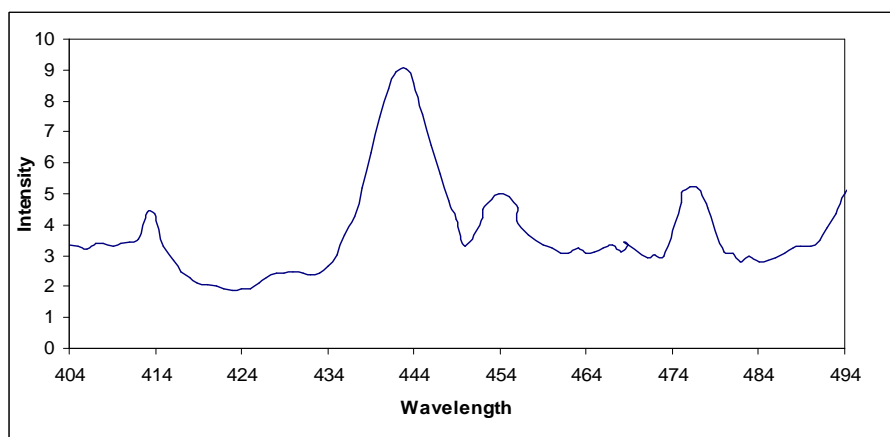


Fig.6. Photoluminescence Spectra of PbSe thin film (Excitation Wavelength 443nm and Thickness 2000Å)

It has been found that the absorption peaks occur at wavelength 411,443,453 and 476 nm (Fig.4, 5&6) and emission peak is found at approximately 606 nm (Fig 1, 2 & 3). The emission peak occurs at a higher wavelength than that of the absorption peaks. In fact the peak emission wavelength is invariably shifted towards red end of the spectrum compared to the peak of the absorption spectrum. This phenomenon is known as the Stokes shift, which finds commercial application in the fluorescent lamps [30]. Fig 4, 5, and 6. Shows the Photoluminescence spectra of PbSe thin films of thickness 500Å, 1000Å and 2000Å. The wave length range is 400-500 nm. The figure shows a broad emission of one dominant peak at 441 nm for all films. The luminescence increase, when the temperature increases, due to the improved crystallinity of the films. The peak intensity in the case of higher thickness films is much higher compare to that of lower thickness films. This could be due to shape effect. The shape of the materials has an important effect on the PL intensity [31]. Other peaks at 411nm at seem to be associated to free electron to neutral to the presence of acceptor and native donor defects. Figure 4, 5 and 6 shows emission spectra of the PbSe thin films. Photoluminescence spectra have been recorded at room temperature with an excitation of wavelength of 441 nm for all the thickness. About 4 emission peaks are observed in the wavelength range 400-500 nm (Blue, Green, Yellow and Red band emission). This future corresponds to Donor Acceptor pair transition between a Selenium vacancy and a Lead vacancy. The peak seems to consist of two components due to the possibility of double structure in the Selenium vacancy which may act as doubly ionized donor. All the emissions are associated with defects emerging during the growth of crystallites and are related to deformation of Crystallinity due to dislocations and large vacancies [32].

CONCLUSION

A strong emission peak is observed at 606 nm. The excitation wavelength was 441 nm. PL emission intensity increases with thickness. The emission peak occurs at a higher wavelength than that of the absorption peaks. In fact the peak emission wavelength is invariably shifted towards red end of the spectrum compared to the peak of the absorption spectrum. This phenomenon is known as the Stokes shift.

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