International Journal of Physics and Mathematical Sciences ISSN: 2277-2111 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jpms.htm
2016 Vol. 6 (4) October-December, pp. 96-100/ Ibrahim and Salame
Research Article

THICKNESS DEPENDENT PHYSICAL PROPERTIES OF LEAD SELENIDE THIN FILMS DEPOSITED BY CHEMICAL BATH DEPOSITION METHOD

***Syed Ghause Ibrahim[1] and Paresh.H.Salame[2]**
[1]Nanostructured Thin Film Materials Laboratory, Department of Engineering Physics, Prof. Ram Meghe College of Engineering & Management, Badnera 444701, Maharashtra, India
[2]Department of Engineering Sciences (Physics), Laxminarayan Institute of Technology, Nagpur 440010, Maharashtra, India
**Author for Correspondence*

ABSTRACT
Lead Selenide thin films have been deposited onto glass substrate by using chemical bath deposition method at 353K. The structural study revealed that lead selenide thin films are nanocrystalline in nature with cubic lattice having preferred orientation along (200) plane. The optical band gap of the deposited film was found to be 2.50 eV and it decreases to 2.12 eV with increase in thickness. The electrical resistivity of lead selenide thin films is found to be of the order of 10^2 Ωcm. The thermo-emf measurement confirms n-type conductivity of the thin films.

Keywords: *Thin Films, Nanostructures, Physical Properties, N-Type Conductivity*

INTRODUCTION
Nanostructured polycrystalline thin film semiconductors have attracted much interest in an expanding variety of applications in various electronic and optoelectronic devices. The technological interest in polycrystalline based devices is mainly due to their economic production costs. The lead selenide thin films attract attention of many researchers due to non-toxic, economically cheaper, abundant and there semiconductor properties. Recently, extensive research has been devoted to grow various kinds of binary and ternary semiconductor thin films. This is due to their potential applications in the area of solar cells, photoconductors, sensor and infrared detector devices. It has been found that the microstructure and the electrical properties of thin films are different from the properties reported for the bulk material with the same composition.
Lead selenide thin films were deposited by using various methods such as electrochemical deposition (Saloniemi *et al.,* 1998; Molin and Dikusar, 1995), chemical bath deposition (Hankare *et al.,* 2003; Shandalov *et al.,* 2008) molecular beam epitaxial growth method (Fang *et al.,* 1998; Wu *et al.,* 1999; Muller *et al.,* 1996), vacuum evaporation method (Zogg *et al.,* 1994; Sachar *et al.,* 1999; Silverman SJ and Levinstein, 1954; Kumar *et al.,* 2005; Damodara *et al.,* 1989; Seetharama Bhat and Damodara Das, 1985; Damodara Das and SeetharamaBhat, 1990; Ali *et al.,* 1995) etc. In the present paper, thickness dependent physical properties of lead selenide thin films deposited by chemical bath deposition method onto glass substrates at 353K was studied.

MATERIALS AND METHODS
Nanostructured lead selenide thin films were deposited on glass substrate using chemical bath deposition method. Prior to deposition, the glass slide was degreased in ethanol for 10 min, followed by ultrasonically cleaned with doubled distilled water for another 15 min and finally dried in air. An aqueous solution of lead nitrate [$Pb(NO_3)_2$] was used as lead source, sodium selenosulphide [Na_2SeO_3] as sulfide source and TEA [$N(CH_2H_2OH)_3$] as complexing agent for depositing lead selenide thin films. For deposition, 20 ml of 0.2 M lead nitrate was complexed with 10 ml of 0.2 M TEA solution. Then, 20 mL of 0.2 M sodium selenosulphide was added slowly to the reaction mixture. The clean glass slide was vertically immersed into the chemical bath solution. After the deposition time of 90 min, 120 min, 150

min and 180 min the glass slides were taken out of the bath, washed with distilled water and dried in desiccators for further characterization.

The average thickness of the as deposited lead selenide thin film was measured by the gravimetric method.

RESULTS AND DISCUSSION

Structural Analysis

The structural studies were carried out using Philips PW 1710 diffractometer with Cu-Kα radiation of wavelength 1.5405 Å.X-ray diffraction patterns of chemically deposited lead selenide thin films with different thickness at 353 K were recorded by varying diffraction angle (2θ) from 10 to 80degree. Figure 1 shows the XRD pattern of lead selenide thin film with different thickness. The pattern shows well defined (111), (2 0 0), (2 2 0), (311) and (2 2 2) peaks with cubic lattice having preferred orientation along (200) plane. Comparison of observed and standard XRD data of Lead selenide thin films is shown in table 1.

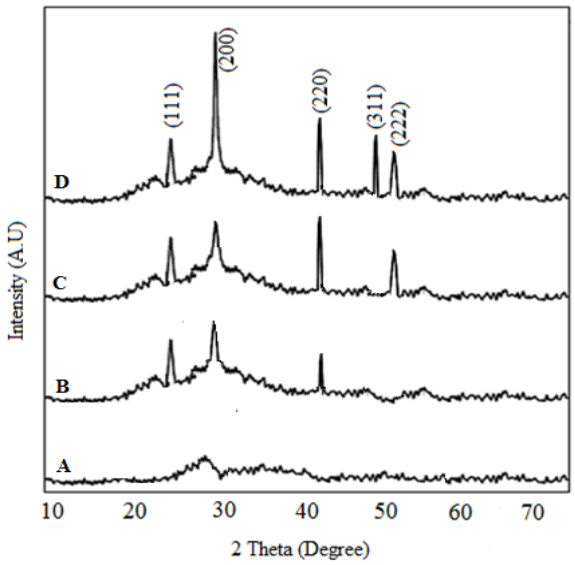

Figure 1: XRD Pattern of Lead Selenide Thin Film Deposited with Different Thickness

Table 1: Comparison of Observed and Standard XRD Data of Lead Selenide Thin Films with Different Thickness (JCPDS card 78-1903)

Film	Observed Data		Standard Data			
	2θ(degree)	d (A^0)	2θ(degree)	d (A^0)	hkl	Phase
A	---	---	---	---	---	---
B	25.501	3.530	25.179	3.534	1 1 1	PbSe
	29.201	3.057	29.154	3.060	2 0 0	PbSe
	41.561	2.168	41.701	2.164	2 2 0	PbSe
C	25.501	3.530	25.179	3.534	1 1 1	PbSe
	29.201	3.057	29.154	3.060	2 0 0	PbSe
	41.561	2.168	41.701	2.164	2 2 0	PbSe
	51.803	1.751	51.688	1.767	2 2 2	PbSe
D	25.501	3.530	25.179	3.534	1 1 1	PbSe
	29.201	3.057	29.154	3.060	2 0 0	PbSe
	41.561	2.168	41.701	2.164	2 2 0	PbSe
	49.467	1.840	49.336	1.845	3 1 1	PbSe
	51.803	1.751	51.688	1.767	2 2 2	PbSe

Morphology

The surface morphological studies were carried out using scanning electron microscope (JSM 6100)**.** Figure 2 shows, SEM images of lead selenide thin films deposited with different thickness which reveals that, the films are uniform in nature with well defined grains. However, the grain growth is observed with thickness. The cubic shaped lead selenide crystal covered the glass substrate surface.

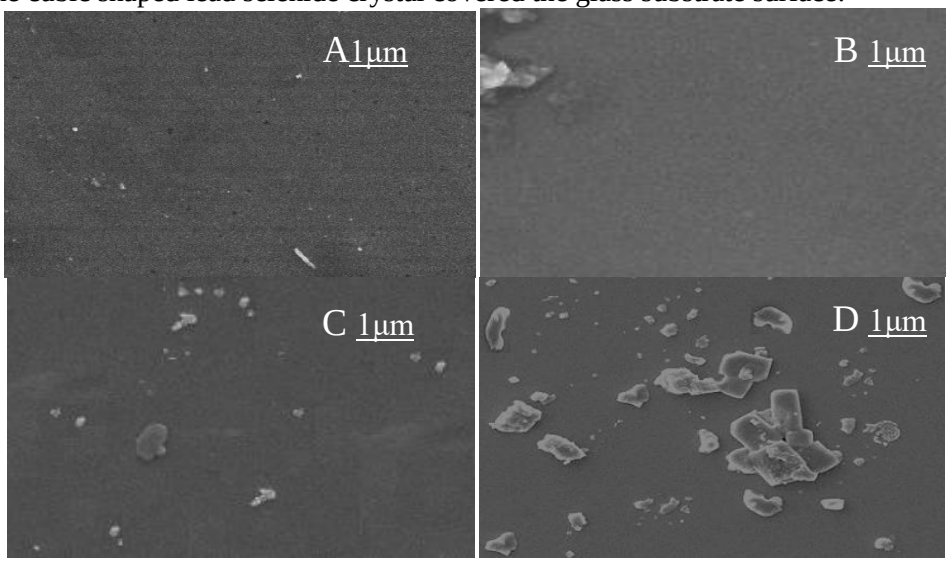

Figure 2: SEM Image of Lead Selenide Thin Film Deposited with Different Thickness

Optical Analysis

The energy gap "Eg" oflead selenide thin film sample was determined from optical transmission. The photons with energies greater than the band gap energy are absorbed while photons with energies less than the band gap are transmitted. The optical absorption is characterized by the relation between the absorption coefficient (α) and the photon energy (hυ) for different allowed transitions as,

$$\alpha = \frac{A(h\upsilon - Eg)^n}{h\nu} \qquad (1)$$

Where,

'α' is absorption coefficient, A is constant,

'hυ' is photon energy,

'Eg' is the optical band gap energy.

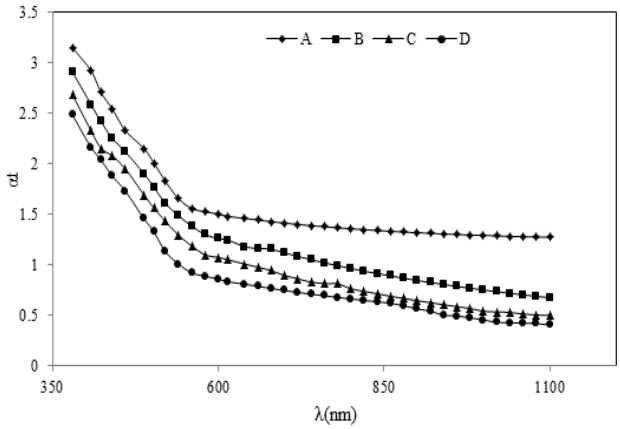

Figure 3: Variation of Optical Absorption vs. Wavelength for Lead Selenide Thin Film Deposited with Different Thickness

The plots of $(\alpha h\upsilon)^2$ versus $h\upsilon$ is shown in Figure 4. The variation of $(\alpha h\upsilon)^2$ with $h\upsilon$ for the as deposited thin film is a straight line. The linear nature of the plots indicated the existence of direct transitions. The value of Eg for lead selenide thin film was found to be 2.50 eV and it decreases to 2.12 eV with increase in film thickness.

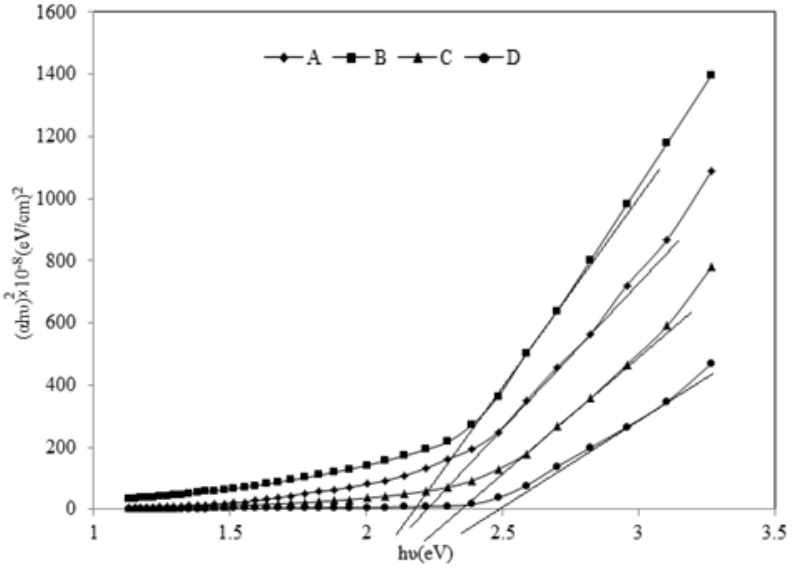

Figure 4: Plot of $(\alpha h\upsilon)^2$ vs. $h\upsilon$ for Lead Selenide Thin Film Deposited with Different Thickness

Conclusion

In the present paper, effect of thickness on physical properties of lead selenide thin films deposited by chemical bath deposition method at 353K has been reported. The structural study revealed that lead selenide thin films are nanocrystalline in nature with cubic lattice having preferred orientation along (200) plane. The optical band gap of the deposited film was found to be 2.50 eV and it decreases to 2.12 eV with increase in film thickness. The electrical resistivity of lead selenide thin films is found to be of the order of 10^2 Ωcm. The thermo-emf measurement confirms n-type conductivity of lead selenide thin films.

REFERENCES

Ali MS, Khan KA and Khan MSR (1995). Temperature effect on the electrical properties of lead selenide thin films. *Physica Status Solidi (a)* **149**(2) 611-618.

Damodara Das V and Seetharama Bhat K (1989). Electrical conductivity of air-exposed and unexposed lead selenide thin films: Temperature and size effects. *Physics Review* **40** 7696-7703.

Damodara Das V and SeetharamaBhat K (1990). Temperature variation of thermoelectric power of vacuum deposited PbSe thin films and its thickness dependence. *Journal of Material Science and Material Electronics* **1**(4) 169-174.

Fang XM, Yuan S, Liu WK and Santos MB (1998). Molecular beam epitaxial growth of $Bi_2Se_3Bi_2Se_3$- and Tl_2SeTl_2Se-doped PbSe and PbEuSe on CaF_2/Si(111). *Journal of Vacuum Science and Technology B* **16**(3) 1459-1462.

Hankare PP, Delekar SD, Bhuse VM, Garadkar KM, Sabane SD and Gavali LV (2003). Synthesis and characterization of chemically deposited lead selenide thin films. *Journal of Materials Chemistry and Physics* **82**(3) 505-508.

Kumar S, Khan ZH, MajeedKhan MA and Husain M (2005). Studies on thin films of lead chalcogenides. *Current Applied Physics* **5**(6) 561-566.

Molin AN and Dikusar AI (1995). Electrochemical deposition of PbSe thin films from aqueous solutions. *Thin Solid Films* **265**(1-2) 3-9.

Muller P, Fach A, John J, Tiwari AN, Zogg H and Kostorz G (1996). Structure of epitaxial PbSe grown on Si(111) and Si(100) without a fluoride buffer layer. *Journal of Applied Physics* **79**(4) 1911-1916.

Sachar HK, Chao I, McCann PJ and Fang XM (1999). Growth and characterization of PbSe and $Pb_{1-x}Sn_xSePb_{1-x}Sn_xSe$ on Si (100). *Journal of Applied Physics* **85**(10) 7398-7403.

Saloniemi H, Kanniainen T, Ritala M, Leskela M and Lappalainen R (1998). Electrodepo-sition of lead selenide thin films. *Journal of Material Chemistry* **8**(3) 651-654.

Seetharama Bhat K and Damodara Das V (1985). Electrical-conductivity changes in PbTe and PbSe films on exposure to the atmosphere. *Physics Review B* **32** 6713-6719.

Shandalov M, Makai JP, Balazs J, Horvath JSH, Gutman N, Saar A and Golan Y (2008). Optical properties of size quantized PbSe films chemically deposited on GaAs. *The European Physical Journal Applied Physics* **41**(1) 75-80.

Silverman SJ and Levinstein H (1954). Electrical Properties of Single Crystals and Thin Films of PbSe and PbTe. *Physics Review* **94** 871-876.

Wu HZ, Fang XM, Salas R Jr, McAlister DM and McCann PJ (1999). Molecular beam epitaxy growth of PbSe on BaF_2BaF_2-coated Si(111) and observation of the PbSe growth interface. *Journal of Vacuum Science and Technology B* **17** 1263-1266.

Zogg H, Blunier S, Fach A, Maissen C, Müller P, Teodoropol S, Meyer V, Kostorz G, Dommann A and Richmond T (1994). Thermal-mismatch-strain relaxation in epitaxial CaF_2, BaF_2/CaF_2, and $PbSe/BaF_2/CaF_2$ layers on Si(111) after many temperature cycles. *Physics Review B* **50** 10801-10810.