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

*Syed Ghouse 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 \(10^2\) \(\Omega\)cm. 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 \([\text{Pb(NO}_3\text{)}_2]\) was used as lead source, sodium selenosulphide \([\text{Na}_2\text{SeO}_3]\) as sulfide source and TEA \([\text{N(CH}_3\text{H}_2\text{OH})_3]\) 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), (3 1 1) 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](image)

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

<table>
<thead>
<tr>
<th>Film</th>
<th>Observed Data</th>
<th>Standard Data</th>
<th>hkl</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2θ(degree)</td>
<td>d (Å)</td>
<td>d (Å)</td>
<td>hkl</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.501</td>
<td>3.530</td>
<td>25.179</td>
<td>3.534</td>
</tr>
<tr>
<td></td>
<td>29.201</td>
<td>3.057</td>
<td>29.154</td>
<td>3.060</td>
</tr>
<tr>
<td></td>
<td>41.561</td>
<td>2.168</td>
<td>41.701</td>
<td>2.164</td>
</tr>
<tr>
<td></td>
<td>51.803</td>
<td>1.751</td>
<td>51.688</td>
<td>1.767</td>
</tr>
<tr>
<td></td>
<td>25.501</td>
<td>3.530</td>
<td>25.179</td>
<td>3.534</td>
</tr>
<tr>
<td></td>
<td>29.201</td>
<td>3.057</td>
<td>29.154</td>
<td>3.060</td>
</tr>
<tr>
<td></td>
<td>41.561</td>
<td>2.168</td>
<td>41.701</td>
<td>2.164</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.501</td>
<td>3.530</td>
<td>25.179</td>
<td>3.534</td>
</tr>
<tr>
<td></td>
<td>29.201</td>
<td>3.057</td>
<td>29.154</td>
<td>3.060</td>
</tr>
<tr>
<td></td>
<td>41.561</td>
<td>2.168</td>
<td>41.701</td>
<td>2.164</td>
</tr>
<tr>
<td></td>
<td>49.467</td>
<td>1.840</td>
<td>49.336</td>
<td>1.845</td>
</tr>
<tr>
<td></td>
<td>51.803</td>
<td>1.751</td>
<td>51.688</td>
<td>1.767</td>
</tr>
</tbody>
</table>
**Research Article**

**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.

![SEM Image of Lead Selenide Thin Film Deposited with Different Thickness](image)

**Optical Analysis**

The energy gap “Eg” of lead 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 (hν) for different allowed transitions as,

\[ \alpha = \frac{A(h\nu-Eg)^n}{h\nu} \]  \hspace{1cm} (1)

Where,

- ‘α’ is absorption coefficient,
- A is constant,
- ‘hν’ is photon energy,
- ‘Eg’ is the optical band gap energy.

![Variation of Optical Absorption vs. Wavelength for Lead Selenide Thin Film Deposited with Different Thickness](image)
The plots of \((\alpha h\nu)^2\) versus \(h\nu\) is shown in Figure 4. The variation of \((\alpha h\nu)^2\) with \(h\nu\) 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 \(E_g\) 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 \((\alpha h\nu)^2\) vs. \(h\nu\) for Lead Selenide Thin Film Deposited with Different Thickness](image)

**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 \(10^2\) \(\Omega\)cm. The thermo-emf measurement confirms n-type conductivity of lead selenide thin films.

**REFERENCES**


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


Wu HZ, Fang XM, Salas R Jr, McAlister DM and McCann PJ (1999). Molecular beam epitaxy growth of PbSe on BaF$_2$/BaF$_2$-coated Si(111) and observation of the PbSe growth interface. *Journal of Vacuum Science and Technology B* 17 1263-1266.