Room Temperature Chemically Synthesized Nanocrystalline PbS Thin Films

V. A. Chavan, V. D. Phadtare, V. S. Jamadade and C. D. Lokhande*
Department of Physics, Shivaji University, Kolhapur- 416004, Maharashtra, India
**Corresponding Author:l_chandrakant@yahoo.com*

Abstract. Nanocrystalline PbS thin films were deposited onto glass and stainless steel substrates by chemical deposition and successive ionic layer adsorption and reaction (SILAR) methods at room temperature (300K). The structural properties of PbS films were studied by means of X-ray diffraction. Optical and surface wettability properties of PbS films were investigated. X-ray diffraction analysis shows nanocrystalline nature of PbS thin films. From optical absorbance studies, optical band gaps 2.2 eV and 2.14 eV were obtained for CBD and SILAR deposited PbS thin films. The SEM shows that film is dense, homogeneous, without visible pores. From thermo-emf studies, electrical conductivity was found to be p-type material. Surface wettability studies suggested hydrophilic nature with water contact angles of about 66^0 and 75^0, respectively.

Keywords: Thin film, Optical, Electrical, Surface wettability,

1. INTRODUCTION

Thin solid films of PbS have been a subject of interest for many years, mainly because of their photoconductive properties. This material has also been used as photo resistance, diode lasers, humidity and temperature sensors, decorative coatings and solar control coatings, among others applications. For these reasons, many research groups have an increasing interest in the development and study of the material However, many of their physical properties were found to be depending on the methods and conditions of preparation. They were usually prepared by the methods of chemical deposition on glass substrates using different solutions in alkaline media.[1]

It is well known that the chemical bath deposition technique (CBD) and SILAR are the most convenient and frequently used deposition technique to grow PbS thin films. This are relatively inexpensive, simple and convenient for large area deposition. And does not require any sophisticated instruments.

It has been found that the properties of chemically deposited PbS thin films depend strongly on the growth conditions.

Samples of Lead Sulfide are prepared by using Chemical bath deposition as well as SILAR method. In this work we investigated the effect of deposition time and number of cycles on the chemically deposited Lead sulphide thin films at room temperature.

2. EXPERIMENTAL PROCEDURE

2.1 Synthesis Of PbS Thin Films

a) By chemical bath deposition method

PbS thin films are grown on an amorphous glass substrates by using Chemical deposition as well as SILAR method. In CBD, the deposition was done in a reactive solution prepared in a 50 ml beaker containing 0.1 molar solutions of lead acetate and thiourea. The pH of the solution was adjusted as 11 with the help of ammonia solution. The well cleaned glass substrates mounted on substrate holder and keep in the prepared solution at room temperature. The depositions are taken at different deposition time.

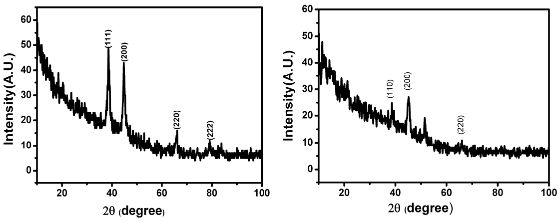
b) By successive ionic layer adsorption and reaction method

The SILAR deposition is maintained at room temperature. Aqueous precursor solutions used were 0.1 M lead acetate [$Pb(CH_3COO)_2.3H_2O$] and 0.1 M sodium sulfide [Na_2S] with complexing agent Triethaloamine for adjusting the pH as 8 and 12 respectively. The SILAR deposition was carried out with adsorption and reaction time as 10 s at room temperature. The no. of cycles varies for getting desired film thickness.

3. RESULTS AND DISCUSSION

3.1 X-Ray Diffraction Studies

The structural analysis of PbS film was studied using X-ray diffraction technique. Fig.1 shows the as deposited X- ray diffraction pattern of PbS film on to glass substrate. XRD patterns show nanocrystalline cubic structure.



a) CBD method b) SILAR method

Figure 1-X-ray diffractogram of chemically deposited PbS thin film.

3.2 Optical Studies

The optical absorption is characterized by the relation between the absorption coefficient (α) and the photon energy (hν) for different allowed transitions as

$$\alpha h\nu = A(h\nu - Eg)^n \qquad (2)$$

Where Eg is band gap energy. The band gap energy of PbS deposited by CBD and SILAR method was 2.2 eV and 2.14 eV [2].

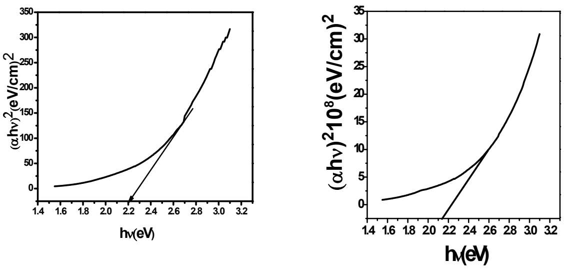


Figure 2 a) CBD method b) SILAR method

3.3 Surface Morphological Studies

The SEM image of PbS thin film deposited onto a glass substrate at 5,000 X magnification. The scale bar length is 5 nm. It is observed that the film is dense, homogeneous, without visible pores and well covered to the substrate.

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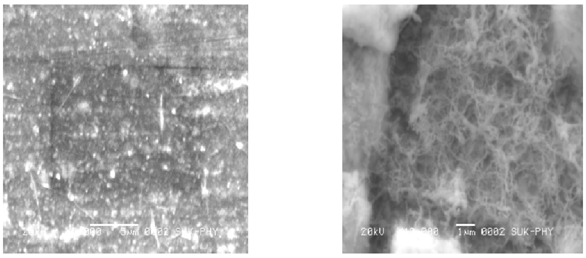

Figure 3 a) CBD method b) SILAR method

3.4 Contact Angle

The water contact angle of PbS thin film was measured which is hydrophilic in nature with value 75^0 for CBD and 66^0 for SILAR method.

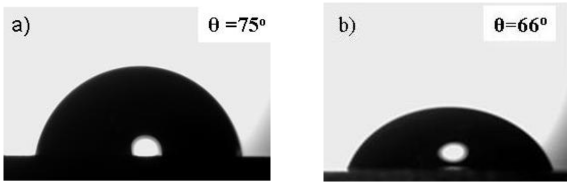

Figure 4 a) CBD method b) SILAR method

3.5 Thickness Measurement

The rate of PbS thin films growth is mostly dependent on the rate of release of Pb^{2+} and S^{2-} ions from the complexed bound state. This is achieved by controlled precipitation of PbS in the reaction bath. Table.1 shows the variation of thickness of PbS thin film in both CBD and SILAR methods.

CBD		SILAR	
Deposition Time (h)	**Thickness (µm)**	**No. of Cycles**	**Thickness (µm)**
5	0.1325	60	0.0744
10	0.1648	70	0.0994
15	0.2058	80	0.1571
20	0.1904	90	0.0560

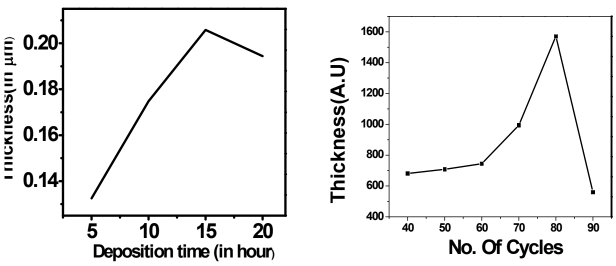

Figure 5 a) CBD method b) SILAR method

CONCLUSION

From optical studies, direct band gap was found to be 2.2 eV for CBD and 2.14 eV for SILAR method. X-ray diffraction pattern shows nanocrystalline nature with cubic structure. The SEM shows homogeneous, fine grained and well covered to the substrate. The water contact angle shows hydrophilic nature with value 75^0 for CBD and 66^0 for SILAR method.

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