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Optical and Microstructural Analysis of Chemically prepared Lead Sulphide (PbS) Thin Film

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ABSTRACT

This paper presents thin films of Lead Sulphide grown by a chemical bath deposition method, using triethanolamine as complexing agent. The films were deposited on both surface of the glass substrate at deposition time of 4hours.The effect of annealing on transmisivity and reflectivity of chemically deposited lead sulphide thin film were studied. Optical microscope and scanning electron microscope SEM were used for measurements. The average grain sizes in the as prepared films were estimated to be 1.3μm while that of the annealed film was estimated to be 2.5μm.

Keywords: *thin films, prepared, annealing, chemical bath deposition, optical properties, microstructures, transmittance, reflectance, prepared sample, annealed sample*

INTRODUCTION

Chemical bath deposition is a widely used materials processing technology. The majority of its application involves applying solid thin-film coatings to surfaces, but it is also used to produce high-purity bulk materials and powders, as well as fabricating composite materials via infiltration techniques [1]. Lead sulphide is a semiconductor material with an approximate energy band gap of 0.4 eV at 300 K [2]. These properties make PbS very suitable for infrared detection application. This material has also been used in photography, solar absorption. In addition, PbS has been utilized as photo-resistance, diode lasers, humidity and temperature sensors, decorative and solar control coatings [3, 4]. These properties have been correlated with the growth conditions and the nature of substrates. For these reasons, many research groups have shown a great interest in the development and study of this material the properties exhibited and determine the transmittance and reflectivity when annealed. Then viewing the PbS samples developed under optical microscope and electron microscope to know the microstructural properties [5, 6].

There are several methods used in photoacelerated chemical deposition, microwave heating [7]. Chemical bath deposition is presently attracting considerable attention as it does not require sophisticated instrumentation [8]. It is relatively inexpensive, easy to handle, convenient for large area deposition and capable of yielding good quality thin films. The characteristics of chemically deposited PbS thin films by CBD strongly depend on growth conditions. In this paper, we report the structural and optical properties of annealed PbS thin films obtained by CBD method for 4 hours.

2.0 Experimental

2.1 Synthesis of lead sulphide

The PbS thin films were grown on ordinary glass slide (5cm×5cm×2mm) substrates. The deposition was done in a reactive solution prepared were constituted from aqueous solution of 1.0 mole of lead acetate, 1.0 mole of thiourea and 1.0 mole Tri-Ethanol Amino

(TEA). Sodium Hydroxide (NaOH) was added to the solution to give a pH value between 9 and 10. Cleaned substrates were vertically immersed into the solution. The concentration of the reagents, at pH (between 9 and 10) with temperature of 300 K was considered for deposition time for 4hrs. The formation of PbS thin film involves the following chemical reactions.

$$Sc(NH_2) + OH \longrightarrow CH_2N_2 + H_2O + HS$$
$$2HS + 2OH \longrightarrow 2H_2O + S_2$$
$$Pb^{2+} + S^{2+} \longrightarrow PbS$$

Glass substrates were removed after 4hours deposition time. One sample was set aside as prepared and the other samples were placed in electric oven for anneling at 423 K for 1 hour [9]

3.0 Results and Discussion

3.1 Microstructure

The films were structurally characterized by scanning electron microscope (model XL 20 SEM) with working voltage of 40 kV and current 10mA at

($\lambda = 1.54040\ \mathring{A}$). The micrograph from SEM for both prepared and annealed samples were shown in Fig. 1 and 2 respectively. The micrograph in Fig. 1 shows a pyramidal shape with a compact surface without any fissures, faults and disturbances. There was presence of precipitates on the sample surface with poor crystalline structure. The micrograph in Fig. 2 shows, the formation of new grains in the recrystallized region. It shows less dislocation density. It was also noticed that the average grain size for the prepared sample was 1.8 μm while that of annealed sample was found to be 2.5μm.

Figure 1: The micrograph from SEM for prepared sample

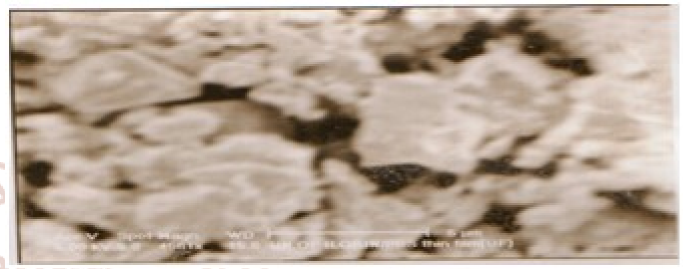

Figure 2: The micrograph from SEM for annealed

Transmittance and reflectance measurements at near-normal incidence were performed over a spectral ranging between 0.30 μm and 0.70 μm thin films deposited on glass substrate using optical microscope. Fig 3 shows the optimal transmission spectra of prepared and annealed samples of lead sulphide. It was observed that the higher transmittance of 70% was obtained for annealed sample while that of prepared sample is 50% at 0.70 μm wavelength. Fig 4 shows the optical reflectance spectra of the prepared and annealed samples of the lead sulphide. It was observed that the reflectance of the annealed sample is 6% while that of prepared is 12% at 0.70 μm, at 0.30 μm wavelength the reflectance of the prepared sample is 0% while that of annealed sample is 2%.

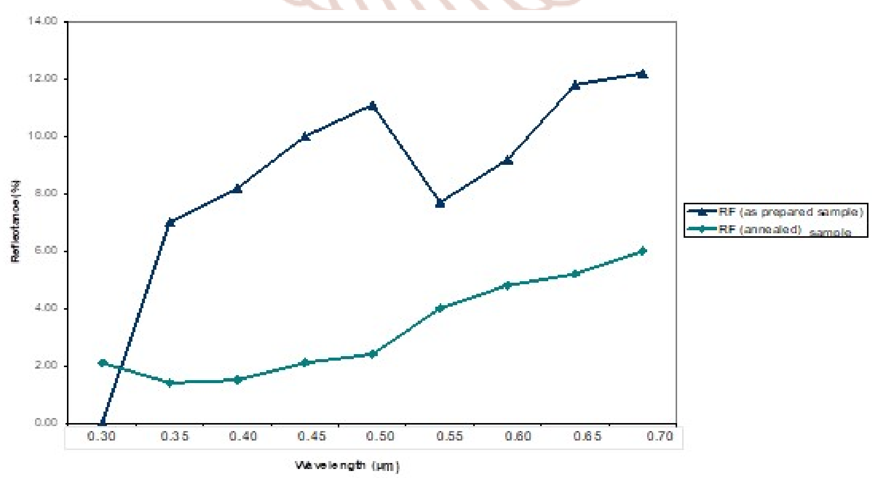

Figure 3: Variation of reflectance with wavelength (μm) for as prepared and annealed PbS sample

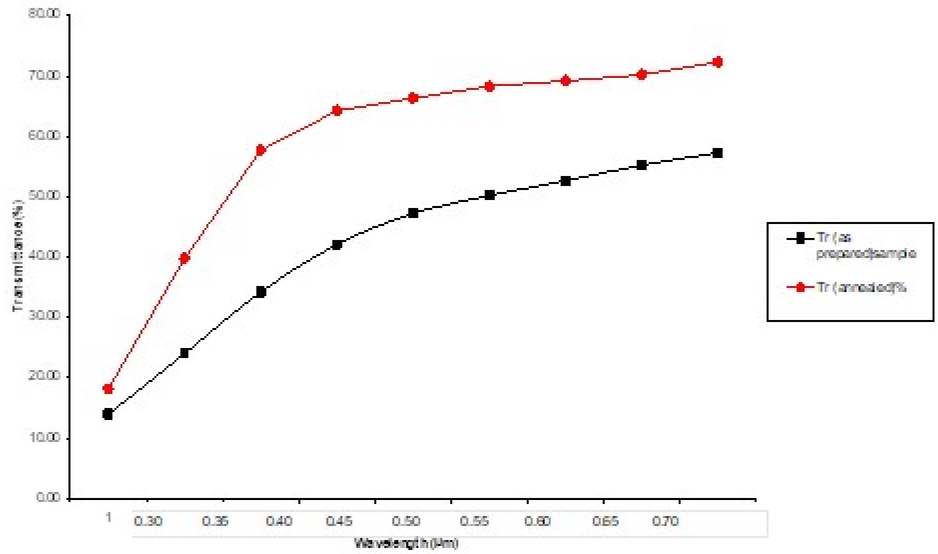

Figure 4: Variation of transmittance with wavelength (μm) of as prepared and annealed PbS samples

Conclusion

In this study, the PbS were prepared by chemical bath deposition (CBD). The optical, microstructural studies of the PbS thin films were carried out. It was observed from the optical micoscope that higher values of transmittance and lower value of reflectance were obtained for annealed PbS. The micrograph of annealed sample presents a good formation of new grains in the recrystallized region with less dislocation density.

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