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Optimization of Chemical Bath Deposited Bismuth Sulphide Thin Films on Glass Substrate

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ABSTRACT

Semiconducting Bismuth sulphide (Bi_2S_3) thin films have been deposited on glass substrates by the simple and economical chemical bath deposition technique. We report the deposition and optimization of the growth parameters that maximizes the thickness of the deposited film. Deposited Bi_2S_3 films are found to be polycrystalline nature by XRD studies. The composition was found homogeneous and stoichiometric by EDAX analysis.

Key words: Bi_2S_3 thin films, Chemical Bath Deposition, Optimization, XRD, EDAX.

INTRODUCTION

Semiconducting thin films have been receiving considerable attention in recent years because of their applications in various fields of science and technology [1-6]. Up to now, several techniques involving chemical bath deposition, electro deposition, spray pyrolysis and successive ionic layer adsorption and reaction have been employed to prepare Bi_2S_3 films. Among these methods, chemical bath deposition is particularly important because of its simplicity and facility to obtain large area films [7]. The chemical bath process is performed by slow release of S^{2-} and controlled free Bi^{3+} ions in solution. Thioria, thioacetamide and sodium thiosulphate are three sulphiding agents commonly used. A chelating agent is used to limit the hydrolysis of the metal ion and impart some stability to the bath, which would otherwise undergo rapid hydrolysis and precipitation [8]. The properties of the deposited films mainly depend on the deposition parameters such as deposition temperature, deposition time, speed of rotation, ph value, concentration of metals and film thickness. In the present study, we report the deposition of Bi_2S_3 films and the investigation of the various deposition parameters to obtain uniform film having required thickness.

MATERIALS AND METHODS

Bi_2S_3 thin films were deposited on glass substrate. The chemicals used were 0.6M bismuth nitrate ($Bi(NO_3)_3$), 0.3M EDTA and 0.6M sodium thiosulphate ($Na_2S_2O_3$). A 100 ml beaker was used as container for reacting chemicals. This was immersed vertically in a water bath and heated to desire temperature and substrates immersed vertically. The substrate had earlier been washed with detergent, acetone and rinsed in demonized water. X-ray diffraction (XRD) pattern of the films so prepared was taken with RIGAKU system. The as grown compound was analyzed by EDAX analysis. The film compositions were found to be in stoichiometric order. Thickness measurement of films was taken with gravimetric technique.

RESULTS AND DISCUSSION

Influence of preparative parameters

Influence of $Na_2S_2O_3$ concentration

The different amount of sodium thiosulphate (0.6M) was added with 0.6M bismuth nitrate (30 ml). The optimum volume of sodium thiosulphate to get a film with maximum thickness (at 12 hrs), was observed to be 18 ml while keeping all other growth parameters same. pH of the growth solution was between 1.5 and 2.5 at room temperature. Thickness of the film goes on increasing with volume of $Na_2S_2O_3$ reaches to maximum and then decreases with further increase in volume of $Na_2S_2O_3$ as indicated in fig.1.

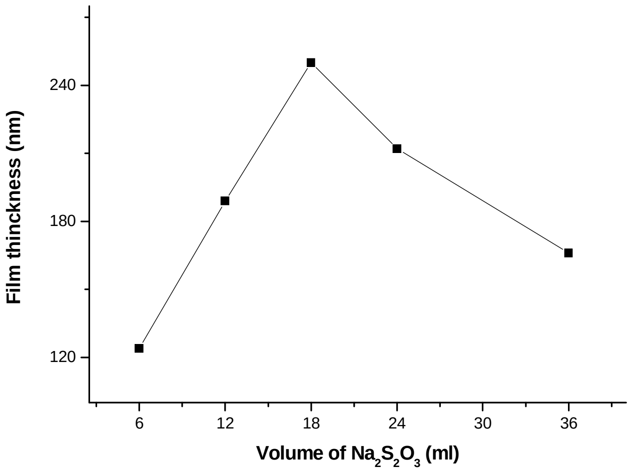

Fig.1. Optimization of volume of 0.6M $Na_2S_2O_3$ for 30ml of 0.6M $Bi(NO_3)_3$

Influence of EDTA concentration

Keeping concentrations of bismuth nitrate and sodium thiosulphate at constant optimum levels and other growth parameters same, the volume of EDTA (0.3M) was varied in to a growth solution. The film with maximum and uniform thickness was obtained with the addition of 24 ml EDTA in to a growth solution as depicted in fig.2. The resulting film in this situation is of better quality.

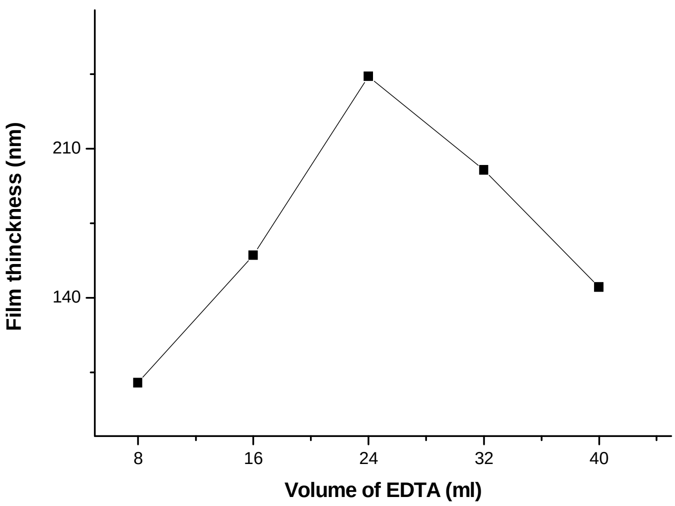

Fig.2. Optimization of volume of 0.3M EDTA for 30 ml of 0.6M $Bi(NO_3)_3$ solution for 12 hours

Influence of bath temperature

The influence of bath temperature on thickness was studied in fig.3. Keeping other parameters same, the bath temperature was varied from 40^0C to 70^0C with an interval of 10^0C. The thickness goes on increasing with bath temperature, reaches to maximum at 60^0C and decreases with further increase in temperature after 60^0C [9].

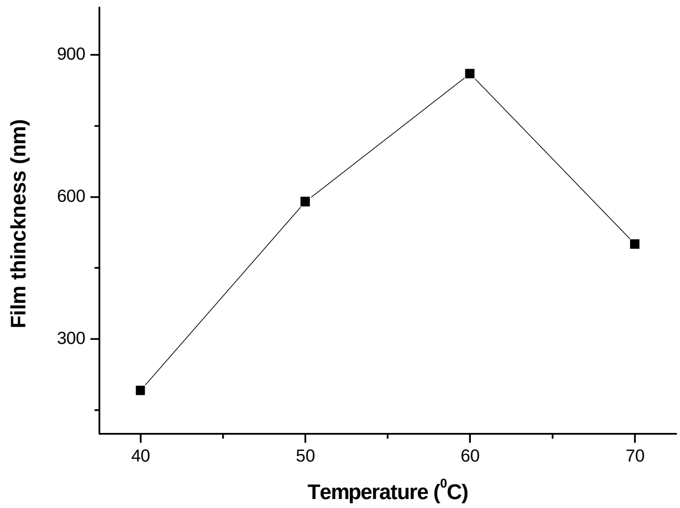

Fig.3. Optimization of bath temperature for Bi_2S_3 of 0.6M $Bi(NO_3)_3$ + 0.6M $Na_2S_2O_3$ solution

Influence of deposition time

Thickness of film goes on increasing with time of deposition (keeping remaining parameters same), reaches to maximum at 12 hours as shown in fig.4.

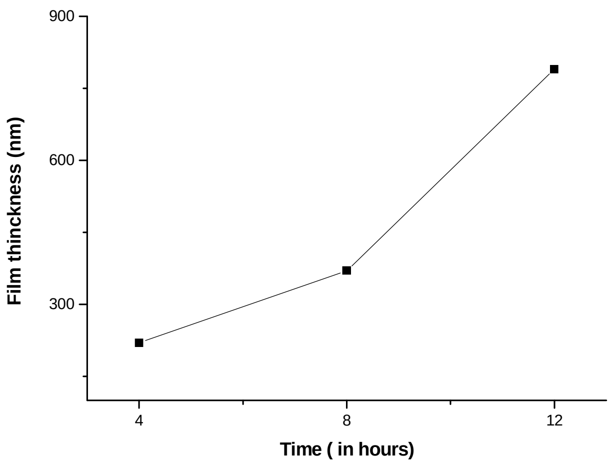

Fig.4. Optimization of deposition time for Bi_2S_3 of 0.6M $Bi(NO_3)_3$ + 0.6M $Na_2S_2O_3$ solution

X-ray diffractograph

XRD of the as grown films with optimum growth parameters was carried out. It is represented in fig.5. The observed peaks are matching well with reported JCPD'S data file. Table.1. represents the observed and reported XRD data. This confirmed the formation of Bi_2S_3 [10-15].

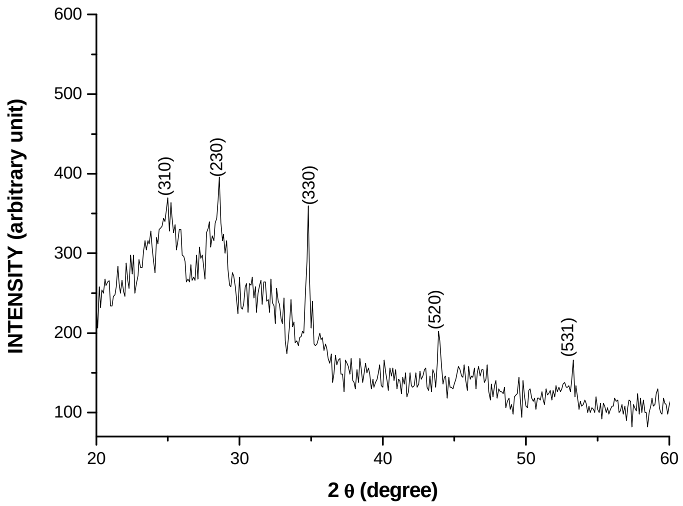

Fig.5. XRD pattern of Bi_2S_3 thin films

Table.1. XRD data of crystalline Bi_2S_3

Planes (hkl)	2θ values (degree)		d-spacing values d (Å)	
	JCPDS	Experiment	JCPDS	Experiment
310	25.288	25.26	3.5190	3.5867
230	28.729	28.76	3.1049	3.1985
330	34.017	34.09	2.6334	2.6743
520	43.751	43.79	2.4404	2.4786
531	53.118	53.16	2.0674	2.0626

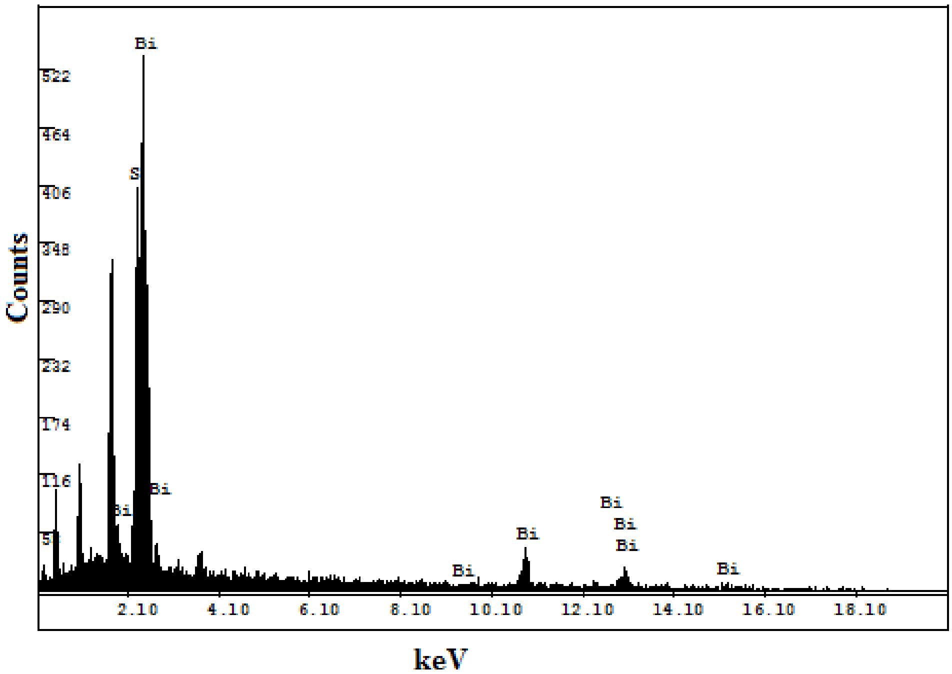

Fig.6. EDAX spectrum of a typical Bi_2S_3 compound

EDAX analysis

EDAX analysis was employed to carryout elemental analysis of the as grown thin films. The composition was found homogeneous and stoichiometric. This confirmed the formation of Bi_2S_3. Fig.6. shows a typical EDAX spectrum of film. Table.2. represents EDAX quantification.

Table.2. EDAX quantification

Element	Weight %	Atomic %
Bi	87.63	52.09
S	12.37	47.91

CONCLUSION

Bi_2S_3 films are prepared by chemical bath deposition technique. The films are sensitive to different growth parameters. The grown films are polycrystalline in nature. The composition was found homogeneous and stoichiometric.The optimum conditions are found to obtain Bi_2S_3 films with maximum thickness.

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