Structural, Morphological and Optical Studies of ZnS Thin Films Produced by Electrodeposition Method

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Abstract. Zinc sulfide thin films have been deposited onto stainless steel substrate by electrodeposition method at room temperature using zinc sulfate and sodium thiosulfate solutions. The various deposition parameters such as deposition time and solution concentration are optimized. Thin films of ZnS with different thicknesses of 952–1484 nm were prepared by changing the deposition time from 10–40 min. The effect of deposition time and solution concentration on structural, morphological and optical properties was studied. The XRD pattern confirms the presence of ZnS thin films with cubic crystal structure. Peak intensity increases with increase in solution concentration and deposition time. The SEM images show nanoflake like morphology. The optical absorption studies in the wavelength range 200–1100 nm show that band gap energy of ZnS thin film deposited with 0.2M solution concentration and 30 min deposition time is 3.94 eV.

Keywords: Thin film; electrodeposition method; structural properties; morphological properties; optical properties.

INTRODUCTION

The synthesis of binary metal chalcogenides in a crystalline form has been a rapidly growing area of research due to their important physical and chemical properties. Zinc sulphide is an important II–VI semiconductor with a wide band gap which is suitable for applications in solar cells, solar selective decorative coatings, UV light emitting diode, photocatalysis and phosphors in flat panel displays. ZnS thin films are nontoxic to human body, very cheap and abundant. The semiconductor thin film deposition from aqueous solution [1-4] becomes increasingly popular because it has advantages of economical and capability of large area deposition. Various techniques have been employed to prepare ZnS thin film including successive ionic adsorption reaction method [5], electro deposition [6], chemical bath deposition [7], spray pyrolysis [8], vacuum evaporation [9] and pulsed laser deposition [10]. The use of complexing agent is very common in the preparation of thin films, .Electrodeposition is a well known deposition process for some chalcogenides such as Zn, Co, Cd, Hg, Pb, sulphides and selenides (11) Zinc sulfide is an important semiconductor material with large band gap (~3·5 eV), high refractive index (2·35 at 632 nm), high effective dielectric constant (9 at 1 MHz) and wide wavelength passband (0·4–13 μm) (12) 1.2.

Experimental

The ZnS nanoflake was synthesized at room temperature by electrodeposition method. In the typical synthesis, (0.2 M) copper sulphide ($ZnSO_4$) and (0.20M) $Na_2S_2O_3.5H_2O$ are used as source of copper and sulfide respectively. Solutions are prepared in double distilled water. The ultrasonically cleaned stainless steel and ITO substrate are used to prepare samples. All reagents were of analytical grade and used without further purification. Copper selenide thin films were prepared on stainless steel, ITO substrate by electrodeposition technique. Electrolytic bath contains 15 ml $ZnSO_4$ and 15 ml $Na_2S_2O_3.5H_2O$ as sources of Zn and S ions. Electrodeposition studies of ZnS thin films were made using potentiostat (Princeton Perkin-Elmer, Applied Research Versa-stat-II; Model 250/270) in three-electrode configuration. Pure graphite plate was used as an anode, stainless steel was used as cathode and saturated calomel electrode (SCE) was used as reference electrode. Brown, Greenish-gray colored, smooth, uniform ZnS thin films were obtained.

RESULTS AND DISCUSSION

X-ray Diffraction

The corresponding XRD pattern (Fig. 1) indicates that all of the diffraction peaks can be readily indexed to the pure cubic phase of ZnS with a lattice parameter of a =b=c 5.409 Å^o which is in good agreement with

the literature values (JCPDS 065-0309). No other diffraction peaks are found

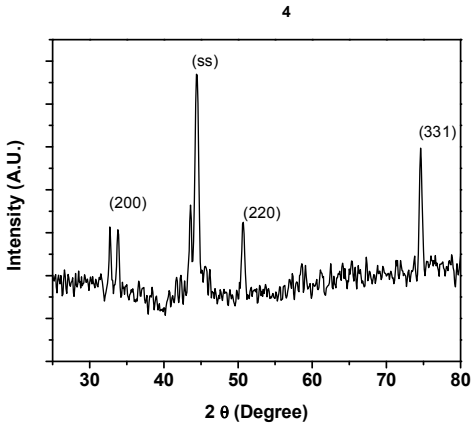

Fig. 1 XRD patterns of ZnS thin film

Scanning Electron Micrograph

Fig. 2 shows the SEM images of the optimized products, which show that nano sized flakes formed on substrate. The flakes in figure shows the nano-flakes have a cubic cross-section. The products are also confirmed as a cubic structure of ZnS by XRD measurement (see Fig. 1). To study the effect of surface morphology of the substrate on the ZnS nanostructures synthesis was also conducted at different conc.

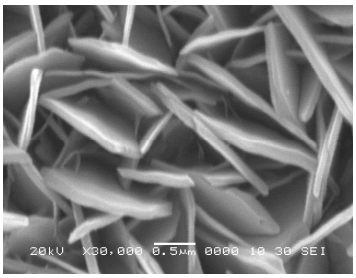

Fig. 2: SEM image of ZnS thin film

Optical Study

Study of materials by means of optical absorption provides a simple method for explaining some features concerning the band structure of materials. The nature of transition (direct or indirect) is determined by using the relation of absorption The plot of $(\alpha h\nu)^2$ vs hν are shown in fig. 3 for ZnS films. The band gap energy value Eg is 3.94eV. The linear nature of the plot indicates the existence of direct transitions.

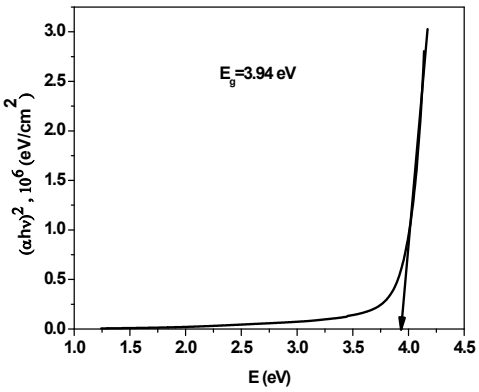

Fig. 3: Optical band gap energy spectra of ZnS thin film

CONCLUSIONS

Zinc sulfide thin films are polycrystalline in nature with cubic structure. Nanoflakes of different dimensions are fabricated by simple and inexpensive method of electrodeposition. Optical band energy of zinc sulfide thin film is 3.94eV .This film suggests their possible application for window buffer layer material for solar cell.

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