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Morphological, Elemental Composition and Optical properties of ZnS films Synthesized Using Electrochemical Deposition Technique

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Abstract- Zinc sulfide thin films were synthesized by means of cyclic voltammetry technique onto stainless steel substrate. The electrolyte bath of aqueous solution containing 0.2 N Zinc sulfate (ZnSO4.7H2O) and 0.2 N sodium thiosulfate with 0.2 N Triethanolamine was used as complexing agent. Cyclic voltammetry was employed to measure its ranges of deposition voltages and thickness of ZnS thin films can be controlled by number of voltage cycles applied during deposition. The bath temperatures have fixed at 600C. The Influence of bath temperatures on optical properties and morphology has been investigated in details. The electrochemical deposited ZnS thin films were characterized by UV-visible spectroscopy and the field emission scanning electron microscopy (FESEM). The UV-visible spectroscopy analysis showed that energy band gap has found 3.76 eV depending at (600C) bath temperatures. The FESEM analysis showed that ZnS thin film deposited at (600C) bath temperature is polycrystalline nature, homogenous, uniform with randomly oriented nanoflakes and nanorods. The good quality of zinc sulphide thin film could be prepared in the presence of triethanolamine.

Keywords- Electrodeposition, bath temperature, ZnS-thin film, morphological and optical properties.

I. INTRODUCTION

Chemical techniques are simpler, inexpensive and cost effective. Thus, they have become more popular in recent times. ZnS thin film has been grown by using electro deposition and various chemical techniques [1] such as Sol-gel, Spin coating, Spray Pyrolysis, chemical vapor deposition and chemical bath deposition etc. The technique of electrodeposition is simple, inexpensive and can be adaptable to large area processing with low fabrication cost. The ZnS thin films have been deposited by two electrode or three electrode cyclic voltammetry electrochemical deposition techniques [2]. Using chemical bath deposition techniques, many researchers have reported different characterization results for thin films with different temperatures [3]. Zinc sulfide (ZnS) is one of the direct II–VI semiconductor compounds with large band gap energy of 3.65 eV at room temperature exhibits a wide optical transparency from the ultraviolet to the infrared region [4]. The material crystallizes in both cubic and hexagonal forms and it is used a material of reference to test several theoretical models in condensed material physics [5] Most of the times it shows mixed phase crystal structure. While cubic structure of ZnS has been reported to have a wide direct band gap of 3.6 eV at optimum temperature, hexagonal structure of ZnS has been reported to have a bandgap of 3.91 eV [6]. The material has been huge potential application in both thick and thin film form in various photovoltaic and optoelectronic devices. Zinc sulfide is also an important phosphor host lattice material used in preparation of electroluminescent devices (ELD). This is because of its large band gap that is enough to emit visible light without absorption and the efficient transport of high energy electrons. Recently, investigation has shown that, layered type semiconducting cadmium chalcogenides group (CdSe, CdS, ZnS, CdTe) which absorb ultraviolet and near infrared light. In the present study we report the synthesis of ZnS, three electrodes potentiation electrodeposition technique with different electrolyte bath temperature was employed to prepare ZnS thin films and their morphological and optical properties.

What is Cyclic Voltammetry Technique?

is a very important electrochemical and linear sweep technique. It is used potentiodynamic electrochemical measurement and to study the redox behavior of compounds and to determine mechanisms and rates of oxidation/ reduction reaction. Also, it is generally used to study the electrochemical properties of an analyte in solution or of a molecule that is adsorbed onto the electrode. In a cyclic voltammetry experiment, the working electrode's potential is ramped in the opposite direction to return to the initial potential. These cycles of ramps in potential may be repeated as many times as needed. The current at the working electrode is plotted versus the applied voltage (that is, the working electrode's potential to give the cyclic voltammogram trace.

II. EXPERIMENTAL WORK

The deposition of ZnS on stainless steel substrate by three electrode cyclic voltammetry technique. The electrolyte was prepared by mixing solution of AR grade Zinc Sulfate, Sodium Thiosulfate of 0.2 N in the volume ratio of 1:1 respectively, with 2 % of total volume of electrolyte bath. Here 0.2 N Triethanolamine was taken as a complexing agent [7].

Figure 1 show a standard cyclic voltammetry experiment consists of a cell with three electrodes such as reference electrode, working electrode and counter electrode. This combination is sometimes referred to as a three-electrode setup. Electrolyte was added to the sample solution to ensure sufficient conductivity. The solvent, electrolyte, and material composition of the working electrode will determine the potential range that can be accessed during the experiment. It was employed to measure its ranges of deposition voltages [8].

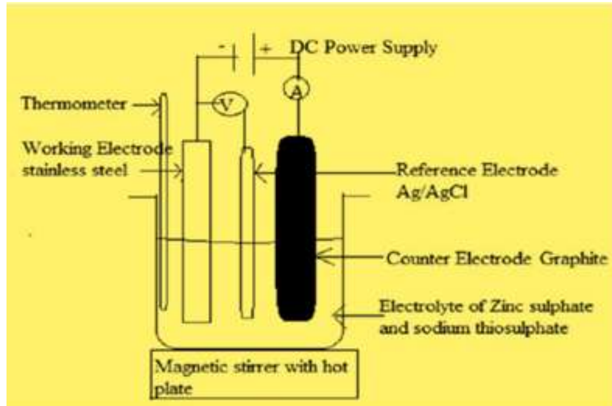

FIG. 1: Electrodeposition method used in the present study of deposition of ZnS thin films with 600 bath temperatures

Distilled water was used for preparation of aqueous solution of above precursor chemicals. The pH of electrolyte solution was maintained fixed at 3.5 by dilute hydrochloric acid. By using magnetic stirrer with hot plate while other parameters being kept constant, the electrolyte bath temperatures were adjusted from 600C. Before deposition the substrate was thoroughly cleaned with double distilled water and acetone.

The distance between the working electrode and counter electrode was kept constant as 1.5 cm during deposition of materials. The deposition parameters were adjusted such as deposition time 25 min and bath temperatures adjusted 600C. It was observed that a formation of uniform and well adherent black ZnS films were obtained on the substrate. The film was dried under IR lamp for 10 min. We obtain that thickness of ZnS films was controlled by number of voltage cycles applied during deposition. The thicknesses of films with different bath temperatures were measured [9]. Also, we obtained hysteresis curve that imply its potential application. We conclude that, the variation of bath temperatures does affect the structure, surface morphology and optical properties of thin films.

III. RESULTS AND DISCUSSION

1. Film Thickness Estimation

The thickness variation of ZnS deposited by using electrodepositon was measured by using mass difference method [10]. t = Δm/Δp where Δm is mass difference of before deposition and after deposition, t is thickness of film, ^ is area of deposition, Θ is density of deposited material. The variation of film thickness as a function of electrolyte bath temperature is shown in Fig. 2. The thickness of films has obtained 13.67 Δm when bath temperature rose at 600C.

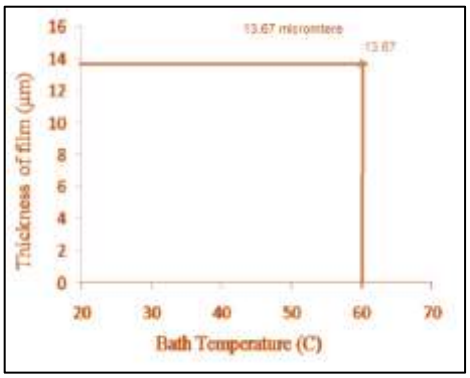

FIG. 2: Thickness Variation of ZnS thin films deposited at 60 0C bath temperature

2. UV- Visible Spectroscopy

The optical absorption measurement was carried out by using UV visible spectrophotometer (BSR-UV-1900) in the range of 190–400 nm. Figure 3 shows the absorption band edge was found at 327 nm at bath temperature (60 0C) respectively. The band gaps of ZnS films were found to be 3.76 eV at 60 0C.

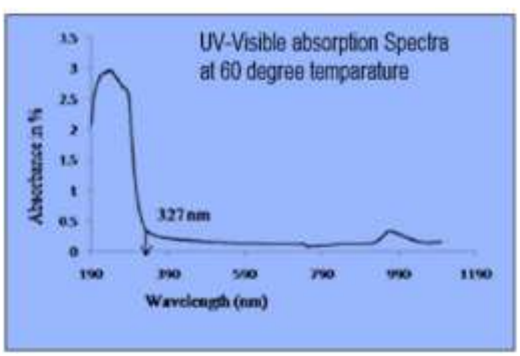

FIG. 3. UV-Visible absorption spectra of ZnS thin film at (60 0C) Bath temperature

3. Energy Dispersive Analysis by X-Ray Spectroscopy

EDS spectra of deposited ZnS thin film shows in Fig. 4. It confirms the successful formation of ZnS. That grown thin film composed of only Zn and S elemental composition. No impurity peaks are observed in this spectrum.

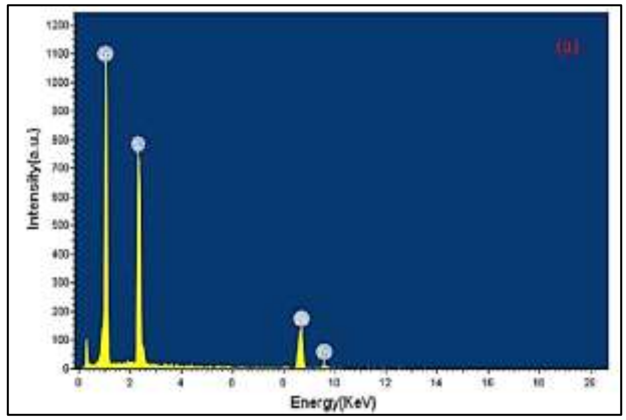

FIG. 4. Energy Dispersive analysis by X-ray Spectroscopy of ZnS thin film

5. Field Emission Scanning Electron Microscopy

The FESEM was carried out to study the effect of different bath temperature on the surface morphology of ZnS thin films. Figure 5 FESEM photographs shows ZnS films at bath temperatures 600C. The crystallinity of ZnS thin film is higher at bath temperature (600C) indicated that the film was dense and pinhole free. The average crystallite size of the film sample has found 158.16 nm and energy band gap 3.76 eV with bath temperatures (600C).

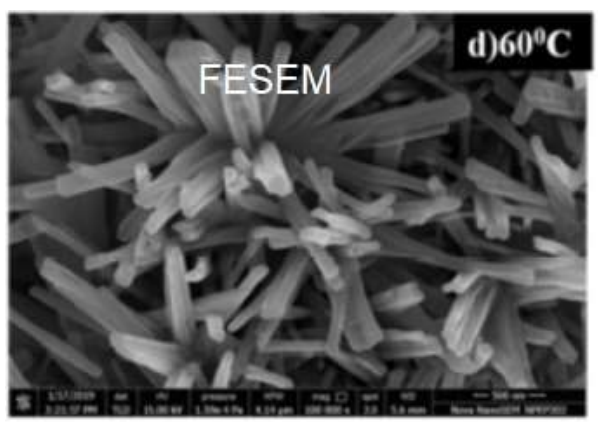

FIG. 5. FESEM micrograph of the ZnS thin films at bath temperatures (600C)

IV. CONCLUSION

The synthesis of ZnS films has been carried out by cyclic voltammetry technique. ZnS has been successfully deposited on stainless steel substrates. The influence of bath temperature on optical properties has been investigated systematically. The ZnS films shows absorption band edges 327 nm with band gap 3.76 eV. The surface morphology of the films shows that films are smooth and uniform with randomly oriented nanorods. The average crystallite size of the film sample has found 158.16 nm and 3.76 eV energy band gap with bath temperature (600C).

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