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Synthesis, Characterization and Optical Properties of ZnS Thin Films

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Abstract: ZnS thin films were prepared by pulsed electrodeposition technique over stainless steel substrates in galvanostatics mode from an aqueous acidic bath containing $ZnSO_4$ and Na_2S. The growth kinetics of the film was studied and the deposition parameters such as electrolyte bath concentration, deposition time, current density and pH of bath are optimized. The X-ray Diffraction (XRD) and electron dispersive spectra (EDS) analysis of the deposited film showed presence of polycrystalline nature. The surface morphology studied by Scanning Electron Microscope (SEM) shows that the deposited films are well adherent and grains are uniformly distributed over the surface of substrate.

Keywords: Electrodeposition, SEM XRD, EDS, ZnS.

1. INTRODUCTION

Nowadays thin films are studied with interest due to their applications in the fields of engineering and science like semiconductor and photovoltaic devices, metallurgical coating, surface morphology testing techniques in engineering etc. Thin film technology is aggressively developing technique due to its wide scope of applications. Use of photo electrochemical solar cells causes large amount of research in thin film polycrystalline materials with acceptable efficiency.[1-4]

Zinc sulfide (ZnS) is a promising device material for the photo luminescent, electroluminescent, detectors, emitters and modulators. ZnS films have been deposited by many researchers with electrodeposition [9- 17].

Interest in the use of photo electrochemical (PEC) solar cells for low-cost energy conversion has led to an extensive research in thin film semiconducting materials [5-8]. Current research on multi-layered thin film of Zn is observed which absorbs visible and near IR light. These are observed promising for PEC solar energy conversion. Such polycrystalline electrodes are economically desirable in photo voltaic applications. Hence we have focused on ZnS polycrystalline thin films.

The structural and optical properties of electrodeposited ZnS thin films are reported. An attempt is made to prepare ZnS thin films through electrodeposition technique on stainless steel substrate. This helped to study the characterization like structural, surface composition, surface morphology and optical properties.

2. METHODOLOGY AND MATERIAL FORMATION FOR THIN FILM

The thin film of ZnS was pulsed electrodeposition on stainless steel substrate. The stainless steel substrates were used as the cathode in three electrodes cell with graphite as the counter electrode and saturated calomel electrode (SCE) was the reference electrode. The electrolyte was prepared by mixing solutions of $ZnSO_4$ (0.1M) and Na_2S (0.1M) in double distilled aqueous bath taken in equal proportion. The pH of electrolyte solution was maintained by using dil HCl. The substrates were cleaned in double distilled water. The distance between the electrodes was 1cm kept constant during deposition. The ZnS film was observed well deposited on substrate. The detailed study of kinetic growth of film was studied by changing pH and deposition parameters.

3. RESULTS

For the determination of exact deposition potential, the polarization curve was plotted. The films were grown at the optimized potential of 1500mV with respect to SCE and at the current density1.5 mA/cm^2 where the film was found to be uniformly thick is shown in Fig1. When the electric field was applied between the counter and working electrode, a fine ZnS thin film formation occurred on the surface of substrate. The film formation process is time dependent. For further study, the formed films are dried and preserved in desiccators. The current density is observed varying from 0.5 to 4.7 mA/cm^2. At other deposition conditions other than 1.5mA/cm^2 the thickness of film was observed less.

The PEC cell in n-ZnS / polysulphide /C is illuminated with 200W tungsten filament lamp. The photons having energy equal to or greater than the band gap energy of ZnS are absorbed on semiconductor and the electron-hole pairs are generated. These electron hole pairs are separated by local electric field present across the interface between

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semiconductor and polysulphide electrolyte. It leads to the generation of photo voltage under open circuit condition. The variation of I_{sc} and V_{oc} is shown in Fig 2. It has been observed that the value of I_{sc} and V_{oc} are relatively higher at deposition time 40sec and at pH 1.5 and at optimum thickness of ZnS thin film at this condition shown in Fig 3. The grown ZnS film deposited at optimized preparation parameters was further characterized by X-ray diffraction (XRD) pattern is shown in Fig 4.

The XRD analysis reveals that film is polycrystalline and some sharp peaks are identified at (0 0 8), (1 0 4), and (1 1 8) Planes of ZnS. The standard 'd' values and observed 'd' values for ZnS are matching with each other which are mentioned in Table 2. The elemental analysis was performed for the optimized ZnS film deposited using electrodeposition technique. The obtained electron dispersive spectra (EDS) shows the presence of both Zn and S, which gives the qualitative confirmation of electrodeposition of ZnS film which is shown in Fig5. This is an agreement with the structural analysis discussed above in XRD study. This confirms the material is ZnS.

The surface morphology of ZnS thin film was studied by SEM. The SEM micrograph shows well adherent, smooth film surface. The surface morphology of ZnS film prepared under optimized condition exhibits grain of uniform size about 13Å spread all over the surfaceshown in Fig6 and Fig7. Atomic composition observed is given in Table3.

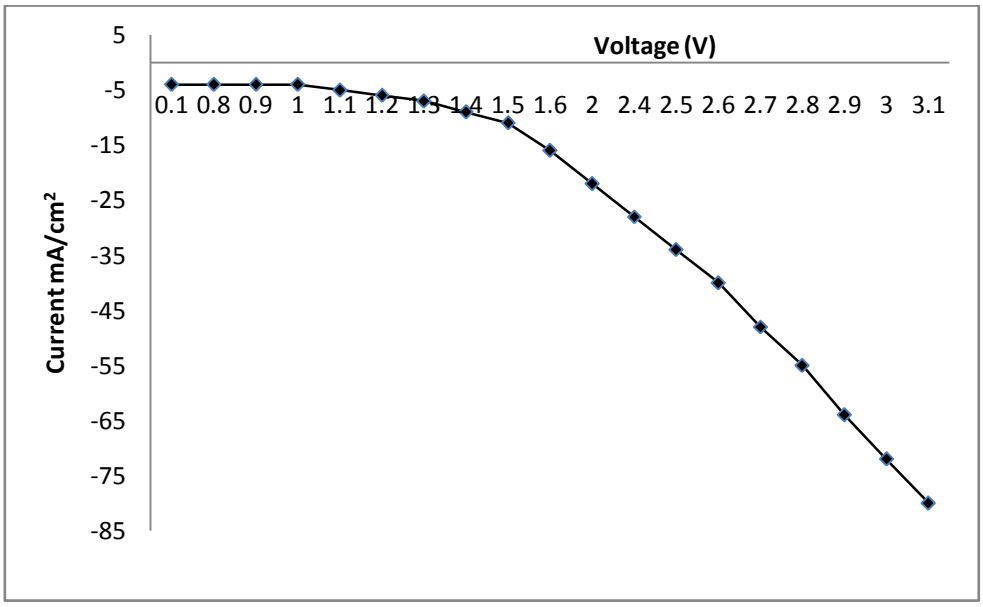

Fig 1: Optimization of deposition potential

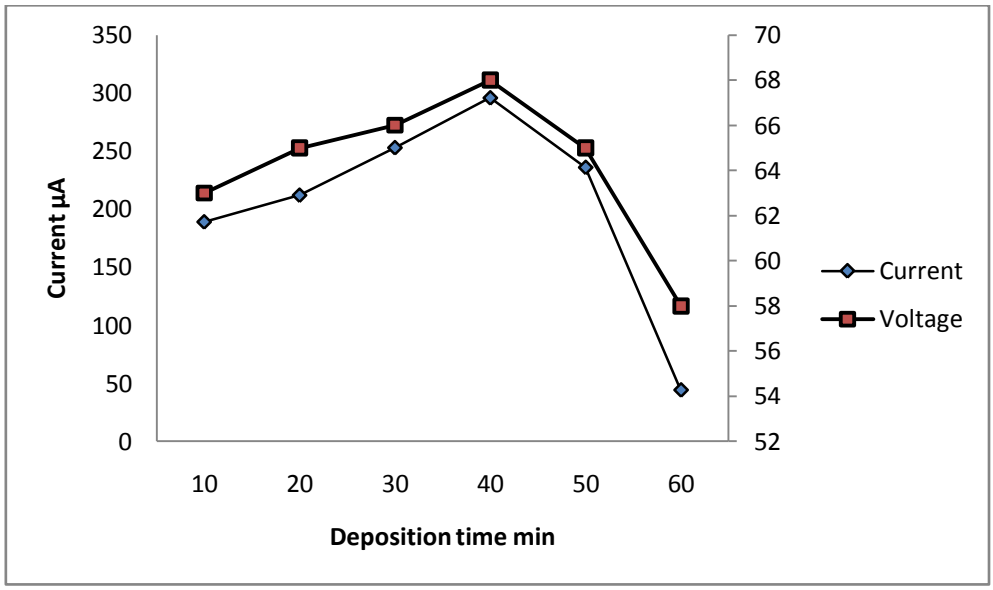

Fig 2. Isc vs Voc reported for the film at pH 1.5

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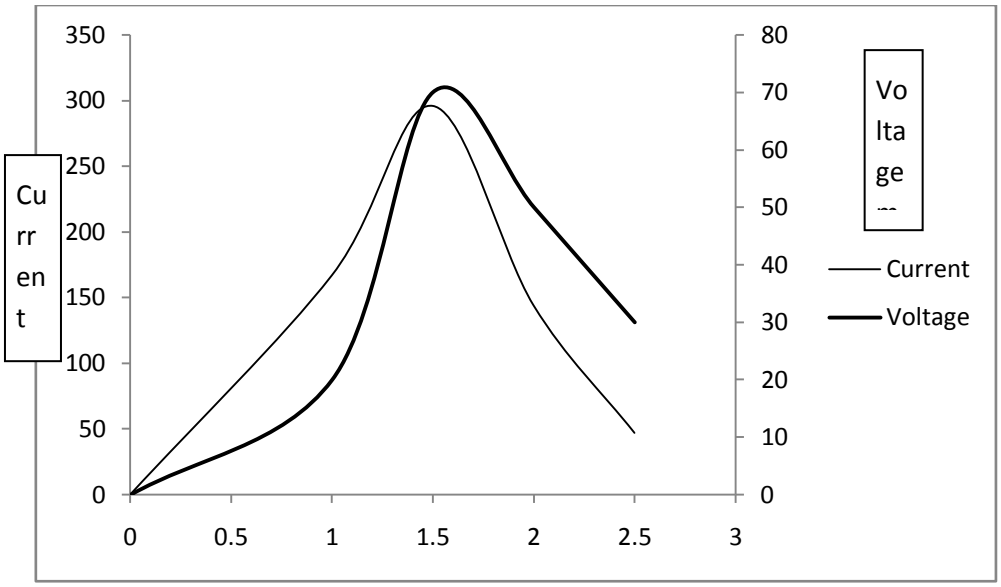

Fig 3A

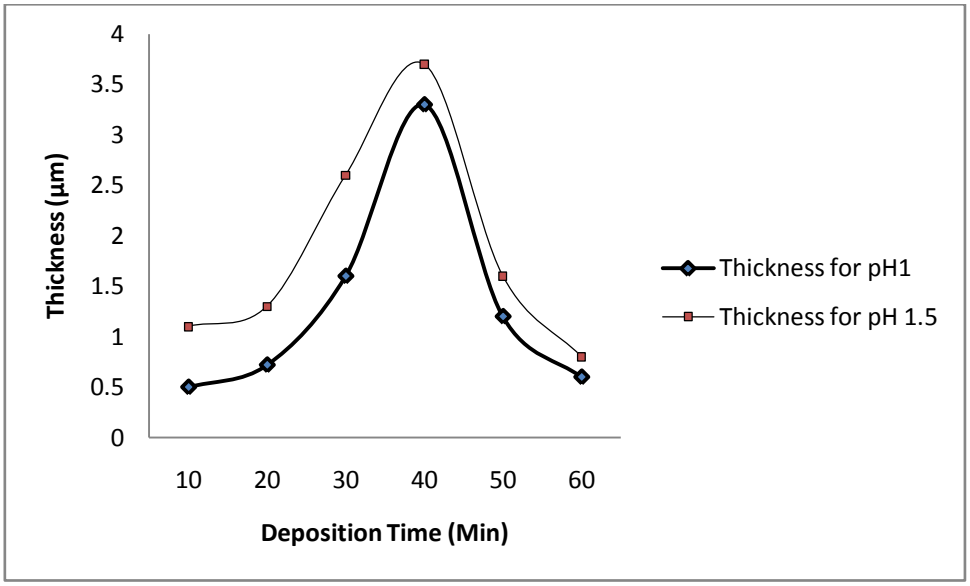

Fig 3B. Thickness of film at different pH

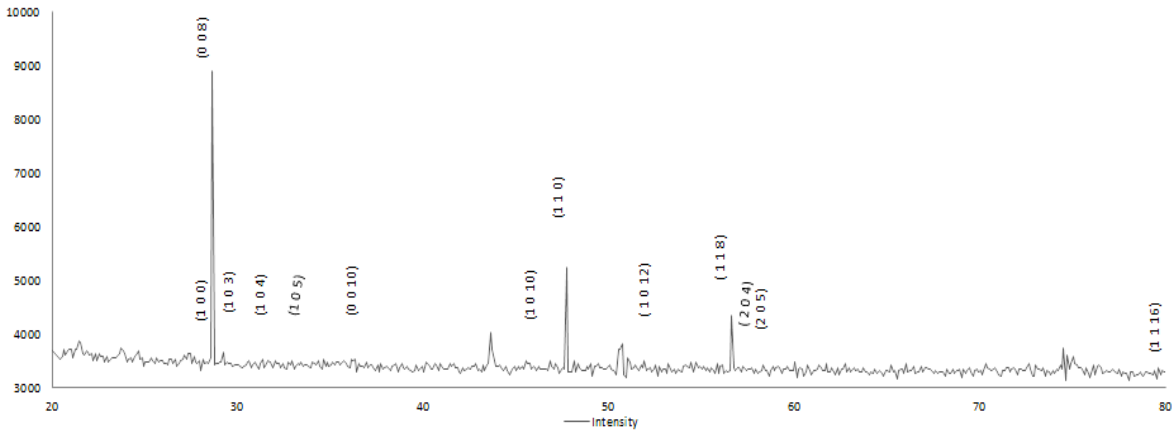

Fig 4 XRD

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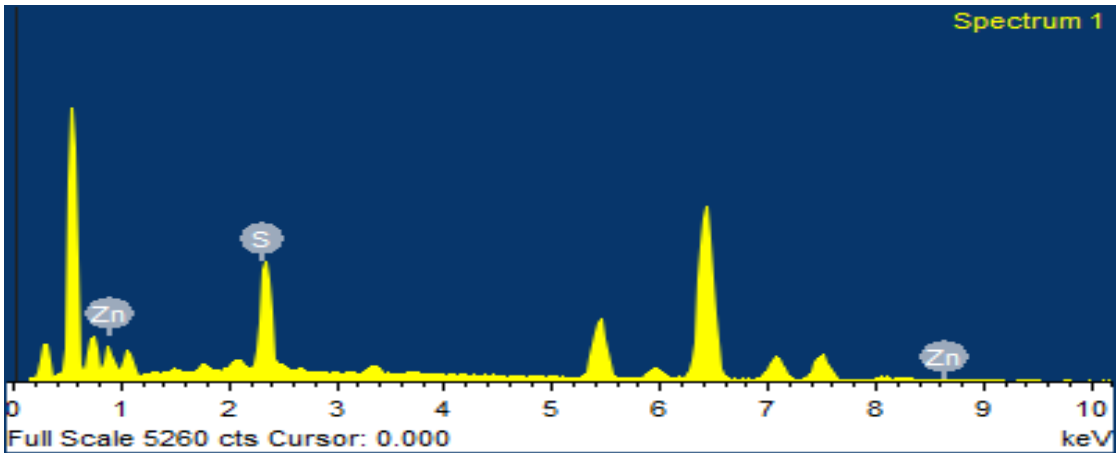

Fig 5. EDS

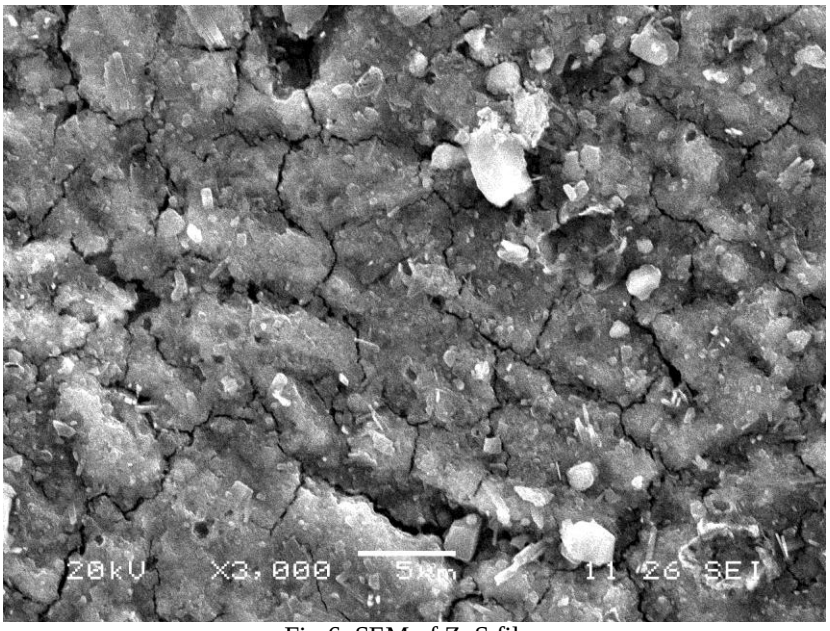

Fig 6: SEM of ZnS film

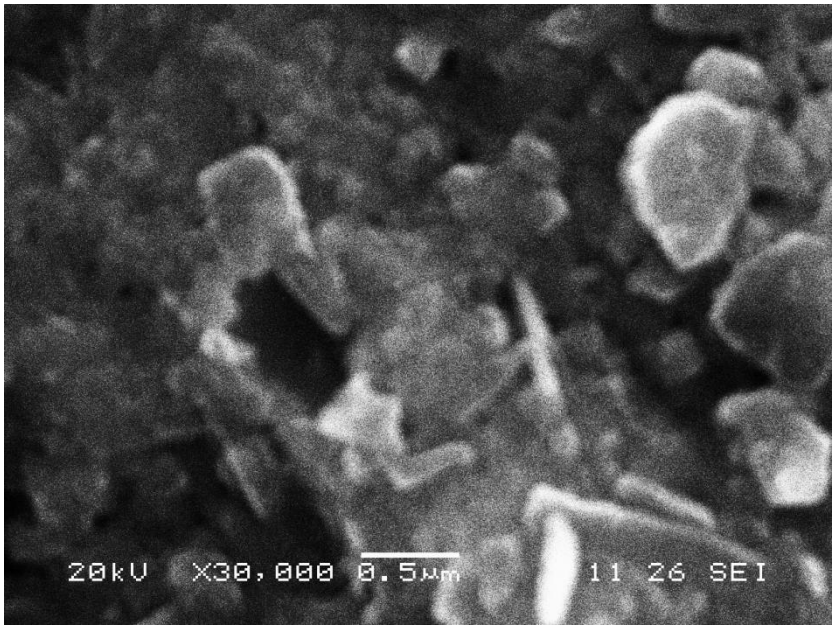

Fig7: SEM of ZnS thin film

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Table 1: Optimized parameters of ZnS film

Sr No	Optimized Parameter	Values
1	Deposing potential	1.5V
2	Current Density	1.5mA/cm^2
3	Deposition time (min)	40
4	pH of both	1.5
5	Temperature of bath	50˚C

Table 2: Some Standard and observed values of 'd' for ZnS film by using ASTM data

2θ	Plane (hkl)	Standard 'd' A˚	Observed 'd' A˚
28.6	0 0 8	0.4775	0.4931
30.5	1 0 4	0.4702	0.4175
56.6	1 1 8	0.9264	0.9810

Table 3: Atomic composition of Zn and S recorded from EDS of ZnS film

Sr No	Element	Weight %	Atomic %
1	S	51.35	50.72
2	Zn	48.65	49.28
		Total = 100	100

4. CONCLUSION

Stoichiometric ZnS thin film formed by electrodeposition technique was taken from acidic bath. The film was developed at optimized pH and time is polycrystalline with cubic structure and the particle sizes are found to be 13^{o}A.

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