Physical Properties of Zinc Sulphide (ZnS) thin film by Electrochemical Deposition

K.S.Sonawane[1], N.A.Davkhar[2], J.A.Borse[3] J.M.Shewale[4], A.V.Patil[5], C.G.Dighavkar[6]

Department of Physics[1, 2, 3, 4, 5,6.] L.V.H.College Panchavati, Nashik. India.

Abstract

ZnS thin films deposited by two electrode electrochemical deposition using the two electrode system on stainless steel substrates from aqueous solution containing 0.3 N Zinc sulphate ($ZnSO_4 \cdot 2H_2O$) and 0.2 N sodium thiosulphate ($Na_2S_2O_3$). The 2 % Triethanolamine was used as a complex agent for complex form of ZnS materials. The Thickness of ZnS thin film was increases up to certain time after that it was found fall by co- deposition with deposition time. The voltage for deposition corresponding current density was optimized by polarization curve method. The good quality adherent films of ZnS were obtained at 1700 mv in two electrode system. The thickness of film was measured by mass difference method. The chemical bonding of functional group of deposited material was studied by IR spectral analysis.The Chemical Composition of ZnS analysed by EDAX.The Structural characterization and surface morphology was studied by XRD, SEM respectively.

Keywords: ZnS, Electrochemical Deposition, IR, EDAX, SEM

Introduction:

Thin films have attracted much interest because of their varied application such as semi conducting devices, photovoltaic, optoelectronic devices, radiation detectors, laser materials, thermoelectric devices, solar energy converters [3]. The Interest in the use of solar cells for low-cost energy conversion has lead to an extensive research in the field for novel and suitable thin film semiconductor materials. Recent investigation has shown that layered type semi conducting cadmium chalcogenide group (CdSe, ZnS, CdTe) which absorb visible and near [6].IR light are particularly promising materials for photo electrochemical solar energy conversion. The ZnS thin film is used as window layer for CdS/CdTe solar cell because band gap energy of window layer should be less [1]. The band gap energy of ZnS material is 3.92 ev [8]. Many workers investigated the ZnS crystal. The structural, optical and Electrical characterization of electrodeposited ZnS thin films have been investigated [7]. Many workers have been succeeded in depositing thin film of ZnS by electrochemical deposition technique by two electrode system on stainless steel.

Material and Method:

The thin films of ZnS were deposited by pulsed electrochemical deposition technique by two electrode system on stainless steel substrate. The stainless steel plates were used as the working electrode in two electrodes system with graphite as the counter electrode and stainless steel plate was the working electrode. The electrolyte was prepared by mixing solution of $ZnSO_4$ (0.3M), $Na_2S_2O_3$ (0.2M), the ratio of 1:1 respectively. The Triethanolamine of 2% was used for complex form of ZnS materials and well polycrystalline in nature [7]. The pH of electrolyte solution was varied by dilute HCL.double distilled water was used for preparation of aqueous solution of above precursor chemicals. Before deposition the substrate were thoroughly cleaned with double distilled water. The distance between the working electrode and counter electrode way kept constant as 1 cm during deposition of materials. From visual observation it was observed that a formation of uniform and well adherent reddish yellowish film of ZnS take place. [8] The detailed growth kinetics was studies by changing the deposition parameters such as the pH of electrolytic bath and deposition time (min). The chemical bonding of functional groups were analysed by FT-IR technique. The Thin film of ZnS was further characterized by XRD, SEM.

Result and Discussion:

The concentrations of Zinc sulphate (ZnSO4), Sodium thiosulphate (Na2S2O3), were 0.3 N and 0.2 N Respectively. The films were grown at the optimized deposition potential of 1700 mV with respect to the current density 4 mA/ cm^2.is shown in graph 1.When an electric field is applied between the working and counter electrode a fine ZnS thin film formation occurs on the surface of the substrate. The process of film formation is observed to be time dependent. From graph 2 the thickness of film increases with deposition time. The thickness of deposited materials were determined by mass difference method. The thickness of film was found 200 μm at 25 min as deposition time. The deposited film has been dried for further study. The current density varied from 2 to 4 mA/ cm^2 during deposition. The film deposited at current density 4 mA/cm^2 was found to be uniform thick. And well adherent to substrate. For other higher and lower values of current density thickness of film was less as compared to 4 mA/cm^2.The PH of electrolytic bath is varied from 2 to 5 by adding dropwise dil 0.1 N HCl with measured thickness of film was found 200 μm and PH=3 was optimized.

FT-IR Analysis:

The FT-IR spectrum is used to understand and analyze more elegantly the structure and molecular arrangements of thin films. Type of functional groups present in the substance is indicated by the absorption that occurs at various frequencies [3]. Figure 4, shows the FT-IR spectra of ZnS thin films in the range of 400-4000 cm−1.The vibrational frequencies of functional group have been presented in Table I. The absorption band of H_2O molecule, 1664 cm $^{-1}$ due to presence of water molecule in bending mode. The absorption peaks were obtained at1134, 1080, 1024 cm^{-1} shows sulphate ion stretching and 813,767,588 cm^{-1} shows presence of, N-H, and C-H bending respectively.

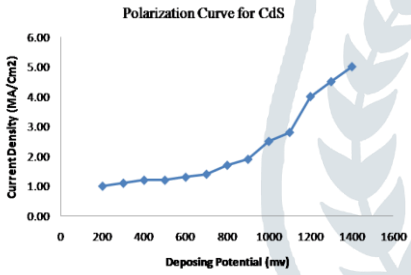


fig 1: deposing potential vs current density

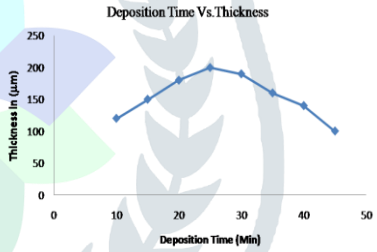
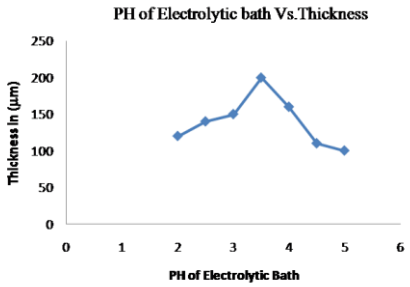
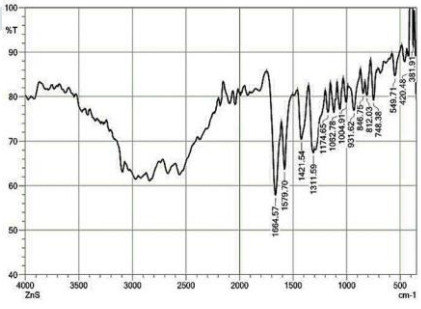
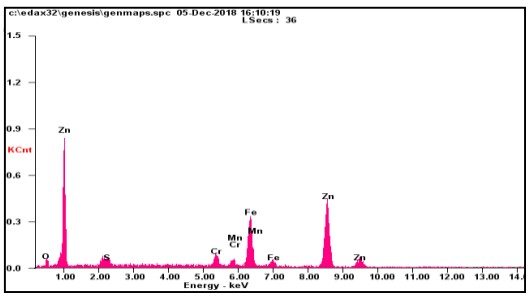


fig 2: deposition time vs thickness of film





fig



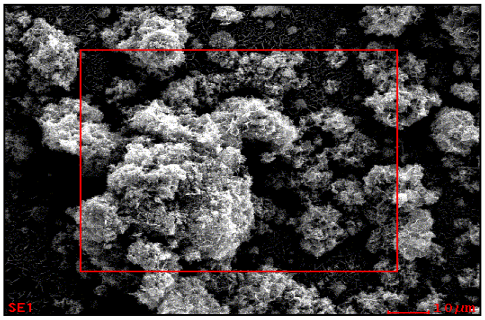


Fig5: EDAX of ZnS thin film and Image of thin film portion for EDAX analysis

Table:1 Elemental composition of ZnS thin film

Element	*Wt%*	*At%*
OK	05.57	18.17
SK	02.60	04.22
CrK	04.35	04.36
MnK	02.61	02.47
FeK	22.44	20.95
ZnK	62.44	49.82
Matrix	Correction	ZAF

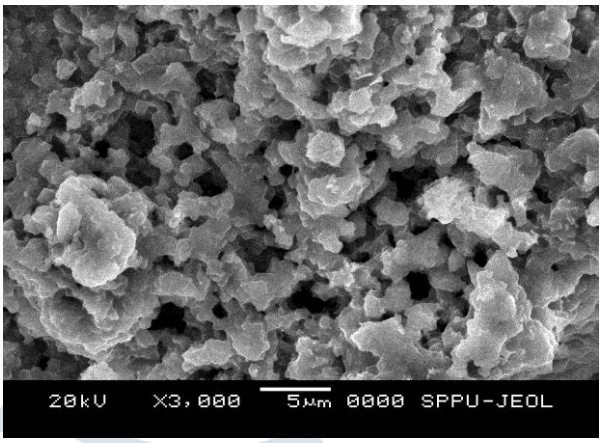


Fig 6: SEM image of ZnS thin film

Fig 5 shows the EDAX analysis of ZnS thin film it has been confirmed the film deposited with Rich composition of Zn relative to S hence it was found n-type conductivity of film.the ratio was Zn:S=62.44:2.60 .it showed in Table 1 and fig 6 showed SEM of ZnS thin film was deposited uniformly and well adherent.

Conclusion:

The ZnS film was successfully deposited on stainless steel substrate by pulsed electrodeposited technique by two electrode deposition system .the deposing potential was optimized at 1700 mv with current density 4 mA/ cm^2 .the thickness of film was optimized 200 µm at 25 min.the ZnS thin film was found n-type conductivity it has been confirmed by EDAX analysis in fig 5.it showed the composition of Zn was rich relative to S..the ZnS thin film deposited uniformly with polycrystalline in nature it has been characterized by SEM analysis in fig6.

References:

[1] Seyed Mostafa Mosavi, Hosein KafashanPhysical properties of Cd-doped *ZnS thin films*.Superlattices and Microstructures, Volume 126, February 2019, Pages 139-149,

[2] Alireza Azmand, Hosein Kafashan Al-doped *ZnS thin films*: Physical and electrochemical characterizations Journal of Alloys and Compounds, Volume 779, 30 March 2019, Pages 301-313,

[3] Alireza Azmand, Hosein Kafashan Physical and electrochemical properties of electrodeposited undoped and Se-doped *ZnS thin films* Ceramics International, Volume 44, Issue 14, 1 October 2018, Pages 17124-17137,

[4] Biswajit Barman, Kasturi V. Bangera, G. K. Shivakumar Preparation of thermally deposited Cux(*ZnS*)1-x *thin films* for opto-electronic devices Journal of Alloys and Compounds, Volume 772, 25 January 2019, Pages 532-536,

[5] Khaoula Ghezali, Loubna Mentar, Boubekeur Boudine, Amor Azizi Electrochemical deposition of *ZnS thin films* and their structural, morphological and optical properties Journal of Electroanalytical Chemistry, Volume 794, June 2017, Pages 212-220,

[6] , K. Ben Bacha, A. Timoumi, N. Bitri, H. Bouzouita Structural, morphological and optical properties of sprayed *ZnS thin films* on various substrate natures Optik, Volume 126, Issue 21, November 2015, Pages 3020-3024

[7] H. Haddad, A. Chelouche, D. Talantikite, H. Merzouk, D. Djouadi Effects of deposition time in chemically deposited *ZnS films* in acidic solution *Thin* Solid *Films*, Volume 589, August 2015, Pages 451-31 456

[8] A. Goudarzi, A.D. Namghib, H. Chang-Sik, Fabrication and characterization of nano-structured ZnS thin films as the buffer layers in solar cells. RSC Adv. **4**, 59764–59771 (2014)