Material Science Research India Vol. **5**(2), 465-468 (2008)

Structural and optical properties of electrochemically deposited Cd In_2Se_4 thin film

J.A. BORSE, A.V. KOKATE, A.B. GITE, R.S. DHAKE, P.D. MAPARI and H.R. KULKARNI

Bhujbal Knowledge City, MET's Institute of Engineering, Adgaon, Nashik (India).

(Received: Septemer 10, 2008; Accepted: October 17, 2008)

ABSTRACT

$CdIn_2Se_4$ thin film are prepared by pulsed electro deposition technique over stainless steel substrates in galvanostatics mode from an aqueous acidic bath containing $CdS0_4$, $InCl_3$, and Seo_2. The growth kinetics of the film was studies and the deposition parameters such as electrolyte bath concentration, deposition time, current density, and pH of electrolyte bath are optimized. The X-ray diffraction (XRD) analysis of the deposited film showed presence of polycrystalline nature. The surface morphology studies by scanning electron microscope (SEM) shows that the deposited film are well adherent and grains are uniformly distributed over the surface of substrate.

Key words: electro deposition, XRD, SEM.

INTRODUCTION

For the last couple of decade's interest in the use of photo electrochemical solar cells lead to large amount of research in the search for thin film polycrystalline material with acceptable efficiency. Some time approaching that of single crystals. In recent years, 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. etc[1-4].

Interest in the use of photo electrochemical (PEC) solar cells for low-cost energy conversion has lead to an extensive research in the field for novel and suitable thin film semiconductor materials[5-8]. Recent investigation has shown that layered type semi conducting cadmium chalcogenide group (CdSe, CdS, CdTe) which absorb visible and near IR light are particularly promising materials for photo electrochemical solar energy conversion. The polycrystalline electrodes are economically desirable for solar cell applications. Hence this study has been directed towards obtaining $CdIn_2Se_4$ in polycrystalline thin films.

Many workers investigated the photo electrochemical property of CdIn2Se4 single crystal. The structural and optical properties of electrodeposited $CdIn_2Se_4$ thin films have been reported. Many workers have been succeeded in depositing thin film of $CdIn_2Se_4$by vacuum evaporation.

In this report an attempt is made to prepare $CdIn_2Se_4$ films through electro deposition technique on stainless steel substrate which enables the film to be used for characterization studies like structural, surface composition, surface morphology and optical properties.

MATERIAL AND METHODS

The thin films of $CdIn_2Se_4$ were pulsed electro deposited on stainless steel substrate. The stainless steel plates 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 solution of $CdSo_4$ (0.1M), $InCl_3$ (0.1M), and SeO_2 (0.1M) in the ratio of 1:2:4 respectively. 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. From visual observation it was observed that a formation of reddish films of $CdIn_2Se_4$ take place. These pulsed plated $CdIn_2Se_4$ films were found to be well adherent and uniform. The detailed growth kinetics was studies by changing the deposition parameters, the pH of solution and current density. XRD, SEM, optical properties and efficiency of thin film solid liquid junction solar cell used the deposited film of CdIn2Se4 for further characterization.

The X-Ray diffraction pattern for $CdIn_2Se_4$ thin film deposited on to stainless steel substrate. Were recorded by Philips X-Ray diffractometer model 1710 with Kα radiation in the span of angle between 10 Å and 100 Å. The surface morphology was studied by using scanning electron microscope using magnification of 5000 at potential 20 kV.

RESULT AND DISCUSSION

The polarization curve were plotted to determine the deposition potential of Cd In_2Se_4 thin film are shown in Fig 1.

The concentration of cadmium sulphide ($CdSO_4$), Indium trichloride ($InCl_3$), and selenium dioxide (SeO_2) were 0.1M. The films were grown at the optimized deposition potential of 1700 mV with respect to SCE and at the current density 1.4 mA/cm^2 When an electric field is applied between the working and counter electrode a fine $CdIn_2Se_4$--- thin film formation occurs on the surface of the substrate. The process of film formation is observed to be time dependent. The deposited film have been dried and preserved in desiccators for further study. The current density varied from 0.6 to 4.6 mA/cm--^{2} during deposition. The film deposited at current density 1.4 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 1.4 mA/cm^2.

The PEC cell n-$CdIn_2Se_4$ /polysulphide/c is illuminated with 200 w tungsten filament lamps. The photons having energy equal to or greater than band gap energy of $CdIn_2Se_4$ are absorbed in semiconductor and the electron-holes pairs are generated these electron hole pair are separated by local electric field. Present across the interface between semiconductor and polysulphide electrolyte. This leads to generation of photo voltage under open circuit and photocurrent under short circuit condition. The variation of Isc and Voc as a function of deposition time at constant pH is presented in fig 2.

It can be seen that the Isc and Voc are relatively higher at deposition time 50 min at pH 2 this may be due to formation of nearly stoichiometric

Table 1: Optimized parameters of deposited $CdIn_2Se_4$ thin film

Parameters	Optimized values
Bath pH	2
Deposition Time (min)	50 min
Deposition potential (mV)	1700 mV
Current density (mA/cm--^{2})	1.4 mA/cm--^{2}

Table 2 Standard'd' and observed 'd' values for $CdIn_2Se_4$ thin film

Planes (hkl)	Standard 'd' values (A^0)	Observed 'd' values (A^o)
101	4.12 A°	4.05 A°
111	3.36 A°	3.35 A°
102	2.60 A°	2.65 A°
202	2.06 A°	2.14 A°

$CdIn_2Se_4$ thin film material at 50 min.and optimum thickness of $CdIn_2Se_4$ for the effective absorption of the photons. Fig 2 shows the variation of Isc and Voc with deposition time and the optimum values of Isc and Voc are found to be for the film deposited for 50 min this may be attributed to the optimum thickness of the film.

Fig 3 Show that variation of Isc and Voc with different pH at constant deposition time. It can be seen that the Isc and Voc are relatively higher at pH =2 at deposition time 50 min and optimum pH of $CdIn_2Se_4$ for the effective absorption of photons. The grown $CdIn_2Se_4$ film deposited at the optimized preparation parameter were further characterized by analyzing the XRD pattern. The X-ray diffraction pattern for $CdIn_2Se_4$ film deposited on stainless steel substrate is shown in fig 4

The XRD analysis reveals that the film is polycrystalline and the sharp peaks are identified as (101), (111), (102), (202). Plane of $CdIn_2Se_4$ .the

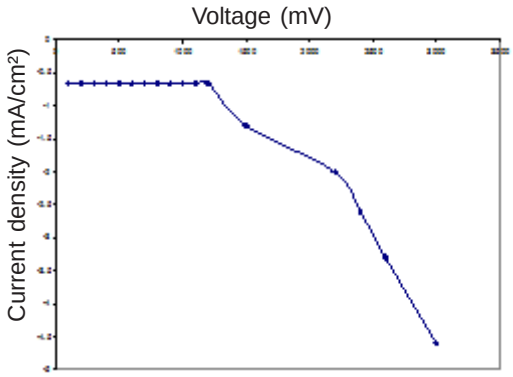

Fig. 1: Varriation of current density with applied voltage (polarization curve)

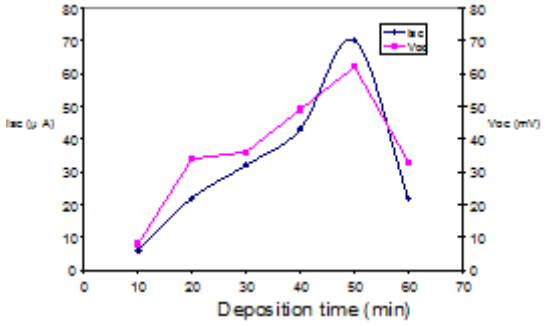

Fig. 2: Variation of Isc and Voc with deposition time

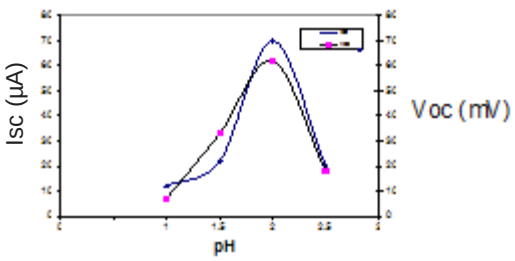

Fig. 3: Variation of Isc and Voc withpH of bath

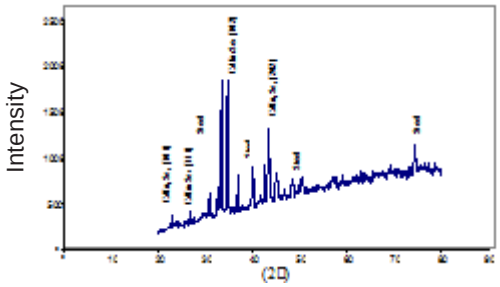

Fig. 4: XRD of deposited $CdIn_2Se_4$ thin film

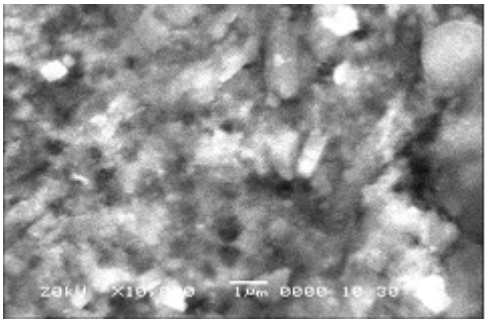

Fig. 5: SEM photograph of $CdIn_2Se_4$ thin film

matching of observed'd' values with standard ones in Table 2. Confirms the formation of the $CdIn_2Se_4$ material.

CONCLUSION

Almost stoichiometric $CdIn_2Se_4$ thin film was formed by electro deposition technique. The film grown is polycrystalline with Tetragonal structure. Deposited film is uniform and well adherent from fig 5 and fig 6.

ACKNOWLEDGEMENTS

I express my deep sense of guidance and heartfelt thanks to my honorable guide Dr.H.R.Kulkarni.for this help and encouragement during this work.

I wish to express my gratitude to Dr.A.A.Kulkarni, Principle of MET' Institute of Engineering, Bhujbal Knowledge City, Adgaon.Nashik for providing the facilities of the Institute and for their encouragement in this work. I am very much thankful to Mr.A.V.Kokate and Mr.P.D.Mapari for their encouragement, help and suggestion during this project work.

I am also thankful to Mr. S.P.Sonavani and Mr.Yogesh Gheware for their help and co-operation in the chemical analysis. Finally, I would like to thank all of my colleagues, staff members, and research scholars of the institute. I wish to thank my family members who have always been very supportive and encouraging.

REFERENCES

1. K. Y. Rajpure. C. D. lokhande. C. H. Bhosale. *Matter. chem. phy.,* **252**: 51 (1997).
2. V.I.mathe.K.Y. Rajpure. C.H.Bhosale. *Bull. Mate sci* **22**: 927 (1999).
3. N.G. Patel. *Solid state elctrochem.,* **35**: 1269 (1992).
4. H.J.Goldsmid.J.E.Giutronich. M.M. Kalia. *Solar energy.* **24**: 435 (1980).
5. X.Mathew.P.J.Sebastian. *Solar energy mater. Solar cells*. **59**: 85 (1999).
6. X.Mathew *J. phy D. Appl. phy.* **33**: 1565 (2000).
7. P. PHankare S.D. Delekar. V.M. Bhuse. P.A. Chate.K. M. Goradkar. *semiconductor sci. technol*. **20**: 257 (2005).
8. Y. Wade. Nishimatsl. *J.elcetrochem. Soc*. **125**: 1499 (1978).
9. R.Chandramohan.T. Mahlingam J.P. Chu. P.J.sebstian.solar energy. *Mater.solar cell.* **81**: 371 (2004).
10. S.K.Deshmukh. *Mate sci. Engg* B. **122**: 206 (2005).