Material Science Research India Vol. **6**(1), 197-200 (2009)

Synthesis and characterization of electrochemically deposited $CuIn_2Se_4$ thin film

S.B. BANSODE, J.A. BORSE, H.R. KULKARNI and S.S. KALE

H.P.T.Arts and R.Y.K.Science College. Department of Physics
Nashik MET's Institute of Engineering, Department of Physics,
Bhujbal Knowledge City.Adgaon, Nashik (India).

(Received: December 14, 2008; Accepted: January 15, 2009)

ABSTRACT

$CuIn_2Se_4$ thin films are developed by electrochemically deposition technique on stainless steel substrates in galvanostatics mode from an aqueous acidic bath. Which contain CuSO4, $InCl_3$ and SeO_2.the properties of film are studies by deposition parameters such as deposition time, current density, deposing potential, pH of bath, temperature of bath, are optimized and crystal structure are studied by X-Ray diffraction analysis. Optical properties studied with effect of temperature. Surface morphology observed by Scanning Electron Microscopy with annealing at different temperature.

Key words: Electrochemical deposition, XRD, SEM. $CuIn_2Se_4$ thin film.

INTRODUCTION

For the last couple of decade's interest in the use of photoelectrochemical 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].

Thin films are thin material layers ranging from fraction of a nanometer to several micrometers in thickness. Electronic semiconductor devices and optical coating are the main application benefiting from thin film construction. Some work is being done with ferromagnetic thin film as well as for use as computer memory. It is also being applied to pharmaceuticals via thin film drug delivery. Ceramic thin film is also in wide use. The relatively high hardness and interest of ceramic material make this type of thin coating of interest for protection of substrate. Material against corrosion, oxidation and wear. in particular the use of such coating on cutting tools may extend the life of these items by several orders of magnitude.

Interest in the use of photoelectrochemical (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].

In this report an attempt is made to prepare $CuIn_2Se_4$ films by electro deposition technique on stainless steel substrate which enables the film to be used for characterization studies like structural, surface composition, surface morphology, optical properties with different temperature of film and film annealing at 150°C. This film exhibit well optical properties and gives well efficiency .deposited film annealing at 150°C. It will show well adherent and uniform.

MATERIAL AND METHODS

The thin film of $CuIn_2Se_4$ is electrochemically deposited on stainless steel substrate.

The stainless steel plate used as a cathode in cell with graphite as the counter electrode. And saturated calomel electrode (SCE) was the reference electrode. The metal salt solution was prepared by solution of $CuSO_4$ (0.1 M), $InCl_3$ (0.1 M) and SeO_2 (0.1 M) in ratio 1:2:4 respectively. The pH of electrolyte solution was varied by dil HCl and ammonia (NH_3).the distilled water was used for preparation of electrolyte solution of above chemicals. Before deposition the substrate were cleaned with acetone and washed with double distilled water. by visual observation it was observed that the formation of reddish film of $CuIn_2Se_4$ take place the growth kinetics of film was studied by different deposition paprameters.such as pH of electrolyte bath, deposition time, deposing potential, current density, temperature of bath, and optical properties (Isc and Voc) by using polysulphide solution. That will be solid liquid junction solar cell. The deposited film of $CuIn_2Se_4$ were used for characterization by X-Ray diffraction analysis to find out crystal structure and SEM for surface morphology also studied the effect of temperature of bath on optical properties. The deposited film are annealing at temperature 150^0c at this temperature film showed well adherent and uniform. The X-Ray diffraction pattern of $CuIn_2Se_4$ thin film were recorded by Philips X-Ray diffractometer model 1710 with Kα radiation in span of angle between $10A^1$ and $100A^1$.

RESULT AND DISCUSSION:

The polarization curve plotted to determine the deposing potential of $CuIn_2Se_4$ thin film are shown in fig 1 .the concentration of $CuSO_4$, $InCl_3$ and SeO_2 were 0.1 M the film were grown at the optimized deposing potential of 1.4 V i.e. fine deposition occurs at potential 1.4V and corresponding current density 6.6 mA/cm^{-2} . when an electric field is applied between working and counter electrode a fine $CuIn_2Se_4$ thin film form on surface of substrate. The process of film formation is observed to be time dependent. The current density varied during deposition. The film deposited at current density 6.6 mA/cm^{-2} was found to be uniform and well adherent to substrate.

The growth kinetics was studied by deposition time with respective thickness of film shown in fig 2.the deposited film showed well thick at deposition time(40 min) the thickness of film increases linearly up to certain time and suddenly decreased by co deposition process so at particular time thickness showed maximum that are optimized.

The variation of Isc and Voc with deposition time of film shown in fig 3 it can be seen that the Isc and Voc are higher at deposition time 40 min at pH 1.5 this may be due to formation of nearly

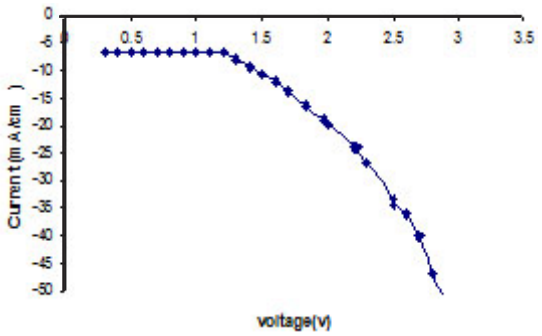

Fig. 1:

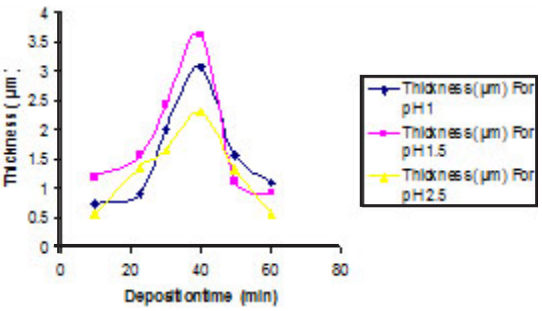

Fig. 2:

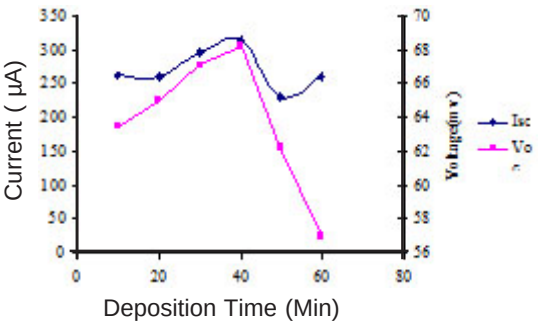

Fig. 3:

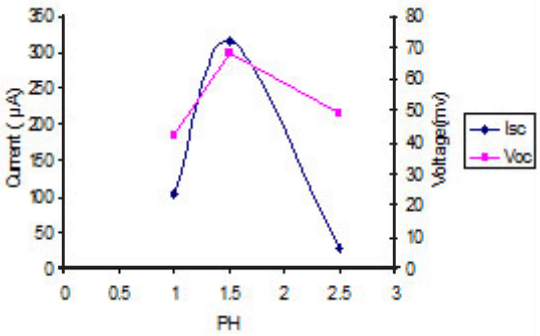

Fig. 4:

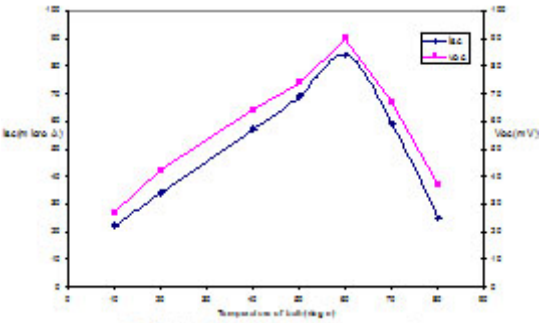

Fig. 5: Variation of Isc and Voc with different temperature of

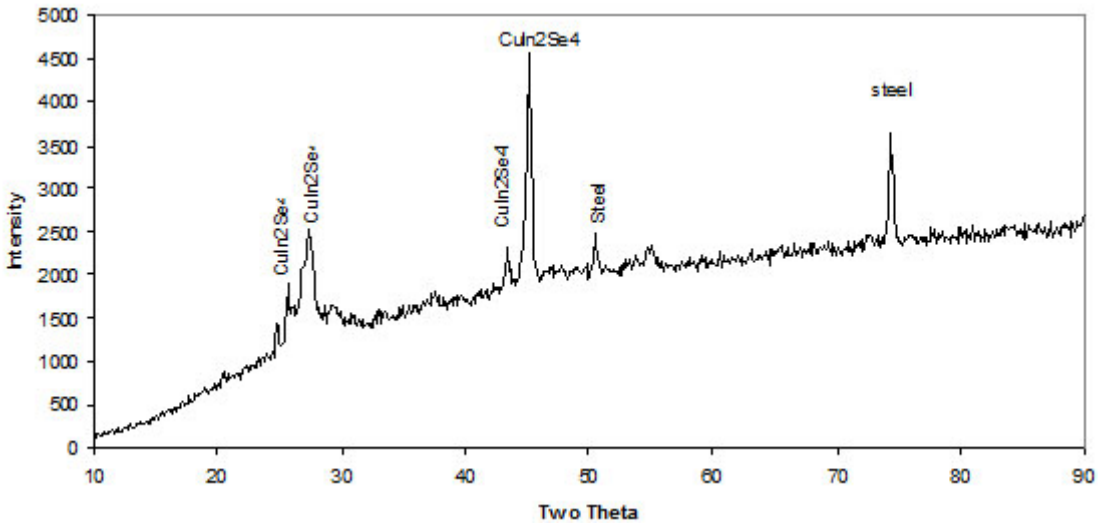

Fig 6: XRD of $CuIn_2Se_4$ thin film

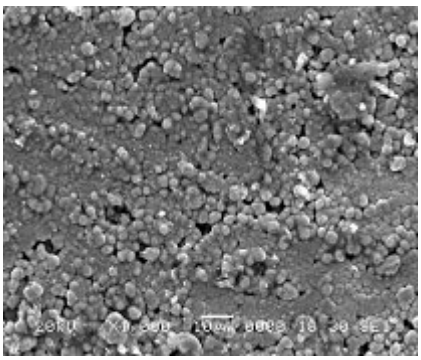

Fig: 7 SEM of $CuIn_2Se_4$ thin film

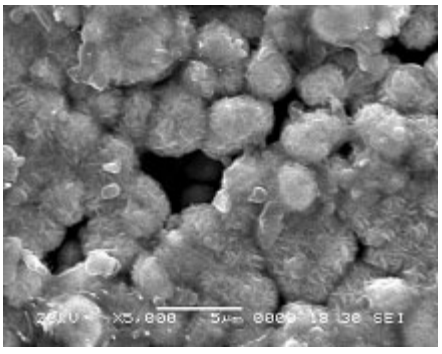

Fig: 8 SEM of $CuIn_2Se_4$ thin film at 150°C

stoichiometric $CuIn_2Se_4$ thin film material at 40 min and optimized thickness of $CuIn_2Se_4$ thin film will be effective absorption of photons.

Fig 4 shows the variation of Isc and Voc at different pH at constant deposition time. it can be seen that the Isc and Voc are relatively higher at pH 1.5 at deposition time 40 min.it gives well optical properties at pH 1.5.

Table 1: Optimized parameters of $CuIn_2Se_4$ thin film

S. No.	Optimized parameters	values
1.	Deposing potential	1.3 V
2.	Current density	1.9 mA/cm^2
3.	Deposition time(min)	40 min
4.	pH of bath	1.5
5.	Temperature of bath	60°c

Fig 5 shows the variation of Isc and Voc at different temperature of electrolyte bath. It can be seen that Isc and Voc were higher at temperature 60^{0}c. Isc and Voc increases linearly up to 60^{0}C then becomes reduced.

The different deposition parameters shown in Table 1. the grown $CuIn_2Se_4$ thin film deposited at optimized parameters were further characterized

Table 2: Standard 'd' and observed 'd' of $CuIn_2Se_4$ thin film by using ASTM data

2θ	Plane (hkl)	Standard 'd'	Observed 'd'
26.6	112	4.16 A°	3.34 A°
27.5	103	3.10 A°	3.24 A°
43.4	204	2.40 A°	2.08 A°
45.1	220	2.40 A°	2.00 A°

by analyzing the XRD pattern. The X-Ray diffraction pattern of $CuIn_2Se_4$ film deposited on stainless steel substrate is shown in Fig 6.

The XRD analysis showed that film is polycrystalline and sharp peaks are at plane (112), (103), (204), (220).the observed 'd' and standard 'd' are matched with ASTM data. Are shown in table 2. it can be seen that formation of $CuIn_2Se_4$ thin film is confirmed. And Fig. 7 and Fig. 8 showed SEM photograph before annealing and after annealing at temperature 150°C.

ACKNOWLEDGEMENTS

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.

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