

Synthesis and characterization of AgInSe₂ thin film and its optical properties

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ABSTRACT

AgInSe₂ thin film is developed by electrochemically deposition technique on stainless steel substrates in galvanostatics mode from an aqueous acidic bath containing AgCl₃, InCl₃, and SeO₂. The growth kinetics of the film was studied by measurement of thickness i.e. Mass difference method. 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. And the interplanar distance (d). The surface morphology studies by Scanning electron microscope (SEM) show that the deposited film is well adherent and uniform.

Key words: Electrodeposition, XRD, SEM, AgInSe₂

INTRODUCTION

Thin films are thin material layers ranging from fractions of a nanometre to several micrometres in thickness. Electronic semiconductor devices and optical coatings are the main applications benefiting from thin film construction. Work is being done with ferromagnetic thin films for use as computer memory. It is also being applied to pharmaceuticals, via thin film drug delivery. Thin-films are used to produce thin-film batteries. Ceramic thin films are in wide use. The relatively high hardness and inertness of ceramic materials make this type of thin coating of interest for protection of substrate materials against corrosion, oxidation and wear. In particular, the use of such coatings on cutting tools can extend the life of these items by several orders of magnitude. Research is being done on a new class of thin film inorganic oxide materials, called amorphous heavy-metal cation multicomponent oxide, which could be used to make transparent transistors that are

inexpensive, stable, and environmentally benign.

Thin-film technologies are also being developed as a means of substantially reducing the cost of photovoltaic (PV) systems. The rationale for this is that thin-film modules are cheaper to manufacture owing to their reduced material costs, energy costs, handling costs and capital costs. This is especially represented in the use of printed electronics (roll-to-roll) processes. Thin films belong to the second and third photovoltaic cell generations.

For the last couple of decades 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.

MATERIAL AND METHODS

The thin films of AgInSe_2 were electrochemically deposited on stainless steel substrate. The stainless steel plates were used as the cathode in three electrodes cell system with graphite as the counter electrode and saturated calomel electrode (SCE) was the reference electrode. The electrolyte was prepared by mixing solution of AgCl_3 (0.1M), InCl_3 (0.1M), and SeO_2 (0.01M) in the ratio of 1:1:2 respectively. The pH of electrolyte solution was varied by dilute H_2SO_4 . double distilled water was used for preparation of aqueous solution of above precursor chemicals. Before deposition the substrate were cleaned with distilled water. The distance between the working electrode and counter electrode kept constant as 1 cm during deposition. From visual observation it was observed that a formation of blackish films of AgInSe_2 take place. These pulsed plated AgInSe_2 films were found to be well adherent and uniform. The detailed growth kinetics was studies by measurement of thickness of film. Changing the deposition parameters such as depositing potential, deposition time, the pH of solution and current density. XRD, SEM, optical properties was studied and efficiency of thin solid-liquid junction solar cell calculated from IV characteristics graph using polysulphide solution. Used for the further characterization.

The X-Ray diffraction pattern for AgInSe_2 thin film deposited on to stainless steel substrate.

Were recorded by Philips X-Ray diffractometer model 1710 with $\text{K}\alpha$ radiation in the span of angle between 10° and 100° . 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 AgInSe_2 thin film are shown in fig 1.

The concentration of cadmium sulphide (AgCl_3), Indium trichloride (InCl_3), and selenium dioxide (SeO_2) were 0.1M, 0.1M, 0.01M respectively. The films were grown at the optimized deposition potential of 1200 mV with respect to SCE and at the current density 1.2 mA/cm^{-2} . When an electric field is applied between the working and counter electrode a fine AgInSe_2 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 2 mA/cm^{-2} during deposition. The film deposited at current density 1.2 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 1.2 mA/cm^{-2} .

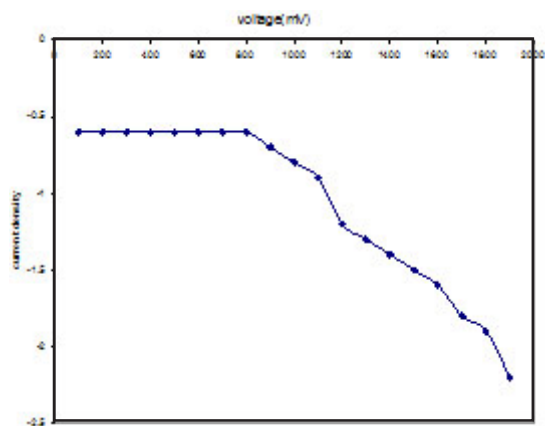


Fig. 1: Polarization curve for depositing potential

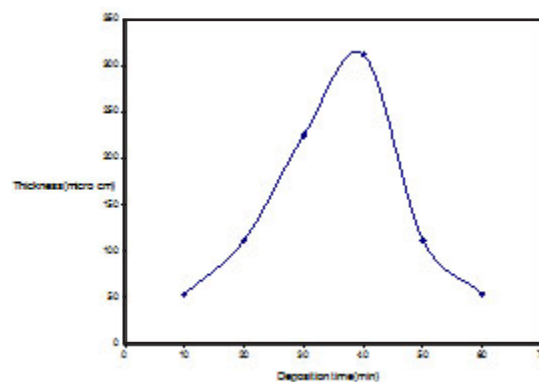


Fig. 2: Thickness optimization

The fig.2 shows the kinetics growth of AgInSe₂ thin film it can be seen that film exhibit large thickness at deposition time 40 min. thickness of film increases linearly up to 40 min above this time co-deposition was started and reduced the thickness of film.

The PEC cell n- AgInSe₂ /polysulphide/c is illuminated with 100 w tungsten filament lamps. The photons having energy equal to or greater than band gap energy of AgInSe₂ 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 3.

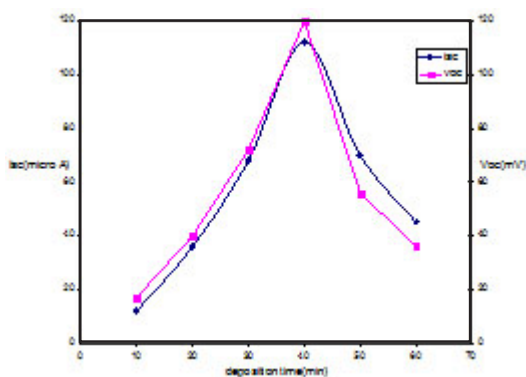


Fig. 3: Variation of Isc and Voc with deposition time

It can be seen that the Isc and Voc are relatively higher at deposition time 40 min at pH 2.5 this may be due to formation of nearly stoichiometric AgInSe₂ thin film material at 40 min. and optimum thickness of AgInSe₂ for the effective absorption of the photons. Fig 3 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 40 min this may be attributed to the optimum thickness of the film.

Fig 4 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 =2.5 at deposition time 40 min and optimum pH of AgInSe₂ for the effective absorption of photons. The grown AgInSe₂ film deposited at the optimized preparation parameter were further characterized by analyzing the XRD pattern. The X-ray diffraction pattern for AgInSe₂ film deposited on stainless steel substrate is shown in fig 5.

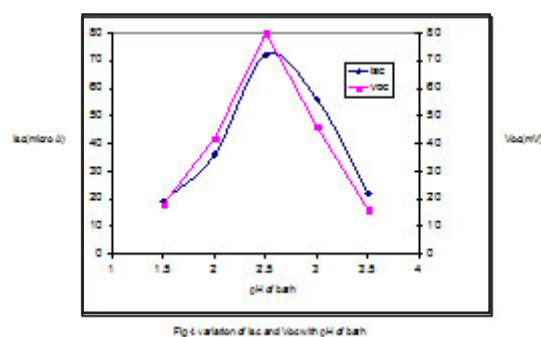


Fig. 4: Variation of Isc and Voc with pH of bath

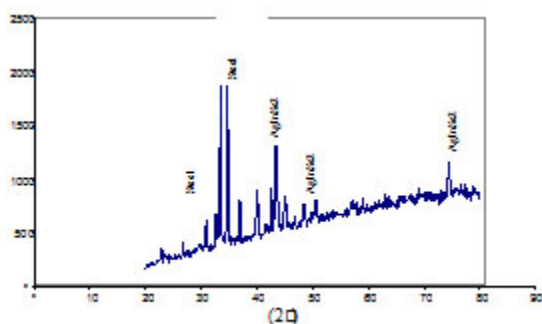


Fig. 5: XRD of AgInSe₂ Thin film

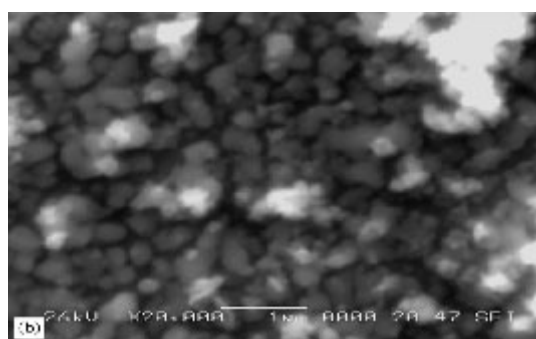


Fig. 6: SEM photograph of AgInSe₂ Thin film

Table 1: Optimized parameters of deposited AgInSe₂ thin film

Parameters	Optimized values
Bath pH	2.5
Deposition Time (min)	40 min
Deposition potential (mV)	1200 mV
Current density (mA/cm ⁻²)	1.2 mA/cm ²

Table 2: Standard 'd' and observed 'd' values for AgInSe₂ thin film

Planes (hkl)	Standard 'd' values (Å)	Observed 'd' values (Å)
111	3.50	3.64
220	2.13	2.53
311	1.82	1.90

The XRD analysis reveals that the film is polycrystalline and the sharp peaks are identified as (111), (220), (311), Plane of AgInSe₂. the matching of observed 'd' values with standard ones in Table 2. Confirms the formation of the AgInSe₂ material. And table shows the optimized parameters of AgInSe₂ thin film.

CONCLUSION

Almost stoichiometric AgInSe₂ thin film was formed by electro deposition technique. The film grown is polycrystalline with Tetragonal structure. Deposited film is uniform, well adherent and crystalline nature from SEM photograph shown in fig 6. it is well efficient to give optical properties.

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