Growth and Characterizations of $Cu_{0.25}In_{0.75}Se$ Thin Films Deposited by Thermal Evaporation Technique

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ABSTRACT

In present work the ternary compound $Cu_{0.25}In_{0.75}Se$ thin films were grown by thermal evaporation technique under the pressure of 10^{-5} torr. The samples were characterized for structural, elemental and optical properties. The XRD pattern reveals that the sample is polycrystalline with monoclinic crystal shape. The AFM estimates the surface roughness about 7.81 nm. The chemical analysis was done by Energy Dispersive Analysis of Xray method. The optical band gap was found to be 1.8 – 2.18 eV. The photo sensing coefficient was calculated about 1.02.

Keywords: XRD, AFM, EDAX, UV-VIS, Photo Sensing.

1 INTRODUCTION

The III – VI group compound are important due its properties like high carrier mobility, high dielectric constants as well as photoconductivity properties. Many researchers are studied over many years to understand their properties, behaviour and characteristics, especially the ternary compound CuInSe. Due to its verity of commercial applications in optoelectronics technology, there has been huge interest in is focused on it. It has many commercial applications like photovoltaic applications [1], detectors [2] photo electrochemical storage cell [3] and ionic battery applications. The materials from III-VI are the most suitable compound semiconductors for optoelectronic applications [4]. The band gap energy of InSe is about 1.3 eV which makes it attractive materials for solar energy conversion [5]. The ternary compound of $Cu_{0.25}In_{0.75}Se$ is a promising and low cost semiconductor material for high efficiency solar cells [2]. CuInSe finds more wide applications in high performance and stable solar cells [6].

2 EXPERIMENTAL

The $Cu_{0.25}In_{0.75}Se$ ternary alloy were made by melt quench method by mixing quantities of highly pure Copper, Indium and Selenium in the atomic proportion. The mixture was sealed in an evacuated quartz tube and heated about 1000℃ for 24 hours, and then quenched in ice cooled water.

The samples $Cu_{0.25}In_{0.75}Se$ were grown by thermal evaporation technique under pressure of 10^{-5} torr. The source to substrate distance was kept about 14 cm. The sample was deposited for fix thickness. The thickness of the films was monitored on Digital Thickness Monitor (DTM-101) provided by Hind-Hi Vac. The deposition rate was maintained 8-10 Å/sec throughout sample preparation. Before evaporation, the glass substrates were cleaned throughout using concentrated chromic acid, detergent and acetone.

3 RESULT AND DISCUSSIONS

3.1 STRUCTURAL PROPERTIES

The crystalline parameters like crystal structure, size and nature are studied by XRD technique. The samples of $Cu_{0.25}In_{0.75}Se$ were scanned in the 2θ range of 0° to 80°. Fig. 1 shows the XRD pattern of $Cu_{0.25}In_{0.75}Se$ thin film of 3000Å thickness.

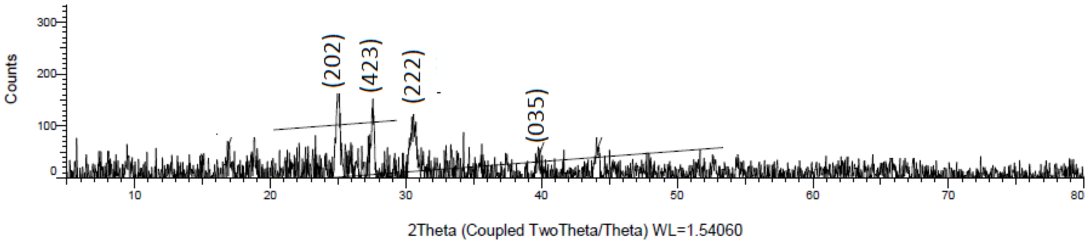

Fig.1: XRD Spectrum of $Cu_{0.25}In_{0.75}Se$ Thin Film

The hkl plans (202), (423), (222) and (035) are observed at 2θ peaks 25.0°, 27.5°, 30.75° and 39.8° respectively. The plans of reflections are good agreement with JCPDS data. XRD pattern has multiple peaks. It shows the material is polycrystalline in nature [7-11]. The major peak is belongs to monoclinic shape. The average crystalline size (D) was calculated by using the Scherrer formula:

$$D = \frac{0.94\,\lambda}{\beta \cos\theta}$$

Where, λ is the wavelength of X-ray, β is Full Width Half Maxima, θ is the diffraction angle. The crystal size was found to 3692 nm. The unit cell parameters a, b and c are found to be 14.47, 17.21 and 14.36 respectively.

The surface morphology and roughness of $Cu_{0.25}In_{0.75}Se$ thin film was studied through AFM images. Fig. 2 shows the 3D image for thickness of 3000Å. The micrograph reveals the grains covers the all area of substrate and is free from macroscopic defects like cracks and peeling. The grains almost uniformly distributed. The grains are closely packed together. The image shows grains have elongated morphology. The roughness of samples is found to be 7.81 nm with in scan area.

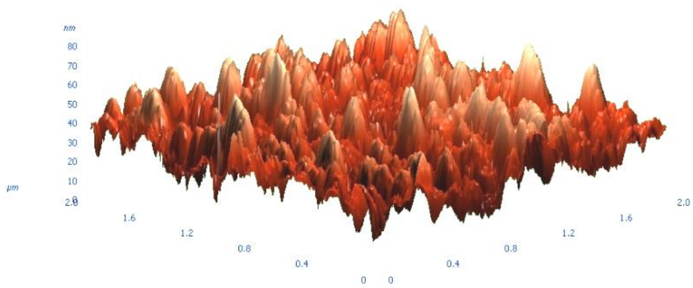

Fig. 2: 3-D AFM Image of $Cu_{0.25}In_{0.75}Se$ Thin Film

3.2 EDAX ANALYSIS OF $Cu_{0.25}In_{0.75}Se$ THIN FILMS

The quantitative elemental analysis of $Cu_{0.25}In_{0.75}Se$ thin films were done by EDAX. The EDAX spectrum of the $Cu_{0.25}In_{0.75}Se$ thin film is shown in Fig.3 for thickness 3000 Å. The present elements were detected at 0.9, 3.3 and 1.4 KeV with atomic percentages of 0.14%, 42.7 and 57.16%. There is no evidence found of any type of impurities. It proves the purity of grown sample. The presences of other peaks are due to the glass substrate and gold coating during the characterizations.

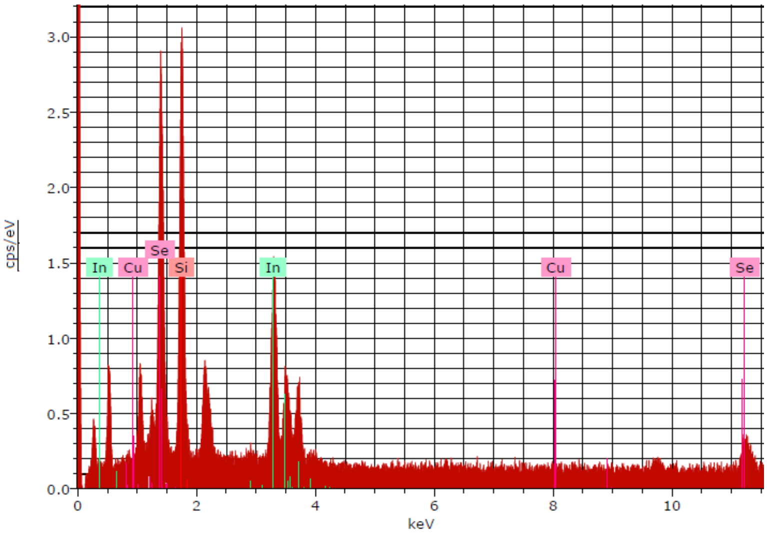

Fig. 3: EDAX Pattern of $Cu_{0.25}In_{0.75}Se$ Thin Film

3.3 OPTICAL PROPERTIES OF $Cu_{0.25}In_{0.75}Se$ THIN FILMS

The optical band gap of grown $Cu_{0.25}In_{0.75}Se$ thin film was studied by using UV – VIS Spectroscopy. The optical absorption patterns were obtained within the 400 – 800 nm wavelength ranges by using UV – VIS Spectrophotometer. Fig 4 and 5 shows the absorbance and transmittance patterns of grown $Cu_{0.25}In_{0.75}Se$ thin films respectively.

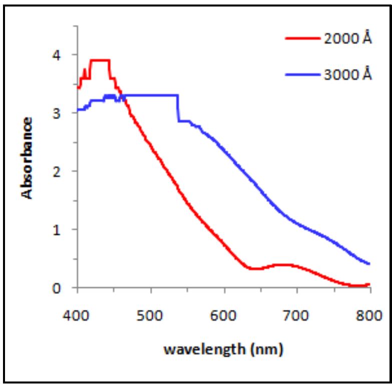

Fig. 4: Absorbance pattern

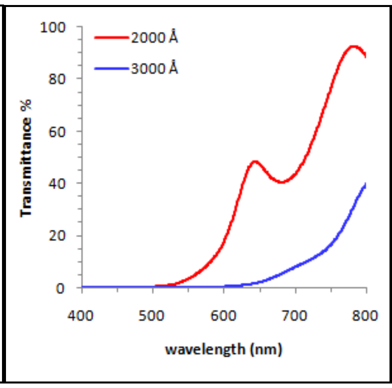

Fig. 5: Transmittance pattern

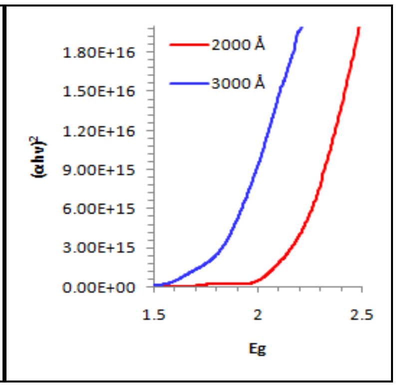

Fig. 6: Band Gap Pattern

The higher absorbance is noticed within the 400-475 nm wavelength regions. The $Cu_{0.25}In_{0.75}Se$ thin films with various thicknesses have good absorbance. The optical band gap of grown thin films has been calculated using the relation (Tauc 1974):

$$\alpha h\nu = A\,(h\nu - Eg)^{n}$$

Where, α is the absorption coefficient, hν is the photon energy, Eg the band gap. The pattern of band gap is shown in fig 6. From the fig 6 optical band gap of the grown $Cu_{0.25}In_{0.75}Se$ thin films were found to be 2.18 and 1.8 eV for 2000 and 3000 Ǻ thickness respectively. The $Cu_{0.25}In_{0.75}Se$ can be used in solar cell fabrication.

Fig 7 shows the I-V plot of $Cu_{0.25}In_{0.75}Se$ thin film for 3000 Å thicknesses recorded under the dark and luminance condition. I-V pattern revels that current get incises with respect to the voltage for both dank and luminance conditions. Also the recorded current in the presence light was relatively higher than the current measured in dark condition. Usually, photosensitive materials show increase in photocurrent on exposure to light. Photo sensitivity of grown $Cu_{0.25}In_{0.75}Se$ thin films calculated 1.02 from light current and dark current as:

$$S = \frac{I_l - I_d}{I_d}$$

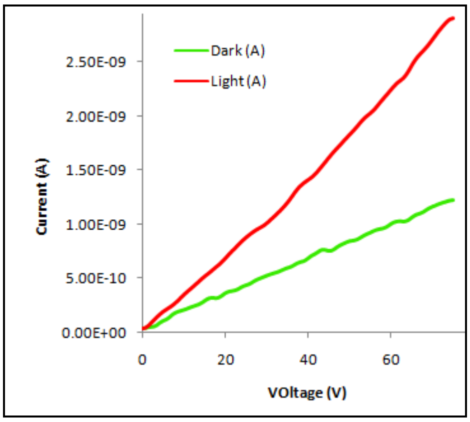

Fig. 7: I-V Plot of $Cu_{0.25}In_{0.75}Se$ Thin Film

4. CONCLUSION

The XRD study reveals that the $Cu_{0.25}In_{0.75}Se$ thin film is polycrystalline having monoclinic crystal structure. The AFM detects the surface roughness about 7.81 nm. The chemical analysis confirms the presence of elements. The optical band gap was found to be 1.8 – 2.18 eV with the help of UV-VIS. The photo sensing coefficient was calculated about 1.02.

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