Synthesis and Characterizations of $Cu_{0.25}In_{0.5}Se$ Thin Films Grown by Sublimation Techniques

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ABSTRACT

The $Cu_{0.25}In_{0.5}Se$ thin films were grown by sublimation technique under the pressure of 10^{-5} torr. The grown samples were characterized for various parameters. Structural characterization was done by the XRD technique. The surface morphology was studied by the Scanning Electron Microscopy (SEM). The optical properties were determined by UV-VIS Spectroscopy. The optical band gap was found to be 2.2 – 2.5eV.

Keywords: XRD, SEM, UV-VIS

1. Introduction

Nanometer scale materials, such as thin films, have been studied over many years. The properties and behaviors observed and measured are typically group characteristics. A better fundamental understanding and various potential applications increasingly demand the ability and instrumentation to observe measure and manipulate the individual nano-materials - nanostructures. Characterization and manipulation of individual nanostructures require not only extreme sensitivity and accuracy, but also atomic-level resolution. It therefore leads to various microscopies that will play a central role in characterization and measurements of nano-structured materials and nanostructures.

The III – VI group compound are important due its properties like high carrier mobility, high dielectric constants as well as photoconductivity properties. These chalcogenides crystallize are promising materials for photovoltaic applications [1], ionic battery applications, detectors [2] and photo electrochemical storage cell [3]. Indium Selenide compounds consist covalent bonded units (Se-In-In-Se) held together by Vander-Walls forces and it is one of the most suitable compound semiconductors for optoelectronic applications [4]. The band gap energy of InSe is about 1.3 eV at room temperature, which makes it attractive materials for solar energy conversion [5]. The grown oxide films together with InSe base create a photosensitive hetero junction [6].

The I-VI group (CuSe) semiconductors are used in microelectronic techniques [7]. CuSe has suitable electrical and optical properties for photovoltaic applications and also as a super radiation filters [8], optical filters [9] and ionic conductor [10].

The ternary compound of $Cu_{0.25}In_{0.5}Se$ 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 [11].

2. Experimental

2.1 Material Preparation

The $Cu_{0.25}In_{0.5}Se$ compositions were made by usual melt quench method by mixing quantities of high-purity (99.999%) Copper powder, Indium powder and Selenium metal in the atomic proportion. The mixture was sealed in an evacuated quartz tube at a pressure of 10^{-5} Torr and heated at 963 K for 24 hours, and then quenched in ice cooled water.

2.2 Thin Film Formation

The films of $Cu_{0.25}In_{0.5}Se$ were grown by thermal evaporation technique under pressure of 10^{-5} torr. The source to substrate distance was kept 14 cm. The samples of different thicknesses were deposited under similar conditions. The thickness of the films was monitored on Digital Thickness Monitor (model No. 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. Results and Discussions

3.1 X-Ray Diffraction Analysis

X – Ray analysis was done by using Bruker diffractometer with CuKα line. The scanning angle (2θ) range was from 20° - 80°. Figure 1 shows the XRD pattern of $Cu_{0.25}In_{0.5}Se$ thin film. The XRD data is well matches with slandered ASTM data. The presence of multiple peaks indicates that the films are amorphous in nature. The dominant diffraction peaks show the formation of well crystalline sample. The intensity of the peaks depends on crystalline quality.

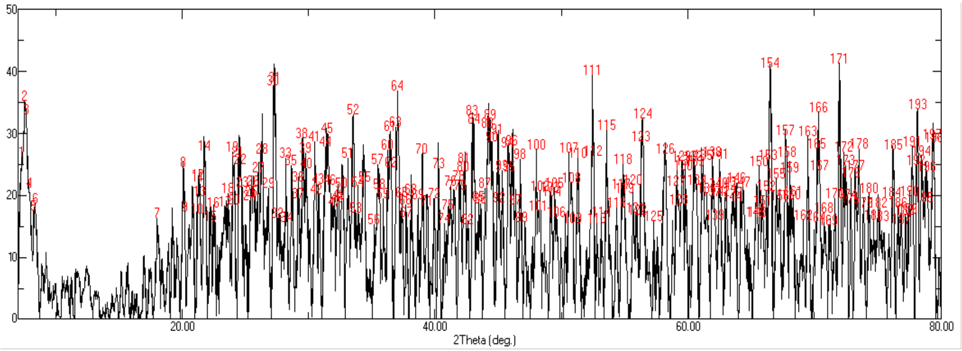

Figure 1: XRD Pattern of $Cu_{0.25}In_{0.5}Se$ Thin Film.

3.2 Scanning Electron Microscopy

Surface morphological study of deposited films was carried out by using Scanning Electron Microscope (Zeiss EVO 50). The SEM micrograph of $Cu_{0.25}In_{0.5}Se$ thin film is shown in figure 2.

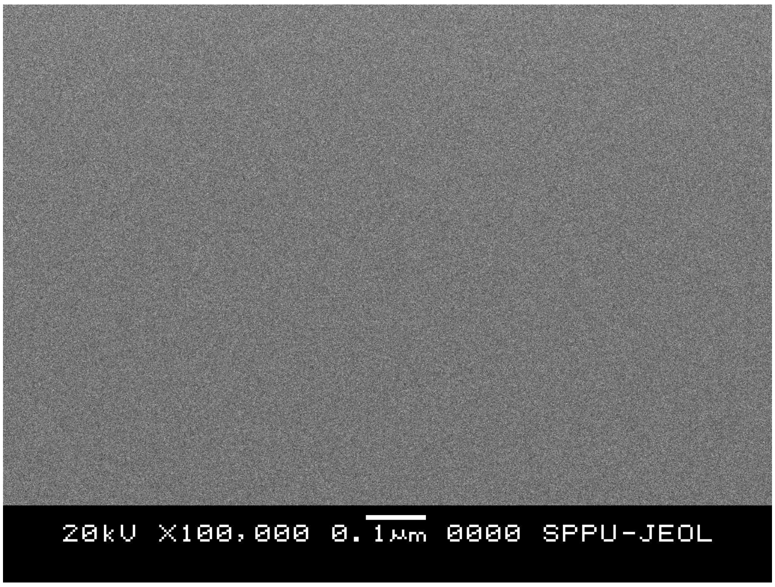

Figure 2: SEM image of $Cu_{0.25}In_{0.5}Se$ Thin Film.

SEM images of $Cu_{0.25}In_{0.5}Se$ thin film reveals the uniform distribution of grains all over the surface of the substrate. The surface showing uniform and smooth grains without any defects like cracks and pinholes. The $Cu_{0.25}In_{0.5}Se$ thin film is can be used for optical waveguide because of its smooth and plane surface.

3.3 UV-VIS Spectrometry

The optical band gap of the films was estimated with the help of absorbance and transmission spectra recorded in 200-900 nm wavelength range by employing a

Shimadzu 2600 UV-VIS Spectrophotometer. The figure 3 and 4 shows the absorbance and transmittance patterns of $Cu_{0.25}In_{0.5}Se$ thin films respectively.

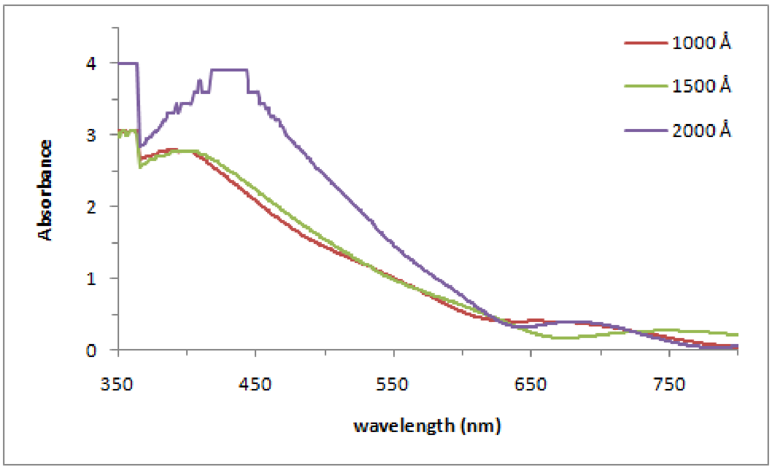

Figure 3: Absorbance of $Cu_{0.25}In_{0.5}Se$ Thin Film.

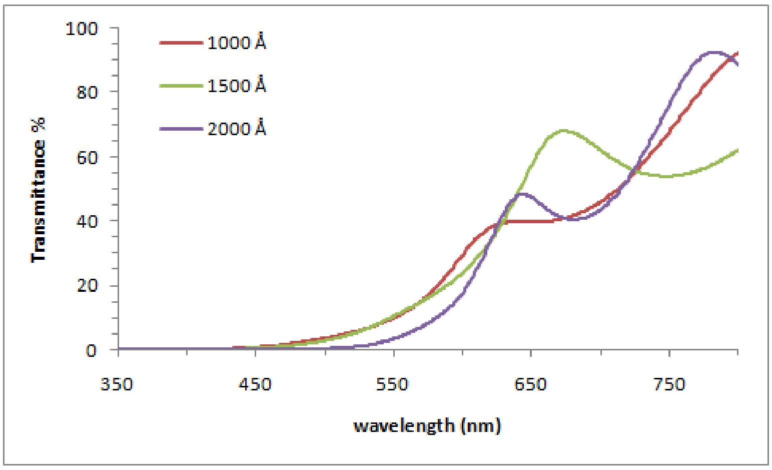

Figure 4: Transmittance of $Cu_{0.25}In_{0.5}Se$ Thin Film.

The absorbance patterns of Cu0.25In0.5Se thin films enhance the absorbance at 430 nm wavelength. The highest absorbance coefficient is found to be 4. It is observed that as deposited $Cu_{0.25}In_{0.5}Se$ thin films have lower transmittance in the UV visible region.

The optical band gap of the $Cu_{0.25}In_{0.5}Se$ thin films has been determined from the plot of Eg Vs $\alpha h\nu^2$ as shown in Figure 5. The linear portion is extrapolated to cut the x-axis, which gives the energy gap. The band gap values were calculated within 2.2 eV – 2.5 eV and it can be used in fabrication of PV modules.

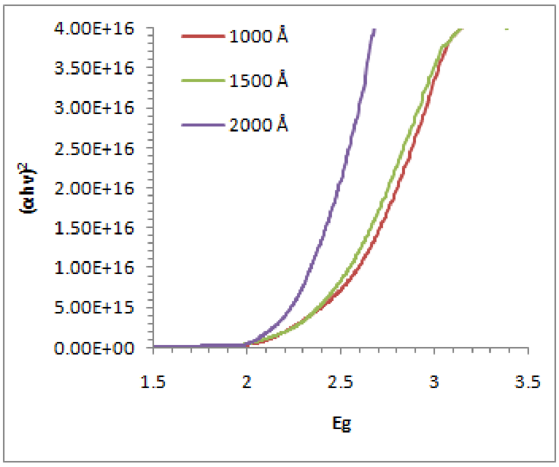

Figure 5: Optical Band Gap of $Cu_{0.25}In_{0.5}Se$ Thin Film.

4. Conclusion

The $Cu_{0.25}In_{0.5}Se$ thin films were grown by sublimation technique under the pressure of 10^{-5} torr. The grown samples were characterized for various parameters. The $Cu_{0.25}In_{0.5}Se$ is found to be amorphous in nature. The Scanning Electron Microscopy (SEM) revels that grown samples have smooth surface. The optical band gap were determined by UV-VIS Spectroscopy and it is found to be 2.2 – 2.5 eV.

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