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Optical and Structural Properties of CuSe Thin Films Deposited by Chemical Bath Deposition (CBD) Technique

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ABSTRACT

Copper selenide (CuSe) thin films have been deposited on to glass slide substrates by using chemical bath deposition (CBD) technique at room temperature. Growth parameters were investigated to obtain good quality thin films. Structural and optical properties of the thin films were studied by X-ray diffraction, Scanning electron microscopy (SEM) and spectrophotometer, respectively. XRD and SEM study revealed that the as-deposited CuSe films were amorphous in nature and the deposition was uniform. Optical study revealed that the direct band gap value is 2.3 eV.

Keywords: thin films; CBD; structural; optical.

1. INTRODUCTION

Copper selenide (CuSe) is a metal chalcogenide p-type semiconducting material, which has electrical and optical properties suitable for opto electronic device applications [1]. CuSe has many applications in fabrication of solar cell [2], photo detectors, thermo electric converter, photo electro chemical cells etc. Copper selenide comes in different stoichiometric form such as CuSe, Cu_2Se, Cu_3Se_2, Cu_5Se_4 and non stoichiometric form $Cu_{2-x}Se$. This material is synthesized in thin film form by various methods such as Chemical Bath Deposition (CBD) [1], Spray pyrolysis [3], Vacuum evaporation [4], electro deposition [5], etc. Researchers are continuously in search of more applications of CuSe due to its promising properties. In the present investigation CuSe thin films have been deposited by chemical bath deposition (CBD) technique.

2. METHODOLOGY

The substrates used for the deposition of CuSe thin film were commercial microscope glass slides (Blue Star).. Before deposition, the substrates were cleaned by commercial detergent and finally rinsed with de-ionized water and dried in air. This process is to ensure clean surface, which is essential for formation of nucleation centers, required for thin film deposition. Thin films of CuSe have been deposited by chemical bath deposition technique using selenium powder, sodium sulphite, cupric chloride and ammonia. All chemicals used in the present investigation were AR grade. A solution of sodium selenosulphate (Na_2SeSO_3) was prepared by refluxing method [6]. Typically, 10 mL 0.25M $CuCl_2 \cdot 2H2O$ solution was taken in a 100 mL glass beaker. Under continuous stirring 1 mL of 30% ammonia solution was added drop by drop. Then 10 mL freshly obtained sodium selenosulphate solutions were added slowly with constant stirring and the pH of the final mixture was adjusted to ~ 10. The rest distilled water is added to make the volume 50mL.

Pre-cleaned glass substrates were inserted into the reaction mixture in the beaker standing parallel with the walls of the beaker, which was kept in room temperature bath for 4 h. After deposition, the glass slides were taken out from the bath, washed with de-ionized water and was dried in air. It was observed that the films were uniform and well adhered.

3. CHARACTERIZATION TECHNIQUES

The as-deposited thin films of CuSe were characterized for structural and optical properties. The CuSe film thickness was measured by weight difference method. Glancing incidence angle X-ray diffraction (GIXRD) pattern of the film was recorded on a Bruker AXS, Germany (D8 Advanced) diffractometer in the scanning range 20–70° (2θ) using Cu-Kα1 radiations with wavelength 1.5405 Å at 0.5° glancing angle. The surface morphology was studied by scanning electron microscopy (SEM, JOEL-JSM-5600). Transmittance and absorbance spectra were recorded in the range 300–1100 nm by means of Jasco V630 spectrophotometer

4. RESULT AND DISCUSSION

4.1 Structural Characterization

Fig. 1 shows the XRD pattern of CuSe thin film. It shows from the pattern that no well-defined peak was found and no well-defined plane was obtained in the case of as-deposited films, which suggests that the as-deposited films were amorphous in nature [7].

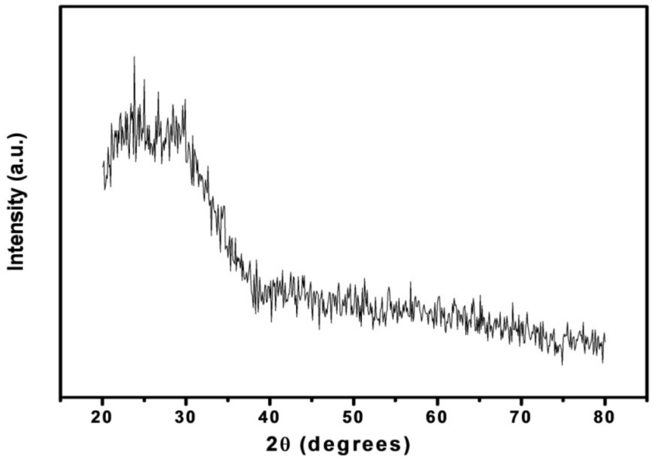

Figure 1. XRD pattern of as-deposited CuSe thin film

4.2 Surface morphological and topographical Characterization

Fig. 2 shows the scanning electron microscopy (SEM) image of as-deposited CuSe films. It is observed that the CuSe thin films are uniform and cover the substrate well. From the image, it is clear that the films were composed of a compact structure single type of small densely packed crystals. The grains are well defined, spherical and almost similar in size, that may correspond to the amorphous phase of CuSe film [8].

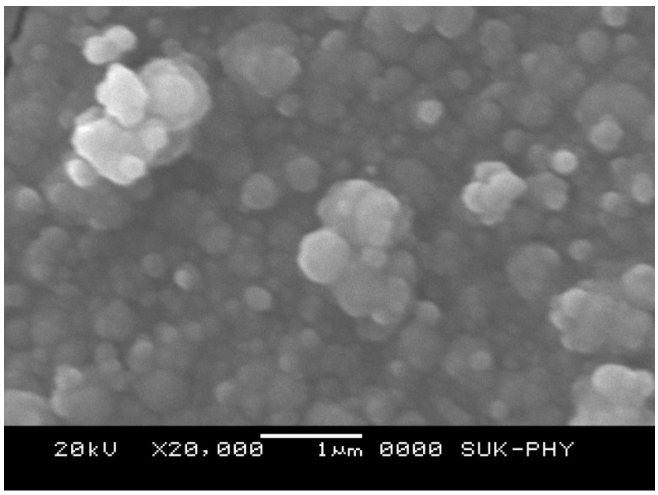

Figure 2. SEM image of as-deposited CuSe thin film

4.3 *Optical Characterization*

Absorbance spectra obtained from as-deposited CuSe thin film is used to obtain optical band gap. The relation between the absorption coefficient α and the incident photon energy (hν) can be written as [6],

Figure 2: (d) Geometrically optimized structure for Ni- CNT at Hexagon position, site D

$$\alpha h\nu = A(h\nu - E_g)^n \qquad (1)$$

where 'A' is constant, n= ½ for direct allowed transition, 'E_g' is optical band gap of the material. Fig. 3 shows the plot of $(\alpha h\nu)^2$ against (hν) for CuSe thin film derived from the optical spectra. Extrapolating the straight-line portion of the plot of $(\alpha h\nu)^2$ vs (hν) [40] for zero absorption coefficient value gives the band gap, which is found to be 2.3 eV at room temperature.

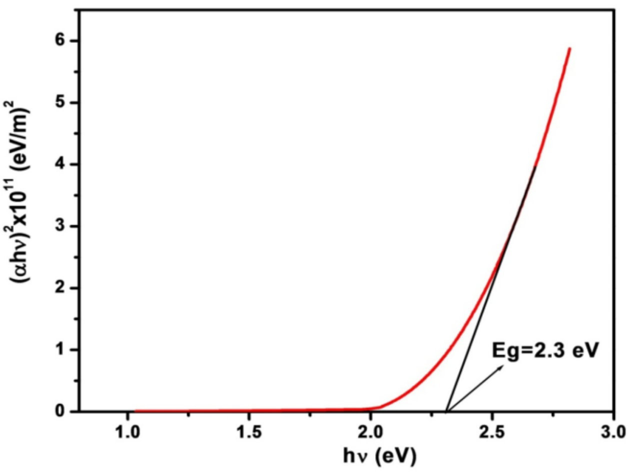

Figure 3. Plot of $(\alpha h\nu)^2$ vs. hν for CuSe thin films

CONCLUSION

Thin films of CuSe have been successfully deposited by Chemical Bath technique. Amorphous nature was confirmed by X-ray diffraction studies. Scanning electron microscopy study revealed uniform deposition. The optical band gap was found to be 2.3 eV.

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