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ELECTRICAL PROPERTIES OF NANOCRYSTALLINE CHEMICALLY DEPOSITED COPPER SELENIDE (CUSE) THIN FILMS

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Abstract: Nanostructured copper selenide (CuSe) have been prepared onto glass substrate by using chemical bath deposition method at room temperature. The structural studies indicates that CuSe thin films are nanocrystalline in nature with a hexagonal structure having preferred orientation along (102) plane. The optical band gap of the deposited film was found to be 2.48eV. The electrical resistivity of CuSe thin films is of the order of $10^{-3}\Omega$cm. The thermo-emf measurement confirms p-type conductivity of CuSe thin films.

Keywords: Thin films; Nanostructures; Electrical properties; p-type conductivity.

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INTRODUCTION

Most materials used in high technology applications are composites, i.e, they have a near surface region with properties differing from those of the bulk materials. Most modern technologies require thin films for different applications. Thin film materials are key elements of continued technological advances made in the fields of optoelectronic, solar photovoltaic technologies, photonic, magnetic devices, microelectronic devices, magnetic thin films in recording devices, magnetic sensors, gas sensor, photoconductors, IR detectors, Super conductivity films, anticorrosive and decorative coating [1]. Recently, metal chalcogenides have attracted considerable attraction due to their potential applications in electrical and optical devices. Among these materials, copper chalcogenide thin films possess unique properties that can result in novel electrical behaviour [2-3]. Copper selenide is a p-type I–VI semiconductor that has gained particular interest due to the excellent optical, structural and electrical properties [4-5].

2. Experimental Details

Copper selenide thin films were deposited on glass substrates using chemical bath deposition technique. The reagents used for the deposition of CuSe were copper tetraoxosulphate (VI) [$CuSO_4$], selenium trioxosulphate (V) [$SeSO_3$], sodium thiosulphate [NaS_2O_3] as a complexing agent and ammonia (NH_3) for pH adjustment. The reaction bath was made up to 50mL and the deposition was allowed at room temperature. The cleaned glass substrate was vertically immersed in the reaction bath at room temperature. The growth parameters such as the deposition time and volume of ammonia were varied to optimize the growth. After the end of every deposition time, the substrate was taken out of the reaction bath, washed with distilled water and dried in air.

The average thickness of the as deposited copper selenide thin film was measured by the gravimetric method. The structural studies were carried out using Philips PW 1710 diffractometer with Cu-Kα radiation of wavelength 1.5405 Å. The optical characteristics were studied using Lambda 25 UV-VIS spectrophotometer, to find band gap energy of copper selenide thin films dc two-point probe method was used. The dependent electrical properties were studied by using electrical resistivity and thermo-emf measurement techniques.

3. Results and discussion

3.1. Electrical Analysis

The dark electrical resistivity of the thin films was measured using a dc two-probe method in the temperature range 303K to 483 K. A plot of inverse absolute temperature versus log (resistivity) for a cooling cycle is shown in Fig. 1. The dependence is almost linear indicating the presence of only one type of conduction mechanism in the film. The electrical properties are dependent on various film and growth parameters such as film composition, thickness and substrate temperature and deposition rate. The investigations of electrical transport properties of the deposited material are important in determining the congruency of the material with our necessities. In the present work silver paste was used to make ohmic contacts to CuSe thin films. The nature of CuSe/Ag contacts were checked up to 30 V using two-probe method by plotting I-V characteristics (Figure1).

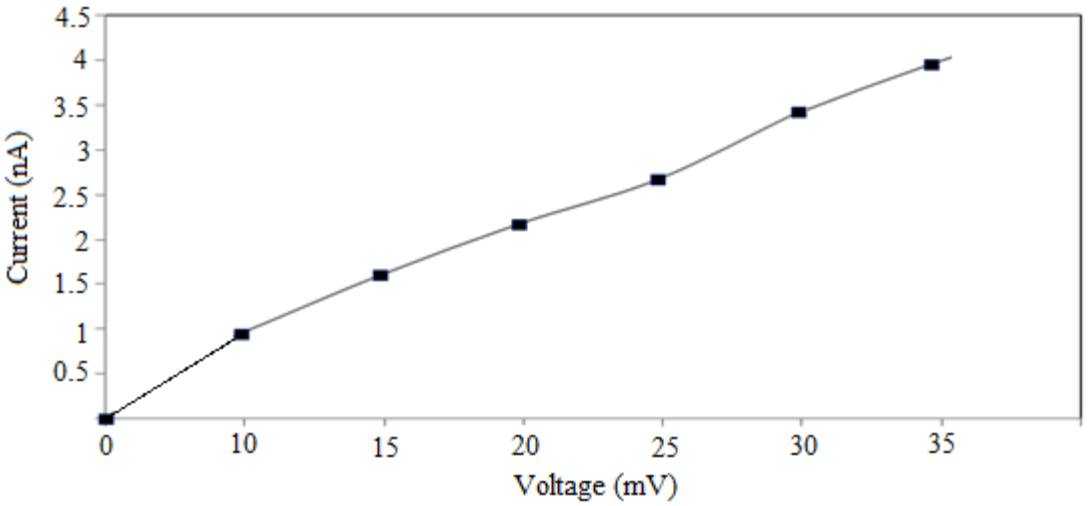

Figure 1: I-V characteristic of copper selenide thin films

The electrical resistance was found to be of the order of $10^{-3}\Omega$cm and is same as that of reported by Gosavi at el. [6].The conductivity of the film samples increases with increase in temperature indicating the semiconducting nature.

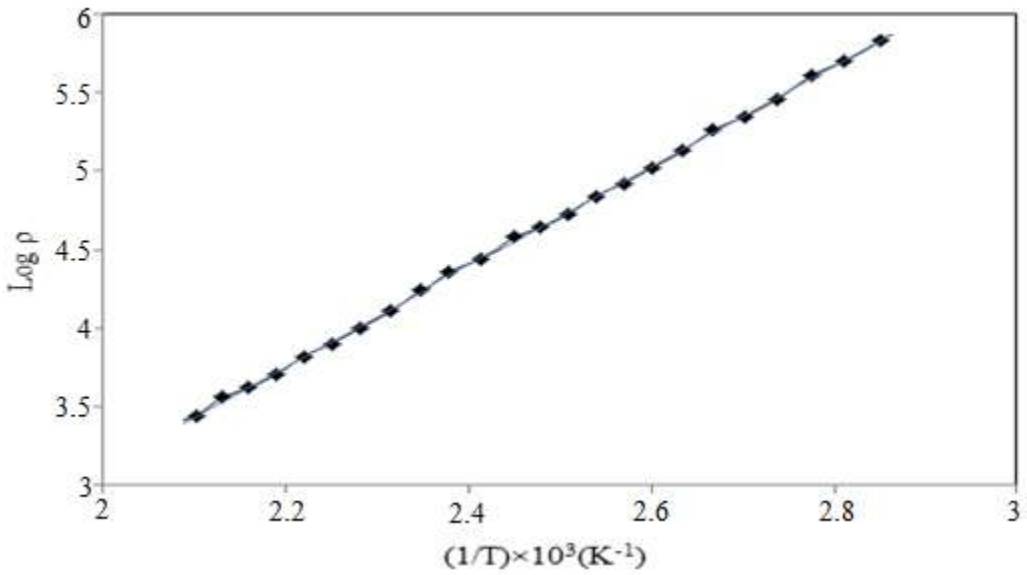

Figure 2: Variation of Log of resistivity with 1/T for copper selenide thin films

The variation of log (ρ) with reciprocal of temperature (1/T) for CuSe films is shown in figure 2. The thermal activation energy was calculated using the relation,

$$\rho = \rho_0 \exp^{(E_0/KT)} \quad (1)$$

where, ρ is resistivity at temperature T, ρ_0 is a constant; K is Boltzmann constant. The activation energy (E_0) was calculated from the resistivity plots.

3.2. Thermo-emf measurement:

Figure 3 shows the curve of TEP vs temperature for copper selenide thin film in the range 300–600 K, which are almost straight lines indicating that TEP increases with increasing temperature.

The thermo-emf developed across hot-cold junction of CuSe thin film in dark was measured as a function of temperature difference. The polarity of the generated thermo-emf was positive at the cold end with respect to the hot end, which confirms that CuSe films are of p-type.

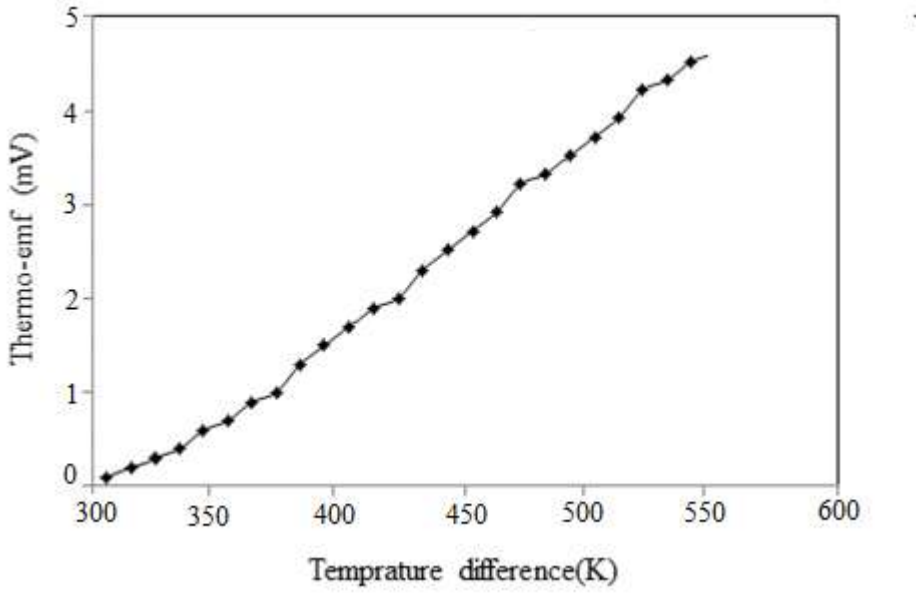

Figure 3: Variation of thermo emf (mV) with temperature difference for copper selenide thin films

4. Conclusion

Thin films of copper selenide have been successfully deposited onto glass substrate by using chemical bath deposition method at room temperature. Copper selenide thin films are nanocrystalline in nature with hexagonal phase. The optical studies confirmed that chemically bath deposited copper selenide thin films exhibits band gap of the order of 2.48eV. The electrical resistivity of copper selenide thin films is of the order of 10^{-3} Ωcm, which shows that the films are highly conducting which may be used in opto-electronic devices. The thermo-emf measurement confirms p-type conductivity of CuSe thin films.

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