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Growth and electrical characterization of zinc sulphide thin films

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Abstract

Nanostructured zinc sulphide thin films were deposited onto glass substrates by using chemical spray pyrolysis deposition method at 673 K and the electrical properties of the as deposited thin films were investigated. In order to determine the electrical characterization, the resistivity measurements of the films were performed by using two-probe method. The optical band gap of the deposited film was found to be 3.51eV. The electrical resistivity of zinc sulphide thin films was found to be of the order of 10^5 Ωcm. The thermo-emf measurement confirms that zinc sulphide thin films have n-type conductivity.

Keywords: thin films, nanostructures, electrical properties, n-type conductivity

1. Introduction

Zinc sulfide (ZnS) is one of the typical II–VI semiconductor compounds with band gap energy of 3.65 eV at room temperature. Zinc sulphide is an important material having various optoelectronic device applications such as blue light-emitting diodes, electroluminescent devices, electro optic modulators and window layers in photovoltaic cells, sensors and lasers [1, 3]. Zinc sulphide films have been deposited by a large variety of techniques such as spray pyrolysis, RF magnetron sputtering [4], chemical vapour deposition [5], spray pyrolysis [6], chemical bath deposition (CBD) [7], solvothermal [8] and sol–gel [9]. Among these methods, spray pyrolysis is well suited for the preparation of these films. This technique is very attractive because it is inexpensive, simple and capable of depositing optically smooth, uniform and homogeneous layers. Furthermore, because this simple coating technique involves processing in an ambient atmosphere, it is easy to incorporate it into an industrial production line.

2. Experimental

Zinc sulphide thin films were grown onto glass substrates by using simple chemical spray pyrolysis technique at a substrate temperature of 673 K. The spraying solution was prepared by mixing the appropriate volumes of zinc chloride (0.1 M), thiourea (0.1 M) dissolved in doubled distilled water. By taking several trials the various deposition parameters were optimized to prepare uniform and adhesive films. The optimized deposition temperature was found to be ≈673K. The films deposited below this temperature were discontinuous and less adhesive. In addition, the optimized spray rate was found out 6 mL min^{-1}. The films deposited above this spray rate are powdery, which may be due to incomplete thermal decomposition.

3. Results and discussion

3.1 Electrical Analysis

The electrical properties depend on various parameters such as film composition, thickness, substrate temperature and deposition rate. To characterize the electrical properties of the zinc sulphide thin films, resistivity measurements were carried out. Tow-probe method has been employed to measure the electrical resistivity of the thin films. 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 ZnS thin films. The nature of ZnS/Ag contacts were checked up to 30 V. The plot of I-V characteristics was shown in figure1.

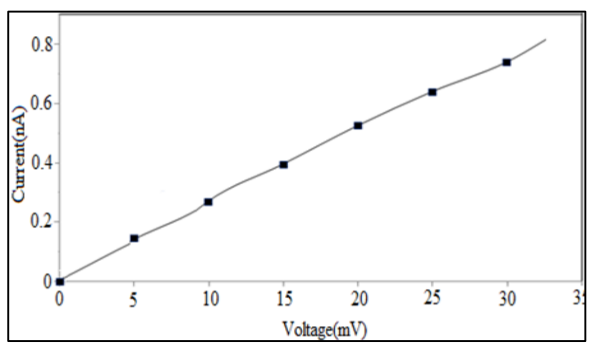

Fig 1: I-V characteristic of ZnS thin films

The linear nature of I-V charact-eristics confirms that silver makes ohmic contact with ZnS films. The variation of dc-electrical resistivity with temperature was studied for ZnS thin films in the temperature range 303K to 483 K. The electrical resistance was found to be of the order of 10^5Ωcm. The conductivity of the film samples increases with increase in temperature indicating the semiconducting nature.

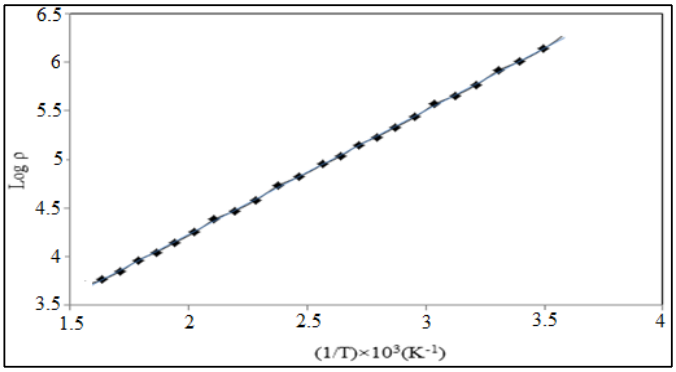

Fig 2: Variation of Log of resistivity with 1/T for ZnS thin films

The variation of log (ρ) with reciprocal of temperature (1/T) for ZnS films is shown in figure 2. The dependence of resistivity on temperature is almost linear indicating the presence of only one type of conduction mechanism in the film. The thermal activation energy was calculated using the relation,

$$\rho = \rho_0 \exp^{(E0/KT)} \quad (1)$$

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 and is found to be 0.76.

3.2 Thermo-emf measurement

The type of conductivity exhibited by spray deposited Zinc sulphide thin films is determined by thermoelectric power (TEP) measurement, the TEP depends on the location of fermi energy level in the material and the type of scattering mechanism. From the sign of the terminal connected towards hot end it can be deduced the sign of the predominant charge carriers.

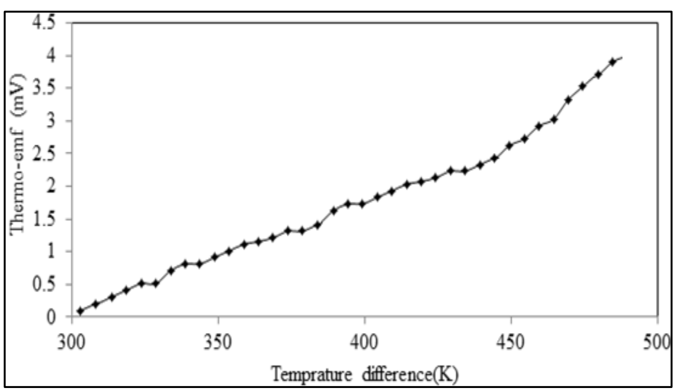

Fig 3: Variation of thermo emf (mV) with temperature difference for ZnS thin films

The thermo-emf developed across hot-cold junction of ZnS thin film in dark was measured as a function of temperature difference (Figure 3). The polarity of the generated thermo-emf was negative at the cold end with respect to the hot end, which confirms that ZnS films are of n-type.

4. Conclusion

In the present work, nanostructured zinc sulphide thin films were deposited onto glass substrates by chemical spray pyrolysis technique at 673 K and the electrical properties of the as deposited thin films were investigated. The optical band gap of the deposited film was found to be 3.51eV.

The electrical resistivity of zinc sulphide thin films is found to be of the order of of 10^5 Ωcm. The thermo-emf measurement confirms that zinc sulphide thin films are n-type in nature.

5. References

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