Original Research Paper

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Electrical properties of spray pyrolytically deposited $CdZnS_2$ thin films

Physics

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Y.D. Tembhurkar Department of Physics, S.K. Porwal College Kamptee (M.S.) India-441002

ABSTRACT

Spray pyrolysis is a simple and inexpensive method to deposited thin films on pre-heated glass substrate on large substrate area. The conductivity types was tested by hot-probe method was of n-type semiconductor. From the Arrhenius plot, the conductivity increases as the temperature increases. The shallow trapping states preferable due to those of interstitial cadmium/zinc or sulphur vacancies are expected to dominate extrinsic conductivity. At higher temperature deep traps state influence are appears. This may be due the grain boundary effect decreases.

1. Introduction:- II-VI group of chalcogenide material is the most important due to their many application in optoelectronic devices. The investigation of electrical and optical properties of sulphur or selenium based chalcogenide glasses have been a subject of interest for both researches and electronic engineers for their applications as photovoltaics and memory switching materials. Many semiconductors glasses , specially sulphur or selenium shows unique property of reversible transformation, which makes them they useful in optical memory devices. Recently, the investigation of election transport in disordered system has gradually been developed and investigation of gap states is of particular interest because of their effect on the electrical properties of semiconductor. The effect of impurity in an amorphous semiconductor may be widely different, depending upto the conduction mechanism and the structure of the material. While in crystalline semiconductors the effect of a suitable impurity is always to provide a new donor or acceptor states. Investigation of the temperature dependence of conductivity, the effect of impurities on the activation energy and the effect of high electrical field on the conduction mechanism are a subject of great interest. The present work incorporates the study of temperature dependence of electrical properties of $CdZnS_2$ thin films.

There the different method to prepare thin films such as chemical bath deposition, vapour deposition, flash evaporation, r.f. sputtering and spray pyrolysis We have chosen spray pyrolysis method because it is easy, cheap, inexpensive to produce thin films on large substrate area.

2. Experimental details:- Aqueous solution of cadmium chloride, zinc chloride and thiourea were prepared in double distilled water. The molarity of each solution was of 0.02 M. Chemical were used by AR-grade. These three solution mixed in the proportion in the ratio 1:1:3.2 by volume. $CdZnS_2$ thin films show the sulphur deficiency (1-2) if the ration of the solution was taken as 1:1:2 by volume. Temperature of the substrate was maintained 300^0C and was measured by pre-calibrated copper constantan thermocouple. The details experimental set-up and preparation of $CdZnS_2$ thin films were explained elsewhere (3,4). Electrical conductivity were measured by four-probe method (5). Thickness of the films were measured weight difference method on unipan microbalance and Michelson interferometer. Thickness of the films measured by above both method are same and was found to be 0.1235 μm . The only difference between these two method was of 0.003 μm.

3. Electrical Properties:- The electrical conductivity of the films was tested by hot probe method was of n-type. The electrical conductivity of $CdZnS_2$ thin films was measured in the air atmosphere at room temperature. Fig.1 shows the Arrhenius plot of conductivity with the reciprocal of temperature $(1/T)x10^3$.

The conductivity of the films was measured between the temperature range 300 K to 573 K.

The temperature dependence of the electrical conductivity can be described by the following Arrhenius equation,

$$\sigma = \sigma_0 \exp(-Ea/kT) \quad (1)$$

Where σ_0 – the conductivity pre-expontial factor, Ea-activation energy for the conduction, k-boltzman constant, T-the absolute temperature. There are two segment observed in the conductivity plot corresponding to two value of activation energy. The slope is less in the low temperature region but increases with further increase of temperature. The low temperature region between 300 K-450 K and second temperature range between 450 K to 573 K. Activation energy calculated in the above two temperature region are 35 meV and 95 meV respectively. This indicates that the conductivity becomes more thermally activated with increasing temperature. This strengthens the predication of dominance (6) of high grain size of the films. Hence grain boundary of the films decreases.

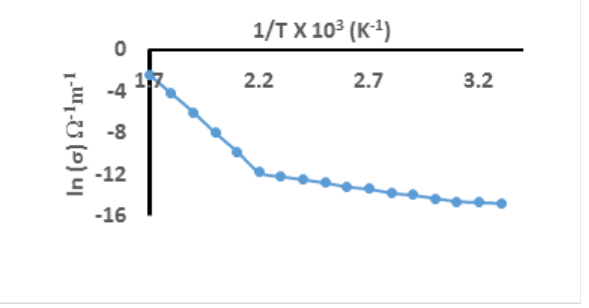

Fig.1 Arrhenius plot of conductivity with the reciprocal of temperature (1/T) of as deposited $CdZnS_2$ thin film

It is seen from the activation energies that the films do not posses the intrinsic conductivity strictly in the entire range of temperature Devi et al have also reported chemical bath deposited CdS thin films. They stated that the shallow trapping states preferable due to those interstitials cadmium or sulphur vacancies are expected to dominate the extrinsic conductivity near the room temperature where as deep trap states influence at high temperature range . The increase the conductivity at high temperature may be attributed to the increase in the band gap of thin films [8] and hence increase the activation energy. The increase the activation energy increases the grain size of the films hence on heat treatment of the films grain boundary effect decreases just like CdSe thin films

4. Conclusion:- The $CdZnS_2$ thin films deposited on glass substrate by spray pyrolysis method are found to be n-type conductivity . The extrinsic conductivity arises mainly from the shallow states originated from interstitials cadmium/zinc or sulphur vacancies deep levels that may be attributed to the complexes of associated cadmium/zinc or sulphur vacancies. At the higher temperature grain boundary of the films decreases.

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