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Study of electrical properties of CdS_xS_{e1-x} thin films by spray pyrolysis

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ABSTRACT

Electrical conductivity were studied by spray pyrolysis prepared CdS_xS_{1-x} thin films for all composition parameters x in the temperature range 77 K to 473 K. Conductivity of the films was of n-type. Donor activation energy systematically increase as composition parameter x increases. But conductivity decreases as temperature decreases for CdSe(x=0) films while conductivity increases as temperature decreases for CdS(x=1) thin films. Donor activation energy increases as the composition parameter x increases.

Keywords:- Electrical properties, CdS_xSe_{1-x} thin films.

1.INTRODUCTION

The study of polycrystalline II-VI compound semiconductor is an important due to their application in semiconductor devices technology . CdS_xSe_{1-x} ($0<X<1$) are very prominzing ternary system. II-VI compound and their solution are as important and provide valuable information regarding the nature of carriers, band structure and scattering mechanism. Thin films of CdS_xSe_{1-x} are used in the fabrication of transistors, solar cells, photoconductors and the application include variable gap structures, vidicons, photodetectors. The activation energies of unidentified donors in CdS were reported by Piper and Halsted andSubhanetal. Wood bury and Avon also reported similar donor activation energies for CdSe. However, similar studies on CdS_xSe_{1-x} single crystal are sporadic reported by Reddy et al.
There are several method to prepare thin films, such as,r.f. sputtering ,flash evaporation, vacuum evaporation, chemical vapour deposition, and spray pyrolysis (3-4).

We are chosen spray pyrolysis due to simple, inexpensive, easy to handle to prepare thin films. In the present work the electrical properties of CdS_xSe_{1-x} thin films were studied in the entire range of composition parameter x (0, 0.25, 0.50,75 and 1) in the temperature range 77 K to 300 K.

2.PREPARATION OF THE SAMPLES

CdS_xSe_{1-x} thin films were grown by spray pyrolysis method at 350^0C on glass substrate using aqueous solution of cadmium choride, thiourea and selenium dioxide for all proportions of x=0, 0.25,0.50,0.75 &1.0. The molarity of each solution was 0.1M. Chemical were used as AR-Grade. Each solution mixed in one and insert in the sprayer. Sprayers mechanically move to and fro to avoid the formation of droplets on the substrate and to insure instant evaporation .Uniform and good quality of thin films of CdS_xSe_{1-x} formed if the ratio of proportion of solution was taken as 1:2.2 by volume. Excess quantity of sulfur and selenium was necessary to form CdS_xSe_{1-x} thin film. The deposited films shows selenium and sulphur deficiency when the ration of solution was taken 1:1 by volume. Excess sulphur and selenium (in the form of thio-urea and selenium oxide) were used to remove this deficiency. The composition parameter x in $CdS_xSe_{1-x}$was varied from 0 to 1.0 in steps of 0.25. Biological glass slides (1.30 mm thick) were used as a substrate. The distance between the sprayer nozzle and substrate was kept at 30 cm. Spray rate was maintained at 3.5 ml/min and spraying was done in air at 12 kg/cm^2 pressure.

3.ELECTRICAL PROPERTIES

Conductivity of as deposited thin films of CdS_xSe_{1-x}prepared at substrate temperature 350^0C of different composition varied significantly. Conductivity of the films was tested by hot-probe method, was of n-type for all composition parameter x. The resistivity was calculated for ranges of temperature 300^0K to 77 K using the relation (6),

$$\varrho = 2\pi s\ V/I\ /G_7\ (t/s) \qquad (1)$$

and $G_7\ (t/s) = 2s/t\ \ln$ (2)

Where s-the distance between the probes, t-be the thickness of the films I be the current generated from constant current source between the inner probes, V-the voltage between outer probes.
Fig.1 shows the plot of conductivity versus inverse temperature of CdS_xSe_{1-x} thin films of all composition parameter x.

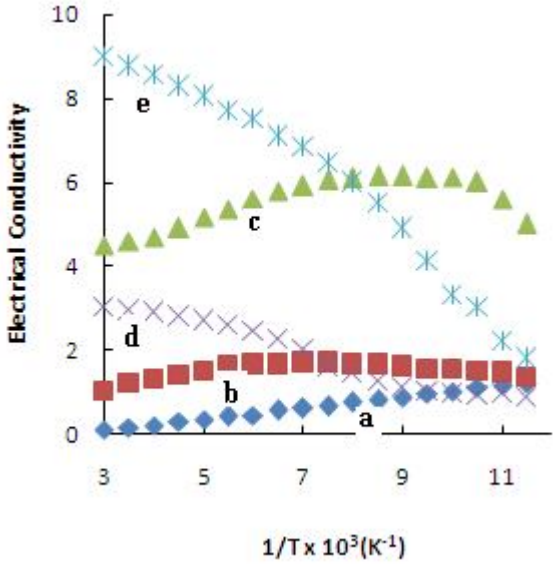

Fig.1. Electrical conductivity v/s inverse temperature of as deposited CdS_xSe_{1-x} thin films of composition parameter a) x= 0 b)x = 0.25 c)x= 0.5 d)x= .75 e)x=1.0

Activation energies was calculated from this plot using the relation.

$$\sigma = \sigma_0 \exp(-Ea/kT) \qquad (2)$$

Where σ_0 the pre-expontial conductivity, k- is the Boltzman constant, T the absolute temperature, Ea the activation energy. The values of activation energies for all composition parameter x are shown in table 1. It was observed that there is a systematic change in the value of activation energy with composition parameter x. But no regular variation with composition was observed in the temperature variation conductivity. For the composition parameter x=0, the conductivity decreases as temperature decreases where as the conductivity increases as temperature decreases for x=1. This could be also understood the rate of decrease of carrier concentration and the rate of increases of mobility as the temperature is decreases. However if the former dominates a decreases in conductivity results of CdS and dominates an increases in conductivity of CdSe. Due to these two factors to conductivity maximum observed of the compositions parameter x=0.25 and x0.5. Similar results also reported by Reddy et (7) for Vapour phase grown CdS_xSe_{1-x}single crystal. They are co-related with the Hall mobility and carrier concentration of the films. Reddy (8) reported that CdS and CdSe are miscible in the entire range of composition of the solid solution hence the covalent radii ration of mixed crystals cannot become lower than 1.3 and n-type of conductivity observed. Our calculated results also matched to the Reddy (8) results.

4.CONCLUSION

Spray pyrolysis is simple, inexpensive method to produce thin films of $CdS_xSe_{1-x}$for all composition parameter x. From the conductivity versus inverse temperature study it was observed the conductivity of CdSe decreases as temperature decreases. However conductivity ofCdS increases as temperature is decreases. But the donor activation energy increases systematically for all the composition parameter x.

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