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Temperature dependence of electrical properties of $CdZnS_2$ thin films by spray pyrolysis

Physics

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

ABSTRACT $CdZnS_2$thin films prepared by spray pyrolysis by using aqueous solution of cadmium chloride, zinc chloride and thiourea of 0.02 M of each at a different substrate temperature. Activation energies calculated from the Arrhenius plot. Activation energies continuously increases if the preparation temperature increases. Indicating the grain size of the films increases which reduces the grain boundary effect. At room temperature shallow trapping states probably due to those interstitial of cadmium zinc or suplhur vacancies dominates the extrinsic conducting whereas as those deep traps influence at high temperature.

1.Introduction :- II-VI group compound semiconductors are important due to application in upto-electric devices. $CdZnS_2$ are the proming ternary system in this category. Thin films of $CdZnS_2$ are used in the fabrication of transistors, solar cells, photoconductor etc. Other application include variable gap structures, vidicons and photodetectors. The ternary group of compounds are important as their optical properties and provide valuable information regarding the nature of carriers, band structure and scattering mechanisms. $CdZnS_2$ is very important ternary group compounds but very few workers is are work on the properties on it. Hence we have to decide to prepare thin films $CdZnS_2$ thin films and study their electrical properties and effect of substrate temperature on it.

There are several method to prepare thin films such as Reactive magnetron sputtering, atomic layer deposition. r.f. sputtering, activated reactive evaporation electro chemical method, chemical vapour deposition, chemical bath deposition, successive ionic layer adsorption and reactive (SILAR), microwave assisted chemical both deposition and spray pyrolysis have been used for the deposition of thin films.

We have chosen spray pyrolysis because it is simple inexpensive easy to handle to prepare thin films on large substrate area.

2. Preparation of the samples :- Aqueous solution of cadmium chloride, zinc chloride and thiourea were prepared in double distilled water. The molarity of each solution was 0.02 M. Chemical were used as AR-grade. The solution were mixed in the proportion 1:1:3.2 by volume. Excess sulphur was required to remove the deficiency of sulphur [1,2]. Thin films shows the sulphur deficiency if the solution of proportion were taken as 1:1:2 by volume. Temperature of the substrate was maintained constant throughout the films preparation. Thin films were prepared at different constant temperature 250°C, 275°C, 300°C and 325°C. Sprayer was move mechanically to and fro to avoid the formation of droplets on the substrate and insure the instant evaporation. Thickness of the films was measured by weight difference method on unipan microbalance and Michelson interferometer. Thickness of the films in both above method was found to be same, only difference was of 0.003 μm. Electrical resistivity measured by Four-probe method.

3. Electrical Properties:- The temperature dependence of dark conductivity was studied from 300 K to 573 K. The resistivity were measured by Four-probe method [3].

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

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

Where S -the distance between the probes, t-the thickness of the films I-the current generated from constant current source between the inner probes. V-the voltage developed between the outer probes.

Figure.1 shows the conductivity verses inverse temperature of $CdZnS_2$ thin films prepared at different substrate temperature a) 250°C b) 275°C C) 300°C and d) 325°C.

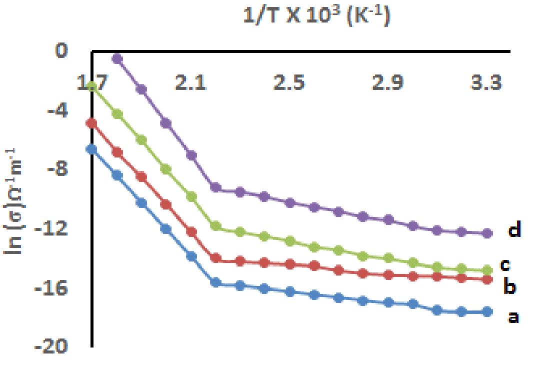

Fig.1 conductivity verses inverse temperature of $CdZnS_2$ thin films prepared at different substrate temperature a) 250°C b) 275°C C) 300°C and d) 325°C.

The activation energies was calculated from the graph using the relation,

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

Where σ_0 – pre-expontial conductivity, Ea-the activation energy k-Boltzmann constant, T- absolute temperature.

The each curves clearly show two segment i.e. two conduction regions. I[st] region between the temperature 300 K to 450 K and II[nd] region 450 K to 573 K. From the curve it was observed that in the low temperature region slope of the curve is less but it is increases with further increase of temperature. From the slopes of the curve , the activation energies are calculated and are listed in table.1.

T (°c)	Activation Energies (meV)		Thickness t (μm)	
	I region	II region	By Weighing method	Michelson interferometer
250	35	95	0.1635	0.1663
275	40	100	0.1795	0.1764
300	55	120	0.1950	0.1981
325	68	135	0.1870	0.1840

From the table it was observed that if the preparation temperature increases the activation energy also increases in both the segment (I-300 K to 450 K and II-450 K to 573 K) but thickness of the films increases upto the optimised temperature 300°C and further increase the temperature, thickness of the films slightly decreases. This is held to explain the band gap decreases continuous upto optimised temperature 300°C. Further increase the temperature, the band gap slightly increases [4].

It is seen from the activation energies that the films do not posses the intrinsic conductivity strictly in the entire range of temperature. The shallow trapping states preferably due to those interstitials of cadmium/zinc or sulphur vacancies are expected to dominate [5] the extrinsic conductivity near room temperature whereas those deep trap states influence at high temperature range. This may be attributed to the increase of band gap energy. Hence grain size of the films also increase. This affect the reduces the grain boundary effect of the $CdZnS_2$ thin films. Similar results also reported by other worker [6,7].

4. Conclusion :- Spray pyrolysis is a simple and inexpensive method to prepare thin films on large substrate area. Arrhenius plot shows the two region have two activation energy, which is continuous increased if the preparation temperature increases. It indicating the grain size of the films which reduces the grain boundary effect. At room temperature, the extrinsic conductivity are seen where as those deep trap states influence at high temperature range.

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