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Original Research Paper

Temperature Effect on Optical Band Gap and Thickness of Cds Thin Films by Spray Pyrolysis

Physics

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ABSTRACT

The spray pyrolysis is a simple and inexpensive method for depositing thin films. The optical study reveals that the CdS thin film has direct allowed transition. The variation of optical band gap and thickness with temperature were studied

Introduction

Semiconducting materials are always focus in the materials science due to their outstanding application in electronic and optical properties. It was used to prepared light emitting diodes, single electron transistors and field effect thin film transistors. Semiconductor materials are tunable by varying their shapes and sizes so it is one of the desired goals in materials science to realize precise controls of the morphology of semiconductor materials [1].

CdS is an important II-VI group of semiconducting material with large band gap 2.47 eV, high refractive index and high effective dielectric constant. The wide band gap CdS has been used as the windows materials together with several semiconductors such a Cu_2S/CdS [2] and CdS/$CuInSe_2$ [3]. However, due to the high cost of such a materials, studies were developed towards polycrystalline semiconductor and particularly thin polycrystalline films. A number of techniques have been examined in the search for reliable and cheapest method of producing thin films. We are chosen chemical spray pyrolysis [4-7] method is one of the principle methods to produce large area and uniform coating and deposit a wide variety of materials in thin films form. In this paper result obtained from the effect of temperature on optical band gap and thickness of the films were reported. There are various techniques for the preparation of thin films.

Experimental Details-

The deposition was carried out onto commercially available biological glass slides. Glass slides were used as substrates. Substrates were cleaned in boiling nitric acid for 5 to 10 minutes. Then they were cleaned with running water and 6-8 minutes ultrasonic agitation in distilled water. The analytical reagent grade chemical was used. Aqueous solutions of 0.1 M cadmium chloride and thio-urea were used for spraying the films. Proportion of $CdCl_2$ and thiourea solution was adjusted to the ratio 1:2.2 by volume in the spraying mixture so as to obtain the CdS thin films. The deposited films showed sulphur deficiency when the ratio of solutions was taken 1:1 by volume. Excess sulphur in the form of thio-urea were used to remove this deficiency [4, 5]. The temperature of the substrate was varied from 250^{0}C to 325^{0}C at the interval of 25^{0}Cand was measured by precalibrated copper constantan thermocouple. Thickness of the films were measured by Michelson-Interferrometer. Transmission was taken on Shimadzu UV-1800 spectrophotometer. Detailed experimental set-up were given elsewhere [8].

Thickness Variation

The thickness of the films deposited at various temperatures was measured by Michelson-interferometer. The variation of thickness with substrate temperature is shown in fig.1. It was observed that the thickness of the films increases as increase in temperature and then decreases for further increase in substrate temperature. At the substrate temperature 300^{0}C, the deposition occur optimum rate. The temperature lower than (<300^{0}C) may not be sufficient to decomposes the sprayed droplets from the solution and therefore the deposit results into a low thickness [9]. At higher temperature (>300^{0}C), film thickness decreases due to higher evaporation rate of the initial ingredients [10].

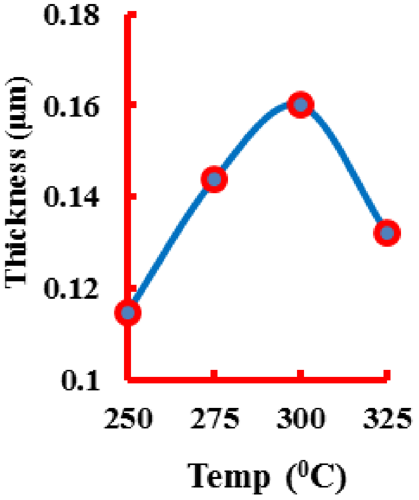

Fig. 1 temperature v/s thickness of CdS thin films

Optical Study

The transmittance of the films was measured at room temperature using UV-1800 Shimadzu spectrophotometer in the wavelength range 350 to 800 nm. Spectrophotometer is generally used to study the transmittance of solutions. In our experiments we used spectrophotometer for measuring the transmittance of the films deposited on glass substrate. Glass plate identical to substrate used was placed in the path of the reference beam and substrate with deposited film was placed in the path of the sample beam for recording transmittance. It was observed from the transmittance vs wavelength graph that onset of decrease of transmittance shifted with change in optical band gap energy with change in temperature.

The absorption coefficient (α) at various wavelengths for the sample of thickness (t) is given by the relation,

$$\alpha = 1/t \log (I_0/I) \quad (1)$$

where I_0 and I are intensities of the incident and the transmitted radiation respectively. The values of absorption coefficient (α) at various wavelengths were calculated from the transmission curve for all films prepared for different temperature.

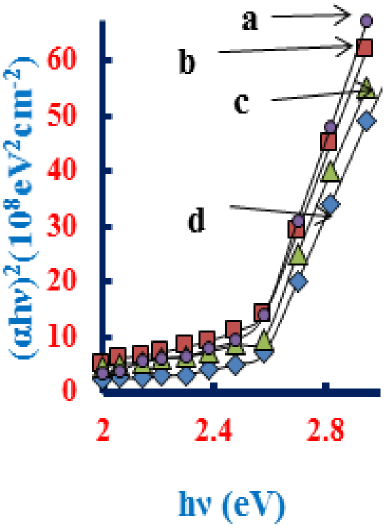

Fig. 2 Plot graph $(\alpha h\nu)^2$ against hν of CdS thin films for different temperature a) 250^{0}C, b) 275^{0}C, c) 300^{0}C, d) 325^{0}C

To calculate the exact value of band gap a graph $(\alpha h\nu)^2$ against hν was plotted (fig.2) for the region near and above the fundamental absorption edge for all films prepared for different temperature, the plot is extrapolated intercept on hν axis gave the value of band gap. The linearity of the graph indicated that the directly allowed transition described by the relation,

$$\alpha = \frac{A}{h\nu}(h\nu - E_g)^{\frac{1}{2}} \qquad (2)$$

was probable responsible for the absorption process. The band gap values obtained were 2.52, 2.49, 2.47 and 2.50 eV for the temperature 250^{0}C, 275^{0}C, 300^{0}C and 325 ^{0}C respectively. Table. 1 shows the calculated band gap and thickness for various temperatures. This shows that band gap value decreases from 2.52 to 2.47 eV with increase in substrate temperature upto 300^{0}C and further increases with increase in substrate temperature. The result agreed well with result obtained by Sawant and Bhosale for spray pyrolytically deposited semiconducting $CdIn_2S_4$ thin films. Our calculated value of band gap 2.47 eV are well agreed with the other various workers prepared at temperature 300^{0}C by different preparation technique [12, 13]. The minimum band gap energy 2.47 eV of the crystalline material at 300^{0}C confirms the stability of material with nearly stoichiometry [9, 11].

Table.1 Variation of temperature measure thickness and Energy band gap value of CdS thin films

Temp (^{0}C)	Thickness (t) μm	Band gap (Eg) eV
250	0.1148	2.52
275	0.1438	2.49
300	0.1600	2.47
325	0.1322	2.50

Conclusion

Spray pyrolysis is a successful method for depositing CdS thin films on glass substrate using aqueous solution of Cadmium chloride and thio-urea solution of 0.1 M. The observed variation in band gap energy for CdS thin films with deposition temperature is due to corresponding variations in particle sizes and films thickness with the deposition temperature. Optical study reveals that these films have direct allowed transition.

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