Substrate Temperature Effect on Thickness and Band Gap Energy of II-VI Solid Solution of Cadmium Telluride Thin Films by Spray Pyrolysis

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Abstract: ***Spray pyrolysis is a simple and inexpensive method for the production ofCdTe thin films of nearlystoichiometry. From the optical study it reveals that variation of band gap energy and thickness with temperature is due to corresponding change in the particles size of the thin films. CdTe thin films show the direct allowed transition.***

Keywords: CdTe thin films, Spray pyrolysis, Band gap

1. Introduction

Semiconducting solid solution II-VI group of compounds very important due to their various application in upto electronic devices and their possible application in the production of solar cells, switching and memory devices. The any material which used in application is complete and meaningful only when it complete study on composition and structure is known. The II-VI group compound specially CdTe, are attracting a lot of attention due to their potential application in producing photo-voltaic devices and wide use in the IR devices. Cadmium telluride is a n and p type semiconductor produce by adjusting the proper proportion and preparation temperature of the substrate. It is also used in solar cell due it band gap energy less than 2 eV. The CdTe can be prepared by various method such as, screen printing, vacuum evaporation, flash evaporation, anodic and cathodic deposition, r.f. sputtering, chemical vapour deposition and spray pyrolysis (1-3).

We have chosen spray pyrolysis method. This method is very simple, inexpensive, cheap, easy to handle to produce on large substrate area. In this method we can change easily the properties of the constituents of the chemical solution.
In the present paper, the effect of temperature on optical band gap energy and thickness of the films studied.

2. Preparation of the Samples

Thin films of CdTe prepare by using aqueous solution of cadmium chloride and tellurium tetrachloride. The molarity of the solution was 0.02 M. Chemical were used as AR-grade. Both the solution was mixed in one by proper proportion of solution of cadmium chloride and Tellurium tetrachloride in the sprayer. Now sprayer is mechanically move to and fro to avoid the formation of droplets on the pre-heated glass substrate and insure the instant evaporation. Temperature of the substrate varied from 300^0C to 375^0Cin the interval of 25^0C. The proportion of the solution was taken 1:2.2 by volume. Thin films shows the tellurium deficiency (1-3) if the proportion of solution was taken 1:1 by volume. The distance between the sprayer nozzle and substrate was kept at 30 cm and maintained spray rate at 3.5 ml/min and pressure at 12 kg/cm^2. Temperature of the substrate were measured by pre-calibrated copper constantan thermocouple. Thickness of the films was measured by Michelson interferometer. The transmission were taken on UV-1800 Shimandzu Spectrophotometer in the wavelength range 350 nm to 1100 nm.

3. Optical Study

Fig 1 shows the variation of transmission verses wavelength of as deposited thin films CdTe prepared at different temperature a) 300 ^{0}C, b) 325 ^{0}C, c) 350^{0}C and d) 375 ^{0}C. The optical absorption coefficient (α) were calculated from the transmission curve of each wavelength of each curve and it is given by the relation,

$$\alpha = l/t \ln (I_0/I) \qquad (1)$$

where, t-the thickness of the films, I_0 and I be the incident and transmitted radiation respectively.

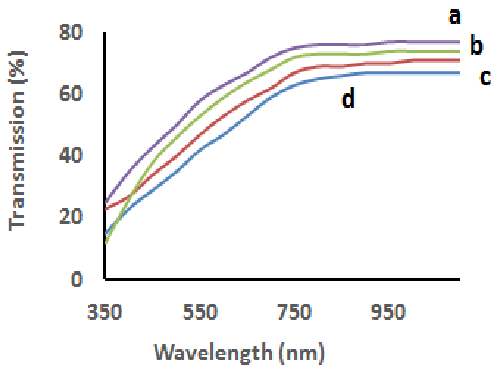

Figure 1: Transmission verses wavelength of as deposited thin films CdTe prepared at different temperature a) 300 ^{0}C, b) 325 ^{0}C, c) 350^{0}C and d) 375 ^{0}C

From the transmission curve it was observed that onset of decrease of transmission gives the value of band gap.

If the preparation temperature increases, the onset of decrease of transmission also shifted towards the lower wavelength side. This indicate that band gap energy decreases as the temperature of the films increases.

An analysis of the spectrum showed that the absorption at the fundamental absorption edge can be described by the relation,

$$\alpha = A/h\upsilon\ (h\upsilon\text{-}Eg)^n \qquad (2)$$

Where A-the parameter that depends on the transition probability,Eg-the optical band gap energy.

For direct allowed transition n=1/2 and for indirect allowed transition n=2.

To calculate the exact value of band gap, plotting the graph between $(\alpha h\upsilon)^2$ verses hυ for different temperature as shownin fig.2.

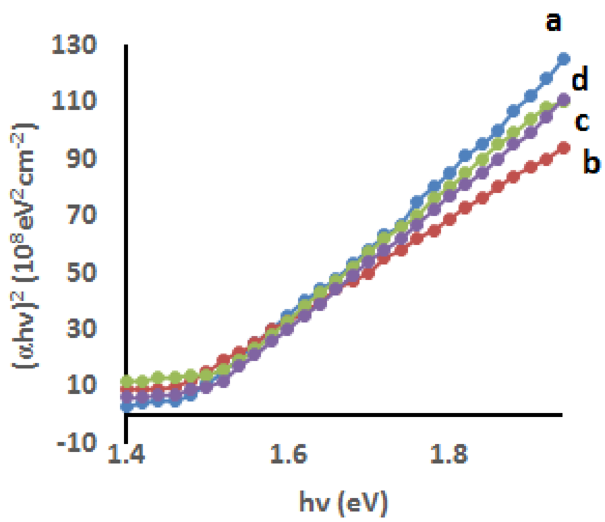

Figure 2: The graph between $(\alpha h\upsilon)^2$ verses hυof as deposited thin films CdTeprepared at different temperature a) 300 ^{0}C, b) 325 ^{0}C, c) 350^{0}C and d) 375 ^{0}C

The linear portion of a each curve was extrapolated to meet hυ axis yields band gap energy Eg. The band gap energy determined for different samples decreases from 1.48 eV to 1.43 eV with increase in substrate temperature upto 350^{0}C and further increase in the substrate temperature the band gap energy again increases. The band gap energy at 350^{0}C of the crystalline material confirms the stability of the material with near stoichiometry (4-6). Our calculated value of band are well agree with the other worker (6,7) for different deposition method.

4. Measurement of Thickness

The thickness of the films deposited at various temperature was measured by Michelson interferometer. The variation of thickness with substrate temperature as shown in table 1. It was observed that the thickness of the films increases as increase the temperature and attain maximum value at 350^{0}C. Then small decreases for further increase of temperature. At lower temperature (<350^{0}C), the temperature may not be sufficient to decompose the sprayed droplets from the solution and therefore the deposit results into a low thickness was estimated (8). This is due to higher evaporation the initial ingredients (9). Table.1 show temperature, thickness and band gap energy.

Table 1

Temperature T (^{0}C)	Thickness t(μm)	Band gap Eg(eV)
300	0.139	1.54
325	0.145	1.52
350	0.163	1.49
375	0.158	1.47

5. Conclusion

Spray pyrolysis is suitable method for formation of nearly stoichiometry thin films of CdTe. The observed variation in band gap energy of CdTe thin films with deposition temperature is due to the corresponding variation in the particle size.

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