Composition dependence of optical constants of $Zn_xCd_{(1-x)}Te$ thin films

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Abstract- Optical constants of vacuum-evaporated thin films $Zn_xCd_{(1-x)}Te$ by use of thermal evaporation of the ternary compound has been investigated. Structural and optical properties of $Zn_xCd_{(1-x)}Te$ solid solution with x = 0.1 to 0.5 were synthesized, from the resulting ZnTe and CdTe composition used in preparation of thin films. Structural investigation indicates they have polycrystalline structure. Composition was confirmed from EDAX while SEM picture shows homogeneity in films. Plots of $(\alpha h\nu)^2$ versus $(h\nu)$ yield straight line indicating direct transition occurs with optical band gap energies in the range 1.7 - 2.3 eV.. It is also found with increase Zn content the band gap of the films increases. Refractive indices and extinction coefficients have been evaluated in the spectral range (200 – 2500 nm).
Keywords - Thermal Evaporation, EDAX, XRD, Optical band gap.

Introduction

Solid solution formation in semiconductors has been of interest for a number of years. An important question regarding ternary zinc-blende compound semiconductors is concerned with the structural and dynamic changes that can occur upon replacement of either cations or anions in the binary base material The II-VI compounds semiconductors and solid solutions based on them are promising source for various types of thin film devices such as thin film transistors [1], Solar cells [2] and photoconductors [3].
Thin films of $Zn_xCd_{(1-x)}Te$ were prepared by variety of techniques, such as, two source vacuum evaporation [4], molecular beam epitaxy [5], chemical vapour deposition and closed space vapour transport [6], physical vapour transport (PVT) [7], vertical Bridgman growth [8]. In the recent study $Zn_xCd_{(1-x)}Te$ thin films are deposited by thermal evaporation at substrate temperature (373K).

Experimental

For the preparation of ternary semiconductors, $Zn_xCd_{(1-x)}Te$ the constituent compounds ZnTe and CdTe have been taken in molecular stiochoimetry proportional weights and crushed and mixed homogenously. The different sets of samples of varying compositions (x = 0.1 to 0.5) were deposited via sublimation of the compound in vacuum higher than 10^{-5} mbar under controlled growth conditions of various compositions onto the amorphous precleaned glass substrates at the temperature of 373 K. The thicknesses of films were controlled by using quartz crystal thickness monitor model No.DTM-101 provided by Hind-High Vac. The deposition rate was maintained 10-15 Å/sec constant throughout sample preparations. The source to substrate distance was kept constant (15 cm) and substrate was kept at constant temperature (373 K). Deposited samples were kept under vacuum overnight. All the samples are deposited under the similar optimized condition. These samples were annealed at reduced pressure of 10^{-5} mbar for the duration of 3 hours at the temperature of 573 K and maintain carefully. These samples were then used for various characterizations.

Results and discussion

All the $Zn_xCd_{(1-x)}Te$ films prepared by the above technique were polycrystalline of multi phase structure indicating preferential of the film crystallites corresponding to textured (100)H and (220)C growth [11]. From the Fig.-1 X-ray diffractograms of various compositions it is observed that for x = 0.1 and x = 0.2 there are only two prime peaks which corresponds to (100) plane of hexagonal CdTe and (220) plane of cubic ZnTe.

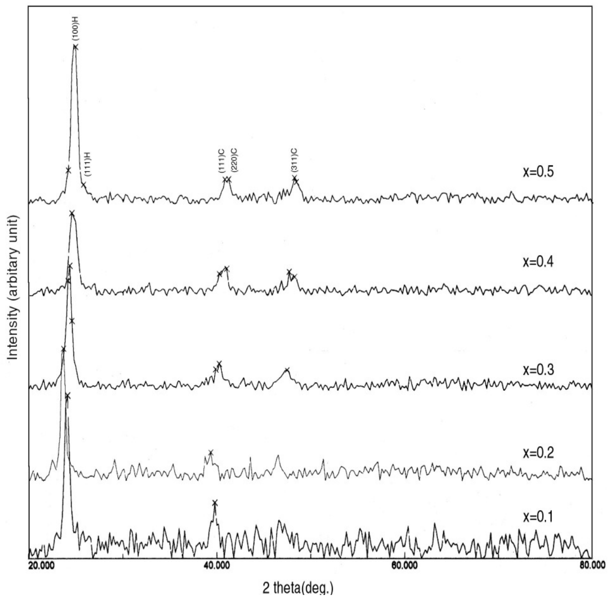

Fig. 1- X-ray diffractograms of various $Zn_xCd_{(1-x)}Te$ structures.

Diffraction analysis suggests that all the samples of various compositions are polycrystalline nature. The shifting of peak positions of these prominent diffraction lines suggests the formation of solid solution corresponding to $Zn_xCd_{(1-x)}Te$ material from the basic starting compounds CdTe and ZnTe. From the scanning electron micrographs, it is found that the straitions, which are exactly parallel equidistance and extend from one end to another end. These straitions indicate the oscillatory growth [12]. The composition of starting basic ingredients and film composition comparison is presented in the table No.1.

Table 1- EDAX data for $Zn_xCd_{(1-x)}Te$ composite thin films.

Basic Ingredient Taken				EDAX Composition		
'x'	At% Zn	At% Cd	At% Te	At% Zn	At% Cd	At% Te
0.1	5	45	50	7.07	40.52	52.41
0.2	10	40	50	13.42	37.78	48.81
0.3	15	35	50	15.59	34.46	49.96
0.4	20	30	50	28.20	25.90	45.90
0.5	25	25	50	31.49	20.95	47.56

The reflectance and transmittance spectra of these samples were recorded using Hitachi Spectrophotometer model-330 in spectral region 200-2500nm. Absorption coefficients □□ı□ have been evaluated using percentage transmittance data as a function of wavelength presented in Fig.-2 for the samples of different compositions.

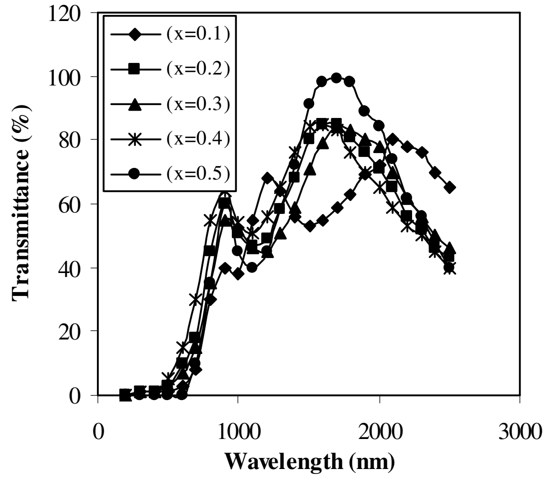

Fig-1 Spectral behaviour of transmittance with wavelength

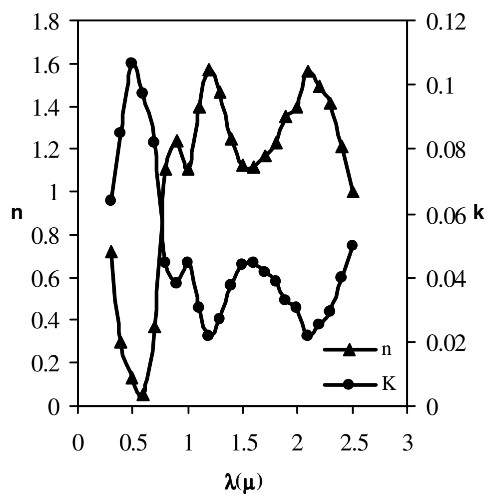

Fig.-3 Variation of 'n' and "k' with Wavelength for $Zn_xCd_{(1-x)}Te$ (x=0.1).

The plot of (□h□)^2 versus h□ are plotted and shows clearly linear dependence for the value of p=½ [9]. This is attributed to an allowed and direct transition with direct band gap energies. The evaluated band gap energies are 1.7 eV, 2.05 eV, 2.2 eV, 2.3 eV and 1.5 eV for the samples of compositions x = 0.1 to 0.5 respectively clearly indicating dependence on compositions of films [13].The variation of refractive indices and extinction coefficients as a function of wavelength as represented in Fig.-3. It is found that variations in refractive indices and extinction coefficients are oscillatory in nature.

Conclusion

In conclusion, homogeneous polycrystalline of multi phase structure of the thin films of $Zn_xCd_{(1-x)}Te$ have been successfully deposited by thermal evaporation technique using basic ingredient ZnTe and CdTe elemental starting materials. EDAX composition seems to be closely matched with starting basic ingredients. The dependence of the optical parameters of the films on the light energy supports the direct character of the interband transition through an optical band gap in the range 1.7 – 2.3 eV. The variation in optical constants as a function of wavelength is oscillatory in nature having well defined maxima and minima, which depends on the composition of the thin films.

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REFERENCES

[1] T.H. Weng, J. Electrochem. Soc., 117 (1970) 725.
[2] G. Hodes, Nature (B), 285 (1980) 29.
[3] M.I. Izaksin, N. Ya. Karasik, L.M. Prokator, D.A. Sakseev, G.A. Fedorova, I.N. Yakimenko, Inorg. Mater. 15 (1979) 178.
[4] R. Weil, M. Joucla, J. L. Loison, M. Mazilu, D. Ohlmann, M. Robino and G. Schwalbach, Applied Optics, 37 (1998) 2681.
[5] A. Rohatgi, S. A. Ringel, R. Sudharsanan, P. V. Meyears, C. H. Liu and V. Ramanathan, Solar Cells, 27 (1989) 219.
[6] S. A. Ringel, R. Sudharsanan, A. Rohatgi, M. S. Owens and H. P. Gillis, J. Vac. Sci. and Technol., A8(3) (1990) 2012.
[7] A. Mycielski, A. Szadkowski, E. usakowska, L. Kowalczyk, J. Domagaa, J. Bk-Misiuk and Z. Wilamowski, J. Cryst. Growth, 197 (1999) 423.
[8] V. M. Lakeenkov, V. B. Utimtsev, N. I. Shmatov and Yu. F. Schelkin, J. Cryst. Growth, 197 (1999) 443.
[9] J.J. Pankove, Optical Processes in Semiconductors, Prentice Hall, Englewood Cliffs, J, 1971.
[10] Goswami, Thin Film Fundamentals, New Age International (P) Limited, (1996) p-442.
[11] H.S. Soliman, F.M. Allam and A.A. EL-shazly, J. of Materials in Electronics, 7 (1996) 233.
[12] M.S. Joshi and A.S. Vagh, J. Appl. Phys., 37 (1966) 315.
[13] U. P. Khairnar, D. S. Bhavsar, R. U. Vaidya, G. P. Bhavsar, Materials Chemistry and Physics, 80 (2003) 421-427.