ISSN 0975 – 2595

PRAJÑĀ

Volume 18, 2010

Journal of Pure and Applied Sciences

SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR
Gujarat – 388 120, INDIA
www.spuvvn.edu

PRAJÑĀ - Journal of Pure and Applied Sciences, Vol. 18: 126 – 128 (2010)
ISSN 0975 - 2595

CHARACTERIZATION OF THERMALLY EVAPORATED ZnTe THIN FILMS

K. D. Patel[1], J. R. Rathod[2*], H. S. Patel[1], V. M. Pathak[1] and R. Srivastava[1]

[1]Department of Physics, Sardar Patel University, Vallabh Vidyanagar 388 120 Gujarat INDIA,
[2]Dr. Jivraj Mehta Institute of Technology, Mogar-388 340, Anand, Gujarat, INDIA

ABSTRACT

Thin films of ZnTe with thicknesses around 8kÅ and 10kÅ have been deposited by thermal evaporation technique on the ultrasonically cleaned glass substrates kept at 373K. The thicknesses of the films were measured using quartz crystal thickness monitor. The structure of ZnTe thin films was investigated by Transmission Electron Microscopy (TEM). This reveals that films have polycrystalline nature with cubic phase. The band tail energy was estimated from optical absorption curves. The electrical resistivity of the films has been investigated as a function of temperature using Lakeshore-7504 Hall measurement set-up. The results of all these studied parameters are presented and discussed in this paper.

Key words: *electrical resistivity, polycrystalline, optical characterization, Band tail.*

INTRODUCTION

Since last two decades, much interest has been shown in semiconducting group II - VI compounds, especially zinc chalcogenides because of their potential towards various applications in electronics [1]. ZnTe is a compound semiconducting material with a band gap around 2.26eV at room temperature [2]. The applications such as opto refractive material for optical data processing [3], non-polarized memory switching [4] and γ-ray detectors have been found to be viable in today's technology. In present paper, the authors report their findings regarding the thin film preparation of ZnTe and its optical as well as electrical characterization.

EXPERIMENTAL

Zinc Telluride powder (99.99% pure, sigma Aldrich Chemicals Company) was evaporated from a tantalum boat under a vacuum of 5×10^{-6} torr. The ZnTe films were deposited on the ultrasonically-cleaned glass substrates maintained at 373K during evaporation. The rate of evaporation, in the range of 2-5 Å/sec, was maintained to deposit films of good quality and uniform thickness. Thicknesses of the films were measured during the deposition process by quartz crystal thickness monitor ("Hind Hivac" Digital Thickness Monitor Model–DTM–101). The TEM was carried using Philips, Netherlands (Model: Tecnai 20) electron microscope. The optical absorption spectra of these films were recorded using a UV–VIS-NIR spectrophotometer (Perkin Elmer USA, Model: Lambda 19). The electrical resistivity of ZnTe thin films were investigated using software controlled Lakeshore-7504 Hall measurement set-up.

RESULTS AND DISCUSSIONS

Diffraction patterns obtained by transmission electron microscopy on two films of thicknesses 8kÅ (Sample No. A) and 10kÅ (Sample No. B) Have been shown in Fig. 1. Using these diffraction patterns the indexing of reflections and the d-values were calculated and the results are presented in Table 1.

* Corresponding author: jrrathod84@gmail.com

This table also contain the d-values obtained from standard JCPDS data. From here it can be seen that there is a good match between the calculated d-values and the standard ones [5].

Moreover the deposited ZnTe films possess the cubic structure [6].

Table - 1 d-values for ZnTe films.

Ring No./ Sample No.	Diameter of ring D cm	Calculated d (=2λL/D) values (Å)	Standard d-values (Å)	h k l
1/A	4.648	3.536	3.523	1 1 1
2/A	6.350	2.589	2.572	1 0 2
3/A	7.770	2.115	2.159	2 2 0
4/A	10.579	1.554	1.526	4 0 0
1/B	4.660	3.527	3.523	1 1 1
2/B	6.350	2.589	2.572	1 0 2

Polycrystalline films are generally considered to consist of crystallites joined together by grain boundaries. The grain boundary regions are disordered regions, characterized by the presence of a large number of defect states due to incomplete atomic bonding. As a result, the diffraction rings with increasing distance due to the higher lattice parameter of ZnTe are observed [7].

The optical characterization was carried to investigate the nature of optical transmissions of carriers involved in the absorption of photons. According to the standard equation, the absorption coefficient (α) is given as,

$$\alpha = A_\alpha (h\nu - E_g)^r / h\nu \quad (1)$$

where $h\nu$ is photon energy, E_g is the energy bandgap and A_α is a characteristic parameter, independent of photon energy, for respective transitions. The transitions of carriers due to the incidence of photons can be assigned as direct or indirect in nature depending upon the value of r.

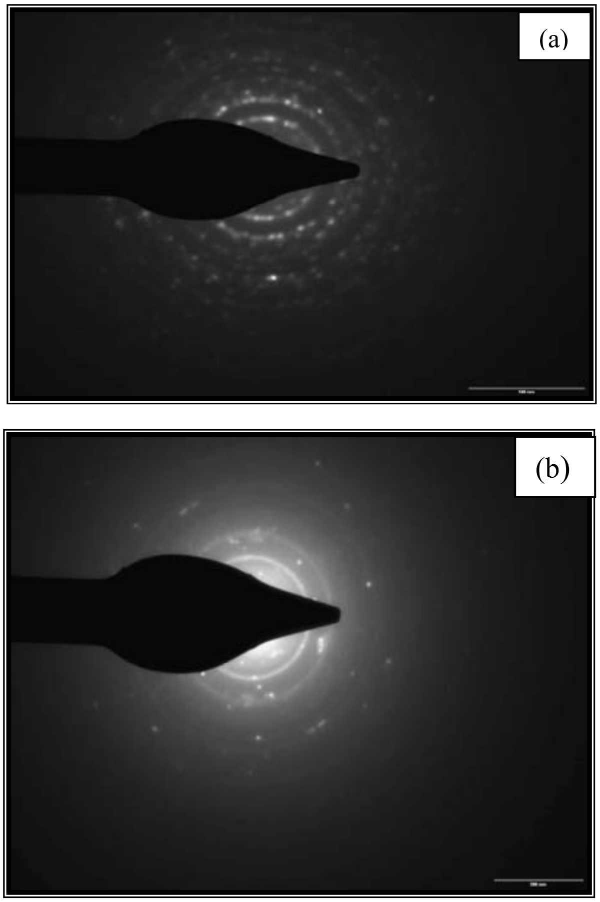

Fig. 1 Electron diffraction pattern for films having thicknesses 8kÅ (a) and 10kÅ (b) respectively.

The calculated values of absorption coefficient corresponding to each energy of incident photons give a good absorption edge. For r =1/2 which confirms the direct nature of the optical transitions of carriers in ZnTe thin films. The plot of $(\alpha h\nu)^2$ vs $h\nu$ for the films are shown in Fig..2.The intercept of a straight line, drawn from the linear portion of the $(\alpha h\nu)^2$ vs hν plots (Fig. 2), on x-axis (energy axis) gives the values of band gap as 2.02eV and 2.0eV for films of thicknesses 8kÅ and 10kÅ respectively [8]. Thus prepared thin films of ZnTe possess direct band gap of around 2eV which is near the earlier reports [9].

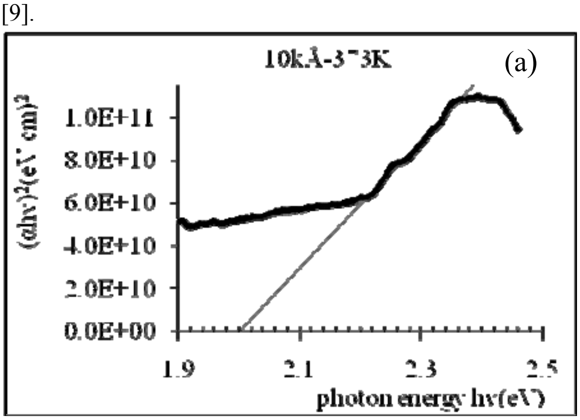

Fig. 2 Plot of $(\alpha h\nu)^2$ vs hν for ZnTe thin films of thicknesses of 8kÅ (a) and 10kÅ

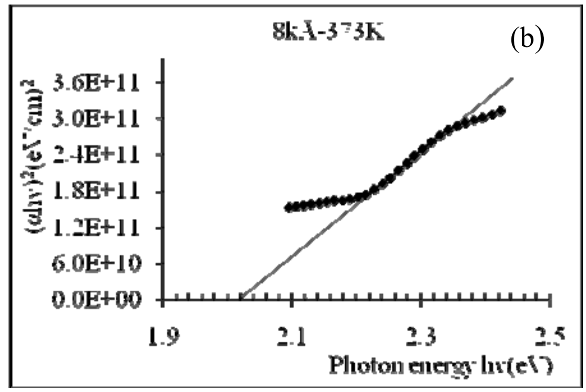

Fig. 2 Plot of $(\alpha h\nu)^2$ vs hν for ZnTe thin films of thicknesses of 8kÅ (b) respectively.

The variation of resistivity as a function of temperature is shown in Fig. 3. The plots suggest that with increase in temperature resistivity decreases for both thicknesses. This confirms the semiconducting behavior of the films.

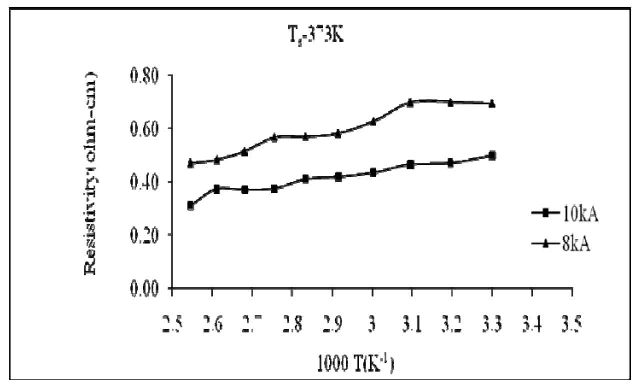

Fig. 3 Temperature dependence of resistivity of films deposited at different thicknesses.

CONCLUSIONS

ZnTe possesses cubic structure when deposited as thin films. It also exhibits a direct band gap around 2eV which decreases with increase in film's thickness. The resistivity decreases as the temperature of the films increases confirming semiconducting nature. It is also seen that the resistivity decreases with increase in thickness of the films.

ACKNOWLEDGEMENT

The authors acknowledge the help of Sophisticated Instrumentation Centre for Applied Research and Testing (SICART) for providing the facilities of the electron microscopy and the spectrophotometer.

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Sardar Patel University,
VALLABH VIDYANAGAR
Gujarat – 388120
Phone: (Lab): 02692-234412 Extn. 111
Mobile: 98254 38147
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