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OPTICAL AND ELECTRICAL CHARACTERISTICS OF VACUUM EVAPORATED ZINC TELLURIDE THIN FILMS

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ABSTRACT

These films of ZnTe compound of varying thickness ranging from 191.3 nm to 248.4 nm have been deposited by vacuum evaporation technique on the clean glass substrates. Optical method (Tolansky method) was employed to measure the thickness of the deposited thin films. The optical properties of the ZnTe thin films were investigated by UV-VIS spectrophotometer and the electrical resistivity have been studied as a function of thickness by Four Probe Kit. The results of all these studied parameters are presented and discussed in this paper.

KEYWORDS: *II–VI Semi-Conductor; Band Gap; Optical Properties; Resistivity; ZnTe Thin Films*

Article History

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INTRODUCTION

Zinc telluride (ZnTe) is one of the important members of II–VI semiconductor family. Over the years, ZnTe have attracted many researchers because it is widely used in potential photovoltaic applications, in particular with solar cells, photodiodes, photo detectors, light emitting diodes (LEDs) and other optoelectronic devices due to its specific optical and electrical properties such as relatively wide direct optical band gap, high transparency in visible and infrared regions, low electrical resistivity, etc.[1-4]. It has a wide and direct band gap of 2.26 eV (at room temperature), which lies in the pure green region of the electromagnetic spectra. [5] This direct band gap makes it a potential candidate for the fabrication of pure green LEDs.

A number of techniques have been employed to prepare ZnTe thin film including pulsed laser deposition technique[1] two-source evaporation method, [5] e-beam evaporation method, [6] closed space sublimation technique, [7] DC reactive magnetron sputtering[8] and thermal evaporation.[9] Stacked Elemental Layer method,[10] etc. Among these techniques, we take thermal evaporation technique because of its high deposition rate, large area scalability and easy preparation of a large size as well as a high conductivity and visible transmittance. In our present work, we studied about the optical and electrical properties of the ZnTe thin films as a function of thickness.

METHODOLOGY

ZnTe powder supplied by Aldrich Chemical Company, pure 99.99% was used for the deposition of ZnTe thin films, which were placed in a Mo boat and were deposited by vacuum evaporation method on glass substrates. For the deposition, we used the vacuum coating unit (Model 12A4D) supplied by HINDHIVAC, Bangalore. Before loading substrate into the vacuum chamber, the glass slides were first treated with Teepol and then washed in running water with a clean brush and kept immersed in dilute acid for 30 minutes. The slides are again washed in running water and rinsed with distilled water. The glass slides are taken out with clean-grease free tweezers and then dried in an oven or by blowing hot air. The dried substrates were cleaned ultrasonically in an acetone bath for five minutes. During deposition, the vacuum inside the chamber was maintained at $\approx 10^{-5}$torr. After finishing the ZnTe deposition, the films were kept inside the vacuum coating unit for one day to prevent reaction with oxygen to form oxides.

The thicknesses of the deposited thin films were measured by using optical method (Tolansky method). All the films have thicknesses ranging from 191.3 nm to 248.4 nm. The transmission and absorption spectra of the deposited thin films were recorded using a SHIMADZU UV-VIS spectrophotometer (Model UV-2600) in the wavelength range from 200 nm to 1100 nm, and the electrical property of the deposited thin films were measured using Four Probe Kit (Model Nvis 6105) supplied by Nvis Technologies Pvt. Ltd., Indore.

RESULT & DISCUSSIONS

Optical Characteristics

The absorption spectra of the all-deposited ZnTe thin films reveal that the deposited films have high absorbance in the UV region and the absorbance decreases with the increase in wavelength, [3] the absorption spectra also reveals that the absorption increases with the increase in thickness, which is shown in figures 1 and 2.

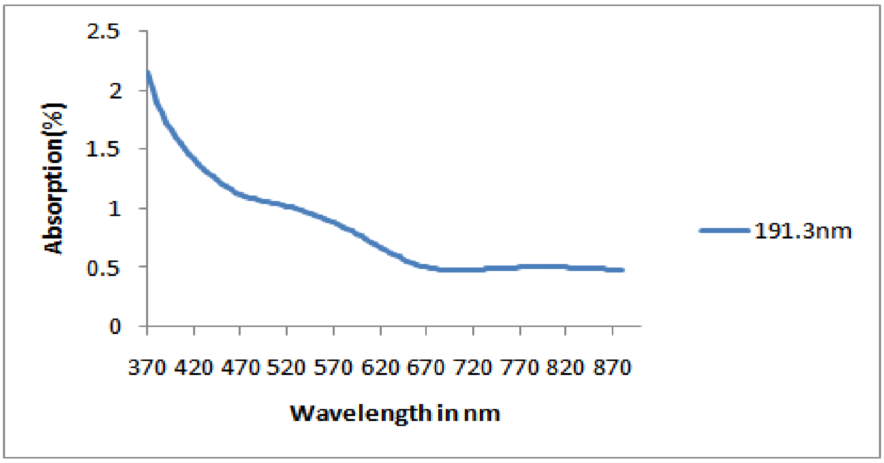

Figure 1: Absorption Spectra of ZnTe Thin Film of Thickness 191.3 nm.

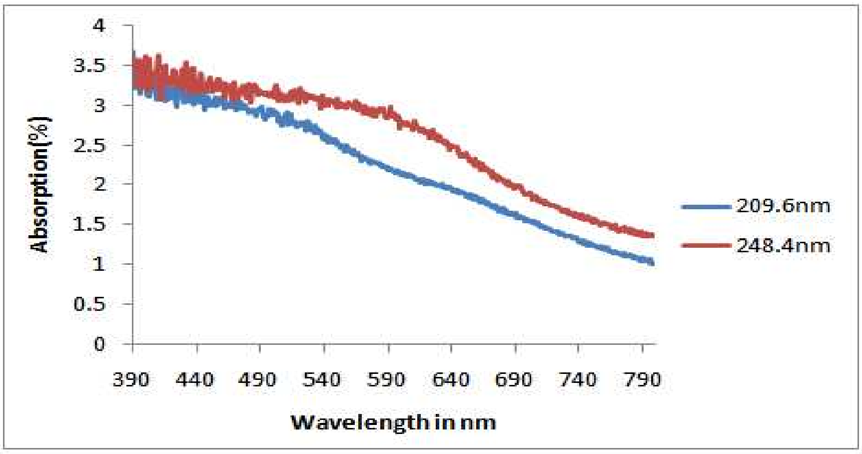

Figure 2: Absorption Spectra of ZnTe Thin Film of Thickness 209.6 nm and 248.4 nm.

The transmission spectra of the ZnTe thin films show that the films have high transmittance in VIS-NIR region[3] and it also shows that the transmission decreases with the increase in thickness due to increase in density of the film,[5] which is shown in figure 3 and 4.

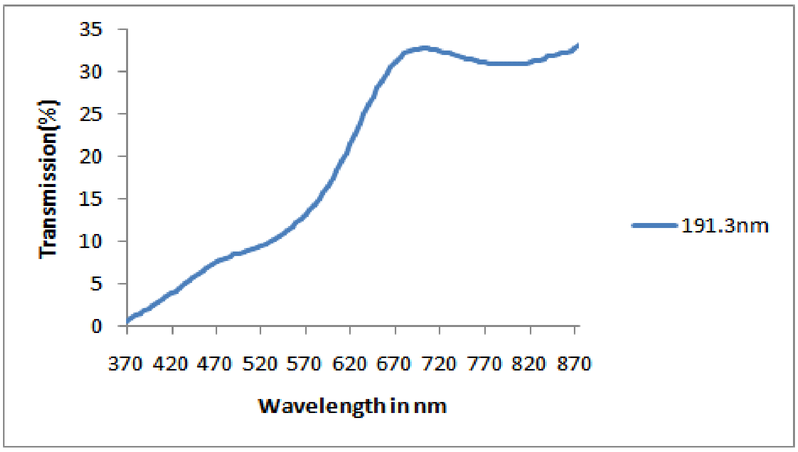

Figure 3: Transmission Spectra of ZnTe Thin Film of Thickness 191.3 nm.

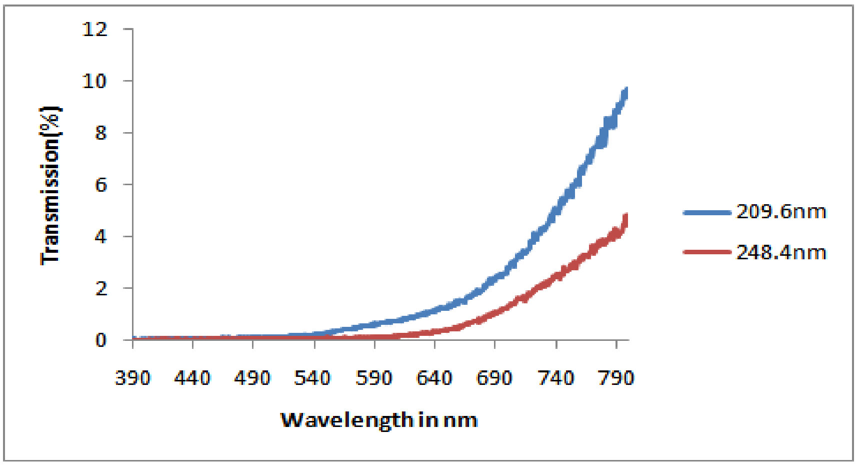

Figure 4: Transmission Spectra of ZnTe Thin Film of Thickness 209.6 nm and 248.4 nm

A relation between transmission co-efficient (T) and absorption coefficient (α) can be obtained by using optical interference phenomena and is given by

$$T = (1 - R)^2 \exp(-\alpha t) \tag{1}$$

From which we can calculate 'α' as

$$\alpha = \frac{1}{t} \ln\left[\frac{(1 - R)^2}{T}\right] \tag{2}$$

If the reflection is less (< 5%), then we may neglect R as compared to 1 in equation (2), i.e.,

$$\alpha = \frac{1}{t} \ln\left(\frac{1}{T}\right) \tag{3}$$

As thin film absorbs some portion of the light incident upon it, corresponding to its band gap, these absorptions are a function of both the band gap and the thickness of the material. The relation can be described in terms of the absorption coefficient α following the works of Brooks and Bardeen as

$$\alpha = A(h\upsilon - E_g)^p \tag{4}$$

where 'E_g' is the optical band gap, 'A' is a constant, 'hυ' is the energy of the photon and 'p' is the transition probability for direct and allowed transition p = ½, whereas for direct but forbidden transitions p = 3/2, but for the indirect and allowed cases p = 2 and for forbidden cases p = 3 or more. Direct and allowed transition equation (5) can be written as

$$\alpha = A(h\upsilon - E_g)^{1/2} \tag{5}$$

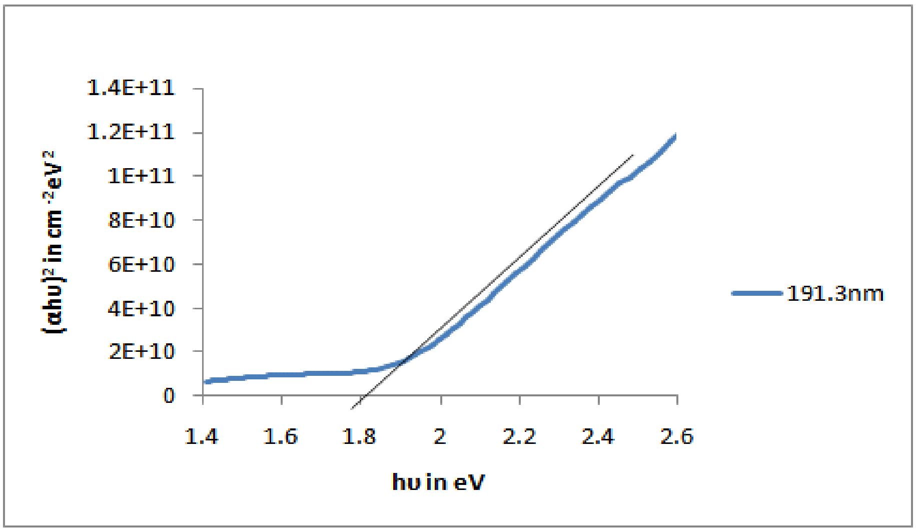

Figure 5: Plots of (αhυ)^2 vs. hυ for ZnTe Thin Film of Thickness 191.3 nm.

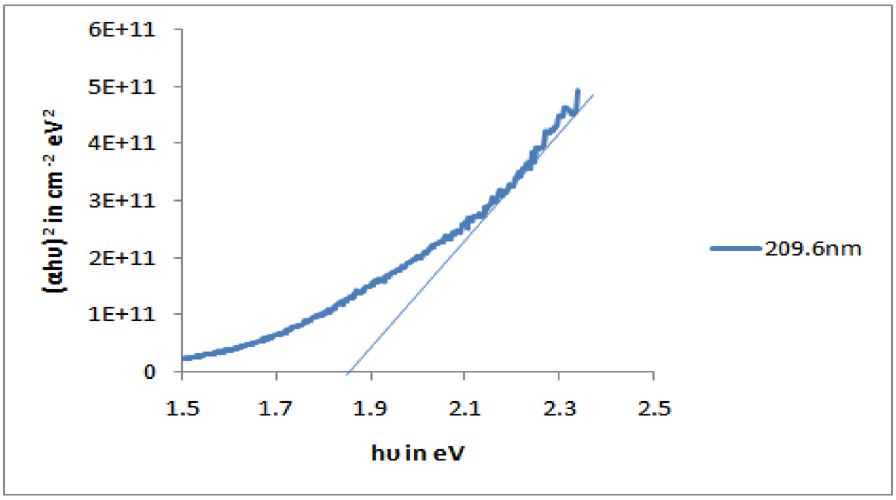

Figure 6: Plots of $(\alpha h\upsilon)^2$ vs. hυ for ZnTe Thin Film of Thickness 209.6 nm.

Figures 5, 6 and 7 show the graph between $(\alpha h\upsilon)^2$verses 'hυ'. The optical band gap E_g was calculated by extrapolating the linear portion of the respective curves to $(\alpha h\upsilon)^2 = 0$.

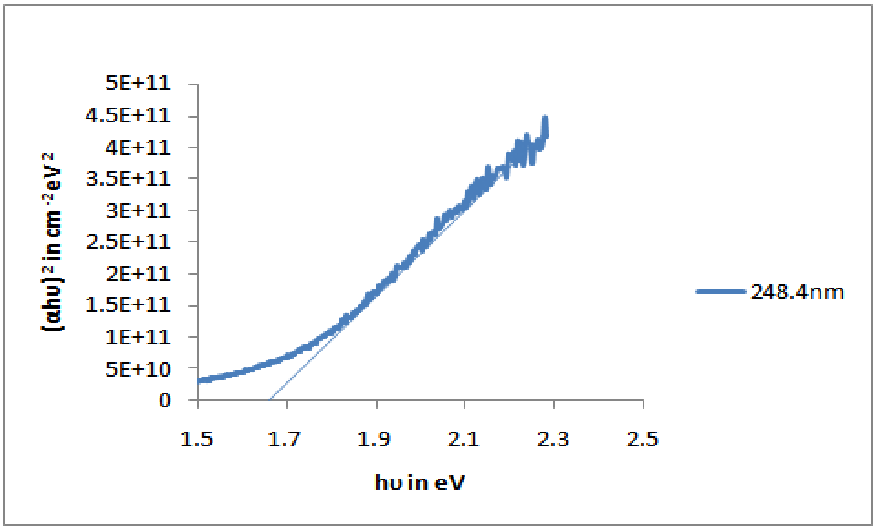

Figure 7: Plots of $(\alpha h\upsilon)^2$ vs. hυ for ZnTe Thin Film of Thickness 248.4 nm.

From figures 5, 6 and 7, we see that the band gap decreases with the increase in thickness, which is shown in the following table 1. The decrease in band gap with the increase in thickness may be due to the increase in grain size of the higher films thickness.[9]

Table 1: Variation of Band Gap with Thickness

Thickness of ZnTe thin films (in nm)	Band Gap (in eV)
191.3 nm	1.87 eV
209.6 nm	1.82 eV
248.4 nm	1.63 eV

Electrical Characteristics

The resistivity of the vacuum-evaporated ZnTe thin film is measured by Four Probe Method. We have to use the following formula for the determination of resistivity of the thin film

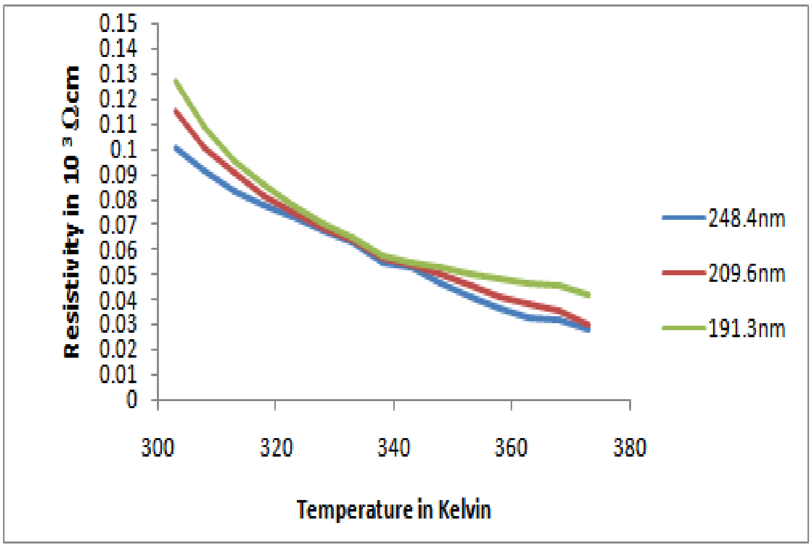

Figure 8: Variation of Resistivity with Temperature.

$\rho = (V \pi t)/(I \ln 2)$, (6)

where 'ρ' is the resistivity of the thin film, 'V' is the potential difference which changes with the increase in temperature, 't' is the thickness of the deposited thin film and 'I' is the current which is kept constant during the experiment.

The variation of resistivity (ρ) of the vacuum-evaporated ZnTe thin film of different thickness with the temperature is shown in figure 8.

From figure 8, it is seen that the resistivity decreases with the increase in thickness. This may be due to the island structure, higher grain size and higher defect density in the films. [5,11]

CONCLUSIONS

ZnTe is deposited on glass substrate by vacuum evaporation technique. It exhibits a direct band gap ranging from 1.63 eV to 1.87 eV, which decreases with increase in film's thickness. The resistivities of the deposited thin films were found to be in the order of 10^3 Ωcm and it decreases as the temperature of the films increases, confirming a semiconducting nature. It is also seen that the resistivity decreases with increase in thickness of the films.

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REFERENCES

1. *Bhumia S., Bhattacharya P. and Bose D. N. 1996. Pulsed-laser deposition of ZnTe thin films. Mater. Lett. 27(6): 307–311.*
2. *Kenji, Y. Minoru, Y. Takayuki, Y. Kenzo, O., Hiroshi, S., Masakazu and Ohisihi 2003. Optical and electrical characterization of high-quality Pbdoped ZnTe substrates. Physica B340–342: 254–257.*

3. *IkhioyaI, L. 2015. Optical and Electrical Properties of ZnTe Thin Films Using Electro deposition Technique. Int. J. Innov. Appl. Stud., 12(2): 369–373*

4. *Rusu, G. I., Prepeliţă. P., Rusu, R. S., Apetroaie, N., Oniciuc, G., Amariei, A. 2006. On the structural and optical characteristics of zinctelluride thin films, J. Optoelectron. Adv. Mater.. 8(3) : 922–926.*

5. *Syed W. A., Ahmed S., Saleem M. S., Shah N. A., 2015. Cu-doped ZnTe thin films for potential energy applications, Chalcogenide Lett. 1 : 215–226.*

6. *Naveen, C. S., Raghu, P., and Mahesh, H. M. 2014. Concentration-dependent optical and structural properties of Mo-doped ZnTe thin films prepared by e-beam evaporation method. Int. J. Electrochem. Sci., 9 :2944–2954*

7. *Mahmood, W., Shah, N. A., Akram, S., Mehboob, U., Malik, U. S. and Sharaf M. U. 2013. Investigation of substrate temperature effects on physical properties of ZnTe thin films by close spaced sublimation technique. Chalcogenide Lett. 10(8): 273–281.*

8. *Kumar, B. R., Hymavathi, B. and Rao, T. S. 2014. Investigation of physical properties of nanostructured ZnTe thin films prepared by DC reactive magnetron sputtering. Chalcogenide Lett. 11(10 : 509–517.*

9. *Patel, K. D., Rathod, J. R., Patel, H. S., Pathak, V. M. and Srivastava, R. 2010. Characterisation of thermally evaporated ZnTe thin films. J. Pure Appl. Sci. 18 : 126–128.*

10. *Shanmugan, S. and Mutharasu, D. 2012. Optical properties and surface morphology of zinc telluride thin films prepared by Stacked Elemental Layer Method. Mater. Sci. 18(2): 107–111*

11. *Shinde U. P., Borse R. Y., Patil A. V., Jagadale B. S. and Pawar T. B. 2014. Studies on Electrical Resistivity of Vacuum-Evaporated Zn-Te Thin Films. J. Eectron. Dev. 19: 1627–1632.*

12. *Pattar, J., Sawant, S. N., Nagaraja, M., Shashank, N., Balakrishna, K. M., Sanjeev, G., & Mahesh, H. M. (2009). Structural optical and electrical properties of vacuum evaporated indium doped zinc telluride thin films. Int. J. Electrochem. Sci, 4, 369-376.*