International Journal of Advanced Science and Technology
Vol. 29, No. 9s, (2020), pp. 5547-5552

Investigation of optical and electrical properties of multilayer thin films of ZnSe/ZnTe/CdSe

Y. C. Sharma[a], P. Ansari[a*] and R. A. Dar[b*]
[a]*Department of Physics, Vivekananda Global University, Jaipur, Rajasthan*
[b]*Department of Chemistry, Maharashtra College of Arts, Science and Commerce, Mumbai, Maharashtra*

Abstract
Zinc Selenide (ZnSe), Zinc Telluride (ZnTe) and Cadmium Selenide (CdSe) are II-VI semiconductors having band gap of around 2.7eV, 2.27eV and 1.74eV, respectively. In present work multilayer ZnSe/ZnTe/CdSe thin films have been prepared by e-beam evaporation; having thickness 50nm/50nm/50nm to 100nm/100nm/100nm. The wavelength of 400nm-1000nm were studied by using UV-VIS spectrophotometer for optical properties of the thin films. The band gap results show the semiconducting nature of films grown. Electrical properties of thin films have also been studied by Current-Voltage (I-V) characteristics and Hall measurement technique.

Keywords: ZnSe/ZnTe/CdSe, UV-VIS, I-V, Hall measurment, Bandgap.

1. INTRODUCTION

Zinc Selenide (ZnSe), Zinc Telluride (ZnTe) and Cadmium Selenide (CdSe) are II-VI semiconductors having bandgap energy of around 2.7eV, 2.27eV and 1.74eV, respectively. In ZnSe it was observed that the energy gap decreases with the increase in the film thickness and increases with the increase in the annealing temperature. CdSe nanocrystals have been prepared using thermal evaporation method and analyzed for optical studies by Kumar et al [1]. Zinc Telluride (ZnTe) thin films were grown onto glass substrates with varying thickness [2] and the optical parameters of films were measured by reflectance and transmission spectra at normal incidence of light [3]. The effect of annealing temperature on the structural and optical properties of ZnSe/CdSe thin films were studied by using XRD [4]. UV-Visible spectroscopy has been used to investigate optical properties of semiconductors by measuring their absorption spectra, which provides information about the nature of band gap because it is used to calculate band gap energy. The transmission spectra were obtained by UV-VIS spectrometer in the range of 200-1000 nm at room temperature [5]. The optical absorption spectra are important for measuring the absorbance of wavelength. The pure ZnSe/CdSe films have been studied by using UV-Visible Spectrophotometer at room temperature [6]. Electrical parameters (Hall Effect measurement) have been obtained and studied at various temperatures [7] and showed that ZnTe films correspond to a p-type semiconductor [8]. The *I–V* characteristic showed good photoresponse, suitable for photosensor applications [9] and it is an important material to be used as an anti-reflective coating layer for heterojunction solar cells [10]. The Hall Effect has been used in a magnetic field on the current (electrons) flowing in a solid and it has been used for characterization of films. The method is one of the most important methods for the evaluation of electrical properties in semiconductor materials such as resistivity, carrier density, and mobility [11]. ZnSe/ZnTe/CdSe have wide range of applications in the field of light emitting diode [12] other optoelectronic devices such as blue light emitting diode [13], Electro luminescence devices and photovoltaic cells which enable wide application in the field of displays [14], sensors and lasers [15], field emitters, photo sensor applications [16], optoelectronic applications [17], power conversion [18], bioimaging [19], photo converters [20]. In this study's thin films of ZnSe/ZnTe/CdSe prepared by e-beam method with different thicknesses and annealing at different temperatures. In this study thin film of ZnSe/ZnTe/CdSe prepared by e-beam method and which are characterized to study the optical, and electrical properties.

2. MATERIALS AND METHODS

ZnSe/ZnTe/CdSe were purchased from Alfa Aesar: having 99.999% purity. Cleaning procedure of glass substrates were done by acetone. ZnSe/ZnTe/CdSe were deposited on glass substrate by electron beam method in a vacuum of 3.75x10-2 Torr. The glass substrate heated in a vacuum chamber at room temperature. The

ISSN: 2005-4238 IJAST

ZnSe/ZnTe/CdSe thin films were annealed at 100°C & 200°C in a muffle furnace. The optical properties were studied using UV-VIS spectro photo meter and the electrical properties of thin films have also been studied by Current-Voltage (I-V) characteristic and Hall measurement technique. HMS 5000, Ecopia corp, Korea: having Hall Effect measurement system property and Agilent Technology, B1500A Semiconductor Device Analyzer, Malaysia: is all in one analyzer supporting IV, CV, pulse/dynamic IV and more were used.

3. RESULTS AND DISCUSION

3.1. Optical properties of ZnSe/ZnTe/CdSe

Optical properties were studied using UV-VIS spectro photometer (make Perkin Elmer Lambda 750) at MRC, MNIT Jaipur. Variation of absorbance of the films w.r.t to variation in wavelength of incident radiations has been plotted in fig 1 & 2.

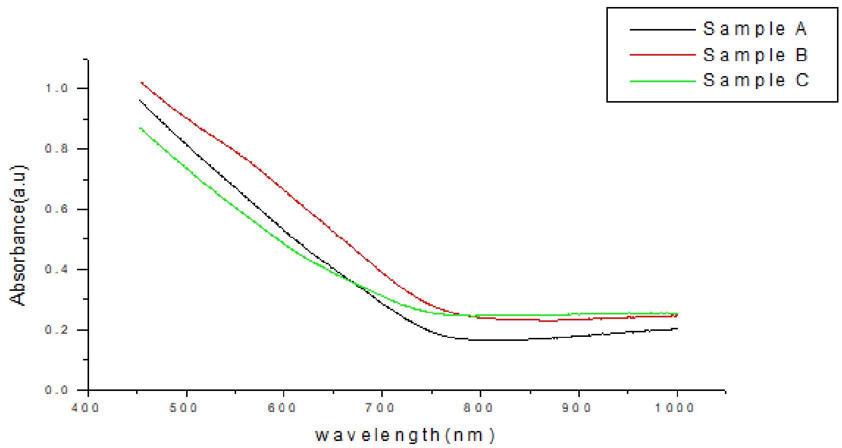

Fig1: Plot of absorbance (a.u) vs. wavelength (nm) for ZnSe/ZnTe/CdSe thin films of 150nm. (A): ZnSe (50nm) / ZnTe (50nm) / CdSe (50nm) film of 150nm at RT. (B): ZnSe (50nm) / ZnTe (50nm) / CdSe (50nm) film of 150nm at 100°C. (C): ZnSe (50nm) / ZnTe (50nm) / CdSe (50nm) film of 150nm at 200°C.

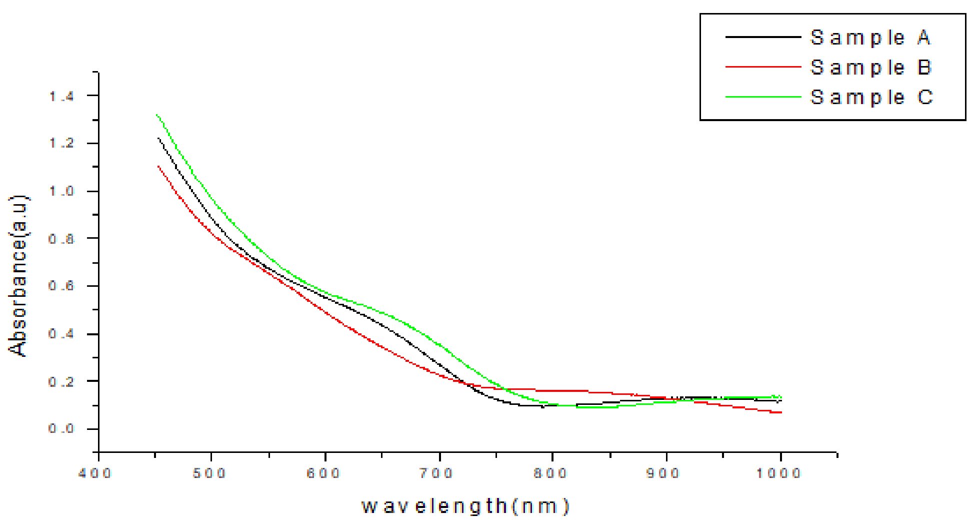

Fig 2: Plot of absorbance (a.u) vs. wavelength (nm) for ZnSe/ZnTe/CdSe thin films of 300nm. (A): ZnSe (100nm) / ZnTe (100nm) / CdSe (100nm) film of 300nm at RT. (B): ZnSe (100nm) / ZnTe (100nm) / CdSe (100nm) film of 300nm at 100°C. (C): ZnSe (100nm) /ZnTe (100nm) / CdSe (100nm) film of 300nm at 200°C.

ISSN: 2005-4238 IJAST

The energy bandgap was determined by using the following relation.

$\alpha hv = C(hv-E_g)^{1/2}$

Where E_g is the energy band gap, C is constant which is dependent on the structure of sample, α is the absorption coefficient and h is a plank constant [21].

The energy bandgap from plot of $(ahv)^2$ vs E(eV) or hv are shown in fig 3 & 4. The linear nature indicates direct nature of transition. From above graphs, it is concluded that absorbance goes on decreasing as wavelength increases. Absorbance increases with increase in thickness.

Our results have been shown in fig 3 & 4 shows the same trend.

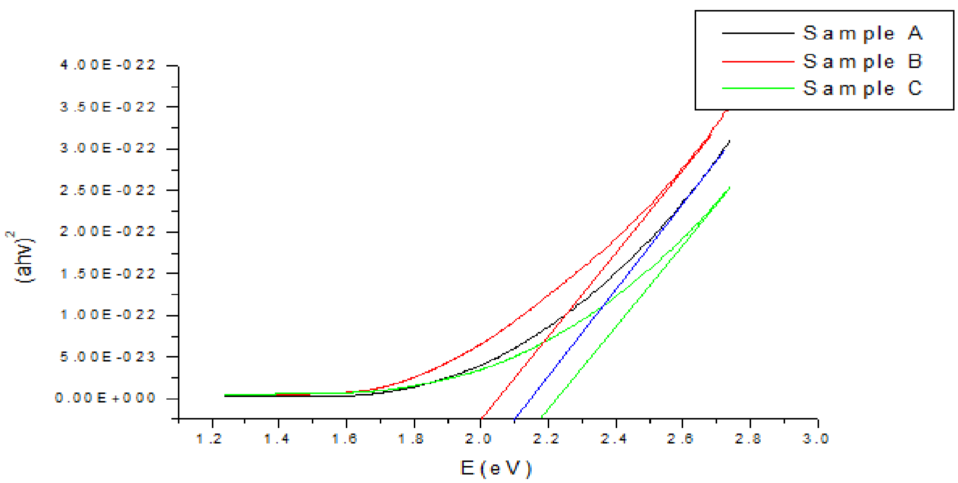

Fig 3: Plot of $(ahv)^2$ vs. E(eV) for ZnSe/ZnTe/CdSe thin films of 150nm. (A): ZnSe (50nm) / ZnTe (50nm) / CdSe (50nm) film of 150nm at RT. (B): ZnSe (50nm) / ZnTe (50nm) / CdSe (50nm) film of 150nm at 100°C.Sample (C): ZnSe (50nm) / ZnTe (50nm) / CdSe (50nm) film of 150nm at 200°C.

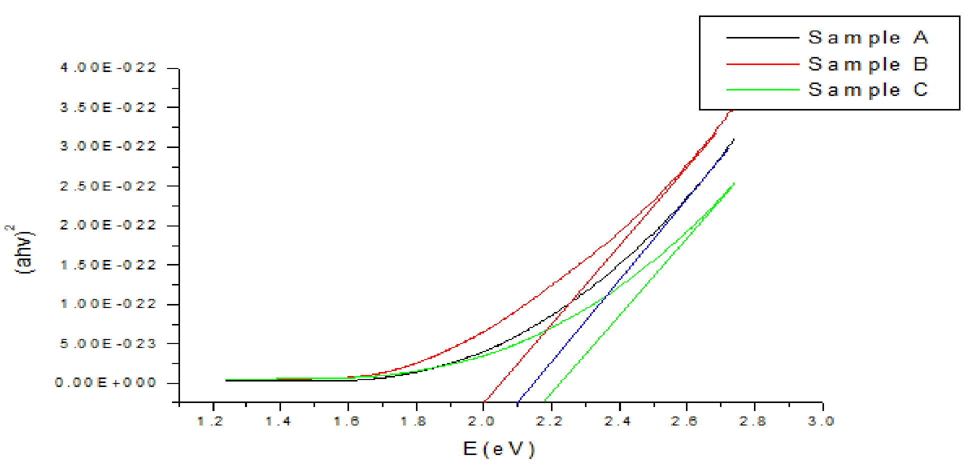

Fig 4: Plot of $(ahv)^2$ vs. E(eV) for ZnSe/ZnTe/CdSe thin films of 300nm. (A): ZnSe (100nm) / ZnTe (100nm) / CdSe (100nm) film of 300nm at RT. (B): ZnSe (100nm) / ZnTe (100nm) / CdSe (100nm) film of 300nm at 100°C. (C): ZnSe (100nm) /ZnTe (100nm) / CdSe (100nm) film of 300nm at 200°C.

3.2. Electrical properties of ZnSe/ZnTe/CdSe

3.2.1. I-V Characteristics ZnSe/ZnTe/CdSe

I-V Characteristics of various samples have been studied using Semiconductor Device Analyzer (Agilent Technology, B1500A, Malaysia) at MRC, MNIT Jaipur. An I-V Characteristics of ZnSe/ZnTe/CdSe thin film for thickness 300nm at room temperature shows the metallic nature or conducting nature of material. While the annealing of this material at 200°C shows the semiconducting behavior of film.

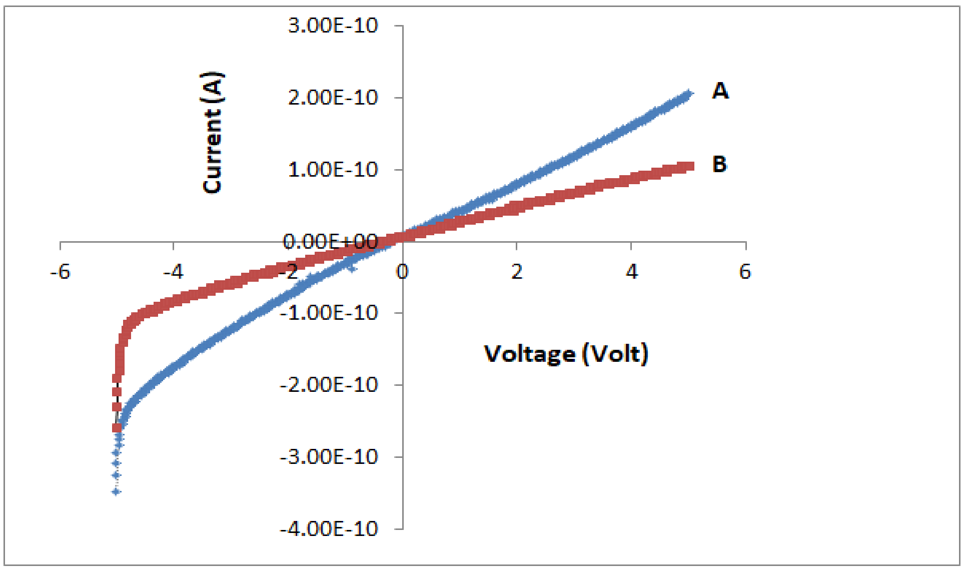

Fig 5: I-V characteristics of ZnSe/ZnTe/CdSe films of 300nm at RT & 200°C. (A): ZnSe (100nm) / ZnTe (100nm) / CdSe (100nm) film of 300nm at RT. (B): ZnSe (100nm) / ZnTe (100nm) / CdSe (100nm) film of 300nm at 200°C.

3.2.2. Hall measurements of ZnSe/ZnTe/CdSe films

Hall characteristics of various samples have been investigated by using (HMS 5000, Ecopia corp, Korea) at MRC, MNIT Jaipur. The ZnSe/ZnTe/CdSe thin films for 100nm at Room temperature show that n-type semiconducting material. While these material annealed at 200°C the thin film exhibits p-type semiconductor.

Sample name	**Resistivity Ωm**	**Conductivity S/m**	**Magneto Resistance**	**Avg hall** *m3/C*
ZnSe + ZnTe + CdSe 300nm RT	3.764×10^{-2} 2.603×10^{-2}	2.656×10^{1} 3.842×10^{1}	1.461×10^{3} 1.549×10^{3}	-4.319×10^{-1} -1.746×10^{-1}
ZnSe + ZnTe + CdSe	2.725×10^{-2} 2.609×10^{-2}	3.669×10^{1} 3.832×10^{1}	1.579×10^{3} 1.602×10^{3}	1.282×10^{0}

ISSN: 2005-4238 IJAST

300nm 200°C				9.513×10^1

Table1: Hall measurement of ZnSe/ZnTe/CdSe 300nm (RT & 200°C)

4. CONCLUSION

It has been concluded good quality multilayer film could be shown by using e-beam evaporation method. The film prepared in the present work shows excellent electrical and optical properties in coherence with the earlier works.

REFERENCES

1. Melvin M.D.K., Devadason S., Rajesh S., (2012), Formation of CdSe/CdTe quantum dots in multilayer thin films using PVD method. AIP Conference Proceedings. 1451: 176.
2. Hossain M. I., Siddiquee K. A. M. H., Islam O., Gafur M. A., Qadir M. R., Ahmed N. A., (2019), Characterization of electrodeposited ZnTe thin films. Journal of Optics. 48: 295–301.
3. Potlog T., Maticiuc N., Mirzac A., Dumitriu P., Scortescu D., (2013), Structural and optical properties of ZnTe thin films. CAS 2012.
4. Melvin M. D.K., Devadason S., (2013), Structural and optical properties of CdTe/CdSe heterostructure multilayer thin films prepared by physical vapor deposition technique. Applied Nanoscience. 3: 453–459.
5. Tareque C.M., Zubair A., Hussain M., (2017), Optical and structural characterization of ZnSe thin film fabricated by thermal vapour deposition technique. Article in AIMS Journal. 4: 1095-1121.
6. Parker C.A., (1968), Optical studies of pure and doped films. American Elsevier, New York, N.Y. 220-222.
7. Gandhi J.R., Patel K.D., Solanki G.K., (2013), Structural and Electrical Properties of ZnTe Thin Films Deposited at Various Substrate Temperatures. Condensed Matter and Materials Physics. 80-84.
8. Ochoa-Estrella F. J., Vera-MarquinaI A., Mejia I., Leal-Cruz A. L., Pintor-Monroy M. I., Quevedo-López M., (2018), Structural, optical, and electrical properties of ZnTe:Cu thin films by PLD. Journal of Materials Science: Materials in Electronics. 29: 20623–20628.
9. Harishchandra K.S , VithalGhule A, Sharma R, (2013), Nanocrystalline ZnSe thin films prepared by solution growth technique for photosensor application. Composites Part B: Engineering: 44: 553-557.
10. Bloss W., Fisterer F.P., Schock H.W., (1988), Advances in Solar Energy. American Solar Energy Society Inc. 4: 275.
11. Thirumavalavana S., Mani K., Suresh S., (2015), Studies on Hall Effect and DC Conductivity Measurements of Semiconductor Thin films Prepared by Chemical Bath Deposition (CBD) method. Journal of Nano- and Electronic Physics. 7: 04024.
12. Antony A., Mirali K.V., Manoj R., Jayaraj M.K., (2005), Growth of ZnS thin films obtained by chemical spray pyrolysis. Mater. Chem. Phys. 90: 105-106.
13. Coe S., Woo W.K., Bawendi M.G., Bulovic V., (2002), Electroluminescence from single monolayers of nanocrystals in molecular organic devices. Nature. 420: 800- 803.
14. Beard M.C., Turner G.M., Schmuttenmaer C.A., (2002), Size–dependent photoconductivity in CdSe nanoparticles as measured by time-resolved terahertz spectroscopy. Nano Lett. 2: 983- 987.
15. Fang X.S., Zhai T.Y., Gautam U.K., Li L., Wu L., Bando Y., Golberg D., (2011), ZnS nanostructures: From synthesis to applications. Prog. Mater. Sci. 56: 175-287.
16. Williams J.E., Camata R.P., Fedorov V.V., Mirov S.B., (2008), Pulsed laser deposition of chromium-doped zinc selenide thin films for mid-infrared applications. Applied Physics A. 91: 333-335.
17. Lohar., Kamble G. M., Punde R. K., Jadhav S. T., S. T., Dhaygude A.S., Relekar H. D., Fulari B. P., (2016), Electrochemical synthesis of ni doped znse thin film for photoelectrochemical cell application. Materials Focus. 5: 4.
18. Gawali S.A., Bhosale C.H., (2011), Structural and optical properties of nanocrystalline CdSe and Al:CdSe thin films for photoelectrochemical application. 129: 751-755.
19. Manikandan N., Vinitha G., Divya S., (2018), A review on cadmium selenide nanomaterials and its applications. International Journal of Control Theory and Applications. 9: 5.

ISSN: 2005-4238 IJAST

20. Arico A.S., silvestro D, antonucci P.L., Giordano N., (1997), Electrodeposited thin film znte semiconductors for photovoltaic applications. Advanced Performance Materials. 4: 115–125.
21. Ghobad N., (2013), Band gap determination using absorption spectrum fitting procedure. Int. Nano Letters. 3: 2.