

## Electrical behavior of Vacuum evaporated $Cd_{1-x}Zn_xSe$ thin films

Sarita<sup>1</sup> and Gulbir Singh<sup>2</sup>

<sup>1</sup>Department of Physics, Govt. (P.G) College, Hisar, <sup>2</sup>Professor, SG (PG) College, Sarurpur Khurd, Meerut, UP

Email:<sup>1</sup>mrs.saritasaroha@rediffmail.com

### ABSTRACT

Ternary system of cadmium and zinc selenide ( $Cd_{1-x}Zn_xSe$ ) is attracting a great deal of attention due to their fundamental experimental and applied interest in thin film devices. Thin films of CdZnSe alloy were prepared by vacuum evaporation technique. The I-V characterization and the electrical resistivity of selenium rich system at room temperature have been studied. The I-V characterization of the samples was done using Keithley I-V measurement system by two probe method at room temperature. The electrical resistivity of the samples has been found to vary between  $0.05 \times 10^6 \Omega \text{ cm}$  and  $0.416 \times 10^6 \Omega \text{ cm}$ . It was also confirmed with the help of EDAX pattern of ( $Cd_{1-x}Zn_xSe$ ) showing that all the films showing less atomic percentage of metallic content (Cd and Zn content) over selenium reveals higher resistance.

**Key words:** electrical properties, EDAX, ternary alloys and vacuum evaporation.

Received 18/11/2017

Revised 30/12/2017

Accepted 17/02/2018

### Citation of this article

Sarita and Gulbir Singh. Electrical behavior of Vacuum evaporated  $Cd_{1-x}Zn_xSe$  thin films. Int. Arch. App. Sci. Technol; Vol 9 [1] March 2018. 55-60.

### INTRODUCTION

The technological interest in ternary alloys of II-VI group based devices is mainly caused by their very low production costs. The major application of thin film science is still in the field of micro- electronics. However, there are growing applications in other areas like thin films for optical and magnetic devices, electrochemistry, protective and decorative coatings and catalysis. Thin films are used for making resistors, capacitors, diodes, magnetic devices, memory devices. Microelectronics Mechanical systems (MEMS) are designed by using mechanically stable thin film. Usually, CdSe is a n-type material and they are of interest for their applications as photoconductors [1], solar cells [2, 3], thin film transistors [4,5], gas sensors [6,7], acousto optic devices [8], vidicones [9], photographic photoreceptors [10], etc. The use of thin film polycrystalline semiconductors has variety of applications in various electronic and optoelectronic devices. ZnSe has a direct bandgap of 2.7 eV and is transparent over a wide range of the visible spectrum. Therefore, it is used to fabricate blue-green light emitting diodes [11], photodiodes [12] and solar cells [13]. Cadmium zinc-selenide [(CdZn) Se] is one of the important ternary materials for use in electroluminescent, photo luminescent, photoconductive and photovoltaic device applications because of its interesting size-dependent properties as well as a high stability and wide optical band gap which covers the maximum electromagnetic spectrum [14-17]. Thin films now occupy a prominent place in basic research and solid state technology. Vacuum deposition method for the fabrication of thin films is the most popular and reliable due to its simpler and more cost effective than the other methods for large area deposition.

## MATERIAL AND METHODS

**Experimental:** The as-deposited thin films of  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  alloy at different composition ( $x=0, 0.2, 0.4, 0.6, 0.8, 1$ ) have been deposited by using vacuum evaporation technique (Vacuum Coating Unit Model 12A4). The fine powder of different  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  ( $0 \leq x \leq 1$ ) compositions has been used as a starting material for deposition. The limiting compositions ( $x=0$  and  $x=1.0$ ) are the case of binary CdSe and ZnSe compounds as the composition at  $x=0$  and  $x=1$  gives CdSe and ZnSe binary system respectively and used directly for evaporation. The high purity (99.999%) binary semiconducting materials (CdSe and ZnSe) having the desired compositional ratio in accordance with their atomic percentage weight have been weighted using an electronic weighing machine and sealed in a quartz ampoules of length  $\sim 5$  cm and internal diameter  $\sim 8$  cm in a vacuum of the order of  $10^{-5}$  torr. The sealed ampoules were kept inside a furnace where the temperature was raised upto  $900^\circ\text{C}$  at a raising rate of  $4-5$  K per minute with frequent rocking to ensure the homogeneity of the melt in the ampoule for 8 hours. The rapid quenching has been done in ice cool water. After quenching, the ingots of quenched  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  ( $0 \leq x \leq 1$ ) ternary alloy were removed by carefully breaking the ampoules. These ingots have been grinded into fine powder using Pastel and Mortar and used for evaporation to get thin films of  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  ( $0 \leq x \leq 1$ ) ternary system. The limiting compositions ( $x=0$  and  $x=1.0$ ) are the case of binary CdSe and ZnSe compounds as the composition at  $x=0$  and  $x=1$  gives CdSe and ZnSe binary system respectively and used directly for evaporation. Thin films of these compositions of  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  alloy will be deposited onto highly cleaned glass substrates by using vacuum evaporation technique. Thin films of these compositions of  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  alloy have been deposited onto highly cleaned non conducting glass substrates by using vacuum evaporation technique. The substrate was cleaned in aqua-regia, washed in distilled water, acetone and isopropyl alcohol (IPA). The silver paste was used to make electrodes on the vacuum evaporated  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  ( $x=0, 0.2, 0.4, 0.6, 0.8, 1$ ) thin films for I-V measurements. The distance between these two electrodes was kept 3 mm. The I-V characterization of the samples was done using Keithley I-V measurement system (Model No. SCS - 4200). The measurements were done in the range of  $-10$  V to  $+10$  V at a step of  $0.05$  V at room temperature using two probe methods.

## RESULT AND DISCUSSION

The figure 1 shows the I-V characteristics of vacuum evaporated  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  ( $x=0, 0.2, 0.4, 0.6, 0.8, 1$ ) thin films at room temperature. For all samples the variation of current (I) with applied bias voltage (V) in the range of  $-10$  to  $+10$  Volt are linear i.e. the conduction is ohmic (I directly proportional to V). From the I-V characteristics of the samples, the electrical resistivity has been determined. The value of electrical resistivity of vacuum evaporated  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  ( $x=0, 0.2, 0.4, 0.6, 0.8, 1$ ) thin films with composition 'x' are given in table 1.

**Table 1: Variation of Resistivity with Composition 'x'.**

Composition (x)	Resistivity (* $10^6 \Omega \text{ cm}$ )
CdSe	0.05
$\text{Cd}_{0.8}\text{Zn}_{0.2}\text{Se}$	0.41
$\text{Cd}_{0.6}\text{Zn}_{0.4}\text{Se}$	0.416
$\text{Cd}_{0.4}\text{Zn}_{0.6}\text{Se}$	0.191
$\text{Cd}_{0.2}\text{Zn}_{0.4}\text{Se}$	0.127
ZnSe	0.119

A plot of resistivity versus composition 'x' at room temperature has been shown in figure 2. This figure shows that the resistivity is maximum for  $x = 0.4$  (i.e.  $\text{Cd}_{0.6}\text{Zn}_{0.4}\text{Se}$ ) and is lowest for  $x = 0$  (i.e. CdSe) in the ternary system of  $\text{Cd}_{1-x}\text{Zn}_x\text{Se}$  ( $x=0, 0.2, 0.4, 0.6, 0.8, 1$ ) thin films at room temperature.

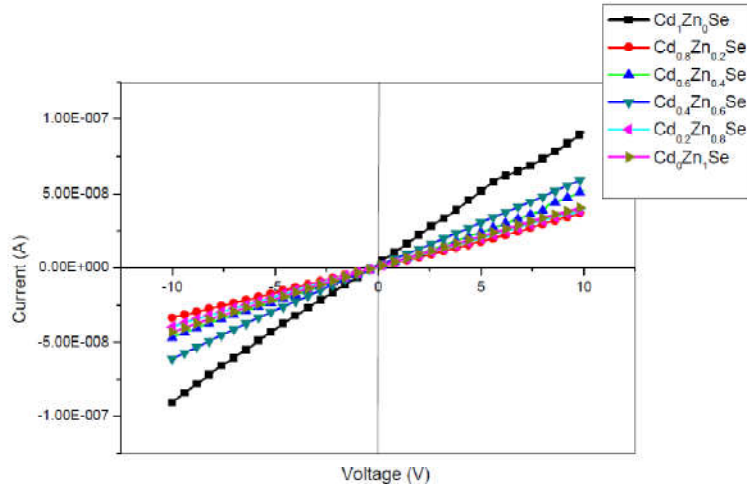


Figure 1: Comparative Study of Current Voltage Characteristics of Vacuum Evaporated  $Cd_{1-x}Zn_xSe$  ( $x=0, 0.2, 0.4, 0.6, 0.8, 1$ ) Thin Films.

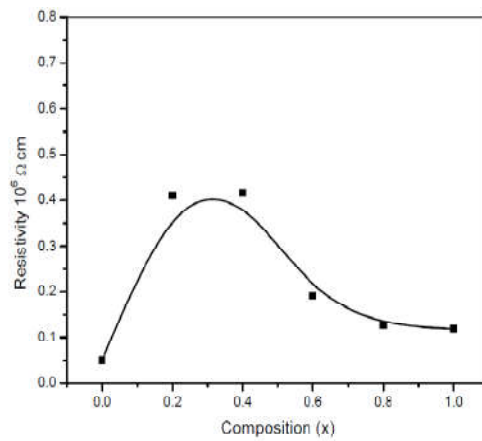


Figure 2: Comparative Study of Resistivity of Vacuum Evaporated  $Cd_{1-x}Zn_xSe$  ( $x=0, 0.2, 0.4, 0.6, 0.8, 1$ ) Thin Films.

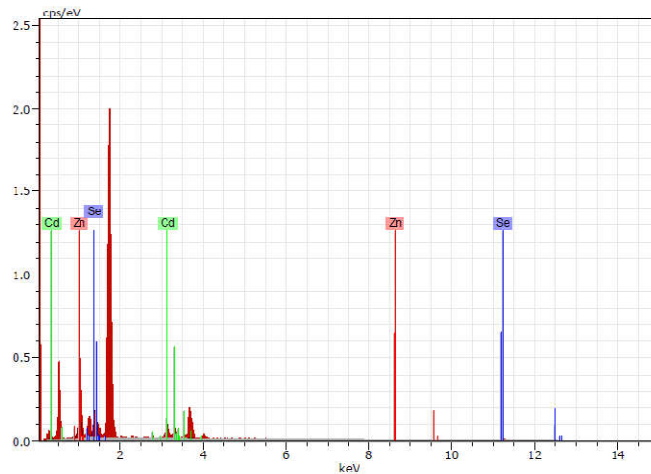


Figure 3 : EDAX Spectrum of Vacuum Evaporated CdSe Thin Film.

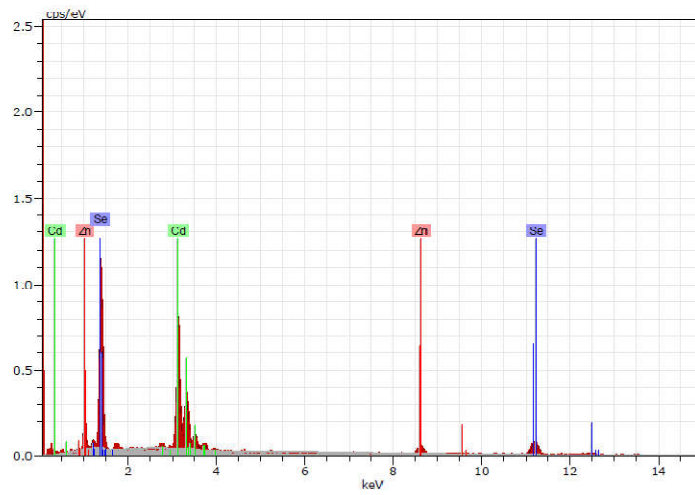


Figure 4: EDAX Spectrum of Vacuum Evaporated Cd<sub>0.8</sub>Zn<sub>0.2</sub>Se Thin Film.

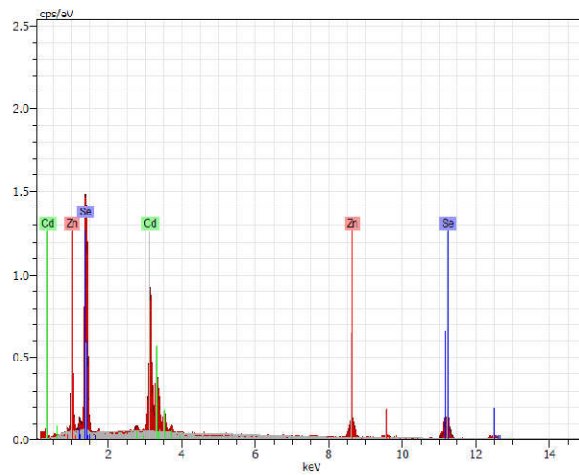


Figure 5: EDAX Spectrum of Vacuum Evaporated Cd<sub>0.6</sub>Zn<sub>0.4</sub>Se Thin Film.

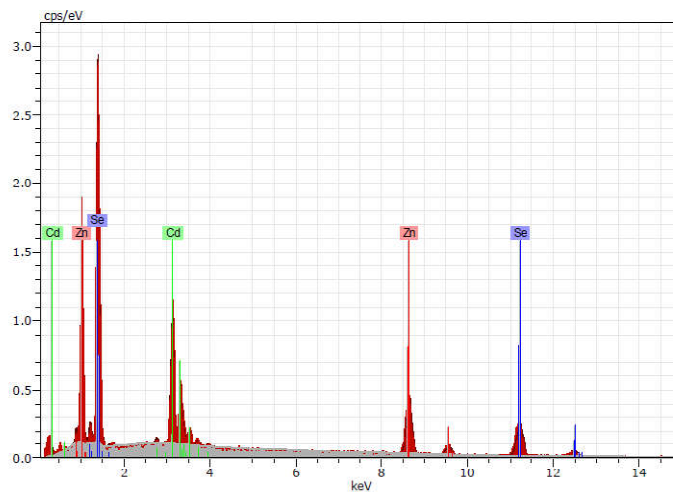


Figure 6: SEM Image of Vacuum Evaporated Cd<sub>0.4</sub>Zn<sub>0.6</sub>Se Thin Film.

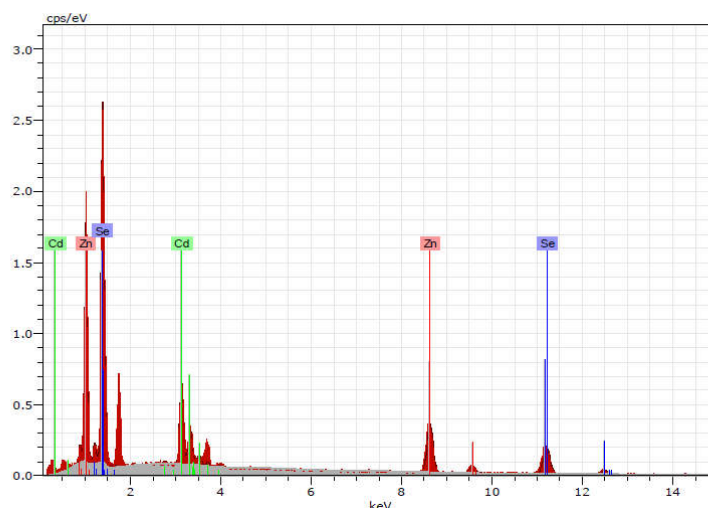


Figure 7: EDAX Spectrum of Vacuum Evaporated  $Cd_{0.2}Zn_{0.8}Se$  Thin Film.

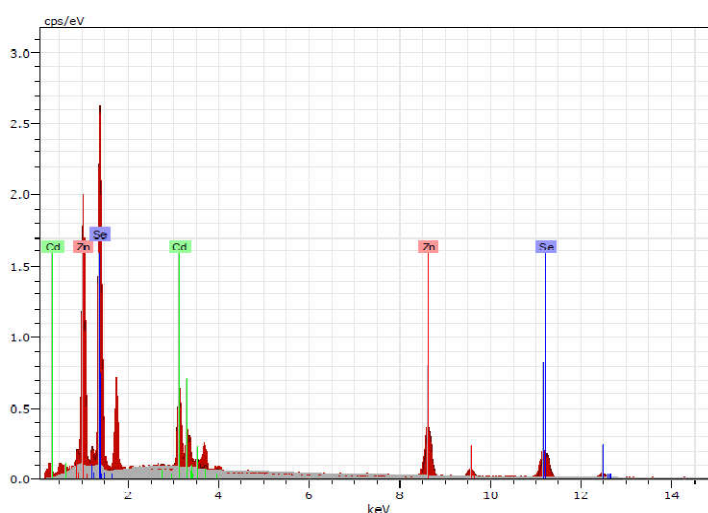


Figure 8: EDAX Spectrum of Vacuum Evaporated ZnSe Thin Film.

EDAX analysis was performed for the elemental compositional analysis of the films. From these EDAX spectrums, different element concentration is observed. The strong peaks of Cd, Zn and Se shown in EDAX spectrums, confirm the presence of the Cd, Zn and Se as the components of the deposited thin films of  $Cd_{1-x}Zn_xSe$  system. The EDAX analysis confirm the presence of Cd, Zn and Se in all ternary thin films of  $Cd_{1-x}Zn_xSe$  ( $x = 0, 0.2, 0.4, 0.6, 0.8, 1$ ). It is found that the all films showing Cd and Zn content less than the percentage present in the starting material. The atomic percentage of Se shows excess of Se in the films. The reason being that as we introduce Zn content in CdSe the resistivity increases and reaches at maximum for  $x = 0.4$ . This may be due to that some Zn content settles down at the interstitial sites of CdSe lattice as the volume of Cd atom (atomic radius 0.171 nm) is greater than that of Zn atom (atomic radius 0.138). Due to this factor there is an increment in the number of scattering center available in the material and therefore, it causes increase in the resistivity.

## REFERENCES

1. K. Shimizu, O. Yoshida, S. Aihara, Y. Kiuchi, (1971). IEEE Trans. Electron Devices ED-18 1058.
2. T. Gruszecki, B. Holmstrom, Sol. Energy Mater. Sol. (1993). Cells 31. 227.
3. A.K. Pal, A. Mondal, S. Chaudhuri, (1990). Vacuum 41, 1460.
4. G. Moersch, P. Rava, F. Schwarz, A. Paccagnella, (1989). IEEE Trans. Electron Devices ED-36 449.
5. A. Van Calster, F. Vanfleteren, I. De Rycke, J. De Baets, (1988). J. Appl. Phys. 64, 3282.
6. V.A. Smyntyna, V. Gerasutenko, S. Kashulis, G. Mattongo, S. Reghini, (1994). Sensors Actuators B 19, 464.

**Sarita and Singh**

7. N.G. Patel, C.J. Panchal, K.K. Makhijia, Cryst. (1994). Res. Technol. 29,) 1013.
8. B. Bonello, B. Fernandez, J. Phys. Chem. Solids 54 (1993) 209.
9. J.C. Schottmiller, R.W. Francis, C. Wood, US Patent, 3884 (1975) 688.
10. B.J. Curtis, H. Kiess, H.R. Brunner, K. Frick, (1980). Photogr. Sci. Eng. 24, 244.
11. Shirakawa Tsuguru. Mater Sci Eng, B, (2002). Solid-State Mater Advanced Technology;91–92:470–5.
12. O. de Melo, G. Santana, M. Melendez-Lira, I. Hernandez-Calderon, (1999). J. Crystal Growth ;201–202:971–4.
13. W. Bohne,S. Lindner,J. Rohrich, Nucl Instrum Methods B 2002;188:55–60.
14. P.P. Hankare, P.A. Chate, M.R. Asabe, S.D. Delekar, I.S. Mulla and K.Garadkar, (2006). J. Mater. Sci.: Mater. Electron., 17 1055.
15. R.B. Kale, C.D. Lokhande, R.S. Mane and Han S H (2007). Appl. Surf. Sci. 253 3109
16. A.L. Vartanian, A.L. Asatryan and A.A. Kirakosyan Physica B 389 (2007) 258 146
17. Y. Gua, I.L. Kuskovskya, R.D. Robinsona, I.P. Hermana, G.F. Neumark, X.Zhoub, S.P. Guob , M. Munozb and M.C. Tamargo (2005). Solid State Commun.134 677.