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Study of Optoelectrical Properties of Vacuum Deposited $Zn_{0.75}Cd_{0.25}Se$ Thin Films for Sensor Application

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***Abstract:** In this study, ZnxCd1-xSe (x = 0.75) semiconductor thin films of thickness 1000 A^0 and 2500 A^0 belong to II-VI group were deposited onto glass substrates for the application of solid-state photo sensor by vacuum deposition method under the pressure of 10^{-5} mbar[10]. Systematic characterizations of morphological, optical and electrochemical properties have been carried out by AFM, FTIR and I-V characteristics [14]. The effect of zinc and thickness on the morphological and optoelectrical properties has been studied in this paper.*
***Keywords:** semiconductor, thin film, AFM, FTIR, optoelectrical.*

I. INTRODUCTION

The $Zn_{0.75}Cd_{0.25}Se$ is an n-type semiconductor material, having wide band gap with high absorption coefficients and has interesting size dependent properties[1] as CdSe is found to undergo photo corrosion when used in PEC cells, as ZnSe is found to be more stable though less photoactive due to wide bandgap. To overcome this shortcoming, Zn can be doped in CdSe so as to provide ZnxCd1-xSe (x = 0.75) ternary alloys. Zinc doped cadmium selenide $Zn_{0.75}Cd_{0.25}Se$ thin film is one of the important ternary materials for use in photovoltaic device applications [2], light emitting diodes, sensors, transistors ,
pronounced effect in enhancing the electrochemical power conversion and sensor efficiency [6]. In present investigation we have prepared $Zn_{0.75}Cd_{0.25}Se$ thin films having thickness of 1000 $A^0$and 2500 A^0 by the vacuum deposition technique and investigate the effect of thickness on their optical and electrochemical properties [10].

II. EXPERIMENTAL

A. Thin Film Deposition

In deposition of ZnxCd1-xSe (x = 0.75) the zinc and cadmium material used was in core granular form and selenium material was in core powder form of purity 99.999 from Sigma Aldrich Company [2]. Initially ampoule of CdSe were formed, then mixed Zinc core material in given proportion and fused to very high temperature in quartz tube for uniform mixing of Zn, and CdSe to form ternary $Zn_{0.75}Cd_{0.25}Se$ compound. Thin films of $Zn_{0.75}Cd_{0.25}Se$ were prepared by vacuum evaporation technique on glass substrate [7]. Then $Zn_{0.75}Cd_{0.25}Se$ compound was grinded to get fine powder and placed in molybdenum boat for evaporation. The evaporation was performed in a vacuum environment (10^{-6} mbar). The low tension (LT) supply for evaporation source is obtained from a 230V input transformer by means of parallel connections in the secondary side of the transformer [1]. There were two pressure gauges used in this machine, Pirani Gauge measures low vacuum and a very sensitive Penning Ionization Gauge measures high vacuum [2] The $Zn_{0.75}Cd_{0.25}Se$ samples of different thicknesses (1000 Å and 2500 Å) were deposited under almost same environment [8]. The thickness monitor model no. DTM - 101 provided by Hind-High Vac. The source to substrate distance was kept constant and the substrate temperature was kept at lower temperature as compare to source temperature. [9].

B. Characteristics

1) *Atomic Force Microscopy (AFM):* This is a unique modern tool available for a real space view of the atomic structure and surface morphology of materials. The technique is based on electron tunneling between a sharp metal tip and the surface of a conducting/semiconducting film [11]. The two-dimensional (2D) atomic force microscopy (AFM) images are given in Fig. 6a–d for the $Zn_{0.75}Cd_{0.25}Se$ films [12]. The surface morphology of $Zn_{0.75}Cd_{0.25}Se$ thin films was studied by atomic force microscopy (AFM). Atomic force microscope studies exhibit the formation of uniform $Zn_{0.75}Cd_{0.25}Se$ thin films with average size of 150 nm. The granular nature of particles and agglomeration of particles is seen from the 3D micrographs [13]. The root mean square

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value of the surface roughness of the film from different areas of the film is calculated. The roughness of the films was also measured by atomic force microscopy (AFM) using Ra values, and we observed a strong dependence of the roughness on the different thicknesses [14]. The calculation of average surface roughness (Ra) values for these films show very low values. Such very low values predict the uniform surface of the $Zn_{0.75}Cd_{0.25}Se$ film prepared by the vacuum deposition technique in the present study [10]. It shows the compactness, pinhole free and well adherent nature of $Zn_{0.75}Cd_{0.25}Se$ films on glass substrates which will be very much useful for photoelectrochemical (PEC) devices [15].

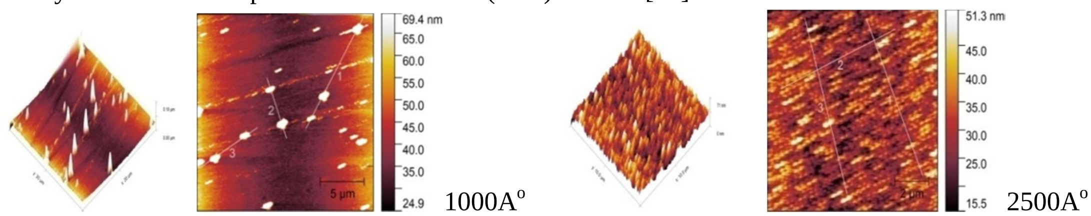

Fig 1 : AFM result of $Zn_{0.75}Cd_{0.25}Se$ thin films.

Thickness	Roughness average (nm)	Root mean square (nm)	Max. peak height (nm)	Average grain size (nm)
1000Å	08.06	13.43	147.8	42.72
2500Å	05.04	06.42	70.60	30.16

Table 1 - AFM result of $Zn_{0.75}Cd_{0.25}Se$ thin films

2) *Fourier Transform Infrared Spectroscopy (FTIR):* The FTIR is a very significant technique to identify the functional groups and chemical bonding in ZnSe thin films. The defects and the impurity contents can also be characterized by using this analytical technique. FTIR measurements have been permitted to understand the molecular structure of the $Zn_{0.75}Cd_{0.25}Se$. The FTIR transmission spectrum of $Zn_{0.75}Cd_{0.25}Se$ thin film of our concern is in the range of 400-4000 cm^{-1}[1,16]. Fig.2 shows the FTIR spectrum of the $Zn_{0.75}Cd_{0.25}Se$ films deposited on glass substrate. The peaks observed at lower frequencies (finger print region) at 601.81 cm^{-1}, 827.49 cm^{-1}, 977.94 cm^{-1} match to the inorganic molecules which are in interest [14,17]. The other peaks are observed at 1072.46 cm^{-1}, 1195.91 cm^{-1} and 1330.93 cm^{-1} correspond to the C–H bending modes. The C-C stretching vibration mode occurs at 2335.87 cm^{-1}. The weak peak at 1510.31 cm^{-1} is assigned to the O–H characteristic vibration resulting from a small quantity of H_2O expected to be present on the sample [10]. The broad absorption peaks at 3726.60 cm^{-1} are credited to the stretching vibration of the O-H bond from water molecules present in the atmosphere.

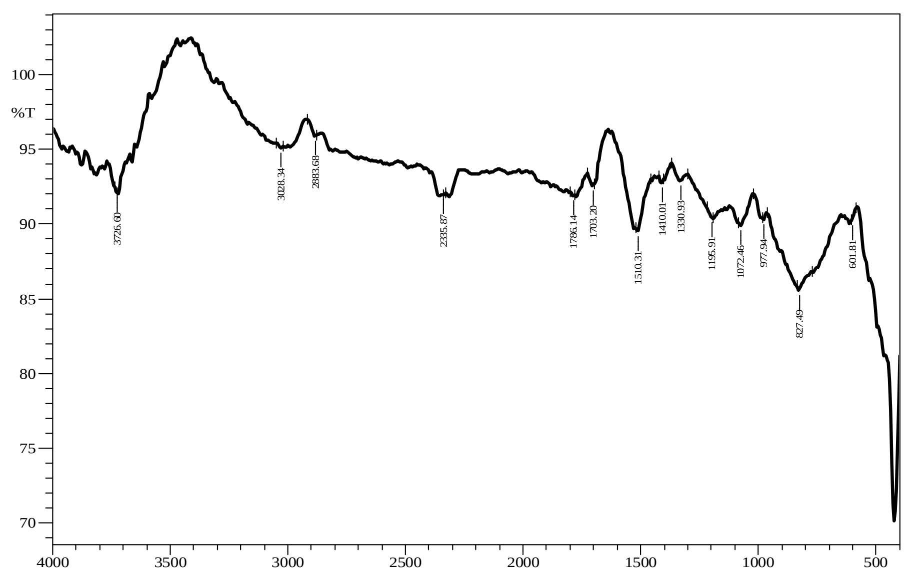

Fig 2 - FTIR result of $Zn_{0.75}Cd_{0.25}Se$ thin films

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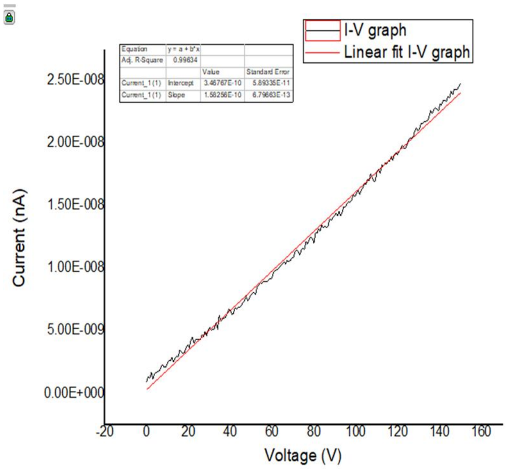
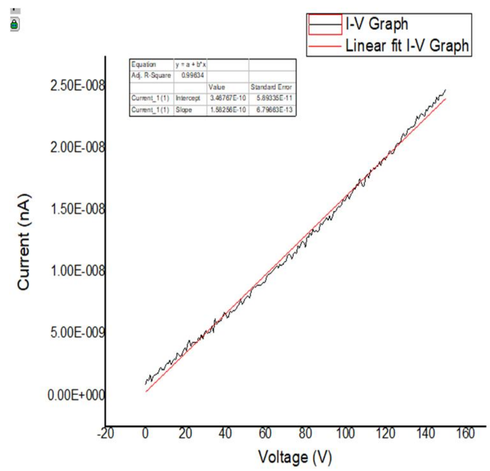
3) *Current Voltage (I-V) Characteristics*: The resistivity of each individual compound $Zn_{0.75}Cd_{0.25}Se$ thin film is observed from I-V characteristics [2]. The I-V Characteristics graph of $Zn_{0.75}Cd_{0.25}Se$ thin films of thickness 1000Å and 2500Å is shown in Fig. 3. a, b. The I-V study shows almost linear curve and ohmic nature of both of these thin films. The relation between I and V, as shown in Fig. 3.7 , appear that a linear relation was obtained. It was observed that $Zn_{0.75}Cd_{0.25}Se$ shows a diode behavior as shown in Fig. 3.7. The increase in forward current can be expected due to the decrease in the barrier height [3]. The decrease in resistivity of all the films with increase in temperature , indicates semiconducting nature of the films. The reason for the high resistivity value for all samples can be explained with dislocations and imperfections [5].



(a)



(b)

Fig 3 (a) 1000A^{o} and (b) 2500A^{o} – I-V characteristics result of $Zn_{0.75}Cd_{0.25}Se$ thin films

III. CONCLUSION

AFM studies shows that, Average Roughness decreases from 8.06 nm to 5.04 nm, the root mean square surface of the films is decreases from 13.43 to 6.42 nm and the average grain size is decreased from 42.72 to 30.16 nm in different samples of $Zn_{0.75}Cd_{0.25}Se$ thin film of thickness 1000A^{o} to 2500A^{o} respectively.

The FT-IR analysis of $Zn_{0.75}Cd_{0.25}Se$ thin films shows that the vibration mode occurs at peak number 601.81 cm^{-1}, 827.49 cm^{-1}, 977.94 cm^{-1} , 1072.46 cm^{-1}, 1195.91 cm^{-1} 1330.93 cm^{-1} 1510.31 cm^{-1} 2335.87 cm^{-1} and 3726.60 cm^{-1} . The crystalline nature of $Zn_{0.75}Cd_{0.25}Se$ thin films increases by increasing the amount of vacuum in vacuum deposition unit.

I-V characteristics of $Zn_{0.75}Cd_{0.25}Se$ thin films of thickness 1000A^{o} and 2500A^{o} shows that, the films are ohmic in nature and there is a perfect linear relation in between current and voltage, so these films can be used for photo sensor application.

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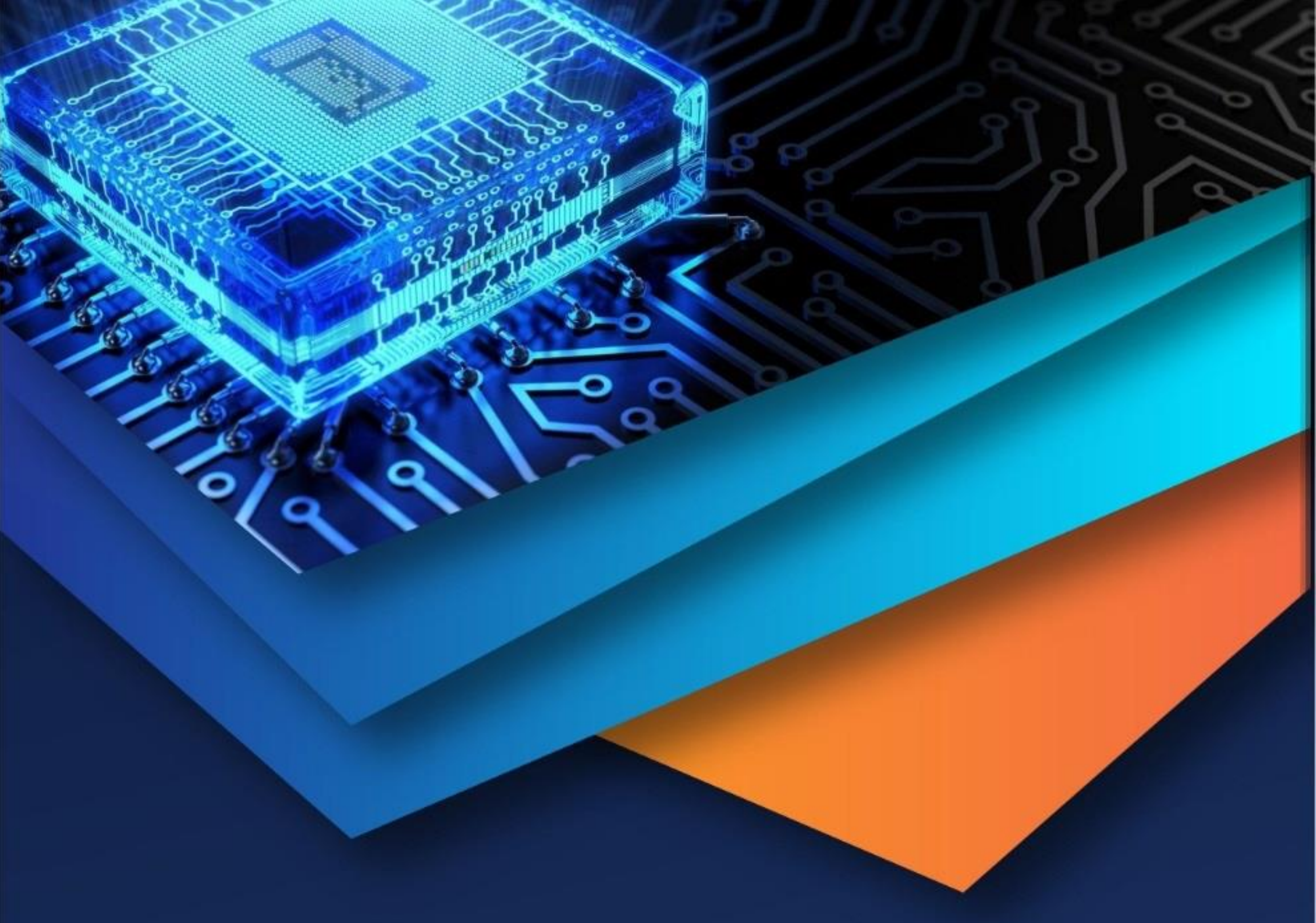

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