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Study of Structural, Morphological and Compositional Characteristics of Vacuum Deposited $Zn_{0.75}cd_{0.25}se$ Thin Films

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***Abstract:** In this study, $Zn_{0.75}Cd_{0.25}Se$ ternary semiconductor thin films of thickness 1000 A^0 and 2500 A^0 belong to II-VI group were deposited onto glass substrates by the vacuum deposition method under the pressure of 10^{-5} mbar. The effect of Zinc content on different physics and chemical properties in $Zn_{0.75}Cd_{0.25}Se$ thin films has been investigated. Systematic characterizations of structural, morphological and compositional, properties have been carried out by XRD, SEM and EDAX.*
***Keywords:** Ternary, cadmium selenide, zinc selenium, thin films, vacuum deposited*

I. INTRODUCTION

The research on Zn doped CdSe nanostructures i.e. $Zn_{0.75}Cd_{0.25}Se$, a ternary semiconductor alloy from group II-VI material, is getting attention due to its application in a photo sensor [1] and other optoelectronic devices. Ternary alloy is a type of alloy which is made up of three different chemical elements; usually two cations and an anion and their band gap is a continuous function of composition of elements [2]. The band gap of ZnxCd1-xSe material can be tuned from 1.70 to 2.70 eV. Zn doped CdSe ($Zn_{0.75}Cd_{0.25}Se$) is an efficient absorber in the visible region of solar spectrum [3]. Recent developments in science and technology related to nano engineered materials have demonstrated that, nanostructure semiconductors have greater flexibility and control in designing various nano scale structures and devices. Zinc doped cadmium selenide thin film is one of the important materials used in photo luminescent, photoconductive and photovoltaic device applications [4], etc. have shown its prominence and ability. Numbers of researchers have prepared $Zn_{0.75}Cd_{0.25}Se$ thin films by various deposition techniques like vacuum evaporation, molecular beam epitaxy, electron beam pumping [5], chemical bath deposition etc [6]. In present investigation we have prepared Zinc doped Cadmium Selenide ($Zn_{0.75}Cd_{0.25}Se$) thin films having thickness of 1000 $A^0$and 2500 A^0 and investigate the effect of thickness on their structural, morphological and compositional properties by controlling the stoichiometric ratio of Zn and Cd in [7] $Zn_{0.75}Cd_{0.25}Se$ thin films.

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 ZnxCd1-xSe were prepared by vacuum evaporation technique on glass substrate [8]. 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) with the help of HINDHIVAC: 15F6D coating unit [3, 9]. 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 [10]. The $Zn_{0.75}Cd_{0.25}Se$ samples of different thicknesses (1000 Å and 2500 Å) were deposited under almost same environment [8,11]. The thickness monitor model no. DTM - 101 provided by Hind-High Vac. machine to determine the thickness of deposited thin films [12]. The deposition rate was maintained constant throughout the sample preparations [3, 9]. The substrate temperature was kept at lower temperature as compare to source temperature with the continuous supply of chilled water [13]

B. Characteristics

1) *X-Ray Diffraction (XRD):* The structural investigation of $Zn_{0.75}Cd_{0.25}Se$ thin films of thickness 1000 Å and 2500 Å has been carried out by The X-ray diffraction (XRD). The particle size (D) is calculated by using The Scherer's formula [1,2] $\mathbf{D} = \frac{\mathbf{0.94\lambda}}{\mathbf{\beta \cos\theta}}$, The lattice parameter (a) for the thin film is determined by using the following expression [6,14]. $\frac{\mathbf{1}}{\mathbf{d^2}} = \frac{\mathbf{h^2+k^2+l^2}}{\boldsymbol{a^2}}$, The interplanar spacing 'd' has been obtained by using Bragg's law [15] ie $\mathbf{n\lambda = 2\mathit{d}\sin\theta}$, Dislocation density is calculated by using formula $\boldsymbol{\delta = 1/D2}$, Micro strain of given thin film is also obtain by formula $\boldsymbol{\varepsilon_s = \beta\cos\theta / 4}$ [11]

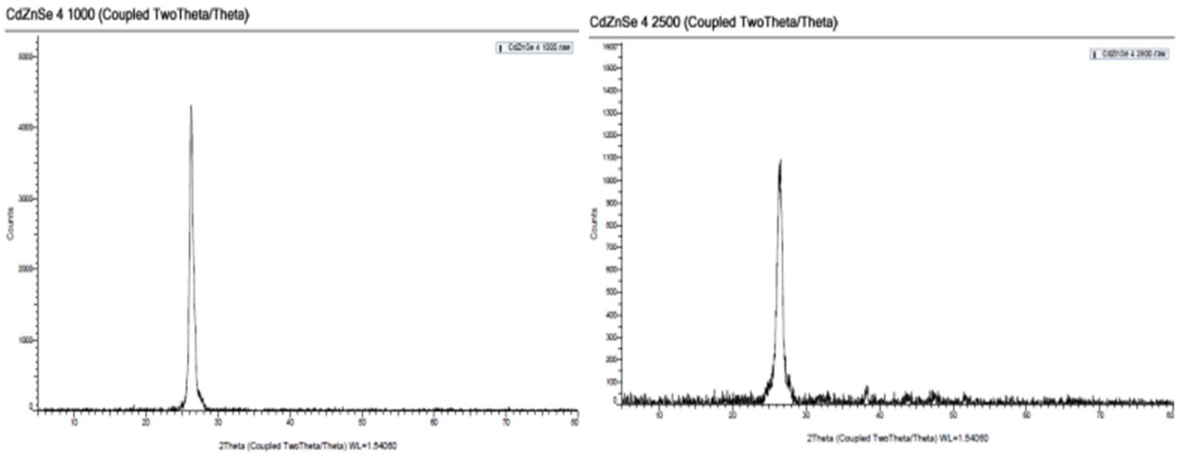


Fig. 1 & 2: XRD of $Zn_{0.75}Cd_{0.25}Se$ films of thickness1000 Å and 2500 Å

[hkl] values from JCPDS data	d(Å) values from JCPDS data of cdse	Observed values of d(Å) $Zn_{0.75}Cd_{0.25}Se$ 1000 Å	Observed (2ɵ)° values of peaks	intensity	Lattice parameter a(Å)	Particle size D (Å)	Dislocation density δ (×10^{15} lines/m^2)	Micro strain (ε_s)
100	3.720	3.720	23.900	536	3.720	2.895	0.1193	0.1250
002	3.510	3.509	25.370	626	7.016	2.930	0.1164	0.1235
101	3.290	3.290	27.080	904	4.652	2.973	0.1131	0.1217
102	2.554	2.555	35.090	276	5.713	3.235	0.0955	0.1118
110	2.151	2.151	41.960	215	3.041	3.560	0.0789	0.1016

Table 1. XRD JCPDS hexagonal data for $Zn_{0.75}Cd_{0.25}Se$ sample of thickness 1000 A^0

[hkl] values from JCPDS data	d(Å) values from JCPDS data of znse	Observed values of d(Å) $Zn_{0.75}Cd_{0.25}Se$ 1000 Å	Observed (2ɵ)° values of peaks	intensity	Lattice parameter a(Å)	Particle size D (Å)	Dislocation density δ (×10^{15} lines/m^2)	Micro strain (ε_s)
111	3.273	3.273	27.230	747	5.669	2.977	0.1128	0.1215
200	2.835	2.836	31.520	363	5.671	3.105	0.1037	0.1165
220	2.004	2.005	45.200	245	5.670	3.757	0.0708	0.0963
311	1.707	1.708	53.600	171	5.661	4.461	0.0502	0.0811
222	1.635	1.635	56.150	160	5.663	4.752	0.0442	0.0761

Table 2. XRD JCPDS cubic data for $Zn_{0.75}Cd_{0.25}Se$ sample of thickness 1000 A^0

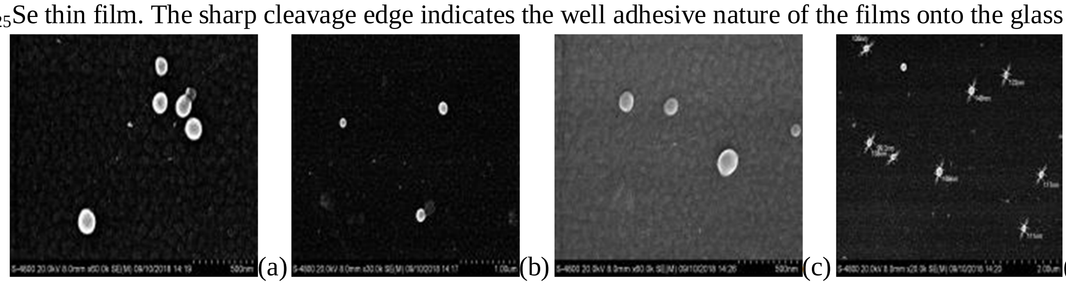
[hkl] values from JCPDS data	d(Å) values from JCPDS data of cdse	Observed values of d(Å) $Zn_{0.75}Cd_{0.25}$ Se 2500	Observed (2ɵ)° values of peaks	intensity	Lattice parameter a(Å)	Particle size D (Å)	Dislocation density δ ($\times10^{15}$ lines/m^2)	Micro strain (ε_s)
100	3.720	3.720	23.900	359	3.720	2.4673	0.1642	0.1467
002	3.510	3.509	25.370	464	7.016	2.4965	0.1604	0.1450
101	3.290	3.290	27.080	567	4.652	2.5335	0.1557	0.1428
102	2.554	2.555	35.090	265	5.713	2.7567	0.1315	0.1313
110	2.151	2.151	41.960	176	3.041	3.0333	0.1086	0.1193

Table 3. XRD JCPDS hexagonal data for $Zn_{0.75}Cd_{0.25}Se$ sample of thickness 2500 A^0

[hkl] values from JCPDS data	d(Å) values from JCPDS data of znse	Observed values of d(Å) $Zn_{0.75}Cd_{0.25}Se$ 2500	Observed (2ɵ)° values of peaks	intensity	Lattice parameter a(Å)	Particle size D (Å)	Dislocation density δ ($\times10^{15}$ lines/m^2)	Micro strain (ε_s)
111	3.273	3.273	27.230	578	5.669	2.536	0.1554	0.1427
200	2.835	2.836	31.520	294	5.670	2.646	0.1428	0.1368
220	2.004	2.005	45.200	227	5.670	3.201	0.0975	0.1130
311	1.707	1.708	53.600	144	5.661	3.801	0.0692	0.0952
222	1.635	1.635	56.150	156	5.663	4.049	0.0609	0.0893

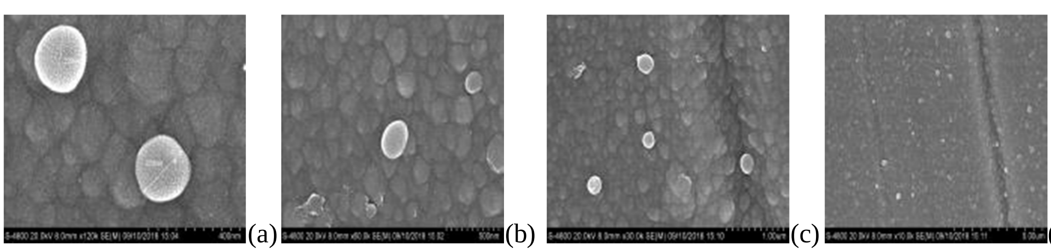
Table 4. XRD JCPDS cubic data for $Zn_{0.75}Cd_{0.25}Se$ sample of thickness 2500 A^0

2) *Scanning Electron Microscope (SEM):* In order to study the microstructures of $Zn_{0.75}Cd_{0.25}Se$ thin films, scanning electron microscopy (SEM) was used [9] as it provides valuable information regarding the growth mechanism, shape and size of the particles and/or grains. Fig. 3 shows the SEM images of vacuum deposited thin films of thickness 1000 A^0 and 2500 A^0 respectively. Surface morphology by SEM studies shows very small, fine and hardly distinguishable grains smeared all over the film surface. These are the characteristic features of zinc-rich surfaces. No crack was observed on the surface of the $Zn_{0.75}Cd_{0.25}Se$ thin film. The sharp cleavage edge indicates the well adhesive nature of the films onto the glass substrates [16]



(a) (b) (c) (d)

Fig 3: SEM pictures for $Zn_{0.75}Cd_{0.25}Se$ films 1000 A° (a) 400 nm, x = 120k (b)500 Nm, x = 60k (c)1.0 µm, x = 30k (d)2.0 µm, x =20k



(a) (b) (c) (d)

Fig 4: SEM pictures for $Zn_{0.75}Cd_{0.25}Se$ films 2500 A° (a)400 nm, x = 120k (b)500 Nm, x = 60k (c)1.0 µm, x = 30k (d)5.0 µm, x =20k

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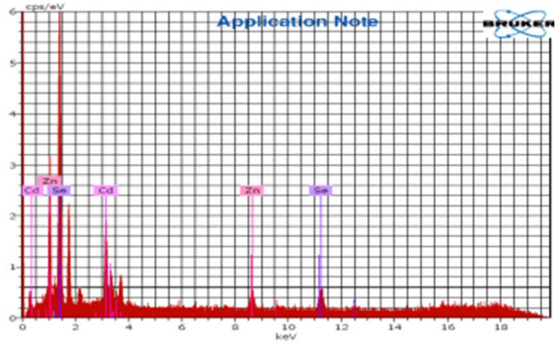
3) *Energy-dispersive X-ray spectroscopy (EDAX):* The presence of elemental constituents in Zn doped CdSe ($Zn_{0.75}Cd_{0.25}Se$) thin film is confirmed from Energy-dispersive X-ray spectroscopy analysis [10]. The selenium content is always present in stoichiometric percentage which nearly equal to starting material [17]. These results show the *n*-type nature of these $Zn_{0.75}Cd_{0.25}Se$ thin films as Selenium is present in a more proportion compare to Zn and Cd.

(5)



(6)

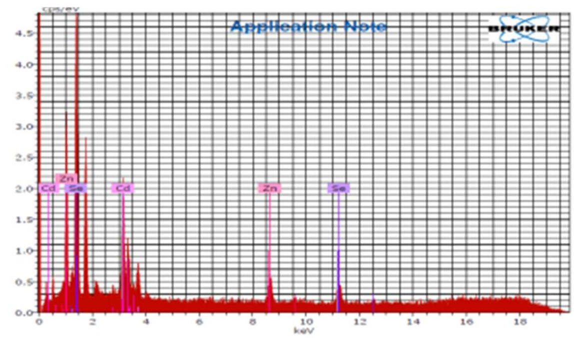


Fig 5 and 6:- EDAX spectra of $Zn_{0.75}Cd_{0.25}Se$ of thickness 1000 A^{o} and 2500 A^{o}

Element	CdSe 1000Å		CdSe 2500Å	
	Mass %	Atomic %	Mass %	Atomic %
Se 34	53.09	57.80	48.14	51.88
Cd 48	35.43	27.10	35.59	26.94
Zn 30	11.49	15.10	16.27	21.18

Table 5 - EDAX mass and atomic Percentages of **Zn, Se** and **Cd**

III. CONCLUSION

From **XRD** It is found that the deposited films i.e. $Zn_{0.75}Cd_{0.25}Se$ of thickness 1000 Å and 2500 Å show wurtzite structure along crystallographic planes (100), (002), (101),(102),(110) and (103) (JCPDS 08-0459) and for cubic structure the preferred crystal orientation is along (111), (200), (220),(311) and (222) planes (JCPDS 19 - 0191). The XRD analysis shows that the films are polycrystalline in nature. The lattice parameters are almost matching with the JCPDS data of CdSe and ZnSe. The values of interplanar spacing's (d) are 2.867 Å and 2.291 Å and lattice constant (a) are 5.067 Å and 5.668 Å for thickness 1000 Å and 2500 Å respectively. While the average particle size (D) is 3.231 Å and 3.810 Å, Dislocation density (δ) 0.0987 and 0.0763 and Micro strain (εs) 0.113 and 0.098 for wuritz and cubic structure respectively of thickness 1000 Å and the average particle size (D) is 2.7535 Å and 3.2466 Å, Dislocation density (δ) 0.1360 and 0.1051 and Micro strain (εs) 0.1328 and 0.1154 for wuritz and cubic structure respectively of thickness 2500 Å. The **SEM** shows uniform growth of $Zn_{0.75}Cd_{0.25}Se$ thin films on a glass substrate. The results of SEM show that the sizes of grain were 99 nm to 169 nm for film of thickness 1000 A^{o} and 154 nm to 228 nm for $Zn_{0.75}Cd_{0.25}Se$ thin films of thickness 2500 A^{o}.

The presence of elemental constituents is confirmed from **EDAX** analysis strong peaks for Zn and Se were found in the spectrum of $Zn_{0.75}Cd_{0.25}Se$ thin film.

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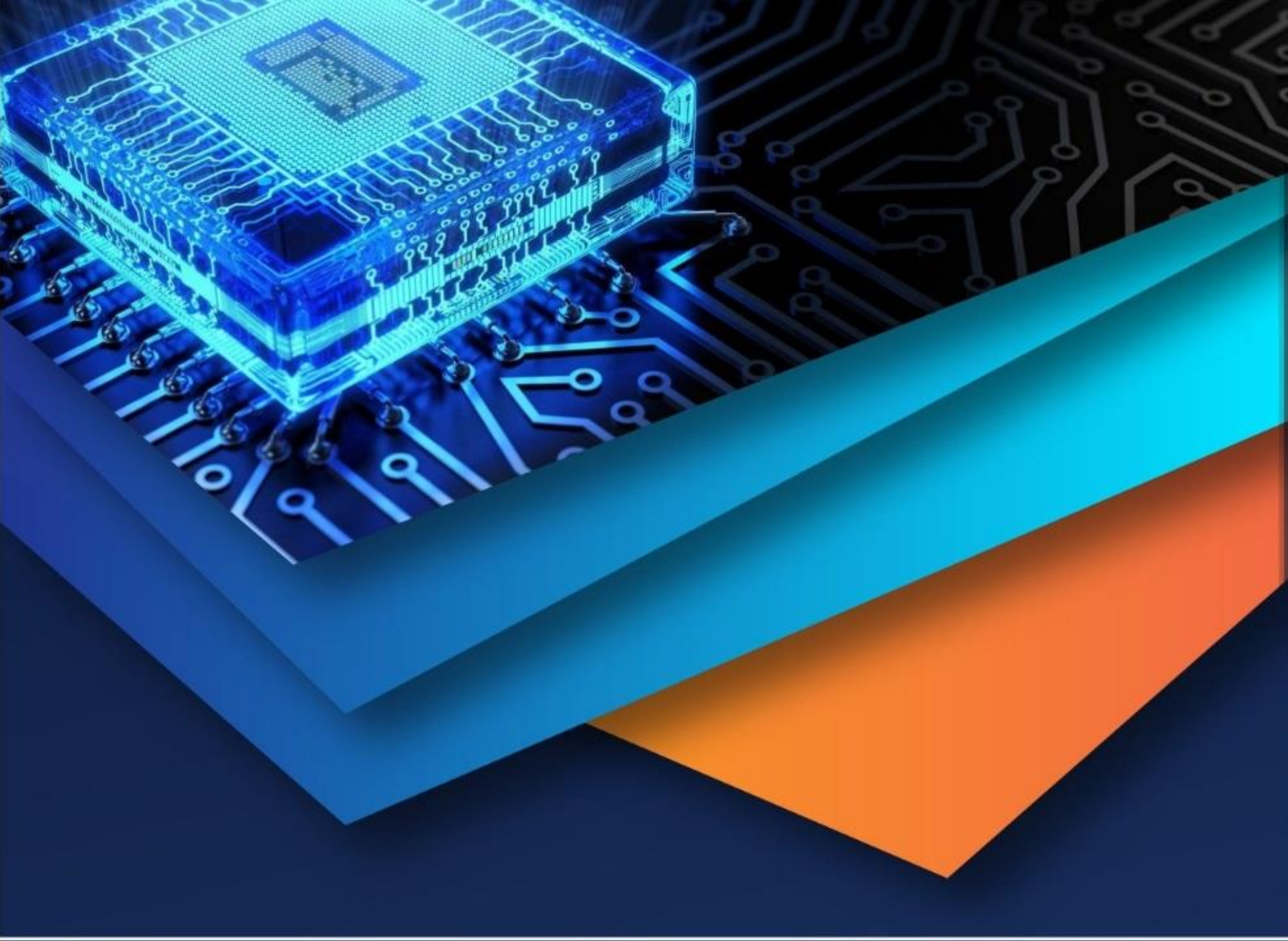

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