Journal of Advances in Applied Sciences and Technology

ISSN : 2393-8188 (print)
2393-8196 (online)
www.milliyasrcollege.org.journal.php

SYNTHESIS AND SURFACE MORPHOLOGICAL STUDY OF NANOSTRUCTURE ZnSe THIN FILMS

J. V. Dhanvij [* 1], ***Y. R. Toda*** [** 2], ***D. N. Gujarathi*** [2]

[1]Department of Physics, Smt. P. K. Kotecha Mahila Mahavidyalaya, Bhusawal (MS) India

[2]Thin Film Lab; Department of Physics, Pratap College, Amalner 425 401 (MS) India.

yogeshtoda@gmail.com

ABSTRACT

Thin films having different thickness of ZnSe were deposited by thermal evaporation techniques, onto precleaned amorphous glass substrate at room temperature. The structural properties of films were evaluated by XRD, Scanning Electron Microscopy. The quantitative analysis was done by Energy Dispersive Analysis for X – Ray to determine atomic % of the material used. The X-ray diffraction (XRD) patterns of these ZnSe samples were recorded by X-ray diffractometer. The X-ray diffraction analysis confirms that films are polycrystalline in nature having tetragonal structure. The lattice parameters (a and c) and crystallite size (D) were calculated and found to be 12 – 71 nm. The internal strain and dislocation density of these films were found to decrease with increase in thickness. The surface morphology of ZnSe thin films were characterized by Scanning Electron Microscope (SEM showed that all the grains are spherical in nature and grains forming conglomerate to form a large particle. Particle size was found to be 100 – 235.5 nm.

KEY WORDS **–** Optical band gap, XRD, SEM, AFM.

1. INTRODUCTION

ZnSe (Zinc Selenide), a direct gap II-VI semiconductor with band gap energy of 2.67 eV, has long been found as promising material for optoelectronic devices such as LED, thin film transistor, blue laser diode etc [1-3]. Because of its large band gap, ZnSe has been used as window layer for the fabrication of photovoltaic solar cells. There are a number of reports on the different structural, optical and electrical properties of ZnSe polycrystalline thin films prepared by various techniques such as Chemical vapor deposition, MOCVD, Electro deposition, Photochemical deposition, Chemical bath deposition(CBD), Pulsed laser deposition and thermal evaporation [4-12]. It is seen that different parameters of a film are structural dependent which is also depended on the method of preparation, its thickness and other factors. Also the mechanical stability of the thin film is one of the major factors for designing various optoelectronic devices. The thermal evaporation method is cost effective and suitable for large area deposition. We have prepared ZnSe thin films of different thicknesses by thermal evaporation method at different substrate temperatures and the different micro structural parameters of these films were determined from their XRD spectra. In the present work, the effect of substrate temperature and thickness of thermally deposited ZnSe films is investigated to optimize the growth condition for a good quality film which will be suitable for optoelectronic devices.

2. EXPERIMENTAL

2.1 PREPARATION OF COMPOUND INGOT

The bulk sample of ZnSe has been prepared by melt quench method. The direct mixture of extremely pure Zn and Se (purity 99.999%), in accordance with their atomic ratio was kept back in evacuated quartz ampoule at pressure 10^{-5} torr. The ampoule was heated at temperature about 920°C for 12 hours duration. Then the ampoule is quenched in ice cooled water.

2.2 SYNTHESIS OF THIN FILMS

Polycrystalline zinc selenide films have been deposited by thermal evaporation technique under pressure better than 10^{-5}torr on chemically cleaned amorphous glass substrate. The substrate to source distance was kept 13 cm. The samples of different thicknesses in the range 1000 – 3000 Å were deposited under similar conditions from 303 K and 403 K for different sets of films.The thickness of the films was controlled by quartz crystal thickness monitor model No. DTM-101 provided by Hind-Hi Vac. Further confirmation of thickness was estimated by Tolansky's method using multiple beam Fizeau fringes. The deposition rate was maintained 5-10 Å/sec throughout sample preparation.

In order to study the structural properties the films were analyzed by an X-ray diffractometer (Bruker, Germany) using CuK_α radiation with wave length (λ) 1.5406 Å in the 2θ range from 20^0 to 80^0. Surface morphological studies of the thermally deposited ZnSe thin films were done using the Scanning Electron Microscope (Zeiss EVO 50) operating with an accelerating voltage 15 kV. The quantitative compositional analysis of the ZnSe films were carried out by EDAX (Energy dispersive X-ray Analyzer) attached with the SEM.

3. RESULTS AND DISCUSSIONS

3.1 XRD CHARACTERIZATION

Fig.1 shows the recorded XRD patterns of the zinc selenide films (on glass substrates) at substrate temperature of 303K. The chemical composition of deposited films was identified by comparing the XRD pattern of film with the standard data [13] and it was concluded that the material is zinc selenide. A peak at 2θ = 28.2^0 corresponding to the reflection plane of (111) appears proving the microcrystalline nature of the film exhibit the formation of the cubic phase of zinc selenide. The presence of large number of peaks indicates that the films are polycrystalline in nature. The average grain size of zinc selenide thin film was determined using Debye–Sherrer's equation,

$$d = \frac{0.9\,\lambda}{\beta\cos\theta}$$

Where, θ is the Bragg angle, λ is the X-ray wavelength and β is full width at half maximum. Calculation based on the peak at 2 θ = 28.2^0 gave a value of 71.5 nm. The degree of purity of the material obtained is relatively high. The lattice parameters a in the prepared thin films have been determined as 5.674 Å respectively and V = 182.67 which are in good agreement with the values listed by the American society for testing materials (ASTM).

The dislocation density (δ), defined as the length of dislocation lines per unit volume, has been estimated using the equation

$$\delta = \frac{1}{D^2}$$

Where δ being the measure of amount of defects in a crystal.

The number of crystallites per unit area (N) and the strain (ε) of the films were determined with the use of the following formulae:

$$N = \frac{t}{D^3}$$

$$\varepsilon = \frac{\beta \cos\theta}{4}$$

Where, t is the thickness of the film. The calculated structural parameters are δ = 19.56 x 10^{15} lines / cm^2, N = 2.735 x 10^{17}, ε = 3.086 x 10^{-3}. The small values of δ obtained in the present study confirm the good crystallinity of the thin films fabricated by the thermal evaporation technique.

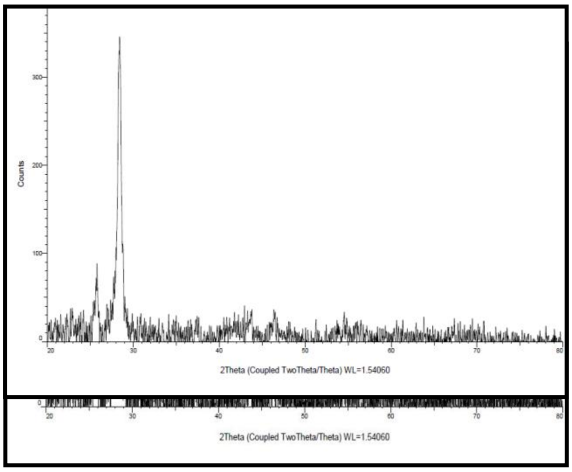

Fig: 1(a) XRD of ZnSe thin film (1000 Å & 2000Å)

3.2 SURFACE MORPHOLOGICAL AND MICRO STRUCTURAL STUDIES

Surface morphology of the synthesized zinc selenide thin films was studied by using scanning electron microscope (SEM). Microphotographs of ZnSe thin films at magnifications 100 K X and 90 K X are shown in Fig. 2 (a) and (b), respectively having thicknesses 1000Å and 2500 Å. The films are dense, smooth and of flowery structure of as synthesized ZnSe films as the substrate temperature increases the films becomes smoother, the image clearly demonstrates granular particles and free from microscopic defects. It is seen that substrate is well covered by ZnSe. The average grain sizes calculated from SEM images was *100 – 235.5* nm.

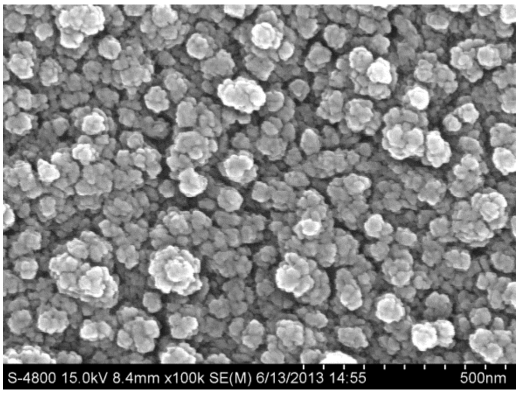

Fig: 2(a) SEM image of ZnSe thin film (1000Å)

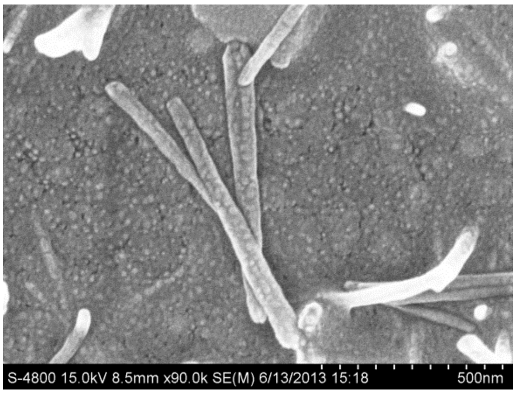

Fig: 2(b) SEM image of ZnSe thin film (2500Å)

The quantitative analysis was performed by EDAX for ZnSe film. A typical EDAX spectrum for ZnSe is shown in fig. 3. The average ratio for atomic percentage of Zn: Se was 61.14: 38.86 showing samples are Zn rich it might be due to vapor pressure difference in zinc and selenium..

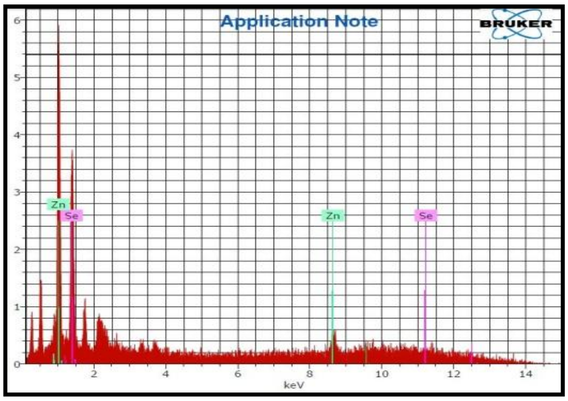

Fig: 3 EDAX spectrum of ZnSe

4. CONCLUSION

ZnSe thin films of different thickness have been deposited successfully on glass substrate with different thicknesses. XRD confirms that the structure of the film is polycrystalline in nature and having cubic structure. From SEM study it is observed that deposited ZnSe film were homogenous and flowery structure with nano crystalline in nature. The particle size varying from *100 – 235.5* nm.

5 REFERENCES

[1] Z. M. Zhu, G. H. Li, N. Z. Liu, S Z Wang, H. X. Han, Z. P. Wang, J. Appl. Phys. **85**, 1775 (1999).

[2] R. R. Alfano, O. Z. Wang, J. Jumb, B. Bhargava J. Phys. Rev. (A) **35** 459 (1987).

[3] K. K. Fung, N. Wang and I. K. Sou, Appl. Phys. Lett. **71**(9) 1225 (1997).

[4] T. L. Chu, S. S. Chu, G. Chen, J. Britt, C. Ferekides C. Q. Wu, J. Appl. Phys. **71** 3865 (1992).

[5] G. Perna, V. Capozzi, M. C. Plantamura, A. Minafra, P. F. Biagi, S. Orlando, V. Marotta, A Gardini, Appl. Surf. Sci. **186** 521 (2002).

[6] G. Riveros, H. Gomez, R. Henriquez, R. Schrebler, R. E. Marotti, E. A. Dalchiele, Sol. Energy Mater. Sol. Cells **70** 255 (2001).

[7] R. Kumaresan, M. Ichimura and E. Arai, Thin Solid Films **414** 25 (2002).

[8] R. B. Kale, C. D. Lokhande, Appl. Surf. Sci. **252** 929 (2005).

[9] M. G. M. Choudhury, M. R. Islama, M. M. Rahmana, M. O. Hakima, M. K. R. Khana, K. J. Kaob, G. R. Lai, Acta Physica Slovaca **54** 417 (2004).

[10] M. El Sherif, F. S. Terra, S. A. Khodier, J. Mater. Sci. Mater. Electron. **7** 391 (1996).

[11] C. D. Lokhande, P. S. Patil, P. S. Triutsch, A. Ennaoui, Sol. Energy Mater. Sol. Cells **55**, 379 (1998).

[12] S. Chaliha, M. N. Borah, P. C. Sarmah, A. Rahman, Indian J. Phys. **82** 201 (2008).

[13] JCPDS X-ray powder files data (Data file 05–0522).