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Characterization of ZnTe Thin Films Deposited at Elevated Substrate Temperatures

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Abstract. In present investigations, Zinc telluride thin films with thickness around 6.0kÅ have been deposited by thermal evaporation method on the ultrasonically cleaned glass substrates kept at 373K temperature under the pressures of $5\ 10^{-6}$ torr. The thickness of the films was measured using quartz crystal thickness monitor during the deposition process. EDAX of such films yielded chemical composition by wt % of as grown ZnTe thin films around 30.60% of (Zn) and 61.50% of (Te). SEM studies revealed that ZnTe films exhibited uniformly distributed grains over the entire surface of the substrate. From the XRD analysis it was seen that the films are polycrystalline in nature with cubic structure. The grain size (246.990 Å), strain (1.4657×10^{-3} lines-m^2), dislocation density (1.6392×10^{15} lines/m^2), and lattice constant (6.1115 Å) were calculated in present case. The optical band gap of ZnTe thin films is evaluated using the optical absorbance spectra and it was found to be 2.30eV with direct band to band transitions.

Keywords: Thermal evaporation, structural and optical characterizations, grain size, thickness, bandgap.

INTRODUCTION

II-VI compound chalcogenide semiconductor ZnTe possesses direct bandgap 2.26eV at room temperature [1] and having high absorption coefficient in visible/infrared which is imperative property as window layer material. ZnTe is promising material for a variety of optoelectronic devices e.g. light emitting diodes, laser diodes, solar cells, microwave devices etc. in the visible/infrared region of electromagnetic spectra [2,3].

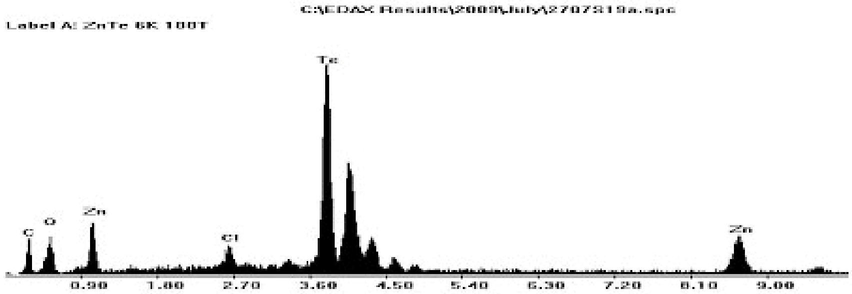
EXPERIMENTAL

Zinc Telluride powder (99.99% pure, Sigma Aldrich Chemicals Company) was evaporated from a tantalum boat under a vacuum of $5\ 10^{-6}$ Torr. The rate of evaporation, in the range of 2-5 Å/sec, was maintained to grow film of good quality and uniform thickness. Thickness of the films were measured by quartz crystal thickness monitor ("Hind Hivac" Digital Thickness Monitor Model–DTM–101). The chemical composition and surface morphology were studied using EDAX and SEM (Philip, Netherlands XL -30 ESEM with EDAX). The structural parameters of ZnTe thin films were investigated using Philips X-ray diffractometer, (model: X'PERT MPD Netherland) with filtered CuKα radiation (λ = 1.5405 Å). The optical absorption spectra of these films were recorded using a UV–VIS- NIR spectrophotometer

(Perkin Elmer USA, Model: Lambda 19).

RESULTS AND DISCUSSION

Elemental Composition



The analysis of the chemical composition for the as-deposited ZnTe thin film of thickness 6kÅ was estimated by using the method of energy dispersive analysis of x-ray (EDAX). Energy dispersive spectra taken from the representative sample of ZnTe film is shown in Fig.1.

FIGURE 1. EDAX spectra of ZnTe thin film deposited at 373K.

EDAX spectra indicate presence of Zn and Te along with some additional peaks which may be due to the amorphous glass substrate. The weight percentage of the constituent elements obtained from the EDAX for the ZnTe films deposited at 373K is shown in table 2.

TABLE 1. Chemical composition by wt % of as grown ZnTe thin film.

Wt(%) of the elements	Stoichiometric proportion	Obtained from the EDAX
Zinc(Zn)	33.88 %	30.60 %
Telluride(Te)	66.12 %	61.50 %
Oxygen(O)	-	3.90 %
Chlorine(Cl)	-	1.90 %
Carbon(C)	-	2.10 %

It can be very clearly seen that the ZnTe film posses some impurities when deposited via a thermal evaporation technique.

Surface Morphology

The surface morphology of the as-deposited ZnTe thin films of various thicknesses were observed by scanning electron microscopy (SEM). Fig 2. shows the SEM micrograph of surface morphology for a 6kÅ thick as-deposited ZnTe thin film. From the micrograph, it can be seen that the film surfaces are intense and squashed in nature. In the case of as-deposited ZnTe thin film, few small spots or pits dispersed haphazardly over the whole sample**.**

FIGURE 2. SEM micrograph of 6kÅ thick as-deposited ZnTe thin film.

Structural Analysis

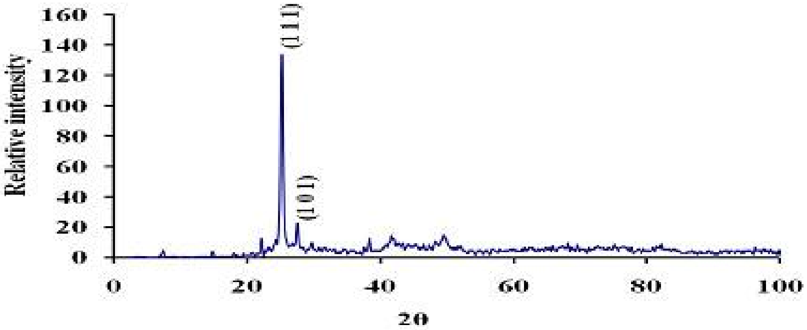


FIGURE 3. XRD patterns of ZnTe thin film (6kÅ-373K).

XRD pattern of film of thickness 6kÅ is shown in Fig. 3, where strong peak is observed at 2θ=25.24° which corresponds to the preferred orientation along (111) crystalline plane of ZnTe. The indexing of XRD pattern confirms cubic structure of ZnTe and the 2θ value is consistent with the value in JCPDS file no. 19-1482. The crystallites size of the grains in the film was estimated using Scherrer formula [2,3]. A weak peak around 2θ=27.42° corresponding to (101) plane has also been observed. Using the Miller indices of these planes, the lattice parameters a=b=c of the cubic unit cell were calculate. The calculated value of the lattice parameter is 6.111A°. The micro strain ε (1.465×10^{-3}lines-m^2) and the dislocation density (1.693×10^{15} lines/m^2) of the deposited films were also evaluated using standard relations [2,3].

Bandgap Determination

The absorption coefficient α, was calculated from the absorption spectra of ZnTe film. In the present case of ZnTe thin films, the plots of $(\alpha h\nu)^2$ vs. hν (figure: 4) show a linear portion indicating that the relation holds good for ZnTe films if r = 1/2. This means that the optical transitions in the case of ZnTe films are direct transitions [4].

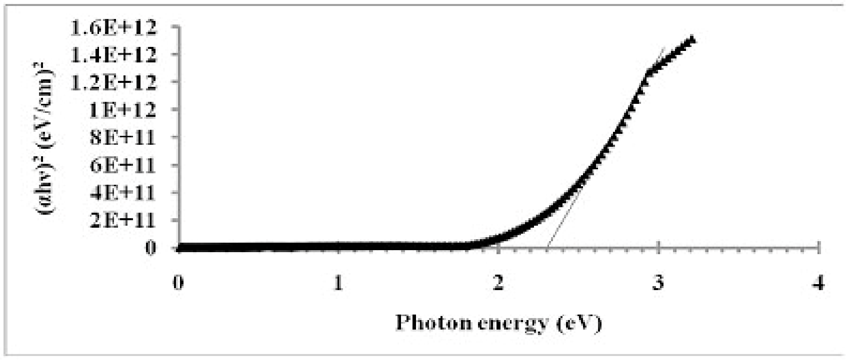


FIGURE 4. Plot of $(\alpha h\nu)^2$ vs hν for ZnTe thin film.

The intercept of a straight line, drawn from the linear portion of the $(\alpha h\nu)^2$ vs hν plots (figure: 4), on x-axis (energy axis) gives the value of band gap as 2.30eV.

CONCLUSION

X-ray diffraction study indicates that the ZnTe film is polycrystalline in structure. The film surface was found dense and uneven in nature by using SEM technique. EDAX method suggests that the elemental compositions of as grown film are non-stoichiometric. The optical band gap is found to be 2.30eV.

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