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RBS Analysis of Zinc Telluride Thin Films by Electron Beam Evaporation Technique

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Abstract

To fully characterize the structure of these alloys it is necessary to augment crystallography with local structural measurements. Here Tellurium dioxide is doped with Zinc acetate dihydrate with Glycene to synthesis the powdered particles of ZnTe by simple chemical synthesis, Zinc acetate dihydrate is taking as the ratio of 90% and Tellurium dioxide as 10% this synthesized powdered particles were pelletized to evaporate on the glass plate by using Electron beam evaporation technique. So many researchers reported this technique for the same materials but RBS scattering is the one of the different analyzing technique for this materials. It has been observed that the energy in MeV of the element is well in agreement with Zinc and Telluride which is present in the preparation.

Keywords: RBS; ZnTe; Co precipitation method; Electron beam evaporation

Introduction

ZnTe is the window material for pure green light emitting diode and highly transparent materials. ZnTe can be used for back contact layer (BCL) on p-CdTe absorber layer in CdTe based solar cells before its metallization because the valence band offset between p-ZnTe and p-CdTe is less than 0.05 eV. ZnTe is a technologically important material since the emission wavelength matches well with the maximum sensitivity of the human eye. The exploration of novel thin film material and simple technique based technologies for future light based communication systems, such as all-optical switches and hybrid device structures.

Both ZnTe and ZnSe have the Zinc-blende structure (F43m) where the Zn atoms and Te, Se atoms occupy the two interpenetrating face-centered-cubic (FCC) lattices. In the alloys the lattice parameter of $ZnSe_{1-x}Te_x$ interpolates linearly between the end member values consistent with Vegard's law. Zinc chalcogenide, which includes zinc selenide, zinc sulfide, zinc telluride and mixed crystals of these, shows a great potential as an optoelectronic device material. Recent efforts in this field are directed towards the realization of blue/green light emitting devices. A cw-operate blue/green laser diode with a life longer than 100 hr has been developed [1], which will open the way to practical applications. Zinc selenide with its wide direct bandgap of 2.67 eV at 300 K is the most promising material for blue region optoelectronic devices [2-4]. ZnSe has been used as a window material for thin film CdTe solar cells [5]. Intense green and red luminescence has been achieved in doped ZnSe [6]. Zinc telluride has been intensively investigated during the last years as a contact material for p-type CdTe in large area low-cost solar cells [7-9]. ZnTe always exhibits p-type conductivity due to a high degree of self-compensation of incorporated donors by native defects and can be readily doped with arsenic to resistivities as low as 1 Ωcm [9,10].

Experimental Section

The Zinc telluride powdered particles were synthesized by using the source materials of Zinc acetate dehydrate and Tellurium dioxide with Glycene. These powdered particles were pelletized and it was placed in water cooled graphite crucible and then evaporated on to glass substrates in hydrogen atmosphere by electron beam (Hind Hivac Model-12A4D) at room temperature. The distance between the electron beam source and the substrate was maintained to be 20 cm. The base pressure of 6×10^{-6} mbar was created before deposition. The vacuum chamber was flushed with oxygen gas several times before evaporation. A beam voltage of 6 kV with the beam current of 20 mA was applied. The oxygen gas was allowed in to the chamber at a flow rate of 0.5 lit/min, and the chamber pressure was maintained at 5×10^{-5} mbar. The duration of evaporation was 15 min. By using this EB evaporation technique ZnTe was deposited on the glass plates and annealed directly 200°C, this annealed sample were analysed by using X-ray Diffractometer and RBS scattering Instrument to confirm the products. The thickness of the film estimated from Mitrutoyo surface Profilometer was in the range of 110 nm.

Results and Discussion

The Xray Diffractometer shows the structural studies of the thinfilm, the crystal size is equal to 42 nm and its thickness is about 36 nm. All diffraction peaks are well assigned to cubic crystalline phase of ZnTe (with the reference pattern JCPDS 893054). From Figure 1, it is noted that the intensity of the Zn peaks decreases with doping of Te content and the full-width at half-maximum (FWHM) widths of the peaks changes with respect to Te content, as well indicates that crystalline size of the thin film equal to 44 nm. The diffraction pattern corresponds to 111 of Cubic ZnTe. All the particle sizes were calculated using the Scherrer equation from the average of three strongest peaks. The strongest peaks can be classified as 111 reflections of ZnTe. The broadening of the peaks indicates that the particles are on the nanometer scale.

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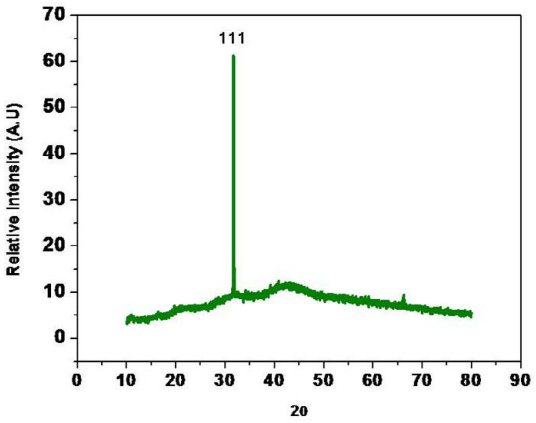

Figure 1: XRD analysis of ZnTe thin film at its preferred orientation 111.

The crystallite size was determined by means of the X-ray line broadening method using the Scherer equation:

$$D = \frac{0.94\lambda}{\beta Cos\theta}$$

Where λ is the wavelength of CuKα radiation (λ=0.154056 nm), β is the full width at half maximum (FWHM) of the *(hkl)* peak at the diffracting angle *hkl* 2θ, the (111) peak is used to calculate the crystalline size D.

The presence of single sharp peak in the Figure 1 which confirms the polycrystalline nature of the ZnTe thin film with high periodicity and crystalinallity, the preferential orientation of the crystal plane (111) corresponds to the Bragg's reflection at 2θ=25.3° instead at 2θ=41.9°, it may be due to the deposition of ZnTe thin film on indium tin oxide plate [11].

The presence of only (111) orientation in these films indicates that the crystallites are preferentially oriented with their C-axis perpendicular to the substrate. The lattice space 'd' values are found increasing from 3.362 Å to 3.496 Å with 10% dopant of Te content.

The lattice parameter *c* of the As-deposited room temperature ZnTe thin film is calculated using the formula for the hexagonal crystal structure. For the cubic crystal system, the lattice parameter *c* is related to *d* with the following equation:

$$\frac{1}{d^2} = \frac{1}{h^2} + \frac{1}{k^2} + \frac{1}{l^2}$$

$2d_{hkl} 2sin\theta = m\lambda$.

Where *h*, *k*, and *l* are all integers, *(hkl)* is the lattice plane index, *a* and *c* are lattice constants, d_{hkl} is distance between two consecutive planes (m=1) with lattice plane index *(hkl)*. The lattice parameter c calculated from the XRD patterns are a=6.098 Aº, respectively. But according to JCPDS file number 893054 expected results of a=6.023 Aº for 111 plane.

The lattice strain (ε) is calculated using the relation $\varepsilon = \frac{\beta Cos\theta}{4}$. Its value is equal to 0.00034 dimensionless quantities. The value of dislocation density δ was calculated using the relation $\delta = \frac{15a}{\varepsilon D}$ and its value is equal to 0.963 × 10^{14} lines/m^2.

Rutherford Backscattering Spectrometry

The alpha particles with energy of 3.5 MeV were used to perform the RBS analysis [5] of the samples with an integrated charge. The scattering angle is to be set at Θ of 165˚ referring to the beam direction. The obtained spectra (Figures 2 and 3) were processed with the Simrana Simulation code. The spectra obtained shows the stoichiometry of the substrate is changed at the interface and some layers with the Zn vacancies between the metal film and the substrate are possibly formed. In Figure 2 represents the presence of Zn atoms on the surface of the substrate and some Telluride atoms also occupied with the Zn vacancies during doping. The initiation of the strongest broad peak shows the thickness of the ZnTe on the surface upto 290 nm while the Figure 3 was 865 nm approximately. The doped Telluride atoms were the present at the surface which was obtained from the RBS spectra and it was continued with the occupied Zn atom after reaching few nanometers. While the Zn atoms were followed by the presence of Tantalum substrate. Both the samples were coated on the Tantalum substrate [12].

Conclusion

The solid powdered particles were pelletized with a pressure of 10^6 kgm/m^2, and of ZnTe binary compounds have been deposited on glass substrates through EB evaporation route. XRD studies showed continuous variation in 'a' values confirming the solid solution formation. The formation of ZnTe nanocrystals grown on glass

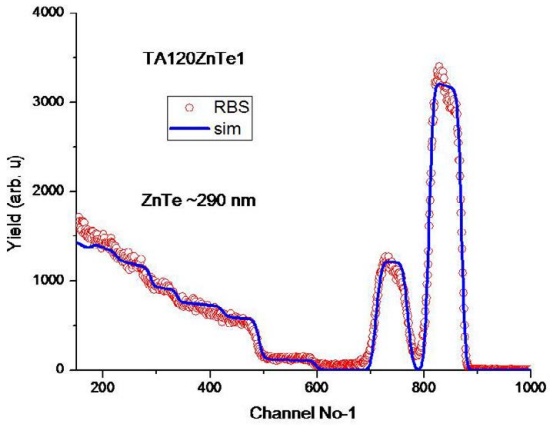

Figure 2: RBS Spectra of ZnTe thin film alpha particles having energy of 3.5 MeV on the surface upto 290 nm.

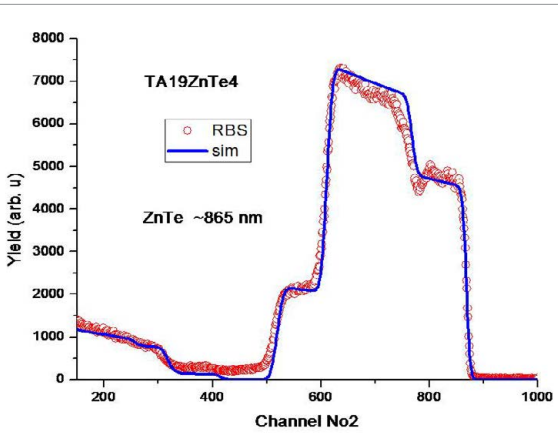

Figure 3: RBS Spectra of ZnTe thin film alpha particles having energy of 3.5 MeV on the surface upto 865 nm.

substrate at 111 planes was achieved by Electron Beam Evaporation. Structural and RBS analysis showed the formation of ZnTe phase as ion fluence increases to 1×10^{14} ions/cm^2.

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