

Structural and optical properties of manganese doped ZnTe: mn thin films prepared by pulsed laser method

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Abstract

In this paper, ZnTe and ZnTe: mn films were obtained by laser deposition using ZnTe and mn co-deposition method. 2Te was used as targets and the ratio of shots was varied to obtain pure ZnTe films and films with 2% mn.

ZnTe films were deposited with mn manganese for the purpose of p-type carrier concentration and to prove the effect of manganese concentration on the structural and optical properties of ZnTe thin films to consider their potential applications in electronic devices. After structural investigations conducted by X-ray diffraction technique, the studied samples are polycrystalline and have a cubic shape with preferred orientation along (111). XRD patterns were used to determine the microscopic parameters (crystal size, lattice modulus). Atomic force microscopy (AFM) was used to study the surface roughness of the thin films.

A UV-Vis spectrophotometer was used to determine the energy gap.

Keywords: ZnTe, Films, Leaser, LEDs.

1. INTRODUCTION

ZnTe is a low cost semiconductor material of the II-VI family. This crystal is usually cubic type zinc with a lattice constant of 6.2230 \AA with a direct wide energy gap transition of 2.26 eV. High absorption, temperature $286 \text{ }^\circ\text{C}$, melting point $1295 \text{ }^\circ\text{C}$ and p-type appears in nature [1]. Recently, ZnTe thin films have been greatly benefited, due to their potential applications to multi-junction tandem solar cells, LEDs, and cells Solar photodetectors, transistors, nanowires [2,3,4] Several methods have been developed to prepare zinc films such as (LPE), molecular beam amplification (MBE), thermal vapor deposition and pulsed laser doping (LPD) [4]. The ZnTe film with Cu has been studied by PLD laser deposition [5]. The microstructure and magnetic study of ZnTe nanoparticles doped with manganese mn [6,7]. PLD technology allows to precisely control the thickness of the film of the film, down to the atomic level, to form manganese-doped films by sequential deposition of two materials in this case, it was used as targets ZnTe and ZnTe: mn. Thus, by changing the layer thickness of each of them, it is possible to control the amount of impurities in the films [8]. In this research, zinc telluride films were grafted with manganese using PLD technique and optical and structural characterization of the pure and doped films were performed.

2. Experimental details

The doped ZnTe: mn and pure ZnTe thin films were deposited by PLD technique using 150 laser pulses. A material with 99.99% purity of ZnTe and mn supplied by KTAN FUNUNCTION MATERIAL was used as targets. 3gm of powder was used to make the pure and denatured samples and the denatured percentage was 2%. Glass substrates were used as substrates. Before the sedimentation process, the glass slides were cleaned with acetone and deionized water and dried with a nitrogen gun. The settling chamber is emptied to a basic pressure of 1×10^{-3} Torr before each membrane deposition. A laser with a wavelength of $\lambda = 1064 \text{ nm}$, a laser pulse duration of 10n sec, a frequency of 6 Hz and an energy of 800mj was used. The UV-Vis transmittance was evaluated using an Ocean Optics Spectra Suite. Measurements obtained from the transmittance were used to calculate the power gap for each sample. The crystal structure of the samples was determined using a Rigku Ultima III X-ray diffractometer with Cu Ka radiation ($\lambda = 0.15406 \text{ nm}$). XRD assays were performed in the range of $10\text{--}80$ of 2θ and the constant $W^\circ = 1$ was used to avoid substrate effects.

3. Results and discussion

3-1: - Structural properties

Figure 1 shows the XRD patterns of pure and doped ZnTe films at 2% Mn concentration. The XRD patterns in Figure (1) are consistent with the deposited samples. In Figure (1), the peaks observed in the XRD of the deposited samples indicate that the films are polycrystalline deposits belonging to the polycrystalline ZnTe phase ($c=b=a 6.103 \text{ \AA}$, $2\theta=28.499^\circ$) with a strong trend in the (111) plane, set at 28.4° from 2θ . In Figure (1), some peaks appear at 31.729° , 36.984° , 43.358° , 44.826° from 2θ , indicating Excess of Te. All of these results are in agreement with the introduction [9]. The intensity of the peaks increases with the thickness of the film indicating simultaneous growth. This shows that if the thickness is large then the atoms have enough time to precipitate on the substrate and the peak is at the preferred level (111). It has the highest density. This leads to the improvement of the crystal structure of the ZnTe samples. Effect of manganese concentration on the crystal size in ZnTe films.

$$t = \frac{0.94\lambda}{B\cos\theta}$$

Where: t is the diameter of the crystal, λ is the wavelength of the X-ray used.

Multi-mode atomic force microscopy (AFM) was performed. The measurements were made to study the surface, crystal formation and growth pattern as well as the grain sizes and surface roughness of ZnTe and mn layers. AFM images show the surface morphology of ZnTe: mn and ZnTe layers at 1500 mv for 30 min on glass substrates shown in Fig. (2a and 2b). The 3D AFM images reveal the growth pattern, both showed that the ZnTe layers have vertical growth of different sizes, the changing sizes of the vertically shaped thin-film materials leave undesirable gaps between the vertical materials.

The researchers stated that these unwanted gaps cause the devices to shorten, which leads to poor performance when used in the manufacture of solar cells according to Fozy et al [7].

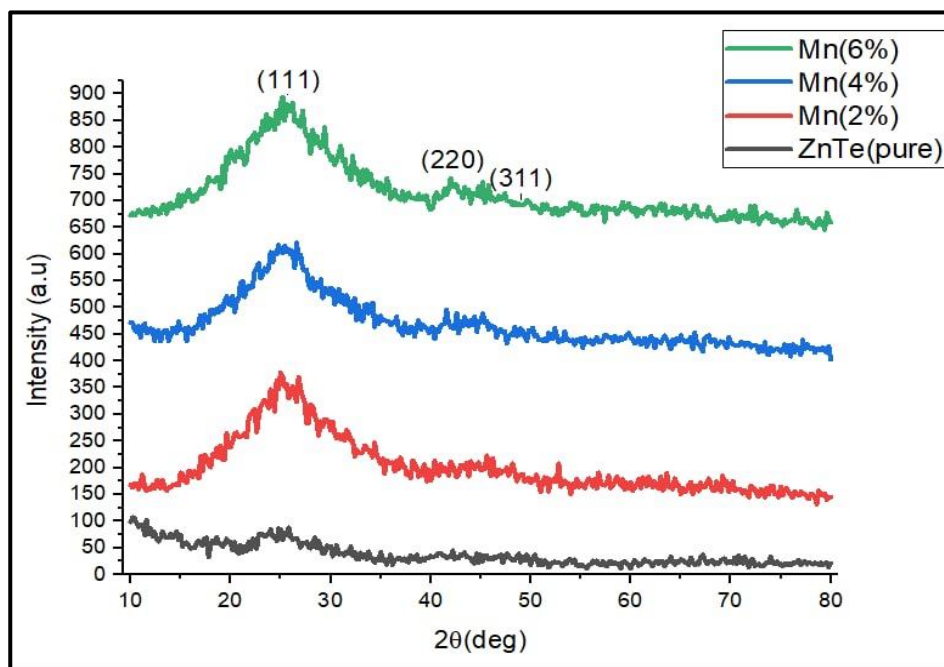


Figure 1: Shows the XRD diagram of pure and doped ZnTe films

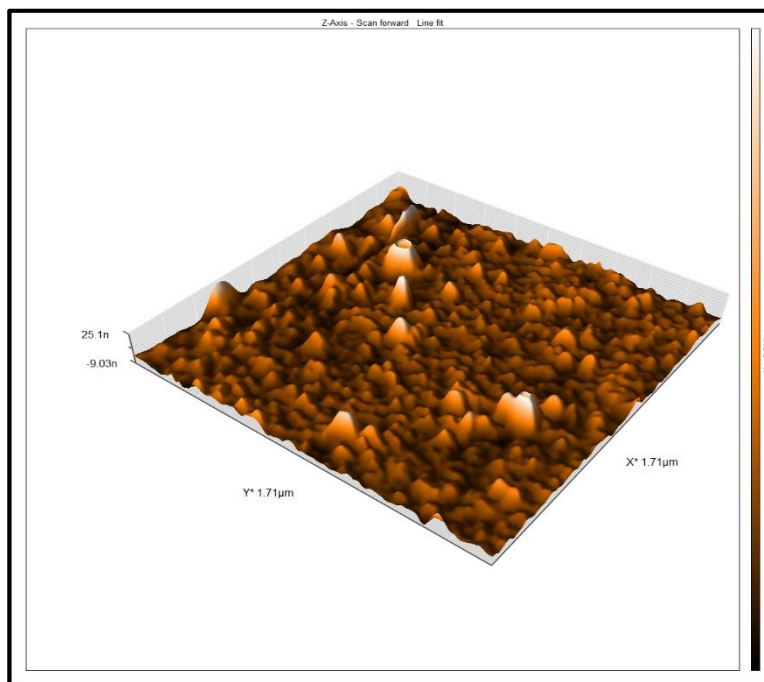


Figure (2a): 3D AFM image of pure ZnTe thin film.

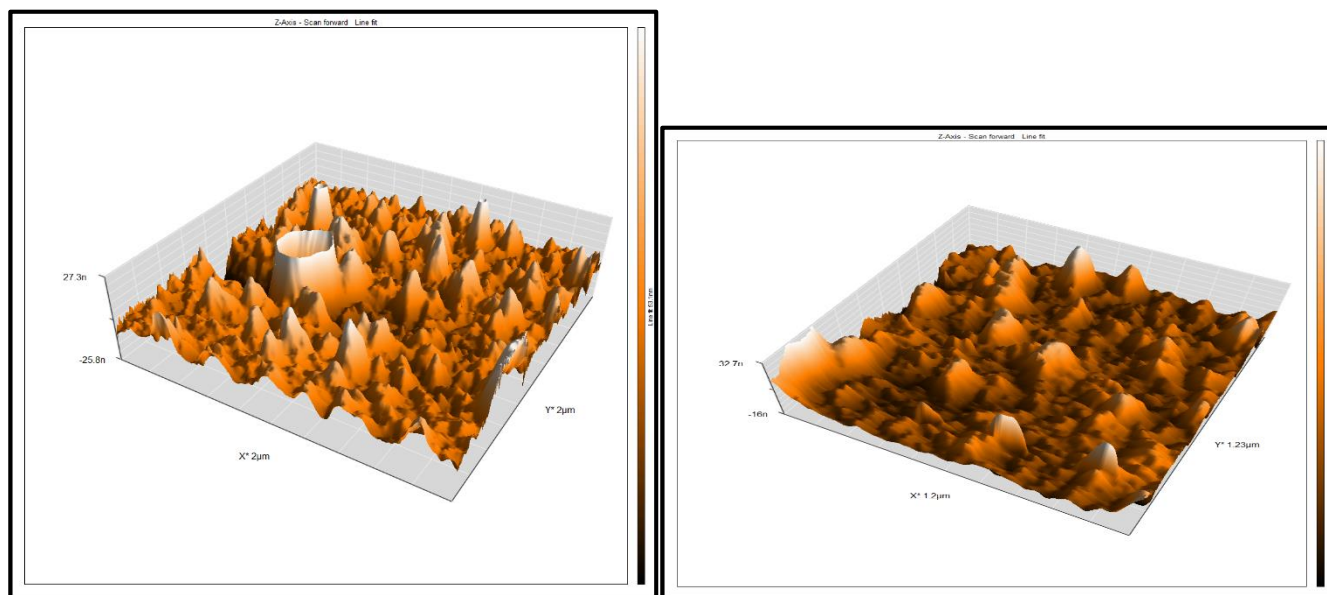


Figure (2b) 3D images of the doped ZnTe thin film.

3-2: - Optical properties

The optical behavior of pure and doped ZnTe samples was determined by Uv-Vis spectroscopy. Figure 3)) displays transmittance spectra in the wavelength range from 1100-300 nm. Different permeability behavior is observed between the films as the precipitated films show permeability values in the range of 90-60%. It was observed that the permeability of the thin films showed a gradual decrease of the permeability spectrum upon doping by (2%).

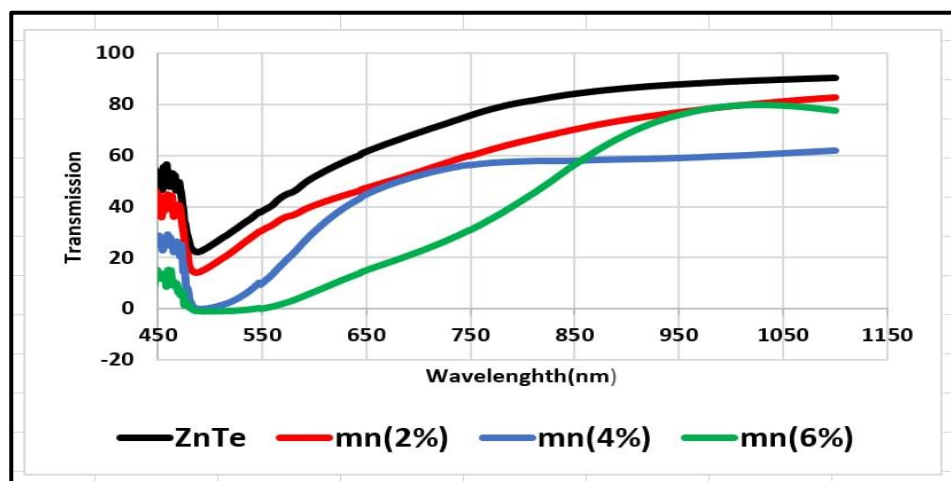


Figure 3: Shows the permeability diagram

4. Conclusion

ZnTe: mn thin films were successfully obtained by pulsed laser technology. Optical and structural properties of ZnTe: mn thin films. The films are closely related to the composition, as the films showed a cubic structure of the mixed phase of zinc telluride with manganese. The thin films showed peaks associated with the increase of Te. Size and lattice parameters were adjusted using Mn as denatured. The permeability showed a decrease in the deformed films. It was found that the energy gap of pure and doped thin films is (1.9-1.92 eV), respectively. The XRD results showed that the films are polycrystalline deposits and the quality of the thin films can be significantly improved by using Mn. The widening of the peaks is observed due to the coarseness of the grain size. With these properties, we can find potential applications in electronic devices, such as solar cells and photodetectors.

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