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Growth of ZnTe films by pulsed laser deposition technique

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ABSTRACT

Polycrystalline zinc telluride films were successfully deposited on glass substrates at different temperatures ranging from 300 K to 773 K by ablating a ZnTe target (99.99%) by a pulsed laser beam. Microstructural studies indicated an increase in the average crystallite size from 40 nm to ~75 nm with the increase in substrate temperature during deposition. X-ray diffraction patterns indicated that structure of the films depended on the deposition temperature. The band gap as determined from the transmittance versus wavelength traces was found to vary between 2.32 and 2.38 eV. The PL spectra measured at 300 K were dominated by a strong peak located at ~1.77 eV which overshadowed the band edge luminescence peak at ~2.23 eV. Characteristics Raman peaks for ZnTe at ~173 cm^{-1} (TO) and ~199 cm^{-1} (LO) were also observed.

1. Introduction

The II–VI semiconductor ZnTe, is a very attractive host for optoelectronic device realizations because of its direct band gap in the green spectral range (2.26 eV). It is used as a potential interlayer to form low resistance back contacts in CdTe solar cells [1]. A small valence band offset of 0.1 eV has been determined at the CdTe/ZnTe interface for thermally evaporated ZnTe, which is nearly ideal for charge transport. Among other device applications, ZnTe is an interesting candidate for bright light emitting diodes (LEDs), since the emission wavelength corresponds to the maximum sensitivity of the human eye. Use of ZnTe layers have been reported for the realization of LED prototypes [2,3], high-efficiency multi-junction solar cells [4] and terahertz (THz) devices [5,6].

The different methods adopted recently for the synthesis of ZnTe thin films are molecular-beam epitaxy (MBE) [7] metal–organic vapor-phase epitaxy (MOVPE) [8] metal–organic chemical-vapor deposition (MOCVD) [9], sputtering [10], successive ionic layer adsorption (SILAR) [11], closed space sublimation (CSS) [12] and electrochemical deposition [13]. A few groups have also studied the formation of ZnTe thin films using pulsed laser deposition (PLD) technique [14–18].

In the current communication, we report a systematic investigation on the synthesis of ZnTe films deposited at different substrate temperatures using PLD technique. Films deposited as above have been characterized by measuring microstructural, compositional, optical, vibrational and luminescence properties.

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2. Experimental details

The deposition of thin films of ZnTe has been carried out in a conventional PLD configuration consisting of laser system, a multi-port stainless steel vacuum chamber equipped with a gas inlet, a rotating target and a heated substrate holder. ZnTe was deposited by ablating a ZnTe target (99.99% purity) using Nd:YAG laser (wavelength λ = 355 nm, pulse duration τ = 10 ns, frequency f = 10 Hz) onto glass substrates. ZnTe films were deposited at five different substrate temperatures: 300, 473, 573, 673 and 773 K. The laser fluence was kept standard at 8 J/cm^2. The laser beam was focused with an f = 23 cm glass lens on the target at an angle of 45°, with respect to the normal. The target was kept rotating at 10 rpm to avoid fast drilling. The distance between the target and the substrate was 6.5 cm and the pressure during deposition was better than 5×10^{-7} Torr. Time of deposition for all the films was ~9 min.

To obtain the micro-structural information, scanning electron microscopy (SEM) images were recorded by using a Supra 55 FESEM from Carl Zeiss with InCA EDS Analyser from Oxford Instruments. X-ray diffraction (XRD) studies were carried out by using Rigaku MiniFlex XRD (0.154 nm CuK_α line). Photoluminescence (PL) measurements were recorded at 10 K and 300 K by using a 300 W xenon arc lamp as the emission source. A Hamamatsu photo multiplier along with a 1/4 m monochromator was used as the detecting system. Raman spectra were recorded using Renishaw inVia micro-Raman spectrometer using a 514 nm Argon laser. FTIR spectra were recorded in the range of 400–4000 cm^{-1} by using a Nicolet™-380 FTIR.

3. Results and discussion

3.1. Microstructural studies

Fig. 1(a–e) shows the SEM micrographs of ZnTe films deposited at different substrate temperature ranging from 300 K to 773 K. All the films were deposited at a fixed duration of 9 min. Inset of Fig. 1d shows a typical EDAX spectrum of the same representative ZnTe film. The composition of the films, as determined by EDAX measurements, are shown in Table 1. The above results indicate that the films deposited at lower temperatures are slightly tellurium rich while films deposited at higher temperatures were

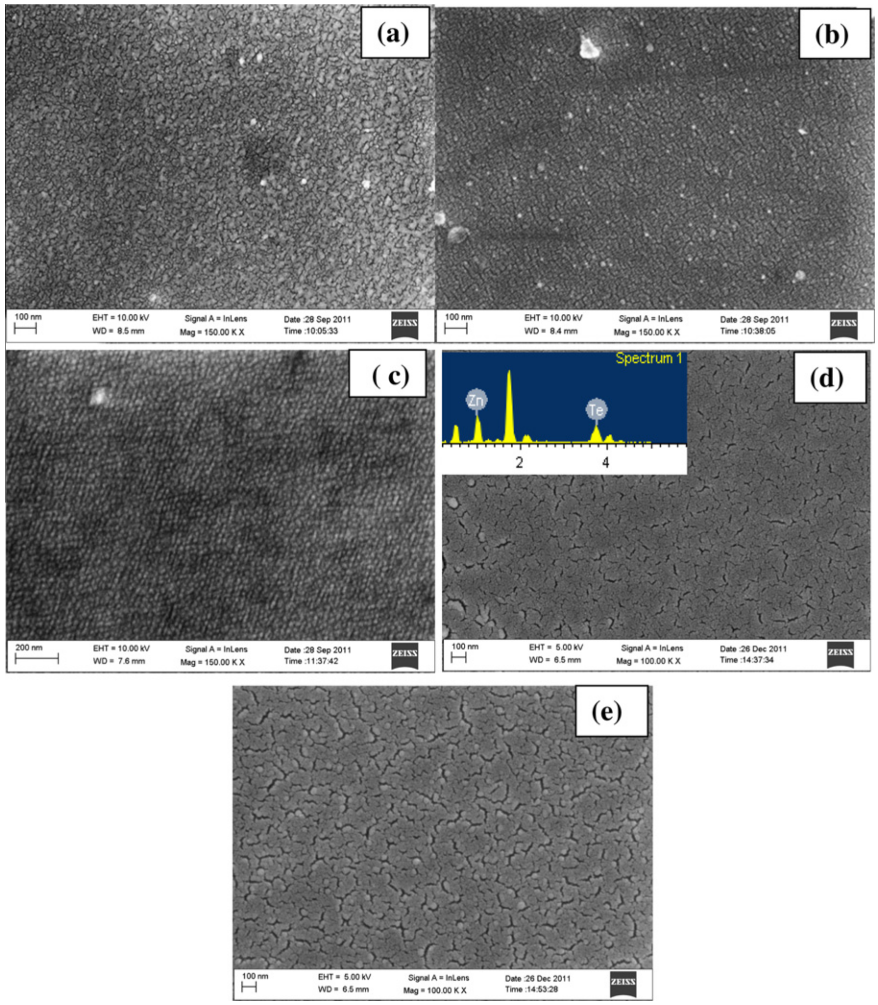

Fig. 1. SEM pictures of five representative ZnTe films deposited at different substrate temperatures: (a) 300 K, (b) 473 K, (c) 573 K, (d) 673 K and (e) 773 K. Inset of (d) shows the corresponding EDAX spectrum.

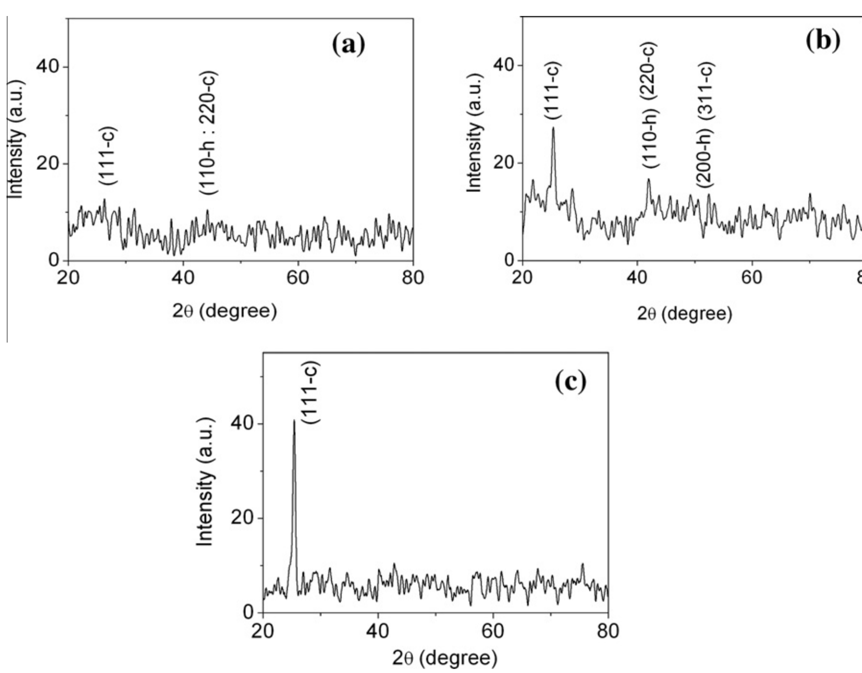

Fig. 2. XRD patterns of three representative ZnTe films deposited at different substrate temperature during deposition: (a) 300 K, (b) 573 K and (c) 773 K.