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Some spectral response characteristics of ZnTe thin films†

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Abstract. **Zinc telluride thin films have been grown at room temperature and higher temperature substrates by thermal evaporation technique in a vacuum of 10^{-6} torr. A main peak in the photocurrent is observed at 781 nm (1·58 eV) with two lower amplitude peaks on the lower wavelength side and one on higher wavelength side. The evaluated thermal activation energy is found to correspond well with the main spectral peak. From these studies it can be inferred that temperatures up to 453 K is still in the extrinsic conductivity region of the studied ZnTe thin films.**

Keywords. **ZnTe thin films; photocurrent; spectral response.**

1. Introduction

Zinc telluride is a promising semiconductor material of II–VI group for fabrication of high efficiency thin film solar cells and other optoelectronic devices (Kalita *et al* 1998) due to its suitable intrinsic energy gap, 2·26 eV (Weast 1977–78). Recent study on ZnTe also reveals that it can be used in optoelectronic detection of THz radiation (Winnewisser *et al* 1997). Photoluminescence study on ZnTe was also carried out in recent years (Nishio *et al* 1999). The ZnTe thin films grown at room temperature and high temperature substrates are found to be polycrystalline in nature (Kalita *et al* 1999). By investigating the spectral response properties of ZnTe thin film semiconductor for light of energy greater than the forbidden energy gap, it is possible to obtain information on its band structure (Kisiel *et al* 1976). Photoconductive materials generally exhibit spectral distribution curve having more or less sharp peaks in the vicinity of the absorption edge. The spectral response curve can be explained by taking into account the recombination of carriers at the surface of the photoconductor (Devore 1956). The energy gaps calculated from optical absorption edge and the energy gap calculated from the thermal activation process can be compared to assess the contributions of the two processes to conductivities. In this paper, an attempt has been made to see the correspondence of the optical and thermal activation processes in ZnTe thin films.

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2. Experimental

Zinc telluride films were deposited on properly cleaned glass substrates with the help of Hind High Vacuum Coating Unit (HINDHIVAC 12A4) at the vacuum of 10^{-6} Torr. Pure (99·999%) bulk ZnTe samples obtained from Koch Light Lab., UK was used to deposit the thin films. The substrate temperatures were fixed at 304 K (room temperature) and 404 K. Prior to deposition of thin films, high purity aluminum electrodes were vacuum evaporated on the glass substrates on which the films were then deposited to obtain gap type cells of 7 mm electrode separation.

Thin tantalum boat was used as source heater. Thickness of the deposited thin films was measured with the help of a multiple beam interferometer. A tungsten halogen lamp with a parabolic focussing mirror was used as the light source. A set of metal interference filters was used to get the monochromatic radiations of different wavelengths. Light intensity was measured with the help of a sensitive APLAB luxmeter. Photo and dark currents were measured with the help of an ECIL electrometer amplifier (EA 815) of input impedance, 10^{14} ohm and higher. A series of highly stable dry cells each of emf 9 V was used for providing the applied bias. The entire experimental set up (including the observer) was housed in a suitably fabricated Faraday cage to avoid the external noise.

3. Results and discussion

The photocurrent due to monochromatic radiation has been measured at two applied biases (27 and 63 V) in ZnTe thin films of thickness, 1969 Å, grown at room temperature substrates. From figure 1, it is seen that the variation of photocurrent density due to monochromatic radiation of light (l = 385–1032 nm) exhibits some peaks at different wavelengths. Here the photocurrent density is defined as

$J_{ph} = J_L - J_D$,

where J_L is the current density due to monochromatic radiation and J_D the corresponding dark current density.

3.1 *Spectral response of photocurrent*

It is observed that there is a maximum absorption peak at 781 nm. From this absorption edge the corresponding band gap is found to be 1·58 eV. It may be mentioned that the spectral response characteristics of thin films grown at high substrate temperatures are found to be identical with those for room temperature substrate only with the difference that the current densities of higher temperature substrate films are higher than those for room temperature films. The optical absorption edges are found to be the same for both room temperature and high substrate temperature films.

In the shorter wavelength side there are two lower amplitude peaks and on the longer wavelength side there is another smaller peak. The optical band gaps corresponding to peaks on the shorter wavelength sides are found to be 1·92 eV and 1·76 eV, respectively, while on the longer wavelength side, the band gap is found to be 1·20 eV.

The positions of the peaks remain the same when observed in films before and after prolonged annealing. As the observed optical absorption edges are lower than the intrinsic energy gap of ZnTe, it can be concluded that at such ambient temperatures the photocurrent is due to the transition of carriers from some existing defect levels, which lie in the intrinsic band gap region.

3.2 *Variation of electrical conductivity with temperature*

The temperature dependence of the dark conductivity, s_D, of the ZnTe thin films is shown in figure 2. It is observed that up to temperature, 453 K, there exists only one slope in the ln s_D vs 1000/T graph. It is seen that ln s_D increases linearly up to temperature, 453 K, from which present observations were taken. From the slope of the graph, the thermal energy

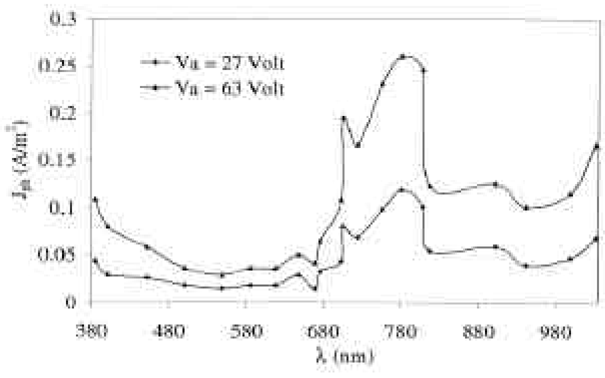

Figure 1. Photocurrent density (J_{ph}) vs wavelength (l) plots for ZnTe thin films (intensity of light normalized at 30 lux).

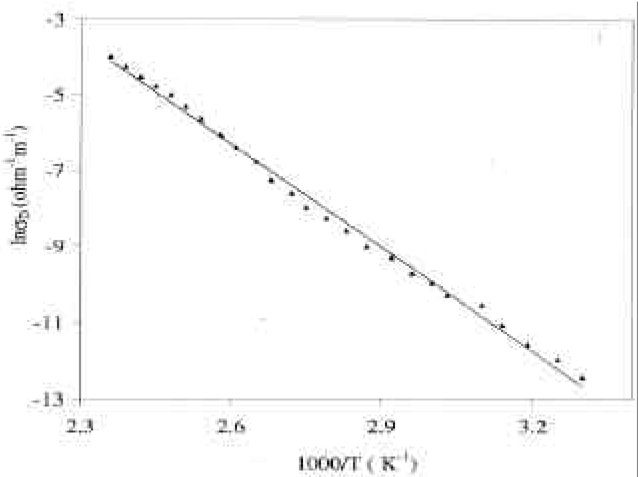

Figure 2. ln s_D vs 1000/T plot of ZnTe thin films (applied bias fixed at 27 V).

gap has been calculated and is found to be 1·58 eV. From this it can be inferred that these ZnTe thin films show extrinsic conductivity up to 453K.

4. Conclusions

It is found that evaluated energy gap from the spectral response and from the thermal activation of ZnTe thin films is the same i.e. 1·58 eV, in both the cases. Thus the optical and thermal activation processes are due to some defect levels in the temperature range of the experiments. Therefore, it can be concluded that the conductivity of the studied ZnTe thin films is of highly defect-controlled type.

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