CHAPTER IV

BORON ION IMPLANTATION IN Cd$_{0.96}$Zn$_{0.04}$Te THIN FILMS
4.1. Introduction

This chapter gives the details about the effect of ion implantation on the properties of the $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ films prepared by vacuum evaporation. Ion implantation is a well-established and technologically important method for introducing dopants into semiconductors requiring controlled dopant profiles, reproducibility and uniformity. It is used for selective area doping and to create electrically isolated regions in semiconductor device structures of II-VI and III-V compounds [1]. Ion implantation into II-VI compound semiconductors has been investigated with increasing frequency in recent years [2-11]. However, ion implantation introduces lattice damage, which can significantly influence structural, optical and electrical properties of semiconductor materials [12-14]. Investigations on effects of implantation in II-VI and III-V compound semiconductors are very much important in view of the wide applications of these materials in the field of microelectronic and opto-electronic devices. In general, the effects observed during the implantation of ions in semiconductors arise from (i) the lattice disorder introduced by implantation and (ii) the electrical activation produced by the implanted species. Understanding of these effects helps in delineating the effects of lattice disorder from that of electrical activation when electrically active species are implanted. Boron ion ($^{10}\text{B}^+$) implants have been widely used in the past for modification of the material properties and to form n$^+$-p diode junctions in $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ for infrared detector applications [15-20]. Even though many reports are available on the implantation effects on the II-VI semiconductors [21-25], no reports are available for ion implantation into $\text{Cd}_{1-x}\text{Zn}_x\text{Te}$ both in bulk and thin film form. Hence in the present investigation Boron ions were implanted into $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ films and the effect of implantations were studied.

X-ray diffraction is the best tool to study the structural changes attributed to implantation induced lattice damage. The change in surface roughness of the films with implantation can be studied by AFM and $\alpha$-Step measurements. Since the defects generated during implantation significantly alters the optical properties, optical absorption spectrometry forms a sensitive technique to investigate the lattice disorder [26,27].
Raman scattering (RS) is the powerful experimental technique ideally suits for probing the implantation induced lattice damage in semiconductors. Earlier reports have shown that Raman scattering is a very sensitive technique for studying the lattice damage produced during implantation since the penetration depth of the laser beam is of the order of the implantation affected surface thickness [6,28-32]. Hence in the present investigation, the Boron ion ($^{10}B^+$) implanted Cd$_{0.96}$Zn$_{0.04}$Te thin films were characterized by using X-ray diffraction, surface roughness measurements, optical transmittance and Raman scattering studies.

4.2. Experimental details

Polycrystalline Cd$_{0.96}$Zn$_{0.04}$Te thin films were prepared by vacuum evaporation at a substrate temperature of 300 K. A film thickness of 300 nm was chosen to study the effect of implantation, in the present work. The Cd$_{0.96}$Zn$_{0.04}$Te thin films were implanted with mass analyzed Boron ions ($^{10}B^+$) of energy 100 keV in the dose range of $10^{12}$-$10^{14}$ ions/cm$^2$ using a low energy accelerator. Low dose was preferred because high dose implantation will cause blistering and interstitial dislocation loops [33-35]. Also, to avoid heating effect of the substrate during implantation, the beam current was maintained at 0.5 µA. The implantations were carried out at room temperature and at a vacuum of the order of $10^{-7}$ Torr inside the chamber. The Boron ion penetration depth ($R_p + \Delta R_p$) is about 230 nm for 100 keV $^{10}B^+$, as calculated using Monte Carlo implant modeling program TRIM (Transport of Ions in Matter) [36].

X-ray diffraction patterns were recorded using a Philips X-ray diffractometer with CuK$_{\alpha}$ radiation ($\lambda = 1.542$ Å) at 40 kV and 20 mA in the scanning angle (2θ) from 20° to 50°. The surface microstructure of the films was investigated by ex-situ atomic force microscopy (AFM). The average surface roughness of the implanted films was also measured by α-Step surface profilometer. The optical transmission spectra of the as-deposited and ion-implanted films were recorded using a UV-VIS-NIR (SHIMADZU 3101 PC) spectrophotometer in the wavelength range 400 – 2000 nm. Raman spectroscopic technique is the most useful method available to study the lattice vibrations and their interactions with other excitations of ternary alloys [37,38]. The Raman spectra of the as-deposited and $^{10}B^+$ implanted Cd$_{0.96}$Zn$_{0.04}$Te films were
recorded at room temperature using the 488 nm Argon ion laser beam of power 200 mW over a 50 μm spot size. The scattered light was collected in the backscattering geometry using a double grating monochromator SPEX model 14018. A thermoelectrically cooled photomultiplier tube model ITT-FW 130 was used to detect the scattered light after passing through a monochromator [39]. The spectral resolution of the monochromator was about 4.2 cm⁻¹. The spectra were recorded using a microprocessor based automated data collection system with a step of 0.5 cm⁻¹ and a collection time of 10 seconds.

4.3. Film thickness and composition

The elemental composition and thickness of the films were analyzed by Rutherford backscattering spectrometry. Fig. 4.1 shows the RBS spectrum of the as-deposited films. From the RBS simulations the films were found to be stoichiometric (Cd: 0.9602, Zn: 0.0398, Te: 1). The ratio between II: VI elements was maintained as 1:1. The thickness of the as-deposited films was determined as 300 nm, which agrees very well with the value of 301 nm, measured by using α-Step surface profilometer. RBS spectra of 10B⁺ implanted Cd₀.₉₆Zn₀.₀₄Te thin films are shown in Fig. 4.2. The Boron ion implanted films are stoichiometric as analyzed by RBS simulations. From the spectra we observed that there is no appreciable change in the thickness of the films with implantation dose and also the elemental compositions of the ion implanted films remains almost the same as that of the as-deposited films.

4.4. X-ray diffraction

As-deposited films

Fig. 4.3 shows the XRD pattern of the as-deposited Cd₀.₉₆Zn₀.₀₄Te thin film of thickness 300 nm. The film exhibited polycrystalline nature with zinc blende structure. The diffractogram showed three diffraction peaks associated with <111> (2θ = 23.89°), <220> (2θ = 39.40°) and <311> (2θ = 46.67°) reflections, of which the intensity of the <111> orientation is very predominant.
Fig. 4.1. RBS spectrum of as-deposited $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ thin films (300 nm)
Fig. 4.2. RBS spectra of as-deposited and $^{10}\text{B}^+$ implanted $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ thin films (300 nm)
Fig. 4.3. X-ray diffraction spectrum of as-deposited Cd$_{0.96}$Zn$_{0.04}$Te thin films
**Effect of Boron ion implantation**

Fig. 4.4 shows the X-ray diffraction pattern of the as-deposited and $^{10}\text{B}^+$ implanted Cd$_{0.96}$Zn$_{0.04}$Te thin films. Similar to that of the as deposited, the $^{10}\text{B}^+$ implanted films also exhibited three diffraction peaks associated with (111), (220) and (311) reflections, of which the intensity of (111) orientation is predominant. The $^{10}\text{B}^+$ implanted films clearly shows a decrease in peak intensity and increase in the FWHM of the (111) peak with implantation dose, which may be due to the implantation induced lattice damage [40]. The observed small increase in the intensity of the (220) and (311) peaks with implantation dose is insignificant. The change in the FWHM value of (111) peak with implantation dose is given in Table 4.1.

<table>
<thead>
<tr>
<th>Implantation dose ($^{10}\text{B}^+$) ions/cm$^2$</th>
<th>FWHM of (111) peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-deposited</td>
<td>0.376</td>
</tr>
<tr>
<td>$10^{12}$</td>
<td>0.397</td>
</tr>
<tr>
<td>$10^{13}$</td>
<td>0.424</td>
</tr>
<tr>
<td>$10^{14}$</td>
<td>0.468</td>
</tr>
</tbody>
</table>

There was no additional peaks observed due to implantation dose, which implies that there was no oxide phase formation because the vacuum inside the chamber during ion implantation was maintained better than $10^{-7}$ Torr and properly mass analyzed $^{10}\text{B}^+$ beam was used for implantation.

**4.5. Atomic Force Microscopy (AFM)**

*As-deposited films*

The surface microstructure of the Cd$_{0.96}$Zn$_{0.04}$Te thin films was measured by ex-situ atomic force microscopy (AFM). Fig. 4.5 shows the large scale two-dimensional and three-dimensional AFM images of the as-deposited films. The evaluated root mean square (rms) roughness of the as-deposited film was 3.7 nm.
Fig. 4.4. X-ray diffraction patterns of as-deposited and $^{10}\text{B}^+$ implanted Cd$_{0.96}$Zn$_{0.04}$Te thin films
Fig. 4.5. Two-dimensional and three-dimensional AFM images of as-deposited Cd$_{0.96}$Zn$_{0.04}$Te thin films
Effect of Boron ion implantation

Fig. 4.6 shows the large scale two-dimensional and three-dimensional AFM images of the \(^{10}\text{B}^+\) implanted \((10^{14} \text{ ions/cm}^2)\) film. It is observed from the Fig. 4.6 that the surface roughness of the films increased with ion implantation. The root mean square (rms) roughness of the films implanted with \(^{10}\text{B}^+\) with the doses, \(10^{12}, 10^{13}\) and \(10^{14}\) ions/cm\(^2\) were 6.5 nm, 9.7 nm and 11.9 nm respectively. The increase in surface roughness could be due to implantation induced defects. It was noted that low-energy ions incur much heavier energy loss on entry into the semiconductor surface than high-energy ions, leading to larger disorder near the surface [41]. The rms roughness and the average roughness of the films evaluated by AFM are tabulated in Table. 4.2.

Table. 4.2. Variation of surface roughness of Cd\(_{0.96}\)Zn\(_{0.04}\)Te thin films with \(^{10}\text{B}^+\) dose.

<table>
<thead>
<tr>
<th>(^{10}\text{B}^+) Implantation dose (ions/cm(^2))</th>
<th>Surface roughness (nm)</th>
<th>(\text{rms roughness (AFM)})</th>
<th>(\text{Average roughness (AFM)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-deposited</td>
<td>3.7</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>(10^{12})</td>
<td>6.5</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>(10^{13})</td>
<td>9.7</td>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>(10^{14})</td>
<td>11.9</td>
<td>12.3</td>
<td></td>
</tr>
</tbody>
</table>

4.6. \(\alpha\)-Step measurements

The thickness and average surface roughness of the as-deposited and \(^{10}\text{B}^+\) implanted Cd\(_{0.96}\)Zn\(_{0.04}\)Te thin films were measured by \(\alpha\)-Step surface profilometer measurements. The thickness and the average roughness of the as-deposited films were 301 nm and 3.9 nm respectively. The thicknesses of the films remained more or less the same with implantation dose. The observed slight increase in the film thickness may be due to the \(^{10}\text{B}^+\) incorporation and at a dose of \(10^{14}\) ions/cm\(^2\) a slight decrease in thickness
Fig. 4.6. Two-dimensional and three-dimensional AFM images of $10^{14} \text{B}^+ \text{ions/cm}^2$ implanted $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ thin films
may be due to the blistering removal effect. But the average surface roughness value of
the films was increased with implantation dose. The average surface roughness of the
$^{10}$B$^+$ implanted films, with the doses, $10^{12}$, $10^{13}$ and $10^{14}$ ions/cm$^2$ were 7.1 nm, 10.5 nm
and 12.6 nm respectively. The increase in surface roughness could be due to implantation
induced defects. The variation in the thickness and average surface roughness of the films
with implantation dose is tabulated in Table. 4.3.

**Table. 4.3.** Values of thickness and average surface roughness of the Cd$_{0.96}$Zn$_{0.04}$Te
thin films with $^{10}$B$^+$ dose.

<table>
<thead>
<tr>
<th>$^{10}$B$^+$ Implantation dose (ions/cm$^2$)</th>
<th>$\alpha$-Step measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Film thickness (nm)</td>
</tr>
<tr>
<td>As-deposited</td>
<td>301.27</td>
</tr>
<tr>
<td>$10^{12}$</td>
<td>301.30</td>
</tr>
<tr>
<td>$10^{13}$</td>
<td>301.32</td>
</tr>
<tr>
<td>$10^{14}$</td>
<td>301.31</td>
</tr>
</tbody>
</table>

4.7. Optical Transmittance measurements

*As-deposited films*

The optical transmittance spectrum of the as-deposited Cd$_{0.96}$Zn$_{0.04}$Te thin film is
shown in Fig. 4.7. At higher wavelength region the transmittance of the films was high.
The interference pattern with a sharp fall of transmittance at the band edge has been
observed from the spectra of the as-deposited films, which indicates the good crystallinity
of the films. An exponential decrease in the optical absorption coefficient was observed
with increase of wavelength.

Cd$_{1-x}$Zn$_x$Te is a direct band gap material, whose band gap lies between 1.45-2.35 eV.
The optical band gap values are determined by plotting graphs between $(ahv)^2$ and $hv$
Fig. 4.7. Optical transmittance of as-deposited \( \text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te} \) thin films
The estimated band gap value for the as-deposited film is 1.539 eV, which is in good comparison with the earlier report [15].

**Effect of Boron ion implantation**

The optical transmittance spectra of as-deposited and Boron ion implanted Cd$_{0.96}$Zn$_{0.04}$Te films in the wavelength range 400-2000 nm are shown in Fig. 4.9. The spectra of as-deposited and implanted films show interference pattern. A decrease in the transmittance with the implantation dose has been observed. The variation of optical absorption with wavelength for the as-deposited and Boron ion implanted films are given in Fig. 4.10. The absorption edge shifts towards the higher wavelength side with the increase of implantation dose, which indicates a decrease in the optical band gap energy with implantation dose. Fig. 4.11 shows the absorption coefficient value increases with increase in the implantation dose. The increase in the absorption during implantation may arise due to several factors, such as, increase in the carrier concentration, production of metallic clusters and primarily due to the production of defect levels in the band gap due to Boron ion implantation. The metal cluster formation due to ion implantation has not been observed, hence the exponential increase of absorption coefficient with energy suggests that the increased absorption is primarily due to the production of defect levels in the band gap [26].

The variation of refractive index with photon energy is plotted in Fig. 4.12. The refractive index value varies from 2.78 to 2.58. For the as-deposited films the value of 'n' decreases gradually with the increase of photon energy and increases a bit at higher energy. For the implanted films the refractive index value decreases with implantation dose. The reduction in the band gap energy has been attributed to the implantation-induced defects. The optical band gap values are determined by plotting graphs between $(\alpha h\nu)^2$ and $h\nu$(Fig. 4.13) and by extrapolating the linear portion of the curve to the x-axis at $\alpha = 0$. The band gap value for the implanted films are found to be decreased with increase in the dose. The band gap value is decreased to 1.48 eV for the $10^{14}$ ions/cm$^2$ implanted films. The progressive reduction of the band gap value with increasing implantation dose is shown in Fig. 4.14. This can be attributed to the increase of
Fig. 4.8. Plot of $(\alpha h\nu)^2$ versus $h\nu$ of as-deposited $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ thin films

$t_f = 300 \text{ nm}$

$E_g = 1.539 \text{ eV}$
Fig. 4.9. Optical transmittance spectra of as-deposited and $^{10}\text{B}^{+}$ implanted $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ thin films
Fig. 4.10. Variation of absorption coefficient with wavelength for as-deposited and $^{10}$B$^+$ implanted Cd$_{0.96}$Zn$_{0.04}$Te thin films.
Fig. 4.11. Variation of absorption coefficient with implantation dose (at 600 nm)
Fig. 4.12. Variation of refractive index (n) with photon energy for the as-deposited and $^{10}$B$^+$ implanted Cd$_{0.96}$Zn$_{0.04}$Te thin films

- a - As-deposited
- b - $10^{12}$ ions/cm$^2$
- c - $10^{13}$ ions/cm$^2$
- d - $10^{14}$ ions/cm$^2$

$\ell_f = 300$ nm $^{10}$B$^+$ implantation
Fig. 4.13. Estimation of band gap energy of $^{10}\text{B}^+$ implanted Cd$_{0.96}$Zn$_{0.04}$Te thin films
Fig. 4.14. Variation of band gap energy (E<sub>g</sub>) with $^{10}\text{B}^+$ dose
implantation induced lattice disorder with increase of implantation dose [40]. Also the reduction in sharpness of the absorption band edge with the increase in the implantation dose may be due to the defects, such as, vacancies, interstitials, dislocation loops, antisite defects, etc., produced by implantation. The reduction in the absorption edge sharpness as well as the reduction in the band gap value can be attributed due to the effect of band tailing due to the defects produced during implantation [26,42,43]. The variation of absorption coefficient, refractive index and optical band gap of the Cd$_{0.96}$Zn$_{0.04}$Te thin films with implantation dose are tabulated in Table 4.4.

Table 4.4. Variation of $\alpha$ and $E_g$ of the Cd$_{0.96}$Zn$_{0.04}$Te thin films with implantation dose.

<table>
<thead>
<tr>
<th>$^{10}$B$^+$ Implantation dose (ions/cm$^2$)</th>
<th>Absorption coefficient (at 600 nm) $\alpha$ (m$^{-1}$)</th>
<th>Refractive index (at 1.5 eV) $n$</th>
<th>Band gap energy $E_g$ (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-deposited</td>
<td>8.395x$10^5$</td>
<td>2.72</td>
<td>1.539</td>
</tr>
<tr>
<td>$10^{12}$</td>
<td>8.872x$10^5$</td>
<td>2.71</td>
<td>1.514</td>
</tr>
<tr>
<td>$10^{13}$</td>
<td>1.113x$10^6$</td>
<td>2.70</td>
<td>1.492</td>
</tr>
<tr>
<td>$10^{14}$</td>
<td>1.172x$10^6$</td>
<td>2.68</td>
<td>1.480</td>
</tr>
</tbody>
</table>

4.8. Raman scattering studies

As-deposited films

In ternary compounds an excellent illustration of lattice dynamics can be obtained by using Raman scattering spectroscopy. Fig. 4.15 shows the typical Raman spectra of the as-deposited and $^{10}$B$^+$ implanted Cd$_{0.96}$Zn$_{0.04}$Te thin films prepared by vacuum evaporation. The Raman peaks are identified at 139.93 cm$^{-1}$ and 163.40 cm$^{-1}$ for the transverse optic (TO) and the longitudinal optic (LO) phonons respectively in Cd$_{1-x}$Zn$_x$Te [44]. The peak at 123 cm$^{-1}$ is the phonon with $A_1$ symmetry of the Te precipitates in CdTe [45]. The origin of the peak at 155 cm$^{-1}$ is not fully understood but could be the phonon with symmetry $E$ seen in the Te single crystals at 147 cm$^{-1}$ [45]. The FWHM of the LO peak was found to be
Fig. 4.15. Raman scattering spectra of as-deposited and $^{10}$B$^+$ implanted Cd$_{0.96}$Zn$_{0.04}$Te thin films
4.8537 cm\(^{-1}\). Similar two-mode (LO, TO) behaviour in Cd\(_{1-x}\)Zn\(_{x}\)Te, which arise from CdTe- and ZnTe-like vibrations were observed by Harada and Narita [38].

**Effect of Boron ion implantation**

The Raman scattering spectra of the Boron ion implanted films are shown in Fig. 4.15. The implantation with Boron ions produces vacancies and interstitials causing lattice damage. Defect clusters such as Boron bubbles and dislocation loops also form during the Boron ion implantation. One can observe from Fig. 4.15, that the peak position (LO, TO) remains more or less the same, but the area under the peaks and the FWHM values increase on implantation, which is due to the ion implantation induced lattice disorder. Interestingly, the relative intensity and the area under the Raman peak are also found to increase with the implantation dose. Fig. 4.16 shows the change in Raman peak position and the change in FWHM of TO peak of as-deposited and Boron ion implanted films. The implantation induced lattice disorder generally results in the reduction of the intensity of the Raman peaks [46]. In our case the observed increase in the Raman intensity, was rather surprising. An increase in the Raman intensity (area under the peak) can be considered using various probabilities. Generally, the possibility for the increase in the intensity of the Raman lines can be due to Resonance Raman Scattering (RRS) effect, which essentially is the enhancement of the Raman intensity when the wavelength of the exciting radiation closely matches the band gap of the film material [47]. But for Cd\(_{0.96}\)Zn\(_{0.04}\)Te, the band gap value is 1.539 eV and the energy of the laser beam was 2.54 eV (488 nm), so the possibility for RRS is very less. One more reason for such an increase in the relative intensity (area under the Raman peak) can be due to the surface roughness introduced by ion implantation [48]. The effect of increasing the energy of the implanted ions is to cause the highly disordered layer to shift more deeply into the crystal. And also the penetration depth of the various continuous laser lines in a semiconductor depends upon the degree of its crystallinity [41]. In the present work low energy ions were implanted, which caused the surface roughness. In order to check this possibility, the surface roughness of the as-deposited and ion implanted films were evaluated by an ex-situ AFM and \(\alpha\)-STEP. An increase in the surface roughness with implantation dose is observed in the films suggests that the increase in the Raman
Fig. 4.16. Variation of area under the peak, intensity and FWHM (TO peak) with implantation dose.
intensity could be possibly due to surface roughness induced enhanced Raman scattering effect (SRERS). The changes in the area under the TO peak and the FWHM of Raman peak (TO) with implantation dose are tabulated in Table. 4.5.

**Table. 4.5. Variation of area under the peak and FWHM of TO peak with implantation dose.**

<table>
<thead>
<tr>
<th>10^B⁺ Implantation dose (ions/cm²)</th>
<th>Area under the TO peak x10⁴ (a.u.)</th>
<th>FWHM of Raman peak (TO) (cm⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-deposited</td>
<td>19.25</td>
<td>4.8537</td>
</tr>
<tr>
<td>10¹²</td>
<td>22.36</td>
<td>5.4478</td>
</tr>
<tr>
<td>10¹³</td>
<td>23.10</td>
<td>5.8945</td>
</tr>
<tr>
<td>10¹⁴</td>
<td>23.97</td>
<td>5.9338</td>
</tr>
</tbody>
</table>

4.9. Conclusions

The effect of Boron ion (10B⁺) implantation on the structural and optical properties of the vacuum evaporated Cd₀.₉₆Zn₀.₀₄Te thin films were discussed in detail in this chapter. The implantation-induced lattice damage was investigated by using various techniques, viz., X-ray diffraction, surface roughness measurement, optical transmittance and Raman scattering and the results were discussed.

Cd₀.₉₆Zn₀.₀₄Te thin films were prepared by vacuum evaporation onto well-cleaned glass substrates at room temperature. The films of typical thickness 300 nm were used for the present investigations. The prepared films were implanted with properly mass analyzed Boron ions (10B⁺) for various doses ranging from 10¹² – 10¹⁴ ions/cm² at room temperature. The as-deposited films are found to exhibit polycrystalline nature with zinc blende structure. The films exhibit three diffraction peaks of which the intensity of the (111) peak was predominant. The effect of ion implantation on the structural and optical
properties of the polycrystalline $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ thin films were analyzed and the results are summarized as follows:

1. There was not much significant change in the thickness and the composition of the films on Boron ion implantation. On ion implantation the intensity of the (111) peak decreases and the FWHM increases and no additional peaks were observed due to implantation, which confirms that there was no oxide phase formation due to implantation.

2. The surface roughness (both rms and average) of the films was increased with increase of implantation dose, which may be due to the implantation-induced surface defects.

3. Raman spectrum of the as-deposited films exhibited peaks at 139.93 cm$^{-1}$ and 163.4 cm$^{-1}$ for the transverse optic (TO) and longitudinal optic (LO) phonons respectively, which arise from CdTe and ZnTe like vibrations. On Boron ion implantation, the Raman peak position remained more or less the same whereas the FWHM and the area under the peak increased with implantation dose. The increase in FWHM was attributed to the ion implantation induced lattice damage and the relative increase in the intensity of the Raman peak with implantation dose was attributed to the ion implantation induced surface roughness.

4. An exponential increase in the absorption coefficient is observed with the increase of $^{10}\text{B}^+$ implantation dose. A progressive reduction in the band gap value was observed with increase of $^{10}\text{B}^+$ implantation dose, which may be attributed to the defects produced during implantation.

The dependence of band gap on the implantation induced lattice disorder in the $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ thin films might be technologically used in tailoring the properties of this ternary semiconductor material.
References: