ABSTRACT

In this work, CdS thin films have been deposited onto the glass substrates by thermal evaporation technique in vacuum of the order of $10^{-5}$ mbar, at different thickness. The effect of gamma radiation from Co-60 by with ray dose 20 Mrad on the structural and optical properties of the CdS thin films was investigated. The crystal structure and orientation of the CdS thin films were investigated by X-ray diffraction (XRD) patterns. The optical transmittance measurements were recorded by using a double beam spectrophotometer. The XRD spectra indicate that the films are of polycrystalline structure before and after irradiation with a preferential growth of crystallites in the (002) plane. The grain size of crystallites was found to be in the range of 9-32 nm. After gamma irradiation, the result indicates that the intensity of XRD spectra and grain size of crystallites increases, while the optical energy gap decreases.

Keywords: Thin films, Gamma radiation, Cadmium sulphide.

1. INTRODUCTION

In recent years, the synthesis of chalcogenides has attracted significant interest and still is the subject of intense investigation owing to their important non-linear properties, luminescent properties and other important physical and chemical properties [1]. Among the wide band gap II-VI semiconductors cadmium sulphide (CdS) with its direct band gap of 2.42 eV at room temperature is a promising material and is applied in wide variety of fields such as solar cells [2,3]. Ionizing radiations such as X-rays, gamma-rays, beta particles, alpha particles, fission fragments, etc. are present in several fields that include industry, medicine, military, particle accelerator based research, nuclear power plants, etc. It is very much essential to ensure that the radiation levels in the environment surrounding these fields are within the permissible limit which can be determined by proper dosimeters [4]. CdS is one of the most extensively investigated semiconductors in thin film form and a large variety of deposition techniques have been utilized to obtain solar cell quality layers of CdS. These preparation techniques include dry process such as sputtering, physical vapor deposition, chemical vapor deposition, and molecular beam epitaxy(MBE)[5]-[8], and wet process such as electro-deposition, spray pyrolysis, successive ionic layer adsorption and reaction, and chemical bath deposition [9]-[12]. The aim of this work is to investigate the effect of Gamma irradiation on structural and optical properties of CdS thin films.

2. EXPERIMENTAL

The cleanness of the substrate surface plays a decisive influence on film growth and adhesion. The commercial glass substrates were washed with a detergent solution, acid and base solutions, after which they were ultrasonically cleaned in distilled water and finally dried. The CdS thin films were deposited on glass substrates (using 99.99 % pure CdS powder) by thermal evaporation technique in vacuum (CVD) at room temperature (300K) at a pressure of the order of $10^{-5}$ torr. Molybdenum boat was used to hold powdered sample. The distance from source to substrate is kept at 20 cm and the rate of deposition was 7 Å/sec. The samples thickness were 100 nm , 200 nm and 300 nm. was determined using thickness monitor (Edward 306 ). Then the as deposited films exposed to gamma radiation dose. Structure of deposited CdS films was analyzed by X-ray diffractometer using Cu$\alpha$ radiation at a slow scanning rate in the 20 range 20-60°, while the optical transmittance measurements were recorded by using a double beam spectrophotometer.

3. RESULTS AND DISCUSSION

3.1 Structural properties

Figures 1and 2 shows the X-ray diffraction pattern of the CdS thin films before and after irradiation by gamma radiation. X-ray diffraction studies showed that these films are well oriented with a preferential growth of crystallites in the (002) plane. XRD studies revealed that the crystallinity of these films was improved on irradiation with a gamma radiation.
There is also observed several dominant peaks represent to (100), (101), (110) and (112) plane are present with low intensities as compared to that of (002) plane.

\[ D_{\text{calc}} = \frac{\lambda}{\beta \cos \theta} \]  

where \( \lambda = 1.54 \) Å is the wavelength of the X-ray radiation, \( \beta \) is the FWHM in radians of the XRD peak and is the angle of diffraction. The crystallite sizes are summarized in the table 1 are found to be within the range 9 - 32 nm.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Thickness</th>
<th>2θ Plane</th>
<th>FWHM</th>
<th>Gran Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before irradiation</td>
<td>1</td>
<td>100</td>
<td>26.00</td>
<td>1.036</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>200</td>
<td>5</td>
<td>0.423</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>300</td>
<td>5</td>
<td>0.342</td>
</tr>
<tr>
<td>After irradiation</td>
<td>1</td>
<td>100</td>
<td>26.00</td>
<td>0.559</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>200</td>
<td>5</td>
<td>0.345</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>300</td>
<td>5</td>
<td>0.333</td>
</tr>
</tbody>
</table>

Figure 1: X-ray diffraction pattern of CdS thin films before irradiation prepared at different thickness (a) 100 nm, (b) 200 nm and (c) 300 nm.

Figure 2: X-ray diffraction pattern of CdS thin films after irradiation prepared at different thickness (a) 100 nm, (b) 200 nm and (c) 300 nm.

Table 1: XRD results for CdS thin films before and after irradiation.
3.2 Optical properties

Absorbance measurements are performed at room temperature in the range of 300 – 1100 nm to obtain information on the optical properties of the CdS thin films obtained at different thickness values. Figures 3 and 4 shows the transmittance as a function of wavelength of the CdS thin films before and after irradiation. The CdS films have high transmittance of about 70 to 80% in the UV-Vis-NIR regions. From the figures we can see that as the thickness increase the transmittance decrease. Also the transmittance decreases after irradiation. The small decreases in transmittance after irradiation may be due to increase in the grain size of these films.

Figure 3: transmittance as a function of wavelength of the CdS thin films (A) before and, (B) after irradiation

From optical absorption spectrum of CdS the band gap was calculated using the Tauc relation \[13\]. We plotted \((\alpha hv)^2\) versus \(h\nu\) as shown in figures 4 and 5. \(\alpha\) is the absorption coefficient and \(h\nu\) is the photon energy. Tauc relation connecting the \(\alpha\), \(h\nu\) and optical band gap \(E_g\) takes the form:

\[
\alpha hv = A(h\nu - E_g)^m
\]

The direct band gap values were determined by extrapolating the linear portion of these plots to the energy axis. Where \(m=1/2\) for a direct band gap material, 2 for an indirect band gap material and 3/2 for a forbidden –direct energy gap. As can be seen in Figuer 5, after irradiation the band gap energy is decreasing. The band gap energies of CdS thin films are given in table 2.

Table 2: The bandgap energies for CdS thin films before and after irradiation.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Thickness (nm)</th>
<th>(E_g) (eV) Before irradiation</th>
<th>(E_g) (eV) After irradiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>2.42</td>
<td>2.42</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>2.38</td>
<td>2.37</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>2.36</td>
<td>2.33</td>
</tr>
</tbody>
</table>

Figure 4: Optical energy gap of CdS thin films before irradiation prepared at different thickness (a) 100 nm, (b) 200 nm and (c) 300nm.
Figure 5: Optical energy gap of CdS thin films after irradiation prepared at different thickness (a) 100 nm, (b) 200 nm and (c) 300 nm.

4. CONCLUSION

CdS are synthesized through thermal evaporation technique in vacuum at different thickness. The x-ray diffraction pattern shows that CdS thin film is polycrystalline with a hexagonal structure before and after irradiation by gamma radiation and the intensity increase after irradiation. The grain size of crystallites was found to be in the range of 9-32 nm. The transmittance and optical band gap energies of the prepared CdS thin films decreases after irradiation.

REFERENCES


