OPTICAL AND STRUCTURAL CHARACTERIZATION OF CADMIUM AND ZINC OXIDE THIN FILMS

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Abstract

A high -quality CdO and ZnO thin film is obtained by optimizing factors that include concentration, flow rate, nozzle to substrate distance. The temperature is differed between 200˚C to 400˚C. The structural and optical qualities were studied through physical investigation. According to XRD, CdO and ZnO films have a cubic and hexagonal crystal structure rA direct band gap of about 2.10 to 2.05 eV and 3.19 to3.23 eV eV was obtained for different temperatures for Cdo and Zno thin films respectively.

***Key-words**: CdO, ZnO, Thin film, Transmission, Band gap and XRD.*

1. Introduction

Numerous coating techniques are used to deposit thin films. This blog's discussion on material deposition starts with the benefits of employing thin films during the previous several decades, which are a result of deposition methods used in applications like engineering materials, which are the thin-film technology of the future. Brown or red crystals or a colourless, amorphous powder can be found in cadmium oxide. Zinc Oxide is an II-VI semiconducting material used in many areas of the semiconductor industry, with an energy gap of 3.37 eV. CdO is an n-type semiconductor with practically metallic conductivity; it has a direct energy band gap (Eg) of ~2.3 eV and two indirect transitions at lower energies [1]. Cadmium oxide and zinc oxide differ in their optical, electrical, and structural properties. Applications for CdO and ZnO thin films are numerous and include gas sensors [2], LEDs [3], solar applications [4], field emitters [5], Piezo electric generators [6], and others. Several techniques are used to create oxide thin films: spray pyrolysis [7,8,9,10,11,12], magnetron sputtering [13], RF sputtering [14], Sol gel [15], pulsed laser deposition [16], SILAR [17], and electrodeposition [18].

2. Experimental

ZnO and CdO thin films were prepared on the glass substrate by spray pyrolysis. To prepare the starting solution, 0.2 M of each of the two acetates—zinc and cadmium—were combined separately with 100 milliliters of triple-distilled water. A few drops of strong hydrochloric acid were then added to the mixture to improve its solubility. After thoroughly stirring the combined solutions, they were heated to 50°C for three hours. Glass substrates that had been heated to 200, 250, 300, 350, and 440˚C in the air were sprayed with this solution. In this way, homogeneous, pinhole-free CdO films measuring between 245 and 298 nm in thickness and ZnO films measuring between 401 and 460 nm in thickness were produced.

3. Result and discussion

The transmission spectra for cadmium oxide films formed at various temperature 200, 250, 300, 350, and 400˚C in the wavelength range of 300–1000 nm is displayed in figure [1]. The transmittance value drops sharply below 300 nm in the ultraviolet region, with maximum of 69% at 650 nm. Within the observed wavelength range of 300-1000 nm, transmission shows that the percentage of transmission rises with rising heating temperatures. The Cadmium oxide film that is formed at 350ºC has the most percentage of transmission.

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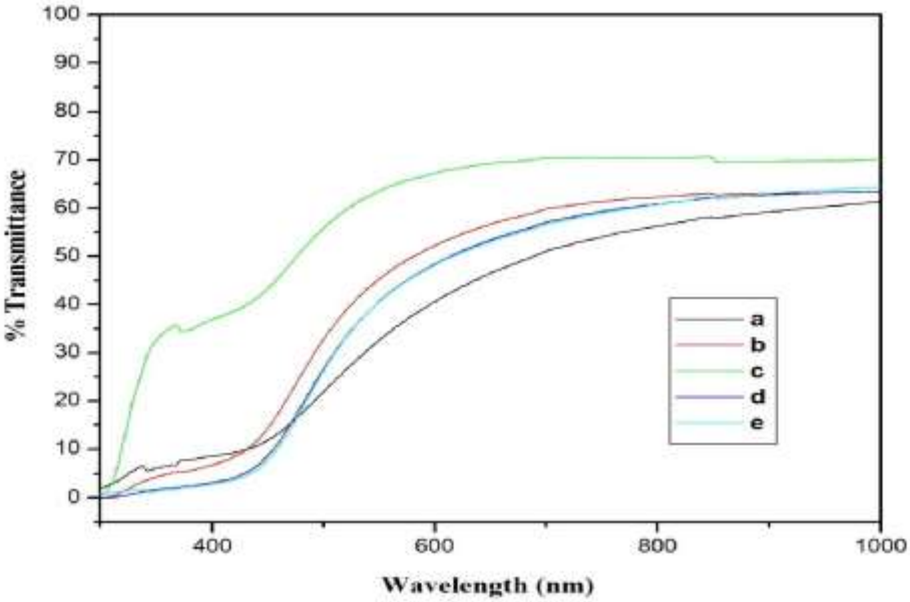

Figure [1] Optical transmission spectra of Cadmium Oxide films a) 200, b) 250, c) 300, d) 350, and e) 400˚C

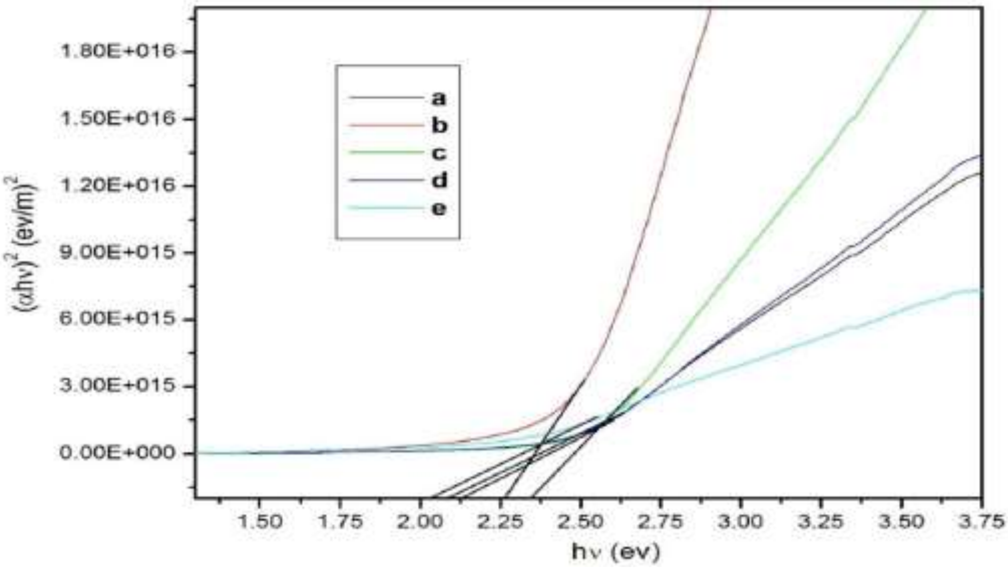

Figure [2] Bandgap energy of Cadmium Oxide films a) 200, b) 250, c) 300, d) 350, and e) 400˚C

Figure [2] illustrates the change in $(\alpha h\nu)^2$ vs. (hν) for the CdO films deposited at various temperatures. The direct band gap value has been determined by joining the plotted line segment to the energy axis. The band gap energies for the CdO films formed at various substrate temperatures 200, 250, 300, 350, and 400˚C are 2.10, 2.25, 2.37, 2.13, and 2.05 eV, according to the intercept on the energy axis. 2.37 eV is the measured band gap energy of the film made at 350˚C substrate temperature. The variable degree of oxygen non-stoichiometry of the deposited films, variations in the films' crystallinity, and grain size variations could all be contributing factors to the wide scatter.

The ZnO films formed under optimal conditions at various substrate temperatures between 200, and 400˚C and within the wavelength range of 300 to 900 nm are shown in their optical transmittance spectra in Figure [3]. In comparison to films deposited at higher temperatures, those deposited at lower substrate temperatures—200°C—showed a slightly milky look and had a reduced transmittance. It is observed that as the deposition temperature rises, the transmittance percentage (%T) in the UV-visible region increases. The ZnO films made at 350°C have the highest transmittance value, which is approximately 85%. According to the XRD result, the films' good adherent and nanocrystalline character are responsible for the improvement in transmittance. Transmittance decreases at higher substrate temperatures above 350°C because of the increased

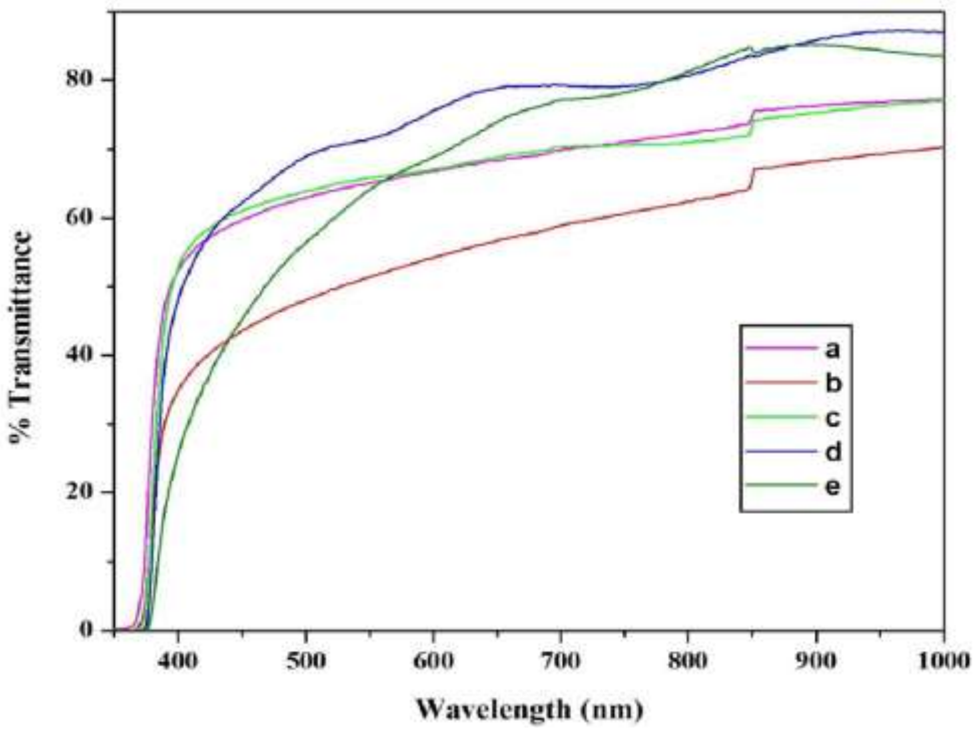

Figure [3] Optical transmission spectra of ZnO films at different substrate temperatures a) 200, b) 250, c) 300, d) 350, and e) 400˚C

Assessment of the optical band gaps of the nanocrystalline ZnO films is done using the optical transmittance curves. In Figure [4], a typical plot is shown. Near the fundamental absorption edge, which is visible in the ultraviolet region, it is evident that the plot is linear in the area of intense absorption. Direct allowable band gap values of 3.19, 3.21, 3.22, 3.26, and 3.23 eV are obtained from the linear intercept at the hn-axis. Band gap of 3.26 eV and preferred orientation along (002) plane are characteristics of ZnO films produced at 350°C.

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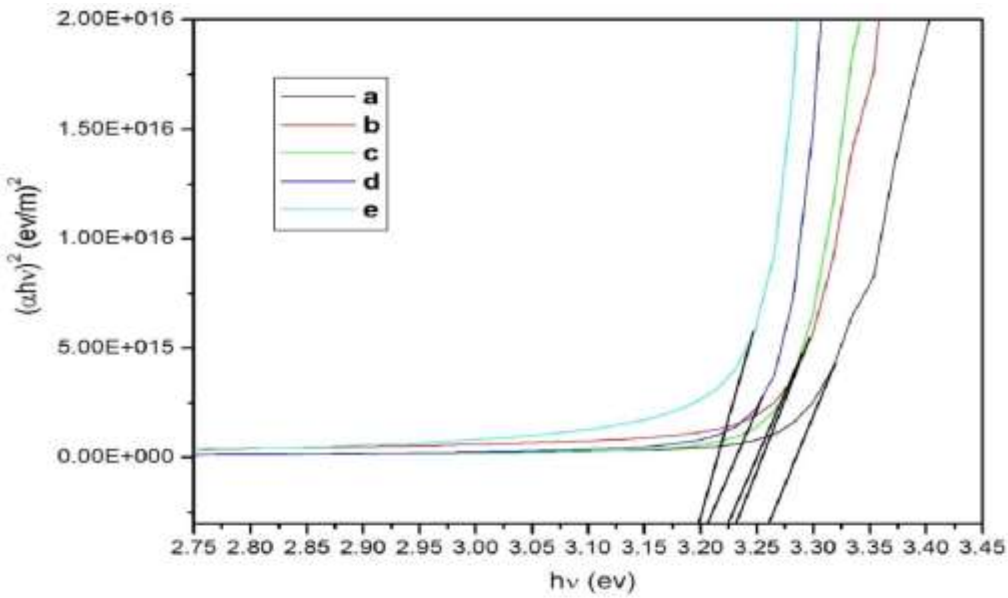

Figure [4] Band gap energy of Zin Oxide films at different substrate temperatures a) 200, b) 250, c) 300, d) 350, and e) 400˚C

3.1 Structural Properties

The XRD pattern of CdO films formed at various substrate temperatures 200, 250, 300, 350, and 400˚C in an air atmosphere is displayed in Figure [5]. The peaks corresponding to the CdO phase began to show even at a lower temperature of 200˚C. It is clear from the picture that the presence of several diffraction peaks in the diffraction patterns revealed the polycrystalline nature of the CdO films, with a favored orientation along (111) and an FCC structure. Additional XRD peaks are also seen in the (200), (220), (222), and (311) directions. The cubic structure of the sprayed CdO films is confirmed by all of the diffraction peaks. The intensity of (111)'s preferred orientation increases with temperature, suggesting a higher degree of crystallinity. With increasing temperature, so does the intensity of the (200), (220), (222), and (311) peaks.

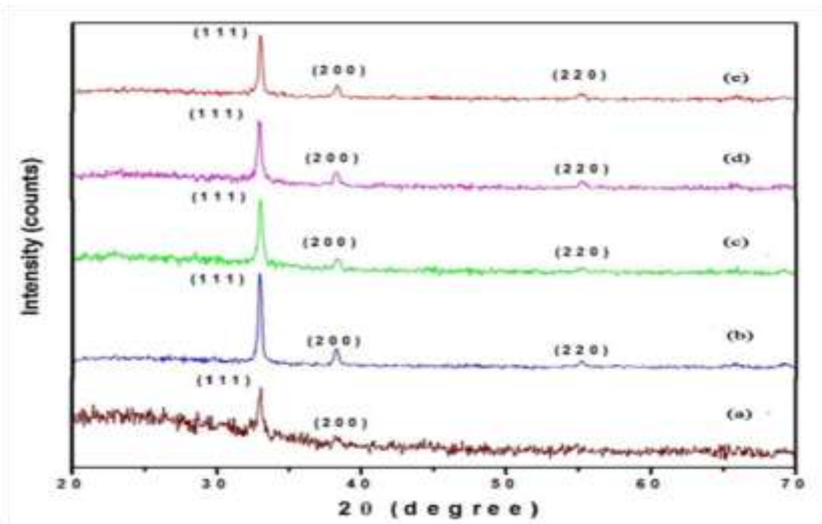

Figure [5] XRD pattern of Cadmium Oxide films prepared at different substrate temperatures a) 200, b) 250, c) 300, d) 350, and e) 400˚C

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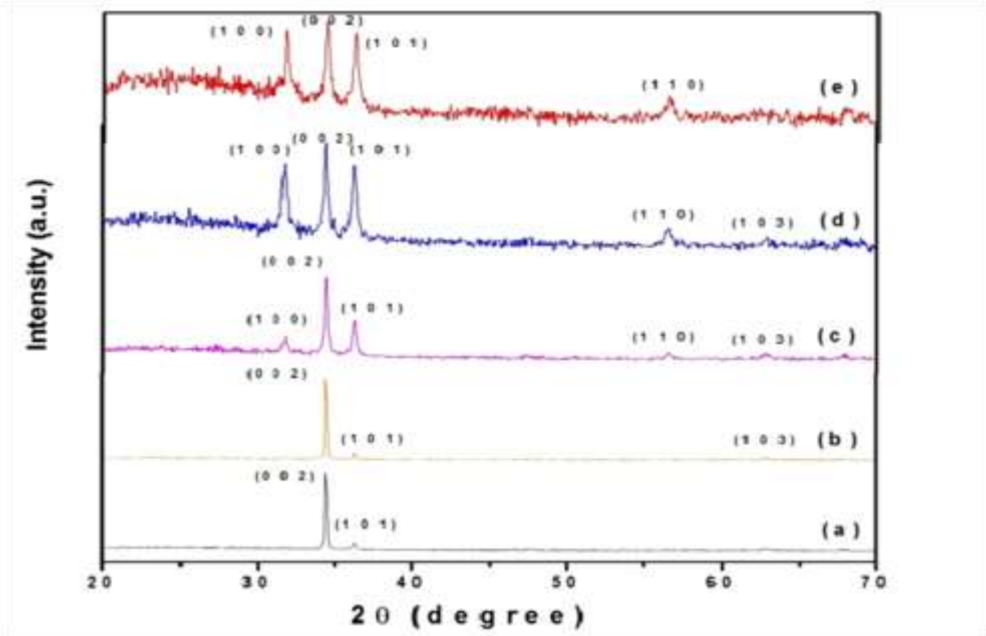

Figure [6] XRD pattern of ZnO films prepared at different substrate Temperatures a) 200, b) 250, c) 300, d) 450, and e) 450˚C

Figure [6]. shows the films deposited between 200˚C and 400˚C, the increase in temperature leads to an improvement in crystallinity.

The films deposited between 200°C and 400°C are depicted in Figure [6]. As the temperature rises, the crystallinity improves. High intensity peaks at 31.69°, 34.35°, 36.18°, 56.50°, and 62.81°, which correspond to the (100), (002), (101), (110), and (103) planes, respectively, are visible in the 400°C-prepared film. the (002) peak's strength and narrowing increases as the substrate temperature rises to 350°C. The prepared films are structured like a hexagon. Peak intensity reduces at high temperature depositions; this could be because the zinc salt evaporates, causing homogenous nucleation and the formation of a powdery surface.

Conclusion

On a glass substrate, spray pyrolysis was utilized to generate thin coatings of zinc oxide and cadmium oxide at different temperatures. The optical properties of CdO and ZnO materials, such as transmittance and the film's band gap energy, were analysed. It is deduced from XRD that CdO and ZnO films have cubic and hexagonal structure. These results suggest that these films have a broad range of uses in solar cell and gas sensing applications.

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