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CdO Films Obtained by Electrodeposition at -0.5 V and -0.7 V Potentials Range

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Abstract: Thin films of CdO were produced by electrodeposition at -0.5, -0.6 and -0.7 V. As voltage increased the band gap increased from 2.23 to 2.35 eV proportionally. The film thicknesses were affected by cathodic voltage. The structural properties of the films were investigated by using X-Ray diffractometer. When the film was obtained at -0.5V, peak intensities of the film were low according to that of the others films.

Key words: CdO, electrodeposition, potential, thin film.

1. Introduction

Nanostructured metal oxides such as Fe_2O_3, TiO_2, V_2O_5, CuO and ZnO have received considerable attention over the past decades, due to their unique thermal properties, optical, electronic and their promising applications in fabricating nanoscale devices [1]. Among the various metal oxide nanoparticles, CdO is an important n-type semiconductor with a cubic structure, which belongs to the II-VI group, with an indirect band gap of 1.98 eV and a direct band gap of 2.5 eV [2]. CdO has been used in applications such as photodiodes, IR detectors, photovoltaic cells, transparent electrodes, liquid crystal displays, phototransistors and anti reflection coat [3]. There are several accepted techniques for the preparation of CdO nanoparticles such as sol-gel method, microemulsion method, precipitation method, thermal decomposition, hydrothermal method, chemical coprecipitation method, and thermal evaporation [4]. Among these method, electrochemical deposition presents a simple, cost and quick method for the synthesis of CdO nanostructure [5].

Reactions of the formation of $Cd(OH)_2$ were given following formulas [6]:

$$NO_3^- + H_2O + 2e^- \rightarrow NO_2^- + 2OH^- \quad (1)$$

$$Cd^{2+} + 2OH^- \rightarrow Cd(OH)_2 \quad (2)$$

When $Cd(OH)_2$ was annealed at temperatures above 280 °C, CdO takes place by the following reactions [6]:

$$Cd(OH)_2 \rightarrow CdO + H_2O \quad (2)$$

2. Experimental Details

$Cd(OH)_2$ films were electrodeposited onto ITO coated glass substrates and reactions taken place with three-electrode which were saturated calomel electrode, a platinum wire and working electrode in using an aqueous solution of containing 0.02 M $Cd(NO_3)_2$. Before the depositions, substrates were rinsed with acetone and then deionized water. The depositions were completed in 45 minutes. The potentials were choosen -0.5, -0.6 and -0.7 V as chatodic potential and named as Set1, Set2 and Set3 respectively. The temperature was kept at a constant value of 70 ºC during the depositions. After the depositions $Cd(OH)_2$ films were annealed at 420 ºC for conversion to the CdO.

The structural properties were investigated by X-Ray diffraction (XRD) (PANalytical Empyrean). The optical properties of the CdO films were analyzed

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by using absorbance measurements with double beam JASCO V-530 UV-vis spectrophotometer. The surface morphologies of the CdO films were investigated by scanning electron microscopy (SEM) (Zeiss SUPRA 40VP).

3. Results

3.1 X-Ray Diffraction

The films thickness could be calculated by using gravimetric method and given in Table 1. When cathodic potential increased, the film thickness increased.

The XRD patterns of the films have been given in Fig. 1. All peaks related to the cubic form of CdO. It is understood from the Fig. 1 that as chathodic potentials increased, the peak intensities increased. The crystallite sizes of the films were calculated Debye Scherrer formula given in Eq. (4) [7]:

$$\text{cs (crystallite size)} = \frac{0.089 \cdot 180\lambda}{3.14 \cdot \text{B} \cdot \cos\theta} \text{(nm)} \qquad (4)$$

where, 2θ is the position of peak center, λ is the wavelength of X-ray radiation (1.54056 Å), B is the full width at the half maximum of peak height (in degrees).

Table 1 The film thicknesses and crystallite sizes of the CdO films.

Potential	-0.5 V (Set1)	-0.6 V (Set2)	-0.7 V (Set3)
Film thickness (nm)	482	635	690
Crystallite size (nm)	30	27	25

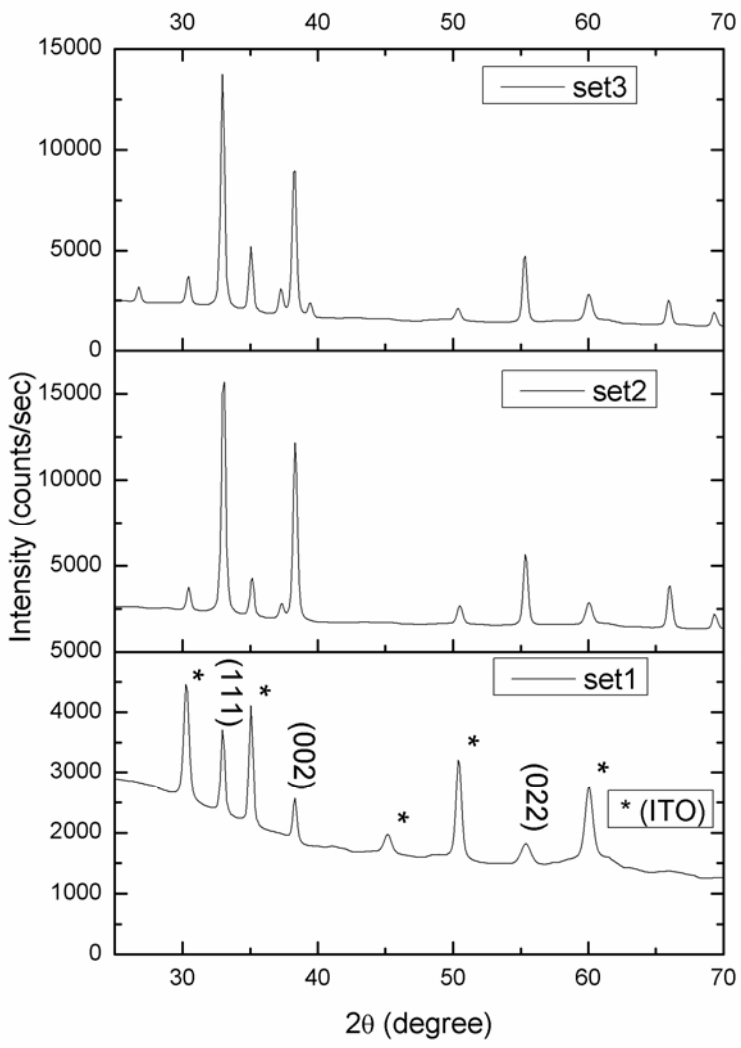


Fig. 1 XRD patterns of the CdO films.

The calculated crystallite sizes of the films have been given in Table 1. When cathodic potentials were increased, the crystallite size of the films decreased.

3.2 Optical Properties of the Films

The optical properties of the films were characterized by using absorbance data at wavelengths from 375 to 550 nm. The absorbance measurements versus wavelength graphs are given in Fig. 2. As chatodic potentials increased, the absorbance decreased. It is concluded that good crystalization caused this situation. For direct allowed transition Tauc relation uses given in Eq. (5) [8]:

$$(\alpha h\nu)^2 = \mathrm{A}(h\nu - E_g) \quad (5)$$

where, A is a constant, $h\nu$ is the photon energy and α is the absorption coefficient and E_g is the band gap of the film [8]. The $(\alpha h\nu)^2$ vs. hν graphs are given in Fig. 3. It is clearly shown from the Fig. 3 that band gap increased according to the increasing chathodic potential. It is concluded that as chathodic potential increased reaction rate increased and therefore

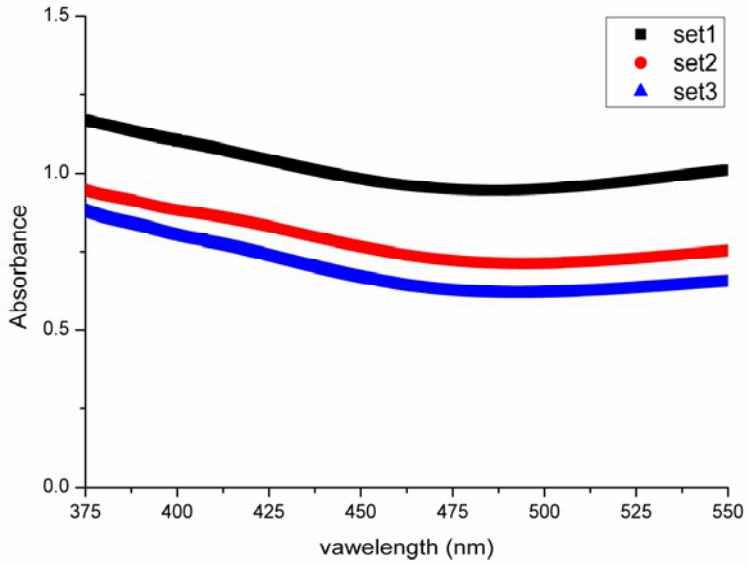


Fig. 2 Optical absorption of the CdO films vs. wavelength.

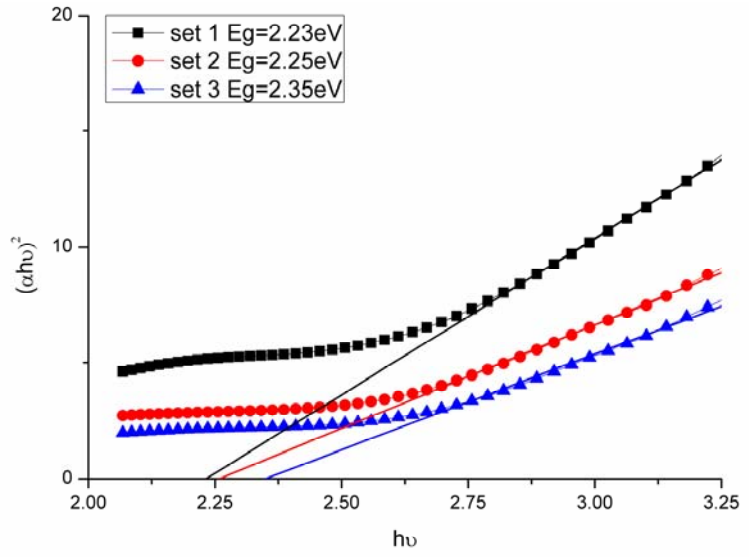
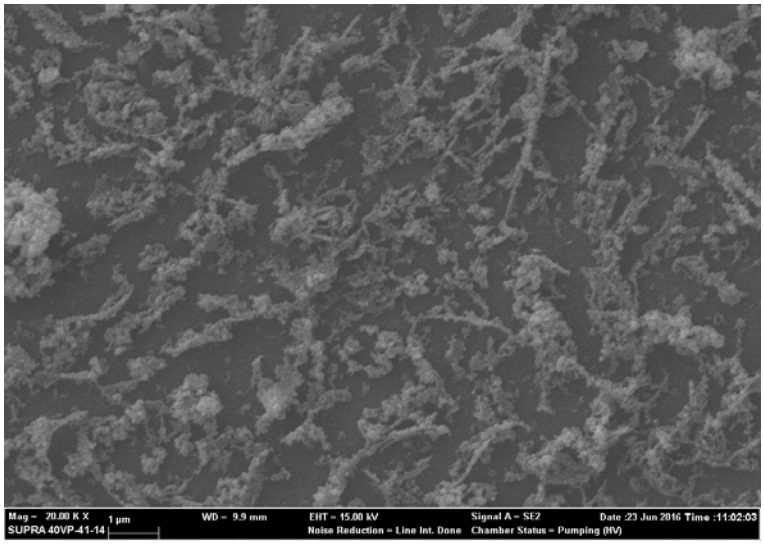
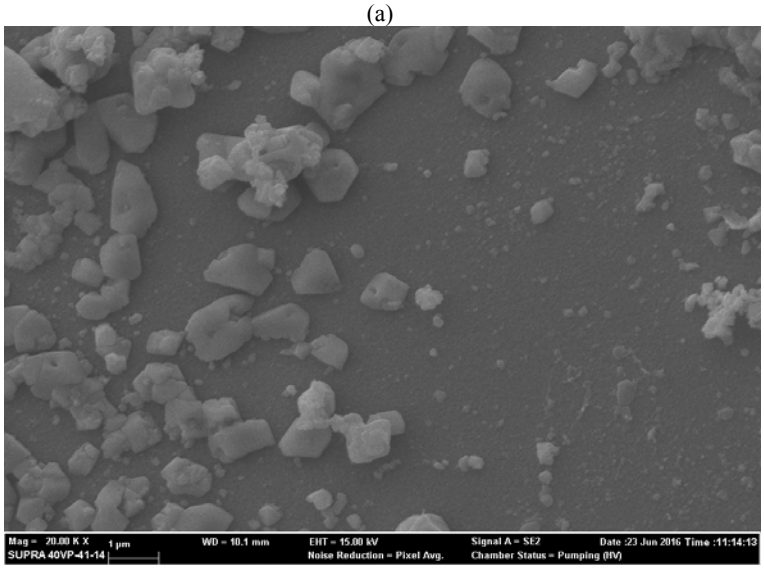


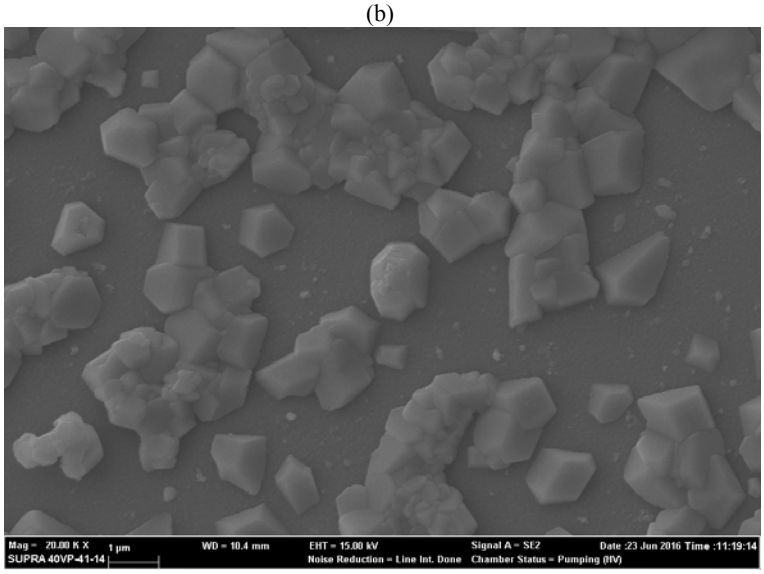
Fig. 3 Plots of $(\alpha h\nu)^2$ vs. hν for the CdO films.



(a)



(b)



(c)

Fig. 4 SEM topographic images of the CdO films which are obtained in (a) Set1, (b) Set2 and (c) Set3.

crystallite size decreased. Crystallite size and band gap depend on one another.

3.3 Surface Morphologies of the Films

Surface morphologies of the films were investigated by using a SEM with coated platinum. The surfaces were magnified 20,000x and surface images of the films obtained in set1, set2 and set3 are given in FigS. 4a, 4b and 4c respectively. Fig. 4a shows SEM images of the film obtained at -0.5 V. This morphology is common form of CdO films. When potentials were -0.6 V and -0.7 V, polymorphic grains appeared on the surface of the films.

4. Conclusions

In this work, CdO thin films have been deposited on ITO coated glass substrate by electrodeposition at -0.5, -0.6 and -0.7 V. All films show cubic grain structure according to the XRD results. Besides, it was shown from the XRD patterns that peak intensities were relatively high when films obtained at -0.6 V and -0.7 V. Optical properties of the films analyzed by using absorbance measurements. It is observed for the first time that relation between band gap and potentials. As potential increased, band gab increased.

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