Nanostructure Cadmium Oxide Thin Film Prepared by Vacuum Evaporation Thermal Technique

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ABSTRACT

Cadmium Oxide films have been prepared by vacuum evaporation technique on a glass substrate at room temperature. Structural optical and morphological properties of the films are studied at different oxidation temperatures (573 To 773) K, for the thickness (300) nm at 30 mint. XRD pattern confirm the films shows the polycrystalline nature of the film with preferential orientation along (111) plane. The film deposited with higher oxidation temperatures shows higher transmittance compared to others. Direct energy band gap of CdO thin film increases with increases of oxidation temperature. From AFM measurement, the average grain size is in the range of nanometer and it shows the faceted columnar microstructure of the film is perpendicular to the surface.

Keywords: Thermal Evaporation, Cdo Thin Films, Thin Films.

اغشية اوكسيد الكادميوم ذات التركيب النانوي المحضرة بتقنية التبخيرالحراري بالفراغ

الخلاصة

تم تحضير اغشية اوكسيد الكادميوم بواسطة بواسطة تقنية التبخير بالفراغ على قواعد زجاجية بدرجة حرارة الغرفة .الخصائص التركيبية ,البصرية والسطحية للاغشية المحضرة شخصت بدرجات حراريه مختلفة (573الى 773) كلفن عند سمك غشاء (300) نانوميتر . تقنية حيود الاشعة السينية شخصت اغشية اوكسيد الكادميوم بمتعدد البلورات وذو اتجاهية مفضلة (111). لقد وجد ان الاغشية الموكسدة عند درجات حرارةعالية تمتلك اعلى نفاذية ,اضافة الى ذلك قيمة فجوة الطاقة تزداد مع زيادة درجة حرارة الاكسدة .من خلال قياس مجهر القوه الذري وجد ان ابعاد جسيمات الغشاء بالنانوميترو ذات بنية الاعمدة المايكروية العمودية على سطح الغشاء .

INTRODUCTION

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The actual and potential applications of Transparent Conducting Oxides (TCO) thin films includes for window defrosters [1], Light emitting diodes, semiconductor lasers, transparent electrodes for flat panel displays and photovoltaic cells. The availability of the raw materials and economics of the deposition method are also significant factors in choosing the most appropriate TCO material. The n-type transparent conducting oxides such as tin oxide [2],zinc oxide [3], cadmium oxide [4-6] etc., cadmium oxide is the wide range of applications as solar cells, windows, flat panel display, photo transistors etc.[7-8]. Cadmium oxide thin films prepared by various techniques, spray pyrolysis [9-11], r.f.sputtering [12], solution growth [10] etc., have been reported. In this paper CdO thin film was prepared by thermal evaporation technique. According to our knowledge, such work on CdO films obtained by thermal evaporation technique has not been reported. In this article we present characterization properties CdO films prepared by thermal evaporation method, such as the structural, optical and morphological properties. The influence of oxidation temperature on the film characteristic properties is investigated.

EXPERIMENTS DETAILS

Cadmium thin films were deposited on an optically flat well cleaned corning glass substrates at room temperature by using thermal evaporation in a vacuum of 10^{-5} torr, then oxidation in air at 5 73,673and 773K for 30 min . An atomic force microscope AFM and XRD measurements have been employed for the characterization of our samples. The film crystalline structure was investigated using standard X-ray diffraction system (LabX-XRD-6000/shimadzu) which has the following characteristics: source radiation of CuKα with (λ = 1.54060 Å) over the range of 2θ = 10° - 80°. Transmittance spectra of the prepared films were measured by UV-visible (UV-VIS) double beam spectrophotometer CECIL, C. 7200 (France). The average particle size and size distribution were characterized with atomic force microscope (AFM) AA300 scanning probe microscope Angstrom Advanced Inc. Other optical properties such as energy band gap Eg (eV) were calculated. Film thickness was determined by weight method using the formula [13].

$$t = m / A \rho \qquad \dots (1)$$

Where't' is the thickness of the film, 'm' is the weight gain, A is the area of the coated film and ρ is the density of CdO. The film thickness was determined to be approximately 300nm.

RESULTS AND DISSECTION

XRD pattern of cadmium oxide films were studied at room temperature. Figure (1) shows that the crystalline pattern of as deposited film (CdO) on clean glass substrate .The peaks observed in all the diffractrogram confirms the polycrystalline nature of the CdO films. The peaks are appearing due to diffraction from (111), (200) and (222) cubic phase formation as compared with standard X-ray diffraction data file [JCPDS file No. 75-0594]. It's clear from Figure that Bragg's peaks more intense for higher oxidation temperature (773) K indicating a clear improvement in crystallinity. The interplanar spacing (d) corresponding to XRD peaks; hkl and JCPDS card [14] have been compared as shown in Table (1). The compares between crystallite size (grain size) (D) calculated using the Scherrer formula given in equation 2 from the full-width at half-maximum (FWHM) (Δ) [15] and (grain size) (D) calculated from AFM measurement also listed in Table (1).

$$D = \left(\frac{0.94\lambda}{\Delta \cos\theta} \right) \quad \dots (2)$$

Where λ is wavelength of the X-rays and θ is Bragg angle.

Table (1) Comparison between experimental and standard d_{hkl}, grain size (nm) and hkl of CdO films oxides at 773K.

T Oxidation	2θ Exp.(degree)	FWHM (deg)	dhkl Exp.(Å).	dhkl standard (Å)	hkl	Grain size (D)nm by (AFM)	Grain size (D)nm by(Scherrer formula)
773	33.560	0.306	2.6681	2.715	111	74	25
	38.660	0.329	2.3271	2.348	200		
	69.780	o.471	1.3466	1.331	222		

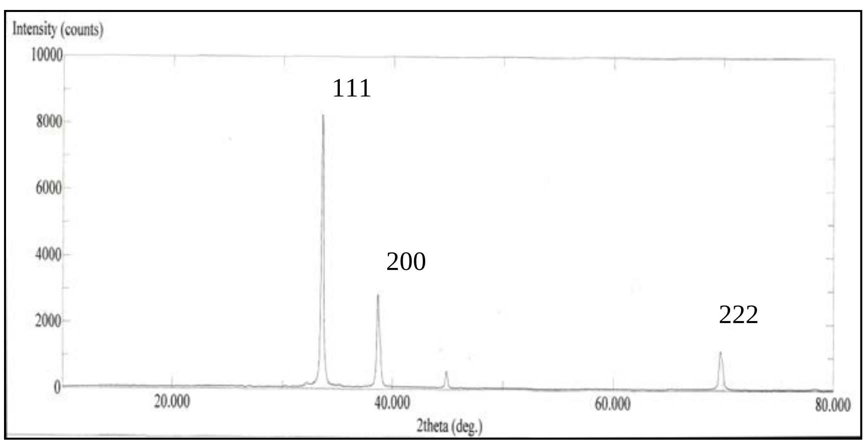


Figure (1) XRD pattern of CdO thin films prepared at oxidation Temperatures 773K.

Transmittance spectra recorded for CdO films as a function of wavelength range 300-1000nm is as shown in Figure (2). The plot shows a sharp rise in transmittance near the band edge attributed to the good crystallinity of the film [13]. Oxidation with 773K shows higher transmittance compare to 573K .This property of high transmittance makes it a good material for optical coatings. Also it is observed that the transmittance increases with increase in oxidation temperature of precursor films. This could be tribute to; at oxidation temperatures 573K and 673K for 30 mints are corresponding to a small amount of the UN oxidized Cd grains mixed, while the oxidized films at 773K exhibited the high transmission of CdO. Also the larger grain size at low oxidation temperature makes the optical properties of deposited films closer to those of single crystal. The typical plots of $(\alpha h\nu)^2$ versus hν for CdO thin films with 573K, 673K and at 773K deposited on glass substrate are shown in Figure (3). It is observed that increase in oxidation temperature of CdO films yields a slight increase in optical band gap (direct band gap) from 2.05 ev to 2.7ev are given in Table (2). These results are in agreement with the theoretical calculations of the band structure [16] and agree within ±0.1eV with the previous values, calculated for films prepared by other methods [17- 18].

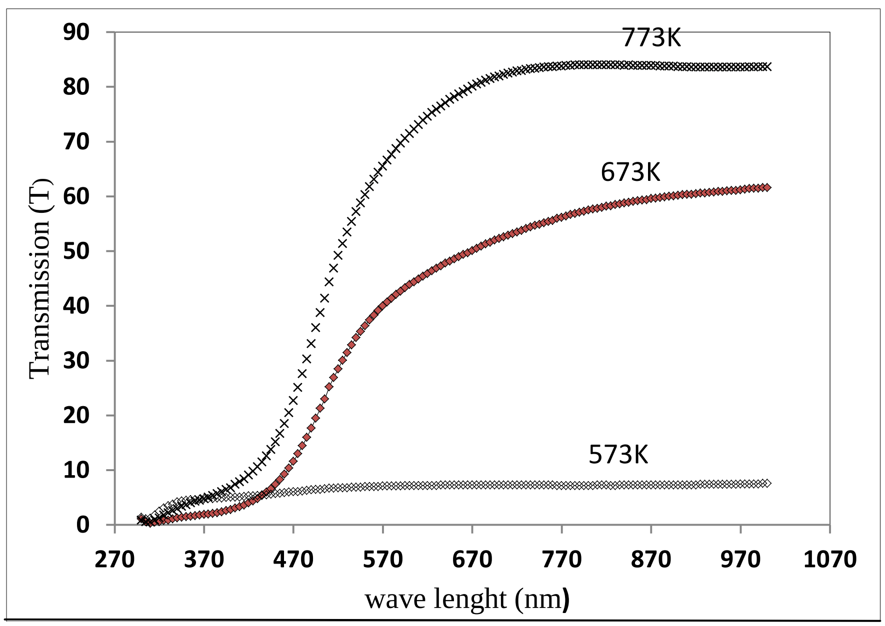


Figure (2) the transmission spectra's of CdO films prepared at different oxidation temperatures (573To773) K.

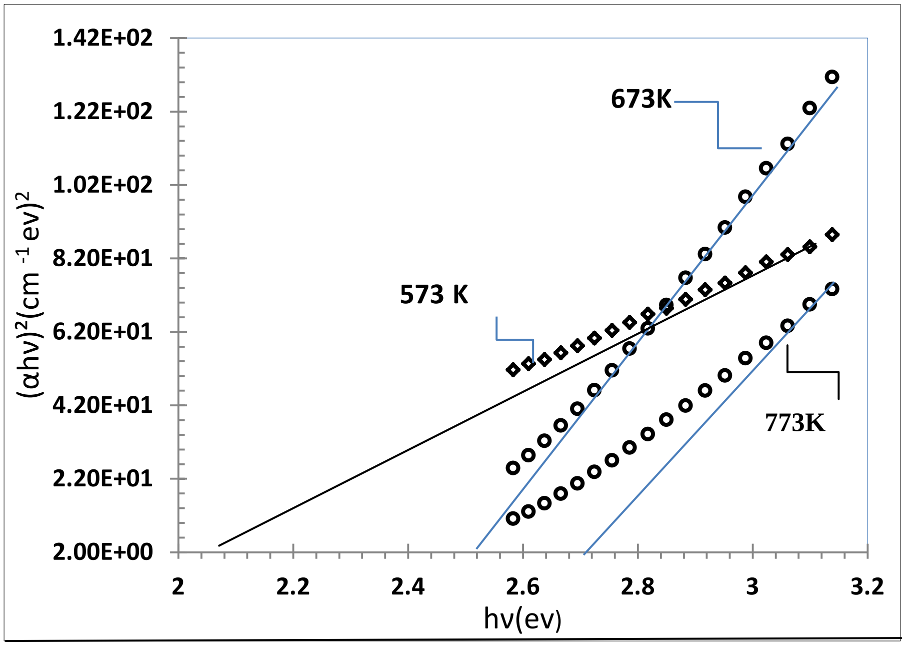


Figure (3) The typical plots of $(\alpha h\nu)^2$ versus hν for CdO thin films with 573K, 673K and at 773K deposited on glass substrate.

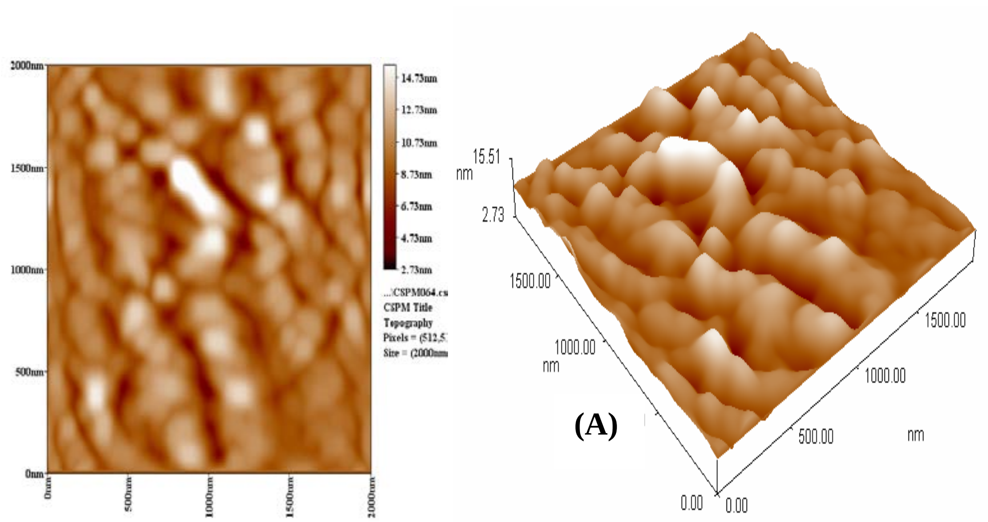
Table (2) Direct Eg(d) and transmittance at 600nm of CdO films of thickness 300 nm oxidation at 573 K,670K and 773 K for 30mints.

Sample	$T_{oxiation}$ (K)	Eg(d) (eV.)	T (600nm)%
1	573.0	2.05	7.2
2	673.0	2.5	43.9
3	773.0	2.7	71.5

The surface morphology, and hence particles size distribution of the cadmium oxide thin film is prepared at three different oxidation temperatures shows in Figure (4 A-C) and Figure (5A-C) respectively. As it is clear from Figure, the crystallinity of the samples has been improved by oxidation temperature and a drastic change in grain shape is observed. Furthermore, it's clearly seen that at low oxidation temperature the mean size of nearly circular shaped grains is about 100 nm Figure (4 A) larger than that of 673K and 773K Figure (4 B-C). The size of the grains decreased as the oxidation temperature increases. This technique confirms the crystalline structure improves in higher oxidation of as deposited film and it shows the faceted columnar microstructure of the film is perpendicular to the surface. Here shadowing is very prominent and the columns are elongated along the preferential growth direction, this is usefully in solar cell application. A higher substrate temperature changes the film morphology towards columnar grains with a smooth matt surface [19-20]. The size of the CdO nanostructure can be controlled in the range of (130 To 74) nm and RMS values for the films prepared at oxidation temperatures (573 To773) K is listed in Table (3). Also As it is clears from Figure (4 A-C) all the films are dense and adhere well to the substrate without any cracks.

Table (3) average grain size (nm) and root mean square (RMS) of CdO films of thickness 300 nm at oxidation temperatures at 573 K, 670K and 773 K for 30mints.

Sample	$T_{oxiation}$ (K)	Average grain size (D)nm by (AFM)	RMS
1	573.0	130	1.67
2	673.0	81	1.02
3	773.0	74	1.45



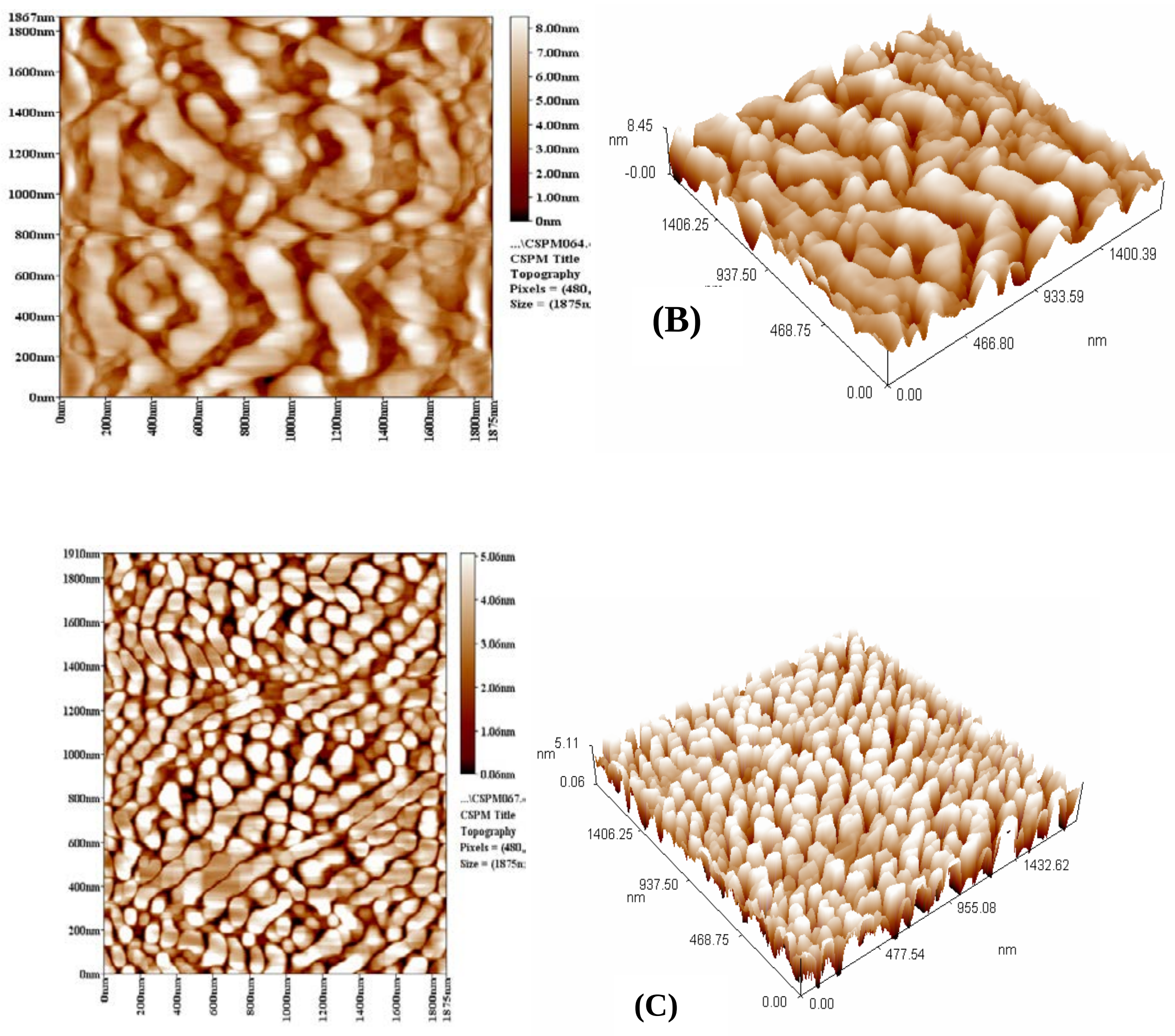


Figure (4 A-C) Surface morphology of CdO thin films prepared at different oxidation temperatures (a)573K ,(b) 673K and (C) 773K.

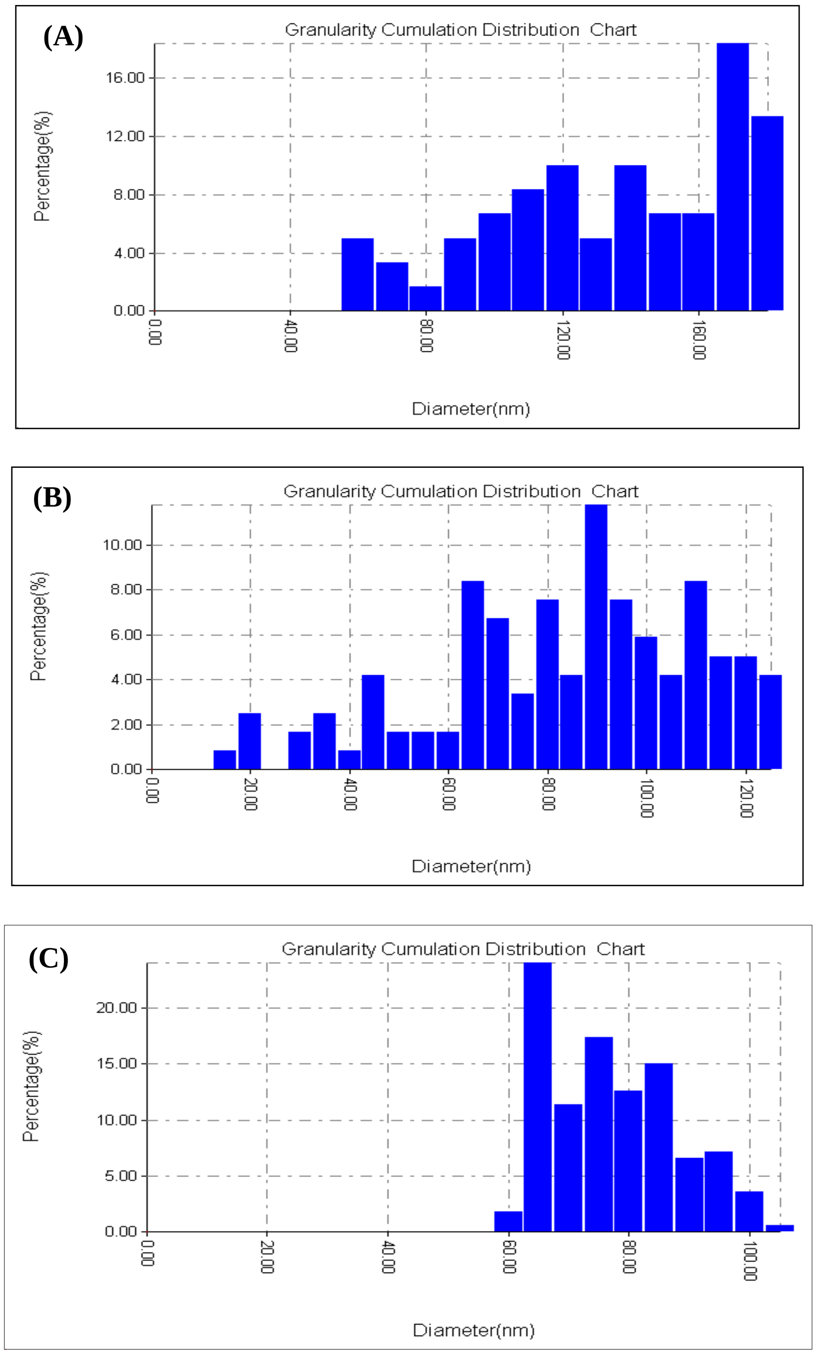


Figure (5 A-C) The height distribution for the AFM images of CdO thin films (A) Oxidation temperature (573) K, (B) Oxidation temperature (673) K (C) Oxidation temperature (773) K.

CONCLUSIONS

Cadmium oxide thin films of different oxidation temperatures were successfully deposited by thermal evaporation method on glass substrate. The present study determines the effect of oxidation temperature of film on the structural, optical and morphological properties of as deposited films. XRD pattern confirm the films shows the polycrystalline nature of the film with preferential orientation along (111) plane. The optical studies carried out on the films reveals that the film deposited in higher oxidation temperature are of high transmittance. It also shows that as the oxidation temperature increases band gap increases. The average grain size is in the range of nanometer and it shows the faceted columnar microstructure of the film is perpendicular to the surface.

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