

Optical and Structural Properties of Cdo Thin Film

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ABSTRACT

Cadmium oxide thin film has been synthesized using spray pyrolysis method. The structural and optical properties of the film were study by using X-ray diffraction (XRD), scanning electron microscopy (SEM), Atomic Force microscope (AFM), and UV- VIS spectroscopy. Result show that the film has spherical shape grain with size (460nm) and band gap (2.49eV). Moreover, the RMS equal to 58.7 nm.

Keywords: Cdo Thin Film, Spray Pyrolysis, Optical Properties, Structure Properties.

الخصائص البصريه والتركيبه لغشاء CdO الرقيق

الخلاصة

تم انتاج غشاء اوكسيد الكاديوم باستخدام طريقة الرش الكيميائي الحراري. درست الخصائص التركيبية والبصرية باستخدام حيود الاشعة السينية و المجهر الالكتروني الماسح و مجهر القوى الذرية ومطياف الاشعة المرئية – فوق البنفسجية. وضحت النتائج ان الغشاء يمتلك حبيبات كروية ذات حجم حبيبي 460 nm و فجوة الطاقة 2.49 eV. بالاضافة الى ذلك RMS تساوي 58.7 nm.

INTRODUCTION

Cadmium oxide (CdO) thin films have a great potential for a variety application, including solar cell, sensor, flat panel display, smart window, optical communication, phototransistor, photodiodes and anti-reflection coatings[1-7].

This material is one of the promising transparent conducting oxides from II to VI group of semiconductors having high electrical conductivity due to oxygen vacancies, good transparent in the visible region of the electromagnetic spectrum with band gap 2.5eV , and high carrier concentration contributed by shallow donors due to inherent non-stoichiometry [2-4] . Various methods were used to prepare CdO thin films such as chemical bath deposition [8], pulsed laser deposition [9], spray pyrolysis [10], successive ionic layer adsorption and reactive [11], chemical vapor deposition [12], sol-gel [13] and thermal evaporation [14], etc. Spray pyrolysis method has advantage compared with other methods. It is simple, inexpensive, and flexible. Also it is used to deposit thin films of a wide variety of materials with large uniform area [2, 3, 5]. In the present work, CdO thin films were prepared by spray pyrolysis method and investigated their structural and optical properties by using SEM, AFM and UV-VIS spectroscopy

EXPERIMENTAL DETAIL

CdO thin film was deposited onto glass substrate by using spray pyrolysis method. The spray solution was prepared by dissolving 0.1 M of cadmium nitrate in distilled water. The substrate temperature was 250 ± 10 °C and controlled by a thermocouple connected to a temperature controller. The air compressor was used as carrier gas and spray rate was maintained at 3 ml/min. The distance from nozzle to substrate was 30 cm. Film thickness was 0.38 μ m as determined by optical interferometer method using the relation [8]:

$$d = \frac{\Delta x \lambda}{x \cdot 2} \quad \dots (1)$$

Where x is fringe width, Δx is the distance between two fringes and λ is the wavelength of He-Ne laser (632.8nm).

The structure study were determined by x- ray diffractometer (Philips model, PW/1710), with Cu K α radiation ($\lambda = 0.15418$ nm at 40 KV and 30 mA). The surface morphology and grain size was carried out by using Atomic force microscopy AFM (Advance Angstrom Inc. SPM AA 3000) and scanning electron microscopy SEM (TEScan – Vega II SBH). An optical transmission spectrum was recorded using UV-VIS Spectrophotometer (Shimadzu 3101 PC) in the wavelength range (300 to 1100) nm.

RESULTS AND DISCUSSION

Structural studies

Figure (1) shows the XRD pattern of CdO thin film. The main peaks can be seen that due to diffraction from (111) and (200) planes with respect to standard data (ICDD). The peaks indicate that film has good crystalline nature. These result are in good agreement with other reported [11, 13, 14].

Figure (2) shows SEM micrograph of CdO thin film with different magnification. The film was homogenous distribution and has dense uniform spherical crystalline grains with size 460nm. Also, it is well adherent with substrate without cracks.

Figure (3) shows AFM image of CdO thin film. It can be seen that the surface is smooth, with the root mean square (rms) roughness is 58.7nm.

Optical properties

Figure (4) shows the transmittance spectra of CdO films. It is observed that the transmittance increased with increase in the wavelength. The optical band gap E_g can be determined from transmittance data using T_{auc} relation [10]:

$$(ahv) = A (hv - E_g)^n \quad \dots (2)$$

Where hv is photon energy, A is constant depending on the type of semiconductor, n is determined by the optical transition, and α is absorption coefficient of the film can be calculated from transmission spectra by the relation [11]:

$$\alpha = \frac{1}{d} \ln\left(\frac{1}{T}\right) \quad \dots (3)$$

Where d is the thickness of film, as shown in figure (5). The optical band gap energy E_g has calculated by plotting $(ahv)^2$ vs. (hv) for direct bandgap. The value was 2.49 eV, which determined by extrapolation of the straight line to photon energy axis at $\alpha = 0$ as shown in Figure (6). These result were agreement with the other reported [1,11,13]

Figure (7) shows the variation of extinction coefficient $K(\lambda)$ as a function of hv , which calculated directly related to the absorption coefficient by using the formula [14]:

$$K = \frac{\alpha\lambda}{4\pi} \quad \dots (4)$$

The width of the localized states associated with the amorphous state, in the forbidden gap, is called Urbach energy. This is determined from the absorption coefficient near the fundamental absorption edge by using relation [13]:

$$\alpha = \alpha_0 \exp\left(\frac{E}{E_U}\right) \quad \dots (5)$$

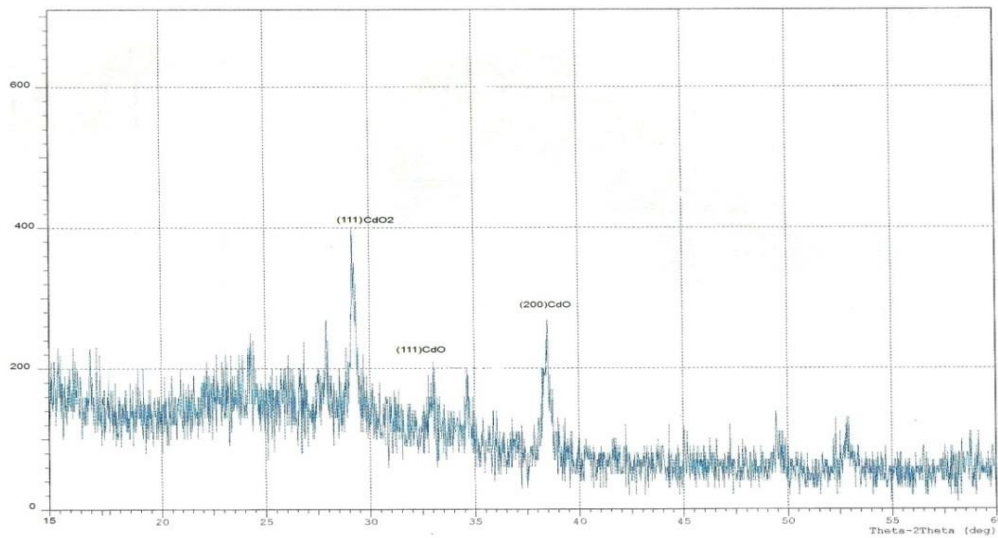
Where E is the photon energy, α_0 is constant and E_U is the Urbach energy. Figure (8) shows the variation of $\ln\alpha$ vs. hv . The inverse of slope gives the value of Urbach energy E_U , which is 4.9 meV.

CONCLUSIONS

The CdO thin film was prepared by spray pyrolysis method, it shows that the polycrystalline nature of film, with (2.49 eV) band gap. The film has spherical shape grain with size (460 nm). The RMS roughness was 58.7 nm.

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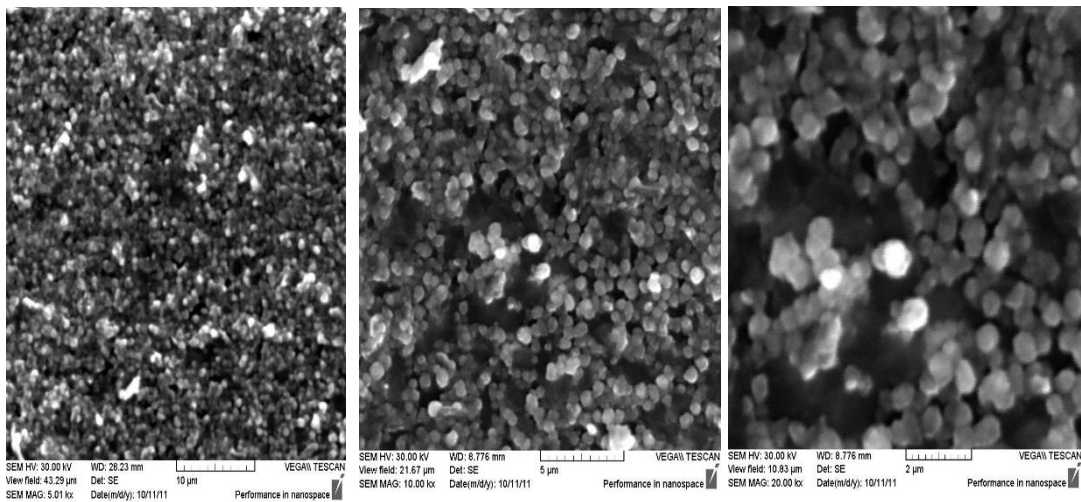


Figure (1) X-ray diffraction pattern of CdO thin film prepared at 250°C.

A

B

C

film

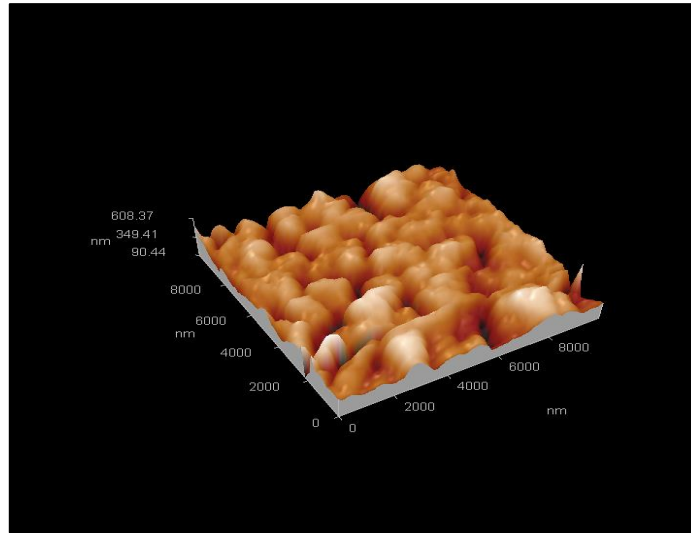


Figure (2)
SEM
image of
CdO thin
with
different

magnification (a- 5000, b- 10000, c- 20000).

Figure (3) AFM image of CdO thin film topography.

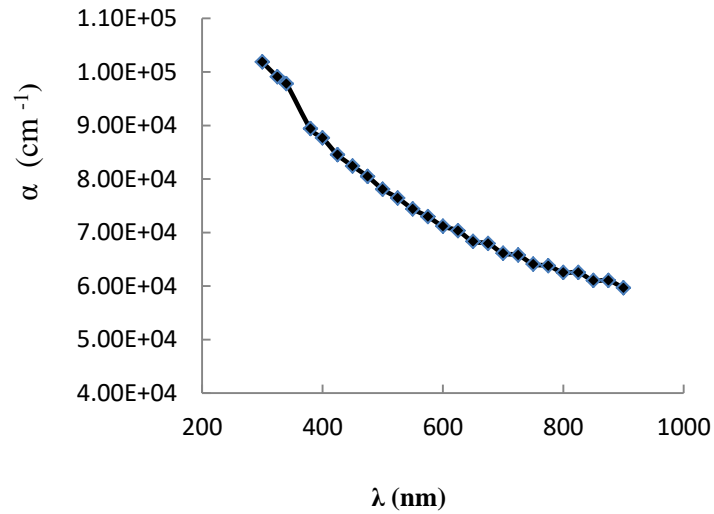


Figure (4) Optical transmission spectra of CdO thin film as a function of wavelength.

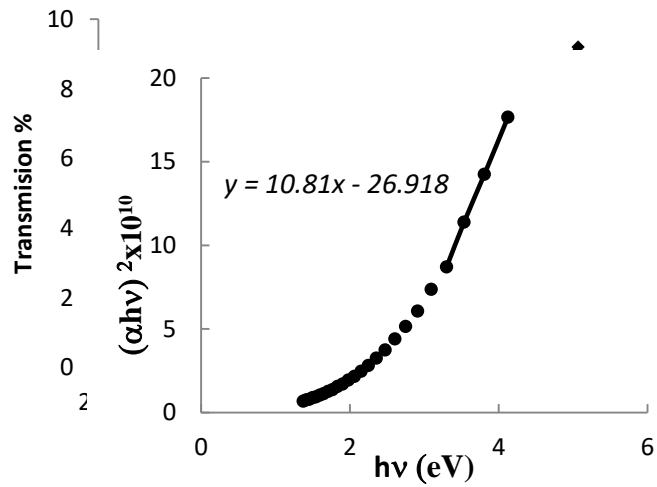


Figure (5) the calculated of absorption coefficient as a function of wavelength.

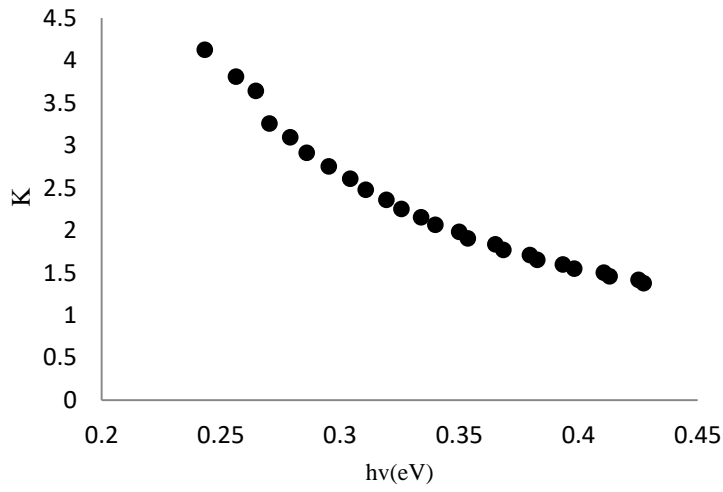


Figure (6) the variation of $(\alpha hv)^2$ vs. $h\nu$.

Figure (7) the variation of extension coefficient with photon energy.

Figure (8) the plots of $\ln(\alpha)$ vs. photon energy for CdO thin film.

