Study the effect oxidation time on physical properties of cdo thin films prepared by thermal evaporated

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Abstract

thin films were prepared by thermal evaporated method of cadmium metal on a glass substrate, then conventional oxides in air at 500º C and different oxidation times (30, 60 and 90) mint. The characterization of samples were carried out by atomic force microscopy and UV-VIS spectroscopy. Detailed optical and morphological properties of the prepared films are presented at different oxidation times. A UV-VIS transmition spectrum of produced films shows high transmission in visible, IR region and low transmission in UV region. Average grain size in the range of nanometer and decreases with increasing oxidation time.

Keywords:, Cadmium thin films, thin films, thermal evaporation .

1. Introduction

Cadmium oxide (CdO) has high electrical conductivity and high optical transmittance with a moderate refractive index in the visible region of the solar spectrum. In recent years it has found various applications in transparent electrodes, solar cells, photo transistors, photodiodes, gas sensors, etc. [1,2]. CdO films are wide, direct band-gap semiconductors with an optical energy gap of about 2.4 eV at room temperature [3]. CdO, with it's cubic structure, is also a II-VI n-type semiconductor with donor defects, such as Cd interstitials and oxygen vacancies [4, 5]. CdO thin films are prepared by many physical and chemical techniques. Many physical and chemical preparation techniques such as pulsed laser deposition [6], sputtering [7], chemical vapor deposition [8], reactive evaporation [9], spray pyrolysis [10], sol-gel [11-13], etc. have been used in order to obtain CdO films .In this study, highly transparent and conductive CdO films were prepared by using thermal evaporation technique. The variations in the morphological and the optical properties of the CdO films with oxidation time are presented.

2. Experiments details

Cadmium material was grown from (Balzers BAE 080) evaporation system under vacuum of 2×10^{-4} torr on glass substrates at room temperature using a molybdenum boat heater. The deposited films oxides

in air at (500)^{o} C by using conventional furnace in different times 30, 60 and 90 mint to prepared transparent and conducting CdO films. The thickness of prepared films was determined after oxidation using weight method [14] and found to be 300 nm. The transmission spectra's and the surface morphologies of the deposited films were taken with a UV-Vis spectrophotometer (PG-instrument) and atomic force microscope (AFM) AA300 scanning probe microscope Angstrom Advanced Inc. Energy band gap Eg (eV) of the Cdo films also calculated.

3. Results and dissection

Figure(1) shows the optical transmission spectra of the CdO films prepared at oxidation temperature 500 ^{o} C and various oxidation times. The optical transmissions of the samples were both increases with increasing wave length and oxidation time and the film shows high transmission in visible and IR region and low transmission in UV region. It's clear from figure 1a shift of their transmission edges towards lower energies. Such type of shift is found in the films prepared by activated reactive evaporation method [14]. The shift towards higher or to lower energies depends on the method of film preparation [15]. The parallel transmission shift however indicates that it is related to changes in film structure [16]. The optical band gap (Eg) of a semiconductor is related to the optical absorption coefficient (α) and the incident photon energy (hν) by [17, 18].

$(\alpha h\nu) = (Eg - h\nu)^{n}$----------(1)

where n depends on the kind of optical transition that prevails. Specifically, n is 1/2 and 2 when the transition is directly and indirectly allowed, respectively. The CdO film is known to be a semiconductor with a directly allowed transition, and its optical band gap can be obtained by plotting the optical absorption versus the photon energy and extrapolating the linear portion of the curve to $(\alpha h\nu)^{2} = 0$. The optical band gap of the CdO film prepared at a oxidation time of 30 min was 2.52 eV, as shown in Fig. 2. This is in good agreement with the previously reported value of 2.54 eV [14].It is observed that increase in oxidation time of CdO films yields a slight increase in optical band gap from 2.52 ev to 2.60ev. These results are in agreement with the theoretical calculations of the band structure [19] and agree within ±0.1eV with the previous values, calculated for films prepared by other methods [20- 21]. This change in optical band gap is due to the decrease (or increase) of the Fermi energy in the degenerated semiconductor, and it is in agreement with the results of Vigil et al. [22], and has been attributed to local mechanical stress produced by impurities and defects [23].

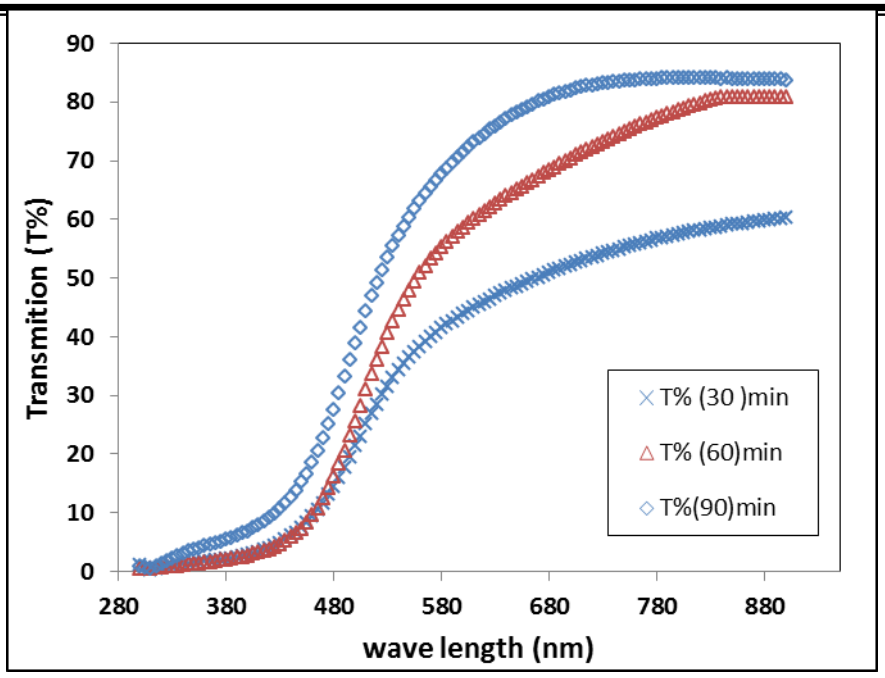
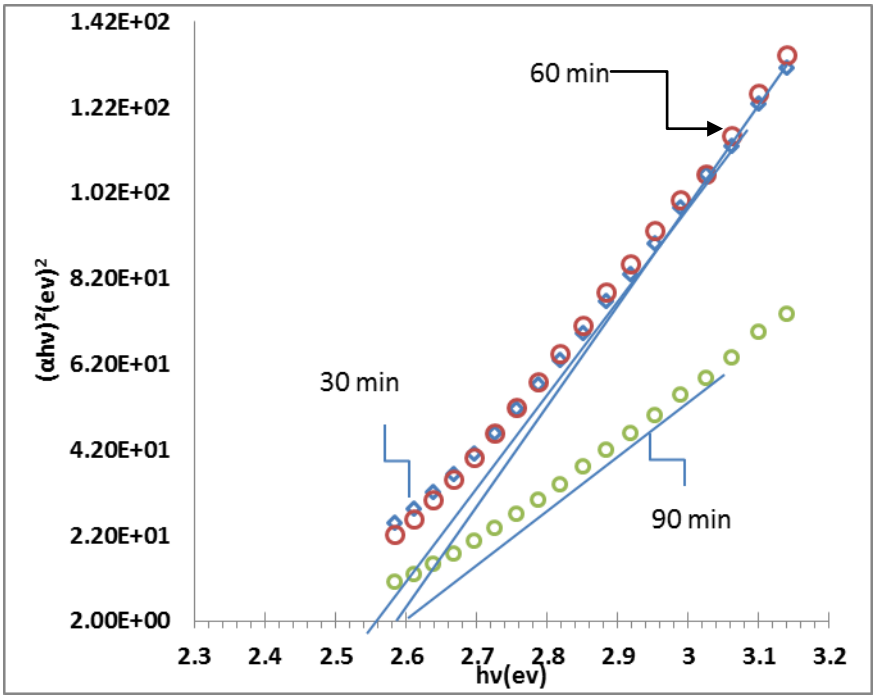


Fig.(1) :uv-vis transmition spectra of Cdo thin films at (500)C and different oxidation times.



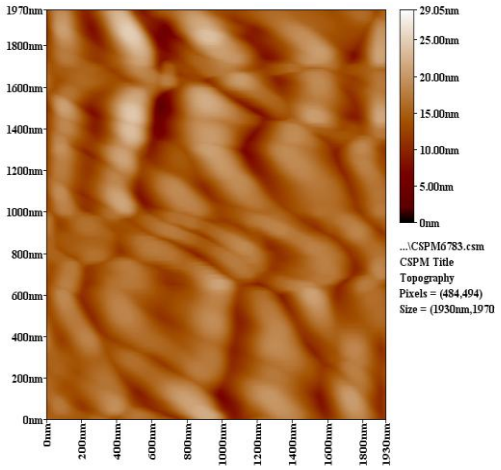
Figure(2): Tauc's plot for CdO thin films

The show in fig. 3 (A- C) shows surface morphology of the cadmium oxide thin film is prepared at oxidation temperature (500) ° C and different oxidation times. As it is clear from figure, the crystallinity of the samples has been improved by oxidation time and a drastic change in grain shape is observed. Furthermore, we can see that the film oxides at 90 min , Fig.3 (C) has a high smooth and homogeneous surface morphology with nearly

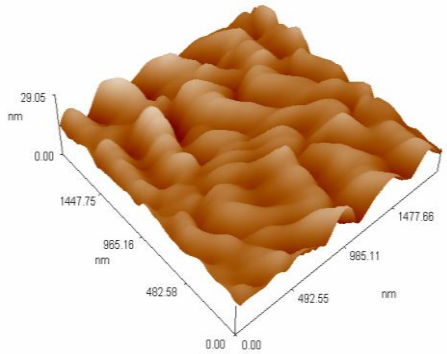
spherical nanocrystalline grains is about (80 nm), also is dense and adhere well to the substrate without any cracks as compared with films oxides at times (30,60) mint fig.3 A,B respectively . The size of the grains decreased as the oxidation time increases. This technique confirms the crystalline structure improves in higher oxidation of as deposited film. The size of the Cdo nanostructure and RMS values for the films prepared at oxidation temperatures (500) º C and different oxidation time are fabulated in table

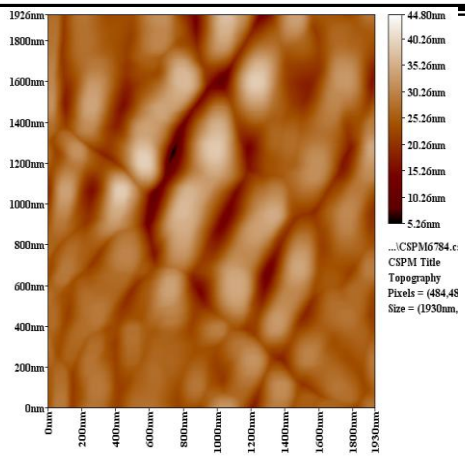
Table 1 The Conditions of thermal evaporated .

Sample	$T_{oxiation}$ (C)	Oxidation time(t)min	Average grain size (D)nm by (AFM)	RMS(nm)
1	500	30	140	3
2		60	110	4.57
3		90	80	1.88

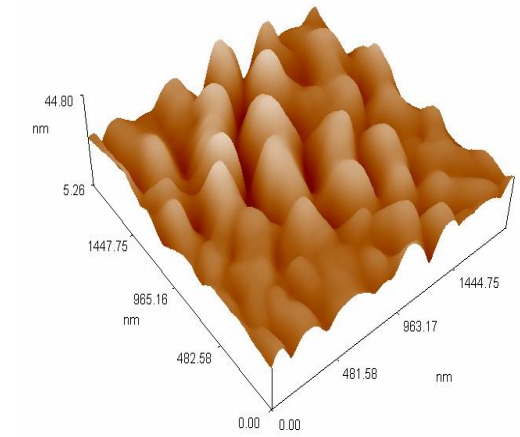


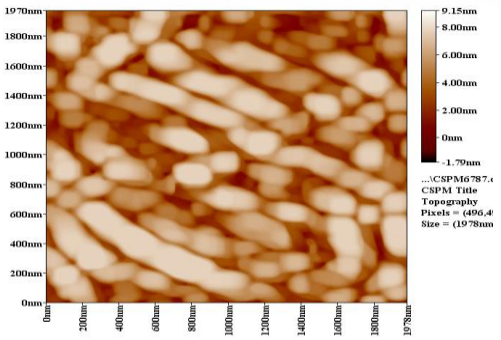
A





B





C

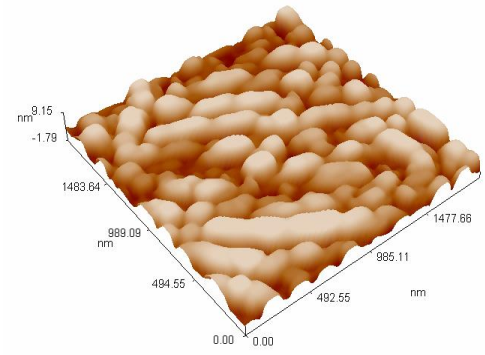


Fig .3(A-C): Surface morphology of Cdo thin films prepared at different oxidation times 30 ,60 and 90 mint.

4. Conclusion

Highly transparent and conductive CdO films were deposited on glass substrates by using conventional thermal oxidation method. The morphological and optical properties of the films were investigated as a function of oxidation time. Optical properties of the CdO films were influenced by oxidation time. The optical band gap values were found to slightly increase from 2.55 to 2.6 eV with oxidation time for direct transitions. Also Oxidation time affected the grain size of the Cdo films.

5. References

[1] R. Ferro and J. A. Rodriguez, Sol. Energy Mater. Sol. Cells 64, 363 (2000).
[2] T. K. Ssubramanyam, S. Uthanna and B. Srinvasulu Naidu, Mater. Lett. 35, 214 (1998).
[3] P. R. Patil, P. S. Patil and C. D. Lokhande, Ind. J. Phys. 266, 14 (1995).
[4] M. G. Ambia, M. N. Eslam and M. O. Hakim, Sol. Energy Mater. Sol. Cells 28, 103 (1992).
[5] Z. F. Liu, F. K. Shan, J. Y. Shon, B. C. Shin, S. C. Kim and Y. X. Li, J. Korean Phys. Soc. 44, 1123 (2004).
[6] Siraj K., Khaleeq-ur-Rahman M., Hussain S.I., Rafique M.S., Anjum S. J. Alloy Compd., vol. 509, 2011, pp. 6756–6762.
[7] Saha B., Thapa R., Chattopadhyay K.K. Sol. Energ. Mat.Sol. C., vol. 92, 2008, pp. 1077-1080.
[8] Zhao Z., Morel D.L., Ferekides C.S.Thin Solid Films, vol. 413, 2002, pp. 203- 211.
[9] Eze F.C. Mater. Chem. Phys., vol. 89, 2005, pp. 205-209.
[10] Vigil O., Cruz F., Morales-Acevedo A., Contreras-Puente G., Vaillant L., Santana G. Mater. Chem. Phys, vol. 68, 2001, pp.249-252.
[11] Aksoy S., Caglar Y., Ilican S., Caglar M. Int. J. Hydrogen Energy, vol. 34, 2009, pp. 5191-5195.
[12] Yakuphanoglu F., "Nanocluster n-CdO thin film by sol–gel for solar cell applications,", Appl. Surf. Sci., vol. 257, 2010, pp. 1413-1419.
[13] Ilican S., Caglar M., Caglar Y., Yakuphanoglu F., "CdO:Al films deposited by sol–gel process: a study on their structural and optical properties,", vol. 3, 2009, pp. 135-140.
[14] M.Mahaboob Beevia , M.Anusuyab, V.Saravananc, IACSIT Member, International Journal of Chemical Engineering and Applications, Vol. 1, No. 2, August 2010.
[15] T. L. Chu, S. S. Chu, J. Electron Mater. 19, 1003 (1990).
[16] J. P. De Neufville, S. C. Moss, and S. R. Ovshinsky, J. Non-Cryst. Solids 13, 191 (1973).
[17] S. A. Park, M. S. Jin, C. S. Yoon, C. I. Lee, M. Y. Kim, S. J. Paik and W. T. Kim, J. Korean Phys. Soc. 42, 838 (2003).
[18] S. Weng and M. Concivera, J. Electrochem. Soc. 139, 3220 (1992).
[19] A. A. Dakhel* and F. Z. Henari, Cryst. Res. Technol. 38, No. 11, 979 – 985 (2003).
[20] D. M. Carballeda-Galicia, R. Castanedo-Perez, O. Jimenez-Sandoval, S. Jimenez-Sandoval, G. Torres-Delgado, C. I. Zuniga-Romero, Thin Solid Films 371, 105 (2000).
[21] K. T. Ramakrishna Reddy, C. Sravani, R. W. Miles, J. Cryst. Growth 184/185, 1031 (1998).
[22] O. Vigil, F. Cruz, A. Morales-Acevedo, G. Contreraspuente, L. Vaillant and G. Santana, Materials Chemistry and Physics 68, 249 (2001).
[23] J. L. Pankove, Phys. Rev. A 140, 2059 (1965).

دراسة تأثير زمن الأكسدة على الخصائص الفيزيائية لأغشية اوكسيد الكادميوم المحضرة بطريقة التبخير الحراري

تم تحضير اغشية اوكسيد الكادميوم بواسطة بواسطة تقنية التبخير بالفراغ لمعدن الكادميوم ومن ثم اكسدته بالهواء بدرجات حراره 500 درجه سيليزيه وازمان اكسدة مختلفه (30 ,60 و90)دقيقه. الاغشية المحضرة شخصت بواسطة مجهر القوه الذري و مطياف المنطقة المرئية وفوق البنفسجية -UV Vis.القياسات البصرية والسطحيه للاغشية شخصت بازمان اكسدة مختلفة . من خلال منحني النفادية للاغشية المحضرة وجد ان الاغشية المحضرة تمتلك نفاذية عالية بالمنطقة المرئية وتحت الحمراء ,وقيم قليلة بالمنطقة الفوق البفسجية تقع في المنطقه المرئية . معدل حجم الحبيبي للجسيمات بالنانوميتر ويقل مع زيادة زمن الاكسدة .