Characterasition of Cdo Thin Films Grown By Sol Gel-Spray Pyrolysis Method

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Abstract

Nanocrystalline semiconducting CdO thin films of thickness of 129 nm were grown onto glass substrates by using sol gel- spray pyrolysis technique. The structural, optical, morphological and electrical properties were studied by X-ray diffrectometry, Uv-Vis spectroscopy, scanning electron microscopy and two probe DC resistivity setup respectively. The scanning electron microscopy studies revealed that the as grown films are porous in nature with uniform grain distribution. Thermo-emf and electrical resistivity measurements showed that the films are of n-type semiconducting nature.

Keywords: nanocrystalline thin films, structural properties, electrical properties, optical properties.

1.Introduction

Now a day's nanomaterial are extensively studied because of their improved physical properties than that of bulk. These novel physical properties makes them promising candidates for the various electronic devices such as solar cells, flat panel display, optical windows, phototransistors, gas sensors etc. In addition to this some photocatalyticnanomaterials like CuS, ZnS, WO, TiO_2, Sb_2O_3,ZnO are used in environmental applications such as water purification .[1-4]

Cadmium oxide is a widely studied nonstoichiometric n-type semiconductor because of its low resistivity of the order of 10^{-2}-$10^{-4}\Omega$ cm [5], wide optical band gap in the range 2.2-3.4 eV [6,13]. It is promising material for the various applications such as solar cells, PEC devices, phototransistors, photodiodes, liquid crystal displays, IR detectors, antireflection coatings, gas sensors, etc. Also AzadehTadjarodi et al [7]recently reported the photocatalytic activity of CdO nanoparticles against various azo dyes under the illumination of visible light.

Up till now CdO conducting thin films were grown onto different substrates using various techniques such as chemical bath deposition [8],spray pyrolysis [9], chemical vapor deposition [10], thermal evaporation technique [12], sol gel dip coating [11] , SILAR [4], etc. There are few results on the synthesis of CdO thin films by spray pyrolysis technique but no report was found by sol gel–spray technique.In the present work conducting thin CdO films were grown onto preheated glass substrates by spraying sol. The structural, optical, electrical properties of the films are discussed.

2. Experimental

Cadmium acetate dihydrate, 2-methoxy ethanol, monoethanolamine were purchased from sd fine (Mumbai) and used as it is without further purification. The amorphous micro glass slides from blue star,Mumbai were used as substrates. The substrate cleaning is very important for the uniform growth and adhesiveness of thin films. The glass slides were washed with liquid detergent and then boiled in concentrated chromic acid (0.5 M) for 1 h and then kept in it for next 48 h at room temperature. The substrates were then washed with double distilled water and finally cleaned in ultrasonic cleaner for 15 min.

To prepare sol, 10 gm cadmium acetate dihydrate was dissolved in 25 ml of distilled water[13]. To it 10 ml of 2-methoxyethanol was added. This mixture was then stirred at 60^0C for 10 minutes. Then the homogeneous and clear solution was obtained by adding 0.3 ml of monoethanolamine drop by drop. The solution was then edged at ambient for one day. This resultant solution was diluted by adding appropriate amount of double distilled water to prepare transparent spray solution.

The various deposition parameters such as nozzle to substrate distance, spray rate, substrate temperature were optimized by taking several trials. Finally, 30ml of as prepared solution was sprayed onto pre heated cleaned glass substrates at 340^0C by using compressed dry air as a carrier gas to get faint yellow transparent CdO thin films. These as deposited films were used for further characterization.

. The structural analysis was carried out on Philips PW 1710 diffractometer with CuKα radiation of wavelength 1.5406 A^0. Surface morphology was examined by using a JEOL 6380 scanning electron microscope. The optical characteristics were studied using Lambda 25 UV–VIS spectrophotometer (PerkinElmer). The dark electrical resistivity measurements were carried out in the temperature range 303–443 K using two-probe method.

The film thickness was measured by the gravimetric method, by considering bulk density of CdO using relation,

$$t = \frac{m}{A\rho} \quad (1)$$

Where, m is the mass of the film deposited onto the substrate, A is the area of the deposited film and ρ is the bulk density of CdO (8.15 g/cm^3). The as deposited thin films have the thickness of the order of 129 nm.

3. Results and discussion

3.1Structural studies: Fig.1 shows the XRD pattern of as deposited CdO thin film. The diffraction peaks (111), (200), (220), (311) show that as grown CdO thin films are polycrystalline in nature with cubic lattice. [JCPDS- 75-0593].

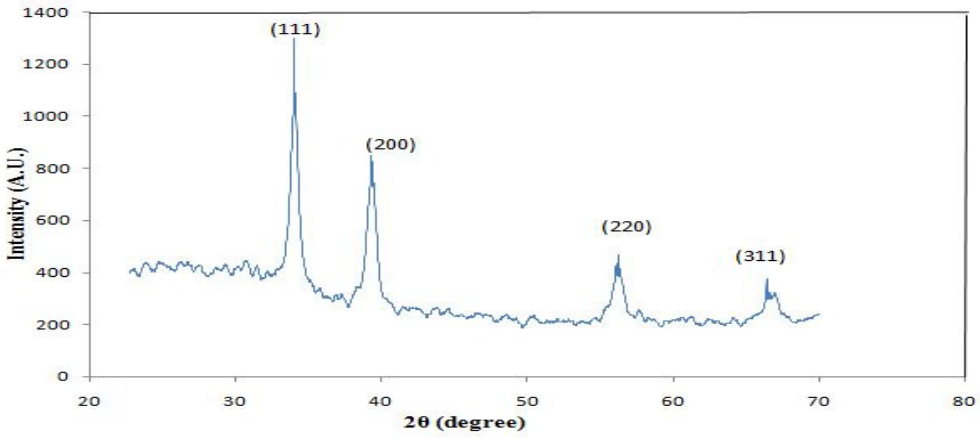

Figure 1: XRD pattern of sol gel-spray deposited CdO thin film

The crystallite size was estimated by using Scherrer's formula,

$$D = \frac{K\lambda}{\beta \cos\theta} \quad (2)$$

Where K is shape factor generally taken as 0.94, β is (FWHM) full width at half of maximum intensity in radian, θ is Bragg's angle in radian, λ is wavelength of CuKα radiation used (1.540 A^0).The crystallite size wasfound to be 19.7 nm.

3.2 Surface morphology: The SEM images of the as grown film at different magnifications are shown in fig 2.The SEM analysis shows uniform distribution of spherical type nanograins with porous morphology without cracks.

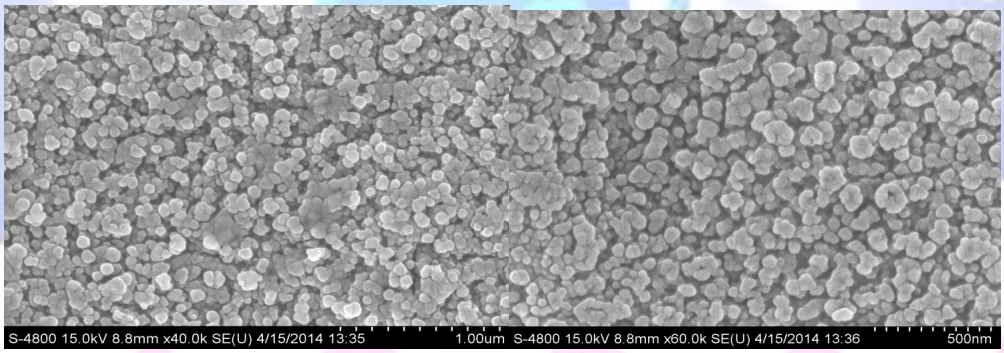

Figure 2: SEM images of CdO thin films

3.3 Optical studies: Optical absorption gives information about band gap energy and band structure. In the present investigation, optical absorption measurements for CdO thin film were carried out in the wavelength range 300–900 nm. Fig.3.The absorption edge of sample observed confirms the good optical band edge property of the sol gel-spray deposited CdO thin film.Thefundamental absorption which correspondence to electron excitation from the valance band to conduction band, can be used to determine the nature and value of the optical band gap. The nature of transition is determine by using Taucequation ,

$$\alpha h\nu = A(h\nu - E_g)^n \quad (3)$$

Where,α is absorption coefficient, $h\nu$ is photon energy, E_g is band gap energy, A and n are constants (n=1/2, 1/3, 2/3, 2).

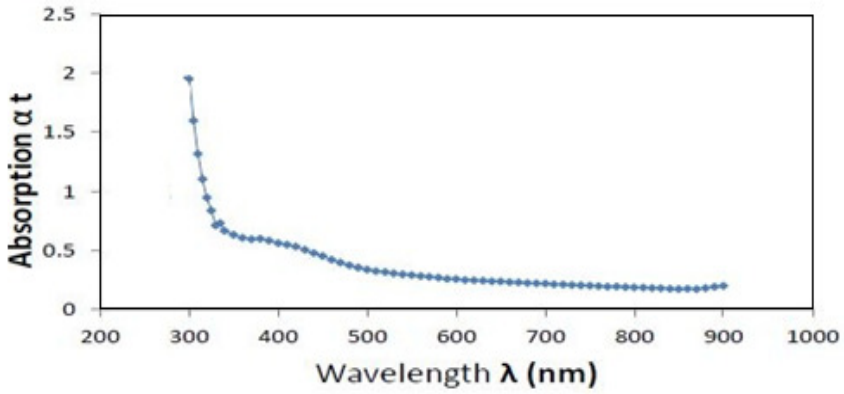

Figure 3: Plot of absorption vs. wavelength for CdO thin film.

Figure 4 shows plot of $(\alpha h\upsilon)^2$vs. hυ for CdO thin film. The linear nature of the plot suggests that the mode of optical transition in the film is of direct type. Therefore taking n=1/2, the direct optical band gap has been calculated by extrapolating the linear portion of the curve to photon energy (hυ) axis for zero absorption coefficient as shown in figure 4.

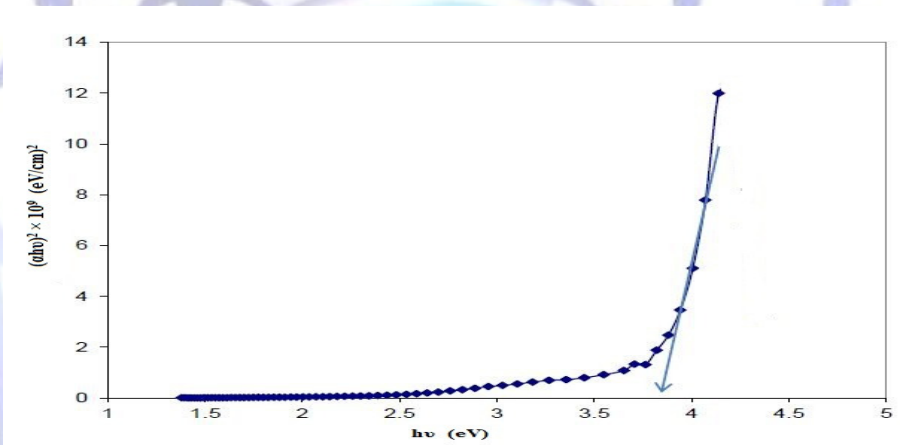

Figure 4: variation of $(\alpha hu)^2$vs. photon energy hu of CdO thin film

The optical band gap of CdO thin film is found to be 3.8 eV. This value is quite large as that of bulk whichmay be due to its crystal structure, particle size and strain in the film [14].

3.4 Electrical analysis: The electrical resistivity of CdO thin films was studied in the temperature range 303 to 443 K using dc two-point probe method. Figure 5 shows the variation of log of resistivity log(ρ) with reciprocal of temperature $(1/T)\times10^3$. It is seen that resistivity decreases with temperature, indicating its semiconducting nature. The thermal activation energy was calculated by using the relation,

$$\rho = \rho_0 e^{\frac{\Delta E}{KT}} \qquad (4)$$

Where, ρ_0 is constant, T is the temperature, E is activation energy, K is Boltzmann's constant. Thermal activation energy of as deposited film was found to be 0.051 eV.

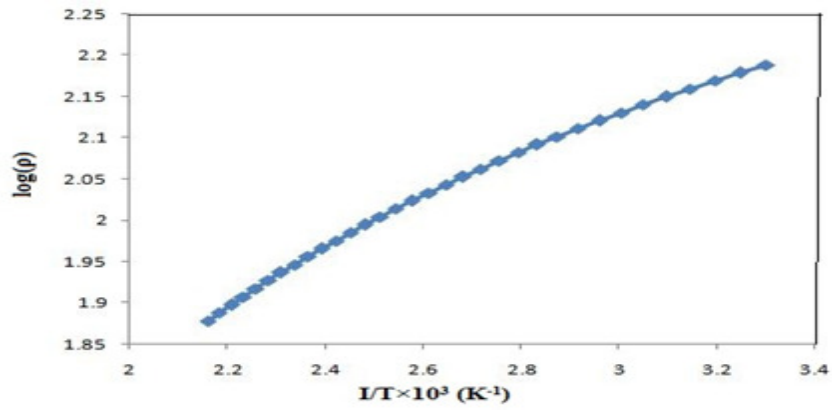

Figure 5: Variation of Log of resistivity vs. 1/T

The thermo-emf developed across hot–cold junction of CdO thin film was measured as a function of temperature difference.The polarity of the generated thermo-emf was negative at the cold end with respect to hot end, which confirms that CdO films are of n – type. Fig. 6 shows that, thermo-emf increases with increasing temperature difference this may be due to increased charge carrier concentration and their mobility.

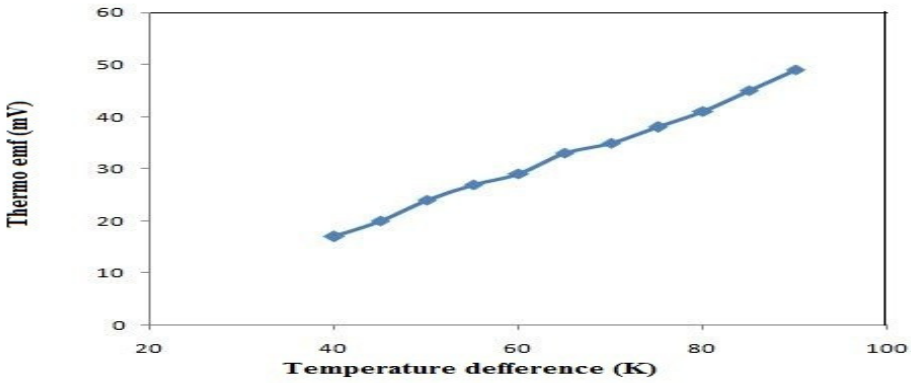

Figure 6:Variation of thermo- emf (mV) vs. applied temperature difference

4. Conclusions

Nanostructured CdO thin films were successfully grown onto glass substrates by sol gel-spray pyrolysis technique at 340^{0}C. The films are nanocrystalline with cubic lattice. The morphological studies revealed that the films are grown homogeneously with uniform grain size and with porous nature. The films are of n-type semiconductor with thermal activation energy 0.051eV. Optical analysis revealed that the CdO thin film exhibits direct optical band gap energy 3.8eV.

References

[1]Giin-Shan Chen, Chiaohung Cheng, Applied Catalysis B: Environmental 150– 151 (2014) 354– 362.

[2] N. Kaneva, A. Ponomareva, L. Krasteva, D. Dimitrov, A. Bojinova, K. Papazova, G. Suchaneck, V. Moshnikov, Bulgarian Chemical Communications, 45(4), (2013), 635–643.

[3]ShaohuaShen, Xiaobo Chen, FengRen, Coleman X Kronawitter, Samuel S Mao and LiejinGuo, Nanoscale Research Letters, (2011), 6:290.

[4] AssumptaC.Nwanya, P.R.Deshmukh, RoseU.Osuji, MalikMaaza, C.D. Lokhande, FabianI.Ezema , Sensors and Actuators B, 206, (2015) 671–678.

[5] Z. Zhao, D.L. Morel and C.S. Ferekides, Thin Solid Films ,413,(2002) , 203-211

[6] K.L. Chopra and S.R. Das,Thin Film Solar Cells, Plenum Press, NY, 57,(1983).

[7]AzadehTadjarodi, Mina Imani, HamedKerdari, KeyvanBijanzad, DorsanKhaledi and Maryam Rad; NanomaterNanotechnol,4(16), (2014).

[8] R.R. Salunkhe, V.R. Shinde, C.D. Lokhande, Sens. Actuators B, 133, (2008), 296.

[9] B.G. Jeyaprakash, K. Kesavan, R. Ashok kumar, S. Mohan, A. Amalarani; J.Ameri. Sci. 6(2), (2010) 75-79.

[10]T.P. Gujar, V.R. Shinde, Woo-Young Kim, Kwang-Deog Jung, C.D. Lokhande, Oh-Shim Joo, Applied Surface Science, 254 ,(2008), 3813.

[11] P.K. Ghosh, R. Maity, K.K. Chattopadhyay, Sol. Energ. Mat. Sol.C.,81, (2004), 279.

[12] Mahdi.H.Suhail, IssamM.Ibrahim and G. Mohan Rao, J. Electron Devices,13, (2012), 965.

[13] A. U. Ubale , S. S. Wadnerkar , P. N. Sonone and G. D. Tayade, Archives of Physics Research, 5 (6) (2014), 43-48.

[14] Ashok U. Ubale, Yogesh S. Sakhare, Monali V. Bhute, Milind R. Belkhedkar, Arvind Singh, Solid State Sciences, 16, (2013), 134-142.