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EFFECT OF THICKNESS ON THE STRUCTURE AND OPTICAL PROPERTIES OF LASER-INDUCED PLASMA CDO THIN FILMS

Hiyam Ch. MAJED[1]

Abstract

Thin films of cadmium oxide (CdO) deposited on glass substrates using Nd-YAG laser wavelength (alpha= 532 nm) and period time (10ns) via laser-induced plasma deposition technique (PLD). The structural properties of these films have been described as a change in thickness (200 , 400 ,and 1000) nm) at substrate temperature of (400 ° C) and energy flounce of (0.4 J / cm2). The X-ray diffraction results show that he mean size of crystallite measured using Scherer formula to adjust the thickness of 200 nm, 400 nm and 1000 nm of CdO thin films is 47 nm, 64 nm and 78 nm respectively .Also the optical properties which included transmittance, absorbance , energy gap and optical constant such as the Refractive index, extinction coefficient real and imaginary parts of dielectric constants were determined .

Keywords: Cadmium Oxide, Pulsed Laser Deposition, XRD, Transparent Conducting Oxide, Structure Properties.

[1] Al-Mustansiriyah University, Iraq, halhelfy@yahoo.com

Introduction

Cadmium oxide is a thermally highly insoluble composite; it is known that it cannot be tested by water or acid. It has a crystal structure with central faces such as NaCl structure with a lattice constant about (a=4.69Å) and molecular weight about (128.4 g / m), density (8.15 g / cm3)[1]. It occurs naturally as a monteponite mineral and is produced commercially by oxidizing cadmium vapour. Oxide to cadmium c Because of their applications in various technologies [4], the community of IIB-VIA oxides has shown much interest. Notably in zinc blonde (B3), quartzite (B4), the semiconducting combination of this group crystallizes, Both or both. One of the binary oxides with important electrical, structural and optical properties is cadmium oxide (CdO), which occurs naturally as the rare mineral monteponite [5].The deposition of thin films containing cadmium oxide is carried out using many methods of deposition. Chemical vapor deposition (CVD) contains these, sputtering of [6] magnetrons,[7] paralysis spray [8, 9] and deposition laser pulsed [10, 11]. PLD has many advantages compared to other approaches, The composition of the films produced by PLD, for example, is very similar to that of the target, (ii) the surface film is so smooth; (iii) Due to the high kinetic energy (> 1 eV) of plasma-generated atoms and ionized species in the laser, good quality films can be deposited at room temperature. [12].In this analysis, thin CdO films using laser induced plasma were prepared on glass substrates at a temperature of 400oC and Analysis of the structural and optical properties of the deposited thin films.

2. Experimental Procedure

Using pulsed laser ablation, high purity (99.99 %) cadmium oxide powder was used as a source for deposition of CdO films on soda lime glass substrates (2.5x5) cm2. The glass substratum was first treated with detergent and washed respectively in running water and alcohol concentration (96%). Then, the substrates dried with a fine tissue paper and washed in an ultrasonic cleaner with isopropyl alcohol (IPA). The mixture powder was pressed cold at 10-6 Pa films using a hydraulic press, The CdO thin film were prepared by sublimated plasma vapors by generating them with a PLD laser device pulsed, The 1064 nm Nd: YAG laser wavelength was used. The rate of repetition was 10 Hz and the target fluency was set at 60J /cm2 for all samples., the distance from the target to the quartz substratum was preserved tt 2,5 cm. Using a turbo molecular pump, the chamber was first evacuated to a base pressure (below 5 *10-4 Pa) and then fed into the chamber with a gas pressure of 10 Pa oxygen gas (99.99 percent oxygen gas). purity).For all experiments the time deposition of 30 min has been preserved. The films were deposited at various substrate temperatures .X-ray diffraction (XRD, Rigaku Dymax) investigated the crystal structure of 40 kV and 250 mA films with a reference Cu and a mono-chronometer. Film thickness was (200 ,400 and1000)nm .

Weighing method was used to measure the film thickness using following formula:

$m=2\pi\rho m r2$…….. (1)

Where m is the mass of the substance that has been evaporated, r is the distance between the boat and the substratum, the density of the material being miss.

The UV-VIS spectrophotometer was used to test the optical properties of the deposited thin films were calculated as a function of the photon energy in the range of (300-900) nm.

3. Results and discussion

A. Structural Properties

Figure (1) reveals the XRD spectrum of CdO Nano powders at different thicknesses 200 nm, 400 nm and 1000 nm. The peaks were observed in (002), (211) and (310) plans (Joint Committee on Powder Diffraction Standards, Powder Diffraction File No. JCPDS-41-1445) (ICSD data) [13]. XRD patterns showed that the CdO nanoparticles are met in tetragonal phase used. [14]

$D=k\lambda/\beta \cos \theta$ …….. (2)

Where D is the average crystallite size, K is shape factor (0.94), θ is (Bragg's angle) in the degree , and β is the full width at half maximum (FWHM) of the radiant diffraction point. The mean size of crystallite measured using Scherer formula to adjust the thickness of 200 nm, 400 nm and 1000 nm of CdO thin films is 47 nm, 64 nm and 78 nm respectively

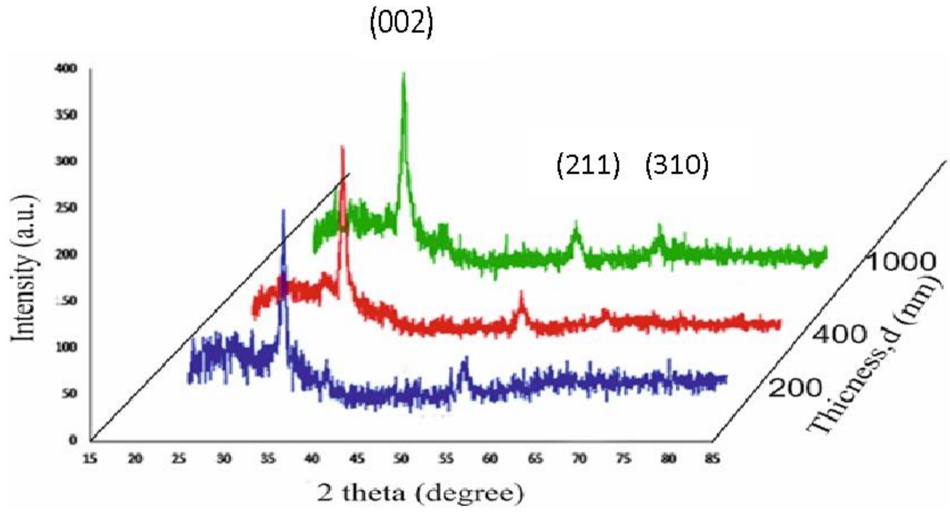


Figure (1) shows the XRD spectrum of CdO Nano powders at different thicknesses 200 nm, 400 nm and 1000 nm

B. Optical Properties

Figure (2) shows the CdO absorption spectra with different thickness of 200 nm, 400 nm and 1000 nm prepared by PLD technique as a function of the wavelength in the rang (300 -900)(nm) It displays the optical absorbance members and indicates that the film's absorbance steadily decreases with an increase in wavelength. All films deposited with different thicknesses show high absorbance in the UV-Vis region and then decrease with increasing of wavelength. Also we can notice from the figure that the absorption in general increases with increasing of film thickness. this may be attributed to none uniformity in the depth composition.

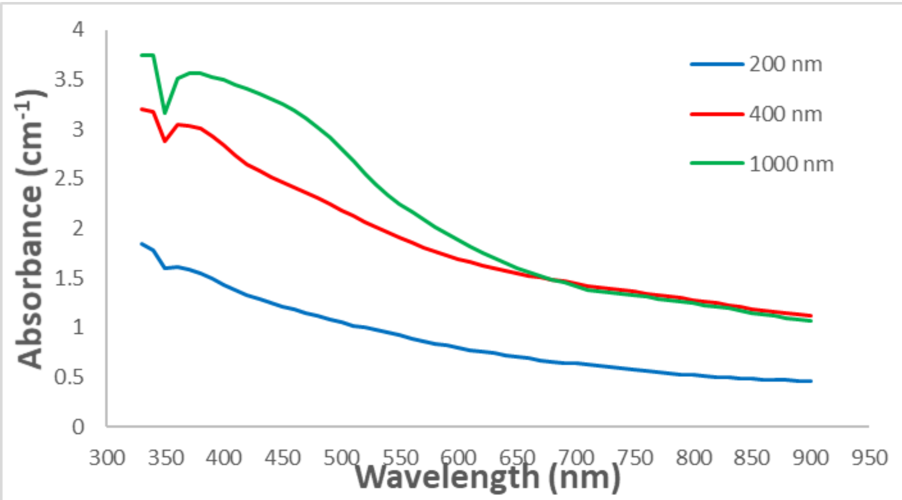


Figure (2) shows the absorbance as a function of wavelength of different thicknesses of CdO thin films

Transmittance spectra observed for CdO as a function of the wavelength in the range of 300-900 nm is shown in the Figur(3). Transmittance (T) was given by the intensity ratio of the transmitting rays(IT), by the film to the intensity of the incident rays (Io) on it [15]:

T=IT/IO…….. (3)

The transmittance was found to increase with the increase in wavelength. The transmittance diminishes with thickness increase. The 200 nm film deposited displays a higher transmittance compared to 400 nm and 1000 nm.

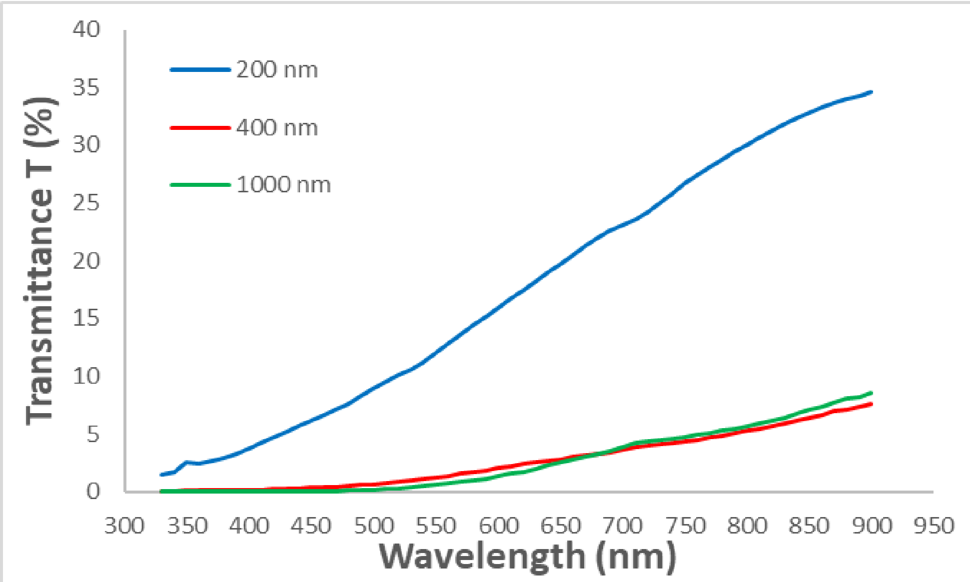
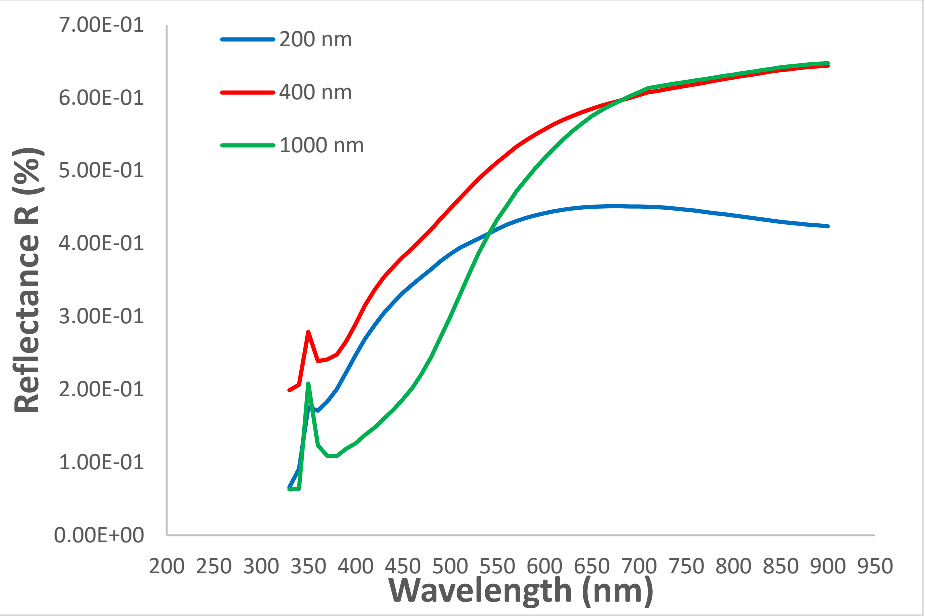


Figure (3) Transmittance spectrum as a function of wavelength of CdO thin films versus thickness

Figure 4. shows the relationship between reflectivity and wavelength, the relationship will obtain reflectivity from the spectrum of absorption and transmission according to the energy conservation law of the following equation:

R +T +A = 1…….. (4)

A rapid increase in reflectance intensity with wavelength increase for all thicknesses 200 nm, 400 nm and 1000 nm, where the reflectance was less than 200 nm .In other words less reflectivity was less dense.



Figuer (4) reflectance spectrum of CdO thin films versus thickness

Figure (5). depicts the relation between the coefficients of absorption versus the energy of photons. The coefficient of absorption (α) is determined using equation: [16]

$$\alpha = \frac{(2.303 * A)}{d} \quad \text{........ (5)}$$

Where α is the coefficient of absorption, A is the absorbance and , hυ is the photon's energy
It was observed that as thin films deposited, the absorption coefficients decrease with an increase in thickness of the film deposited at 200 nm and 400 nm thickness displays small absorption coefficients as compared to 1000 nm thickness.

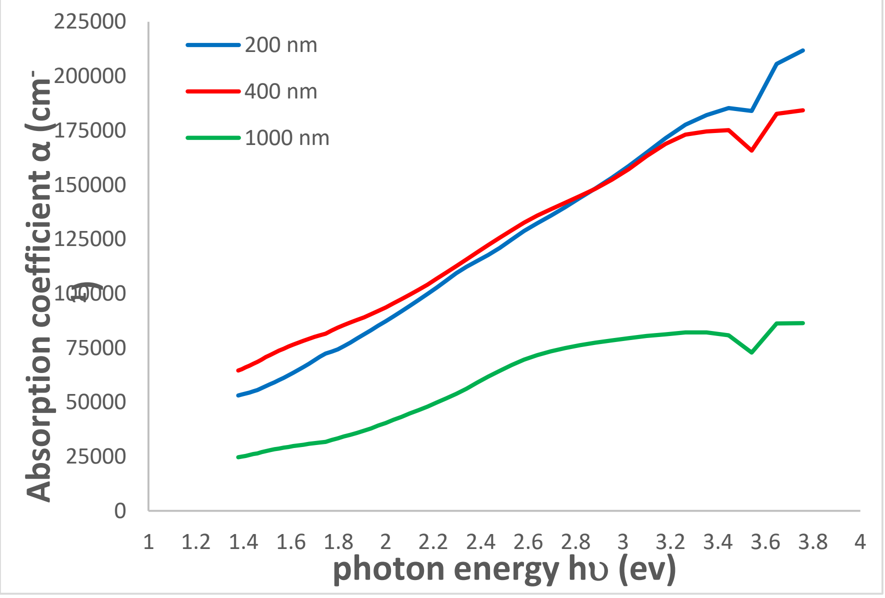


Figure (5) Absorption coefficient of CdO thin films versus thickness

Figures (6 , 7 and 8).Illustrate the energy of the photon versus the energy of the photon:[17] .The energy gap (Eg) can be calculated :

. (αhv)2 = A (hv-Eg) …….. (6)

From the graphs it was clear that there is a shift in band edge in the visible region by growing the deposit film thickness from200 nm, 400 nm and 1000 nm deposited by PLD on glass substratum. For thin films CdO, it is observed that an increase in CdO thickness resulted in a small reduction in the optical band gap of 2.4eV, 2.3eV and 2.05eV respectively.

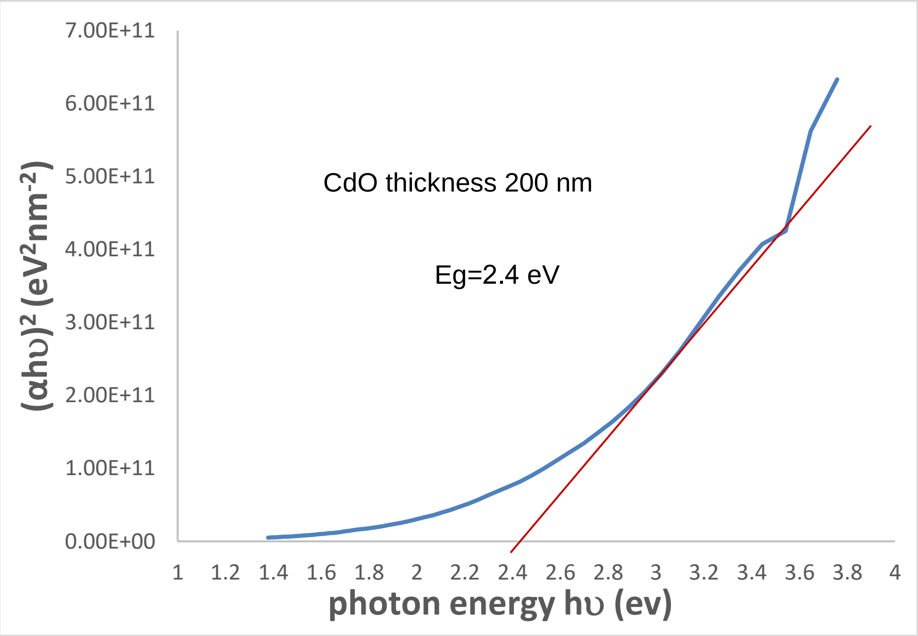


Figure (6) distribution of CdO thin films per photon energy.

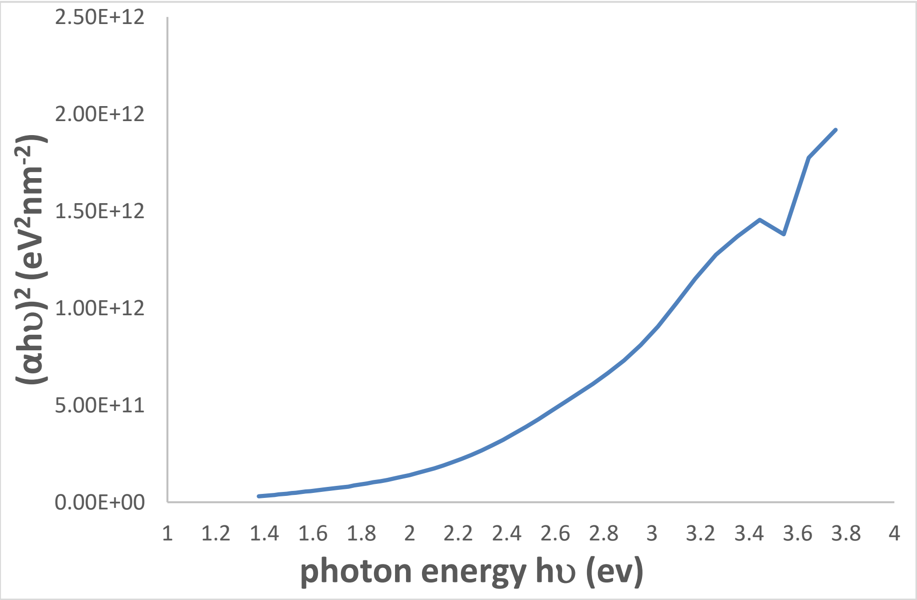


Figure (7) $(\alpha h v)^2$ CdO Thin Films versus Photon Energy.

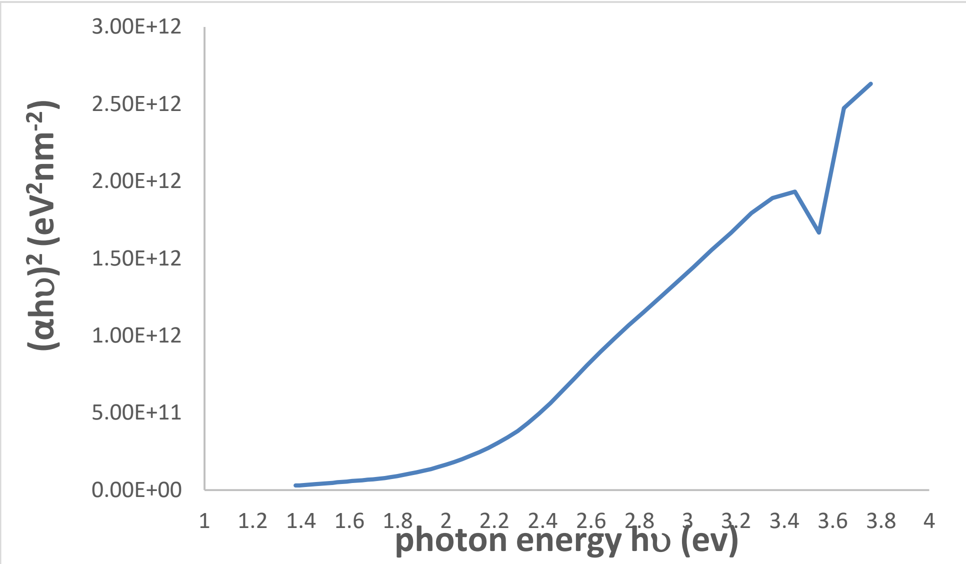


Figure (8) Vs the photonic energy of CdO thin films.

Figure 9. shows the refractive index relationship and photon energy, the refractive index can be taken into account as follows: [18].

$$n = \frac{1+R}{1-R} + \sqrt{\frac{4R}{(1-R)^2} - K^2} \quad \ldots\ldots$$

Where k is the rate of Extinction and can be calculated by [19]:

$k = \alpha\lambda/4\pi$ …….. (8)

For all CdO thin film thicknesses, 200 nm, 400 nm and 1000 nm, we noticed a rapid decrease in refractive index value with an increase in photon energy, but at thickness 200 the refractive index was the lowest.

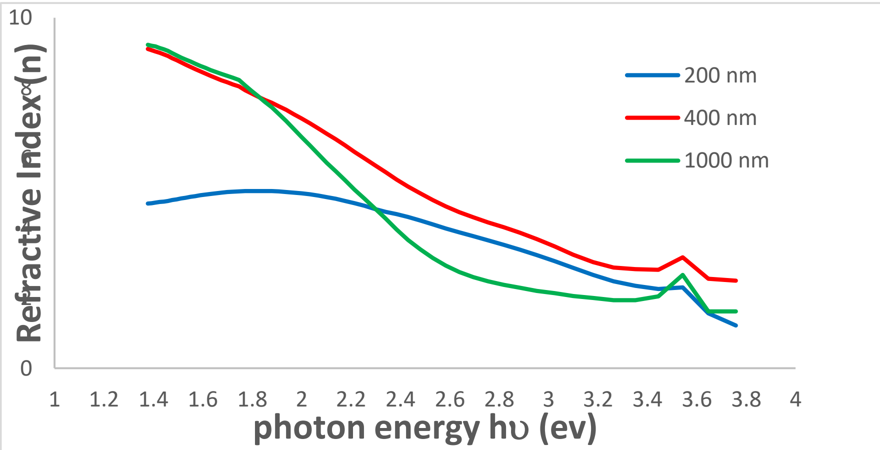


Figure (9) Refractive index for CdO thin films versus photon energy

Figure (10). shows the coefficient relationship of extinction and photon energy.For each curve we find that the behavior of the curves is the same. Increasing the extinction coefficient as photon energy increases. The effect of thickness on With increased thickness, the value of the extinction coefficient decreases. [20]. Find that the coefficient value decreased at extinction with increase in thickness.

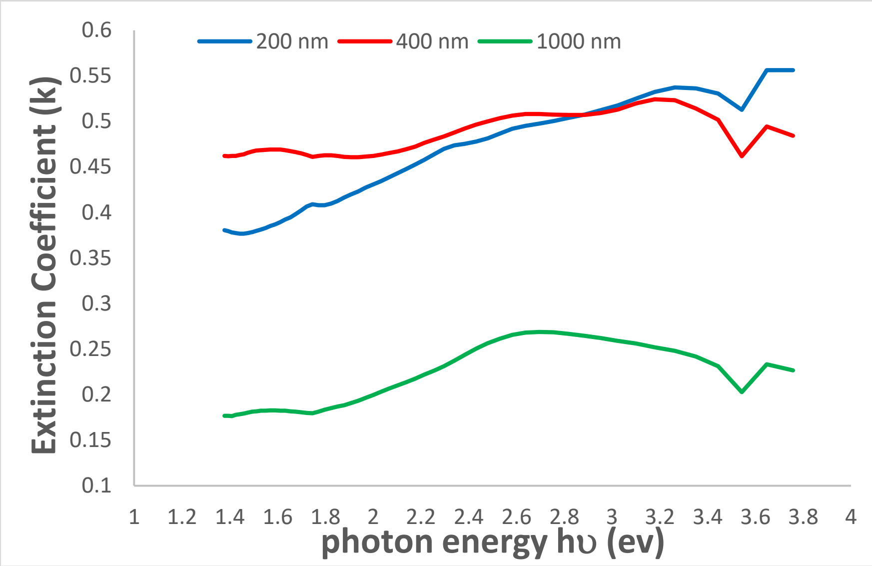


Figure (10) extinction coefficient for CdO thin films versus photon energy.

Figure (10) extinction coefficient for CdO thin films versus photon energy.

The actual part depended on the coefficient of refractive index and extinction according to the equation: [21]

ε1= n2-k2…….. (10)

ε1 - real part of dielectric constant

figure (11). shows the relationship between dielectric constant real component and photon energy. However, when increasing photon energy a sharp reduction in the real part of the dielectric constant.

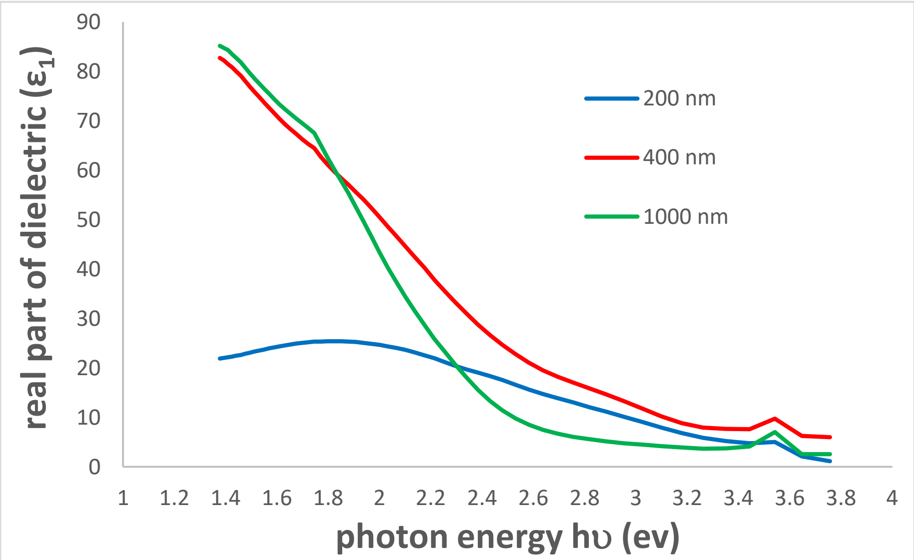
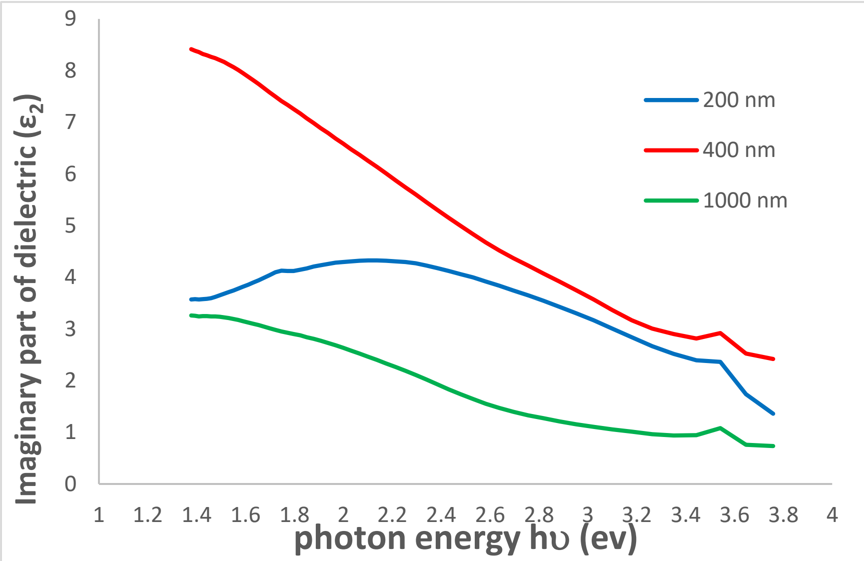


Figure (11) The real part of the dielectric constant of CdO thin film versus photon energy.

Figure(12). Shows the relationship between the imaginary component of dielectric constant and the energy of photons.From the refractive index and extinction coefficient the imaginary component could be calculated according to the following equation: [21]

$\varepsilon 2 = 2\ n\ k$…….. (11)
ε2 – imaginary part of dielectric constant

We find a connection between this relationship and the extinction coefficient curve, since it depends with great degree on the extinction coefficient. Increase in photon energy, decrease in value of the imaginary part of dielectric constant, but their values were less than the actual part of the dielectric constant when the thickness of 1000 nm was greater.



Figure(12)Imaginary portion of CdO thin film dielectric constant versus photon energy.

4. Conclusion
In this analysis, thin cadmium oxide films were produced using plasma particle by the pulsed technique of laser deposition. Using a profilometer, these thin films were examined through UV-VIS absorption spectra and their thickness. Pulsed Nd : YAG laser was used to prepare thin CdO films with identical pulse energy as well as annealing temperature under O2 gas condition. As-grown film's optical properties such as the Refractive index, reflectance and transmutation.

References
Patnaik, Pradyot (2003). Handbook of Inorganic Chemical Compounds. McGraw-Hill. ISBN 0-07-049439-8.
T. L. Chu; Shirley S. Chu (1990). "Degenerate cadmium oxide films for electronic devices". Journal of Electronic Materials 19 (9): 1003–1005. Bibcode:1990JEMat..19.1003C. doi:10.1007/BF02652928.
S. K. Vasheghani Farghânî; et al. (2013). "Temperature dependence of the direct bandgap and transport properties of CdO". Applied Physics Letters 102 (2): 022102. Bibcode:2013ApPhL.102b2102V. doi:10.1063/1.4775691.
4.H. Liu, H. Mao, M. Somayazulu, Y. Ding, Y. Meng, and D. Häusermann, "B1-to-B2 phase transition of transition-metal monoxide CdO under strong compression," Physical Review B, vol. 70, no. 9, Article ID 094114, 5 pages, 2004. View at Publisher · View at Google Scholar · View at Scopus.
5C. E. Sims, G. D. Barrera, and N. L. Allan, "Thermodynamics and mechanism of the B1-B2 phase transition in group-I halides and group-II oxides," Physical Review B, vol. 57, no. 18,

pp. 11164–11172, 1998. View at Publisher · View at Google Scholar · View at Scopus.
A. Schleife, F. Fuchs, J. Furthmüller, and F. Bechstedt, "First-principles study of ground- and excited-state properties of MgO, ZnO, and CdO polymorphs," Physical Review B, vol. 73, no. 24, Article ID 245212, 14 pages, 2006. View at Publisher · View at Google Scholar · View at Scopus.
H. Liu, J. S. Tse, and H. Mao, "Stability of rocksalt phase of zinc oxide under strong compression: synchrotron x-ray diffraction experiments and first-principles calculation studies," Journal of Applied Physics, vol. 100, no. 9, Article ID 093509, 5 pages, 2006. View at Publisher · View at Google Scholar.
F. Peng, Q. Liu, H. Fu, and X. Yang, "First-principles calculations on phase transition and elasticity of CdO under pressure," Solid State Communications, vol. 148, no. 1-2, pp. 6–9, 2008. View at Publisher ·View at Google Scholar · View at Scopus.
R. J. Guerrero-Moreno and N. Takeuchi, "First principles calculations of the ground-state properties and structural phase transformation in CdO," Physical Review B, vol. 66, no. 20, Article ID 205205, 6 pages, 2002. View at Publisher · View at Google Scholar · View at Scopus.
B. S. Rao and S. P. Sanyal, "High pressure structural phase transition in BaSe and BaTe," Physica Status Solidi B, vol. 165, no. 2, pp. 369–375, 1991. View at Publisher · View at Google Scholar.
J. HU and Gordon, R. G. J. Appl. Phys., (1992), 71, 880.
Aiping Chen, Hua Long, Xiangcheng Li, Yuhua Li, Guang Yang and Peixiang Lu, Vacuum, 83 (2009) 927.
Joint Committee on Powder Diffraction Standards, Powder Diffraction File No.JCPDS-41-1445) (ICSD data).
A.C. Bose, P. Thangadurai, S. Ramasamy, Grain size dependent electrical studies on nanocrystalline SnO 2, Materials chemistry and physics 95 (2006) 72-78.
Al-Sabayleh M.A., "The effect of substrate temperature on the optical properties of spray deposited ZnS thin films prepared from non-aqueous media "Al-Qura Univ. J.Sci.Med.Engg., 20, 2008,pp 17.
W.Miao, X.Li, Q.Zhang, L.Huang, L.Zhang and X.Yan,"Transparent conducting In2O3 doped Mo thin films prepared by reactive direct current magnetron sputtering at room temperature".Thin Sold Films, 500, 2006, pp 70.
V.R.Shinde, T.P.Gujar, C.D.Lokhande, R.S.Mane and S.H.Han, " Mn doped and undoped ZnO films: A comparative structural, optical and electrical properties study" Mater.Chem.Phys., 96, 2006,pp 326.
Aktaruzzaman, A. F., Sharma, G. L. Thin Solid Films, (1991), 198, 67. And Malhotra, L. K. [9] Goyal, D., Solanki, P., Maranthe, Takwale, M. and Bhide, V B., Jap. J. Appl. Phys. 1, (1992), 31, 361.
Suzuki, A., Matsushita, T., Wada, Sakamoto, Y. and Okuda, M. N., Jap. J. Appl. Phys. 2, (1996), 35, L56.
Hiramatsu, M., Imaeda, K., Horio, Nawata, M. N. J. Vac. Sci. Technol. A, (1998), 16, 669.
Chrisey, B. D. and Hubler, G. K. Pulsed laser deposition of thin films, Wiley, (1994).