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Study the properties of CdO thin film Prepared by 1064 nm and 532 nm Nd:YAG laser

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Abstract

In the present work, we studied Cadmium oxide CdO thin films were deposited by pulsed laser deposition technique at different wavelength laser on glass substrates. They found The XRD analysis shows that CdO films are polycrystalline with cubic structure. Transmittance decreased with increasing and laser wavelength also that the same behavior for energy gap, and absorption coefficient have been calculated. The sensitivity of the CdO film to NO_2 gas have been calculated.

Keywords: Cadmium Oxide, Pulsed Laser Deposition ,X-Ray, UV-Visible, Gas Sensor.

Introduction

Pulsed laser deposition (PLD) is an extremely simple technique, which use pulses of laser energy to remove material from the surface of a target. That technique has been used to deposit high quality films of materials for more than a decade. The technique uses high power laser pulses (typically~108 Wcm^{-2}) to melt, evaporate and ionize material from the surface of a target. This "ablation" event produces a transient, highly luminous plasma plume that expands rapidly away from the target surface. The ablated material is collected on an appropriately placed substrate upon which it condenses and the thin film grows. Applications of the technique range from the production of superconducting and insulating circuit components to improve wear and biocompatibility for medical applications. In spite of this widespread usage, the fundamental processes occurring during the transfer of material from target to substrate are not fully understood and are consequently the focus of much research[1]. A considerable attention has been paid to pure cadmium oxide CdO for its wide range of applications in optoelectronics like transparent conducting oxide (TCO), solar cells, smart windows, optical communications, flat panel display, photo-transistors, as well as other type of applications like IR heat mirror, gas sensors, low-emissive windows, thin-film resistors, etc. [2,3– 6]. Cadmium oxide is conducting, transparent in the visible region with a direct band gap of (2.2–2.5) eV. CdO is an n-type semiconductor [7,8]. CdO films have a cubic structure such as NaCl, lattice constant equal 4.69 A[9].

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Experimental

Cadmium oxide CdO used in this experiment is a Pellet with diameter 1cm and 0.2cm thick and it was powder then compressed under pressure 5Ton. The glass substrate of microscope, have width 75mm × length 25mm × thickness1.2 mm). The glass were cleaned chemically and ultrasonically.

The deposition process occurs inside the vacuum chamber and the pressure of vacuum is about (10^{-2}Torre).for high emission spectra and good deposition ,the laser(900mJ) focused on the target and makes with it angle 45. substrate temperature it is equal to room temperature (TS=RT). The preparation of the thin films is done by the Nd:YAG laser have a1064 nm and 532 nm and another parameters like the width of Pulse (10ns), frequency of laser (6 Hz), refrigeration system. A cycle of cold water.

For study the structural characteristic, the analysis of crystalline structure is done by SHIMADZU 6000 XRD system . the intensity is register as a function of Bragg's angle. The Cu radiation source has a wavelength (1.5406Å), I (30mA) and V (40 kV). The angle of scanning is 2θ is to be in the scale of (20 – 60) degree with a velocity of 4 deg/min.

Absorption and transmittance are measured by a UV/VIS Spectraphotometer (Metertech) SP8001, for CdO samples that prepared by (PLD). The energy gap in this test is measured by the absorption coefficient of different wavelengths, calculated using reflectivity and transmittance data.

In order to fabricate the gas sensor, a special mask needs to be fixed carefully on the surface of CdO layer. Interdigitated aluminum ohmic metal contacts are deposited on the CdO films by using vacuum evaporation technique. And finely to determine the sensitivity of the sample. the sample is placed inside the chamber and raise the temperature of the chamber and

then open the gas NO_2 to be observed change in resistance sample.

Results and Discussion

Characterization by X-rays

XRD studies were carried out in order to get an idea of the nature of the crystal structure of CdO thin films prepared by PLD technology. Through the study of diffraction X-ray, we can understand the crystalline growth of CdO films prepared by PLD on a glass slide at room substrate temperature. X-ray beam is diffracted at certain angles relative to the incident beam depending on the phases of the sample. When the crystal size is getting smaller to the nanoscale range then diffraction peaks broadening is observed and the width of the peak is directly correlate with the size of the nanocrystalline according to Debye Scherrer formula.

$$\mathbf{D} = \frac{K\lambda}{\beta\cos\theta} \quad \text{..... (1)}$$

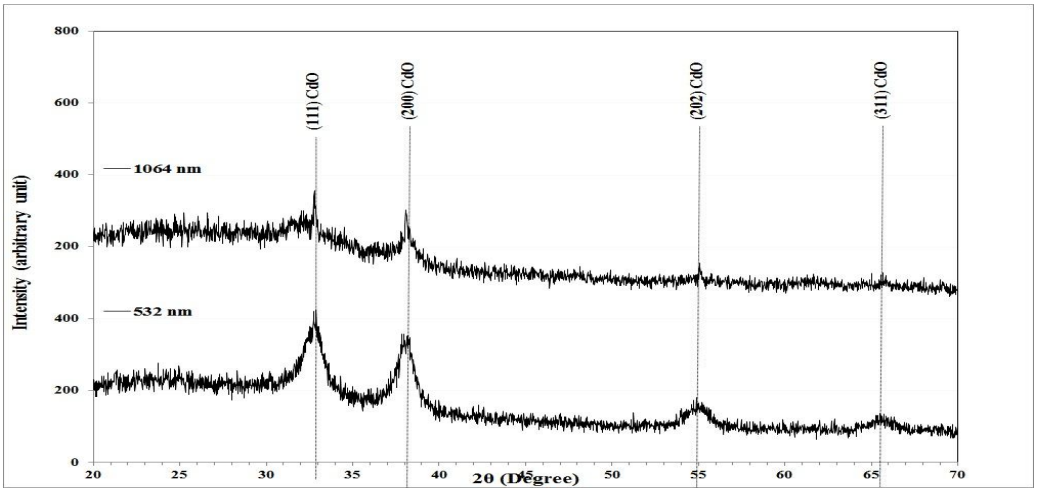

Figure I
X-Ray Diffraction for Thin Films at room Temperature

Figure (I) shows that the XRD patterns of CdO thin films after at room temperature be It can be observed that the films are polycrystalline having cubic phase, and a face centered cubic (fcc) structure with intensity peak along the plane (111),(200),(202) and (311).

Table 1
Shows the Peaks and its Bragg's Angle, Inter Planar Distance, and Full Width Half at Maximum for CdO Thin films at RT C Annealing Temperature

2θ (Deg.)	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	hkl	d_{hkl} Std.(Å)	Phase	Card No.
532 nm	32.7857	1.3572	2.7294	6.10	(111)	2.6848	Cub. CdO	96-900-6690
	38.0714	1.2372	2.3617	6.80	(200)	2.3251	Cub. CdO	96-900-6690
	55.0020	1.2857	1.66817	6.96876	(202)	1.6441	Cub. CdO	96-900-6690
	65.6429	1.3440	1.42116	7.03602	(311)	1.4021	Cub. CdO	96-900-6690
1064 nm	32.6786	1.0503	2.7381	7.89	(111)	2.6848	Cub. CdO	96-900-6690
	38.0714	1.0707	2.3617	7.85	(200)	2.3251	Cub. CdO	96-900-6690
	54.9286	1.1050	1.67022	8.10566	(202)	1.6441	Cub. CdO	96-900-6690
	65.5714	0.9643	1.42253	9.80257	(311)	1.4021	Cub. CdO	96-900-6690

Optical Properties

The optical properties of CdO films grown on glass substrate which involve the transmittance, absorption coefficient, the optical energy gap (E_g^{opt}). The transmission spectrum of CdO films at 900mJ laser energy and different laser wavelengths have

been determined using UV-Visible transmission spectrum in the spectral range (320-1100) nm as shown in fig II.

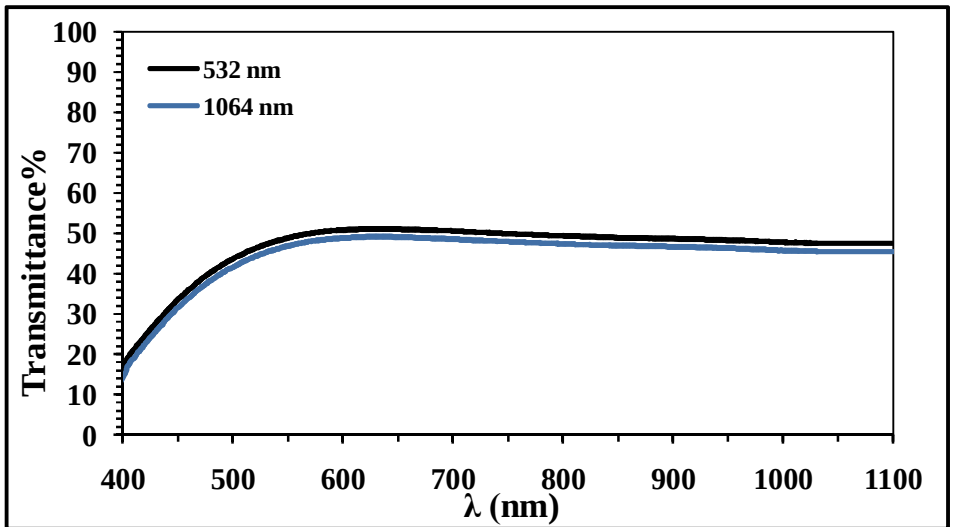

Figure II
Transmittance spectrum as a function of wavelength for CdO films that prepared by1064 nm and 532 nm laser

The transmittance of the second harmonic wavelength at 532nm is higher than the first wavelength 1064nm because of the amount of energy absorbed by the target [10]. And also The variation of the Absorption Coefficient as a function of the wavelength for deposited CdO thin films at 900 mJ energy and different laser wavelengths.

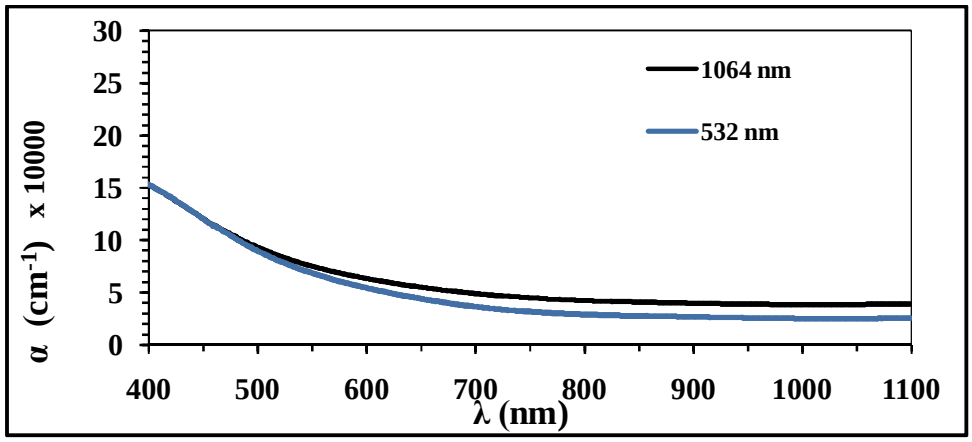

Figure III
Absorption Coefficient as a function of wavelength for CdO films that Prepared by1064 nm and 532 nm laser.

The reason for this is due to the increase in the crystal size in the CdO thin films with increasing laser pulse energy thus, the increase in size leads to increase absorption coefficient. The energy gap of pure CdO thin film also calculated, the energy gap values depends in general on films crystal structure, the arrangement and distribution of atoms in the crystal lattice, also it is affected by crystal regularity. Eg value is calculated by extrapolation of the straight line of the plot of $(\alpha h\nu)^2$ versus photon energy at different laser wavelengths.

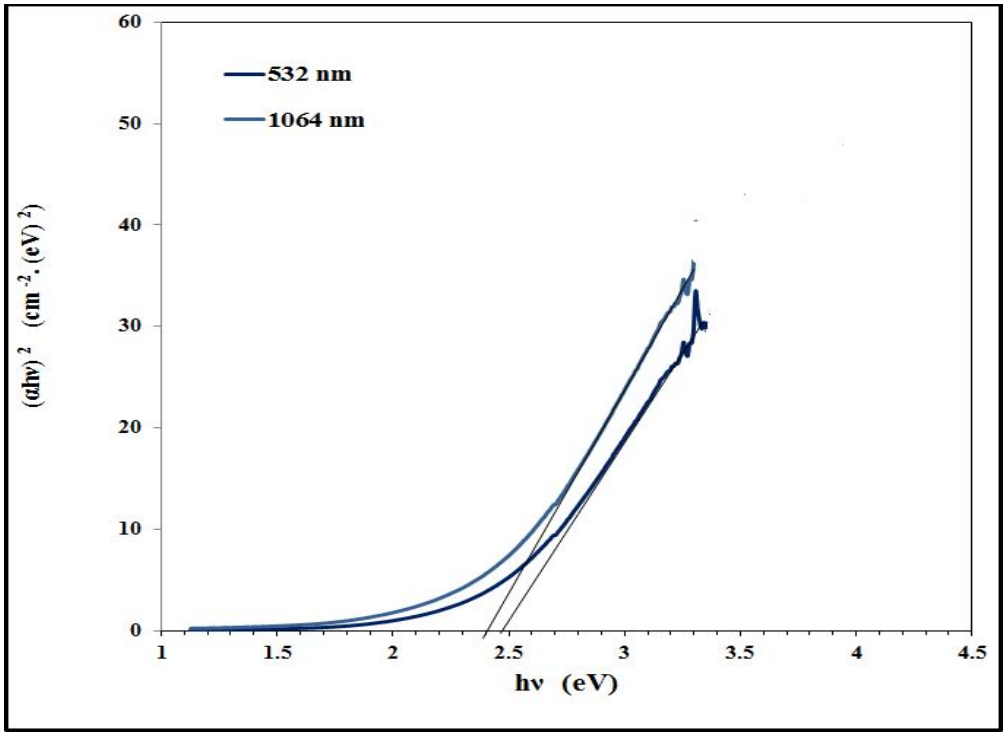

Figure IV
The energy gap as a function of wavelength for CdO films that Prepared by1064 nm and 532 nm laser

Laser wavelength plays an important role in the process of laser energy absorption by the target material, It has been found that at the shorter wavelength (532nm), the band gap energy is larger than that of the wavelength (1064nm). The reason for this is due to the high energy of the photon at 532nm which produces smaller nanoparticles and similarly with other semiconductors.

Gas Sensing Measurement

Sensitivity was calculated for the pure CdO that Prepared at various laser wavelengths of gas (NO_2) at 50ppm concentration. The sensitivity of thin films cadmium oxide thin films was calculated. The sensitivity experiment were done (NO_2 gas) at RT and then increased to 200 °C by 50 °C step. The Fig below shows the sensitivity as a function of the operating temperatures for CdO films where Prepared by using wavelength 532 nm is greater than thin film where Prepared by using 1064 nm This is because the fragmentation by 1064 nm photons only affects the larger nanoparticles, which have a high extinction coefficient. In contrast, the fragmentation produced at 532 nm leads to a reduction in the size of the nanoparticles in target [11].

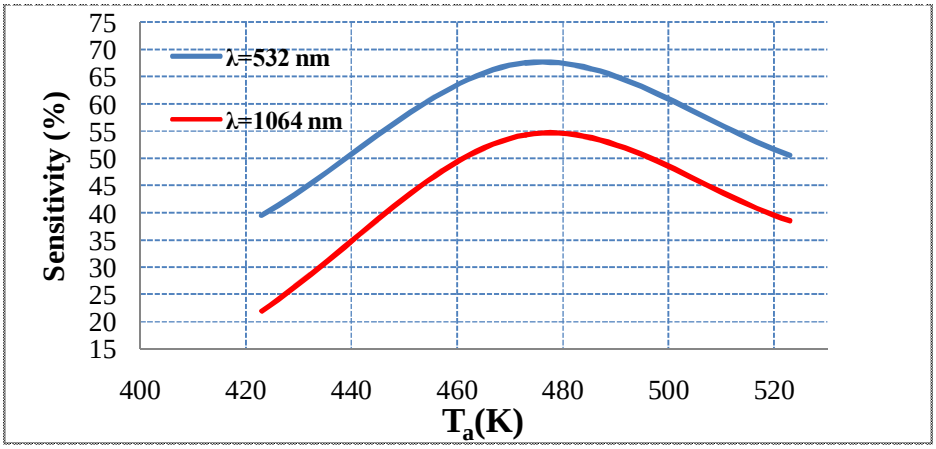

Figure V
The difference of sensitivity as a function of the operating temperatures for CdO samples for NO_2 gas

Conclusion

It is found that the crystallization of CdO was polycrystalline and that was found through X-ray diffraction results, with cubic phase. Transmittance decreased with increasing of laser wavelength Also that the same behavior for energy gap absorption coefficient increased with increasing of laser wavelength. The sensitivity of the CdO film to NO_2 gas was began at 423 K and the maximum sensitivity at 473K.The high sensitivity and fast response time is achieve produced at 532 nm that has small grain size.

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