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The Structure and Optical Properties of Ag doped CdO Thin Film Prepared by Pulse Laser Deposition (PLD)

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Abstract:

At a temperature of 300 K, a prepared thin film of Ag doped with different ratios of CdO (0.1, 0.3, 0.5) % were observed using pulse laser deposition (PLD). The laser, an Nd:YAG in λ=1064 nm, used a pulse, constant energy of 600 mJ ,with a repetition rate of 6 Hz and 400 pulses. The effect of CdO on the structural and optical properties of these films was studied. The structural tests showed that these films are of a polycrystalline structure with a preferred orientation in the (002) direction for Ag. The grain size is positively correlated with the concentration of CdO. The optical properties of the Ag: CdO thin film we observed included transmittance, absorption coefficient, and the energy gap in the wavelength range of 300-1100 nm. The prepared films, direct energy gap is negatively correlated to concentration of CdO.

Keywords: Energy gap, Grain size, Silver.

Introduction:

Thin film technology is on the leading edge of the study of semiconductors, primarily by giving a clear idea of many of their physical and chemical properties (1). Pulsed laser deposition (PLD) is one versatile thin film deposition technique, where flashes of laser light are used to generate an atomic spray that produces a thin film (2). The advantages of this technique are speed, flexibility in the choice of material, greater control of growth in any environment, variable growth rate (3), epitaxy at low temperature and growth by varying laser parameters (4). The disadvantages of technique include uneven coverage (5), high defect or particulate concentration and mechanisms dependence on parameters not well understood (6).

Silver is nearly white lustrous (7) element with the highest electrical conductivity of all metals. Due to its great value as a precious metal, it has not been used as a semiconductor for optoelectronic applications. It is increasingly used in solar energy, where silver paste is used to convert solar energy into electrical energy (8). The crystalline structure of Ag is a cubic face (9). In addition to silver, the Cadmium oxide (CdO) cubic structure semiconductors are n-type (10) with a band gap of 2.18 eV at room temperature and have been utilized in optoelectronic devices, solar cells, and photodiodes (11).

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Material and Methods:

Ag and CdO were mixed together at (0.1, 0.3, 0.5) % wt using agate mortar for one hour under a five-ton hydraulic type SPE CAC to mask pellets at 1.5 and 3 cm diameters. Substrates were transferred to glass using deposition films. Then the glass bases were washed with water and washing powder and then distilled water. To ensure a clean surface, the rinse is placed in a beaker and placed inside the ultrasonic waves for 15 minutes. Pulse laser deposition at 600 mJ was used to achieve the desired, film thickness of 250 nm by using an optical interferometer with a repetition rate of 6 Hz. The laser used was an Nd:YAG in λ=1064 nm with 400 total pulses.

Results and Discussion:

- **x-ray diffraction measurements (XRD)**

This analysis was used to identify thin film quality and crystalline structure by X-ray diffraction on the thin film. Fig. (1) shows the results of x-ray diffraction measurements (XRD) for Ag-doped CdO thin film at 300K and a thickness of 250 nm on the glass substrates. All thin films have a polycrystalline structure and Ag cubic phase with a preferred orientation along 200. The average crystallite size (D) was measured by Debye-Scherer formula (12):

$$D = \frac{0.94\lambda}{\beta \cos\theta} \dots\dots (1)$$

Where θ is the degree of the diffraction peak, β is the peak width of the diffraction peak profile at half maximum.

Table (1) shows the effect of varying concentration on of the substrates and their effect on the degree on the film, when all the films are a polycrystalline a cubic structure. The d_{hkl} (full width at half maximum) and grain size are positively correlated to the concentration of CdO.

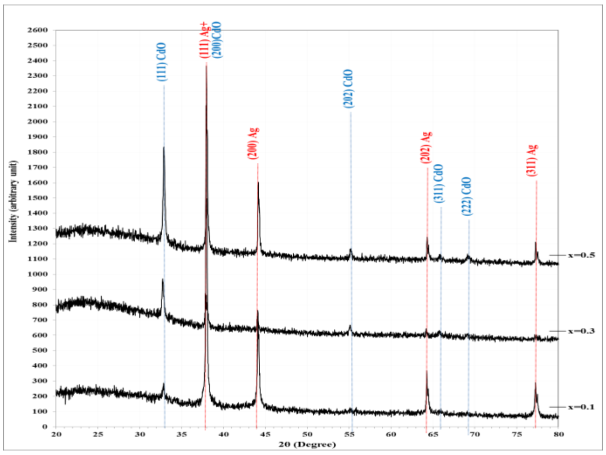


Figure 1. X ray diffraction patterns of Ag-doping CdO thin films at the 300K and different concentration of CdO (0.1, 0.3, 0.5) % wt.

Table 1. Result of the XRD for Ag-doping CdO thin films at the 300K and different concentration of CdO (0.1,0.3,0.5) % wt.

X	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	d_{hkl} Std.(Å)	Phase	hkl	card No.
	32.8395	0.3292	2.7251	25.2	2.7108	CdO	(111)	96-900-8610
	37.9424	0.2881	2.3695	29.2	2.3500	Tet. Ag	(111)	96-901-3049
0.1					2.3477	CdO	(200)	96-900-8610
	44.1152	0.2469	2.0512	34.7	2.0352	Tet. Ag	(200)	96-901-3049
	55.1440	0.4527	1.6642	19.8	1.6600	CdO	(202)	96-900-8610
	64.2798	0.2881	1.4480	32.6	1.4588	Tet. Ag	(220)	96-901-3049
	77.2840	0.2881	1.2336	35.3	1.2440	Tet. Ag	(311)	96-901-3049
	32.7572	0.2881	2.7317	28.7	2.7108	CdO	(111)	96-900-8610
	37.8601	0.3292	2.3744	25.5	2.3500	Tet. Ag	(111)	96-901-3049
					2.3477	CdO	(200)	96-900-8610
0.3	44.0329	0.2058	2.0548	41.6	2.0352	Tet. Ag	(200)	96-901-3049
	55.1029	0.3704	1.6654	24.2	1.6600	CdO	(202)	96-900-8610
	64.1975	0.2469	1.4496	38.0	1.4588	Tet. Ag	(220)	96-901-3049
	65.7202	0.3703	1.4197	25.5	1.4157	CdO	(311)	96-900-8610
	69.1358	0.4527	1.3576	21.3	1.3554	CdO	(222)	96-900-8610
	77.3663	0.4527	1.2325	22.5	1.2440	Tet. Ag	(311)	96-901-3049
	32.8807	0.2881	2.7217	28.8	2.7108	CdO	(111)	96-900-8610
	37.9424	0.2058	2.3695	40.8	2.3500	Tet. Ag	(111)	96-901-3049
					2.3477	CdO	(200)	96-900-8610
0.5	44.1564	0.2058	2.0494	41.7	2.0352	Tet. Ag	(200)	96-901-3049
	55.1852	0.2880	1.6631	31.1	1.6600	CdO	(202)	96-900-8610
	64.3210	0.2469	1.4471	38.0	1.4588	Tet. Ag	(220)	96-901-3049
	65.8436	0.4115	1.4173	23.0	1.4157	CdO	(311)	96-900-8610
	69.1770	0.5350	1.3569	18.0	1.3554	CdO	(222)	96-900-8610
	77.2840	0.3293	1.2336	30.9	1.2440	Tet. Ag	(311)	96-901-3049

- **optical measurements**

The study of the optical properties are closely related to the composition of the energy levels and the crystalline structure of the material prepared for Ag-doping with different concentrations of CdO (0.1, 0.3, 0.5) % wt, using UV-Vis light in the range of 300-1100 nm. The optical properties were studied for thin film prepared by PLD, and in preparation for conditions that included a baseline temperature of 300°C, an oxygen pressure of 0.1 mbar and a laser power of 600 mJ.

Fig. (2) shows the transmittance spectrum of Ag-doping with different concentrations of CdO on a glass substrate. We note that transmittance decreases slightly with increased vaccination rates and their values vary according to wavelength, most likely due to the fact that vaccination rates are low. This may lead to the formation of significant levels of impurities within the energy gap that lead to increased absorption and hence reduced permeability.

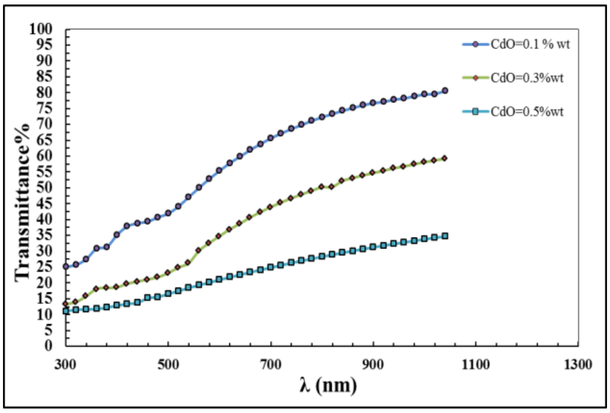


Figure 2. The transmittance for Ag-doped CdO thin films at the 300K and different concentrations of CdO (0.1,0.3,0.5) % wt.

The absorption coefficient behaves as absorption behavior, where increasing rates of vaccination to levels of added impurities within the energy gap. From fig. (3), we show the absorption coefficient changes as a function of wavelength that all films were fairly high values reached above $10^4 cm^{-1}$. This indicates a high probability of direct electronic transitions and the high energies these values were calculated for are the energies of a direct energy gap. The absorption coefficient is low at the low photonic energies and the probability of electronic transmissions is low. The absorption coefficient values increases at the absorption edge its high energies.

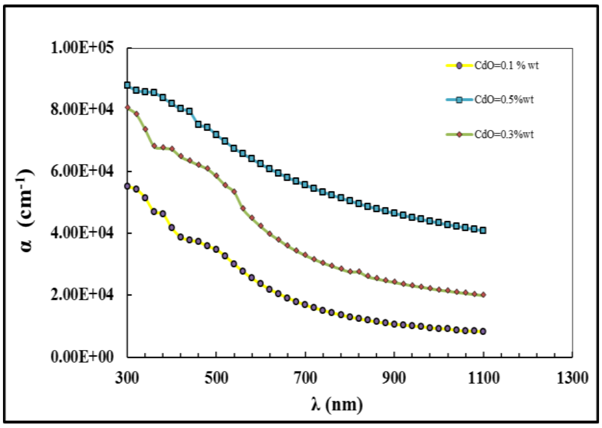
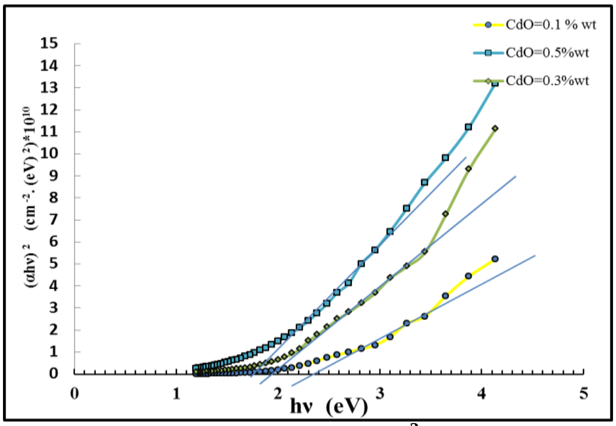


Figure 3. The variation of absorption coefficient wavelengths for Ag- doped CdO thin films at the 300K and different concentration of CdO (0.1,0.3,0.5) % wt.

Fig. (4) shows the (αhυ) as a function of hv for Ag-doping with different concentration of CdO thin film with the 250 nm thickness on the glass. The optical energy gap (Eg) determined by Tauc equation for the thin film (13):

$$\alpha(hv) = B(hv - E_g)^r \ldots\ldots.(2)$$

were B is a constant involving the properties of the bands, υ is the frequency of incident photon and, r is a constant depending on the nature of transition.
Extending the straight part of the curve to cut the photon energy axis at the point, we derive the value of the power gap prohibited for the direct transfer allowed.
Fig. (5) shows that there is a clear decrease in the value of the energy gap with an increase of the added concentration of CdO. This decrease in energy gap values was explained to the levels of CdO impurities within the energy gap. These levels are increased by increasing deflection rates, thereby reducing the width of the gap. It can be observed that the energy gap (1.8, 2, 2.4) decreased with the increased concentration of CdO.



Figure(4). The variation of $(\alpha hv)^2$ versus photon energy for for Ag- doped CdO thin films and different concentration of CdO (0.1,0.3,0.5) % wt.

Conclusion:

The pulse laser deposition (PLD) technique was used to grow the Ag:CdO thin film at 300K with different concentration of CdO at a thickness of 250 nm on glass. The results of x-ray diffraction indicated that all thin films have a polycrystalline structure and an Ag cubic phase, with a preferred orientation along (200) direction. The average crystallite size increased with the increase concentration of CdO. The optical transitions in CdS thin film is direct transition.

Conflicts of Interest: None.

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الخواص التركيبية والبصرية للأغشية الفضة المطعمة بأوكسيد الكادميوم المحضرة بتقنية الليزر النبضي (PLD)

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الخلاصة:

في درجة حرارة (300)كلفن تم تحضير اغشية رقيقة من مادة الفضة المطعمة بنسب مختلفة من اوكسيد الكادميوم (0.1,0.3,0.5) wt% بتقنية الليزر النبضي (PLD)وذلك باستخدام ليزر نوع ندميوم ياك وبطاقة ترسيب 600 مليجول باستعمال ليزر النيدميوم ياك النبضي وبمعلمات ترسيب ثابتة وهي الطول الموجي 1064nm عند طاقة ثابتة 600 ملي جول لمعدل تكرار6 هرتزوكان عدد النبضات المستخدمة(400) .تم دراسة تأثير إضافة تراكيز مختلفة من مادة اوكسيد الكادميوم على الخصائص التركيبية والبصرية للأغشية المحضرة. وأظهرت الاختبارات التركيبية للأغشية المحضرة أن هذه الأفلام هي أحادية التبلور والاتجاه السائد (222) لمادة الفضة ويلاحظ أن حجم الحبيبات يزداد بزيادة التراكيز. الخصائص البصرية شملت قياس النفاذية ومعامل الامتصاص وفجوة الطاقة لأطوال موجية تمتد من (300-1100)نانومتر. تبين ان الاغشية المحضرة تمتلك فجوة طاقة مباشرة تقل بزيادة التراكيز المضافة من مادة اوكسيد الكادميوم.

الكلمات المفتاحية: الحجم الحبيبي، فجوة الطاقة، الفضة.