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Synthesis and Characterization of $(CdO)_{1-x}\ Mg_x$ films by pulsed laser deposition

Jasim M. Hussein[1], Awatif S. Jasim[1], Kadhim A. Aadim[2]

[1]Department of Physics, College of Sciences, University of Tikrit, Iraq

[2]Department of Physics, College of Sciences, University of Baghdad, Iraq

E-mail: awatif58@yahoo.com, Kadhim_adem@scbaghdad.edu.iq

Corresponding author: jasim1988mohamad@gmail.com

Abstract

In this study, the effect of grafting with magnesium (Mg) ratios (0.1, 0.3, 0.5) on the structural and optical properties of cadmium oxide films (CdO) was studied, as these films were prepared on glass bases using the method of pulse laser deposition (PLD). The crystallization nature of the prepared films was examined by X-ray diffraction technique (XRD), which showed that the synthesis of the prepared films is polycrystalline, and (AFM) images also showed that the increased vaccination with magnesium led to an increase in the grain size ratio and a decrease in surface roughness, The absorption coefficient was calculated and the optical energy gap for the prepared thin films .It was found the absorption increases and the energy gap decreases with the increase of doping ratio.

Key words

Cadmium oxide, pulse laser deposition, Mg doped CdO.

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تحضير وخصائص اغشية اكسيد الكادميوم والمغنيسيوم باستخدام الترسيب بالليزر النبضي

جاسم محمد حسين[1]، عواطف صابر جاسم[1]، كاظم عبد الواحد عادم[2]

[1]قسم الفيزياء، كلية العلوم، جامعة تكريت، العراق

[2]قسم الفيزياء، كلية العلوم، جامعة بغداد، العراق

الخلاصة

تم في هذا البحث دراسة تأثير التطعيم بالمغنيسيوم (Mg) بالنسب (0.1، 0.3، 0.5) على الخواص التركيبية والبصرية لأغشية أوكسيد الكادميوم (CdO)، حيث تم تحضير هذه الاغشية على قواعد من الزجاج باستخدام طريقة الترسيب بالليزر النبضي (PLD)، تم فحص طبيعة التبلور للأغشية المحضرة من خلال تقنية حيود الأشعة السينية (XRD) والتي بينت بأن تركيب الأغشية المحضرة هو متعدد التبلور، وكذلك بينت صور (AFM) ان زيادة التشويب بالمغنيسيوم ادى الى زيادة معدل الحجم الحبيبي وانخفاض خشونة السطح، كذلك تم حساب معامل الامتصاص وفجوة الطاقة البصرية للأغشية المحضرة حيث وجد أن معامل الامتصاص يزداد وان فجوة الطاقة تقل مع زيادة نسبة التطعيم.

Introduction

The study of some materials in the form of thin films is an appropriate way to know many of their physical and chemical properties that are difficult to obtain and are in their natural form, as thin films play a very important role in solid state physics research [1] where cadmium oxide is one of the semiconducting material for what it has It has various physical properties, such as transparency and its possession of a high absorption coefficient and a relatively large energy gap, so it is used in many optical and electrical applications and in many important industrial applications that have contributed effectively to contemporary technological and scientific advances such as cells. For solar and optical reagents [2], as CdO has a molecular weight (128.4), density (8.15 g/cm^3), as well as having a forbidden energy gap of a value that made it with an amount ranging between (2.16- 2.6) ev, it can be used as a transparent conductive material and a thin film in many practical applications and different technological industries [3]. One of the advantages of this material is its ease of preparation in the form of thin films with good specifications of its chemical solutions and its absorption coefficient is high and thus can be used primarily in solar systems to increase their efficiency and in photovoltaic cells as well as in commercial coating systems as a Coating Substance [4, 5], and there are several methods for preparing (TCO), including the method of chemistry of elemental vapor deposition (CVD) [6], the method of atomization [7], the method of vaporization [8] and the method of chemical decomposition [9, 10]

Experimental

The pure cadmium oxide material Supplied or provided from the German company (FLUKA) was used with a purity (99.9%) to prepare the pure cadmium oxide films, as well as the preparation of the cadmium oxide film impregnated with magnesium by adding the pure magnesium (Mg) prepared from the same company and with a purity (99.8%) With vaccination ratios (0.1, 0.3, 0.5), then the mixture mixes well and then the powder of pure and tainted materials is placed under the hydraulic piston where a pressure of (8Ton) is applied to form the target with a diameter (2.5 cm) and a thickness (0.5 cm) where The target material should be cohesive as possible.

Glass slices were used with dimensions of (1 x 76 x 26 mm) and these slices (the bases) were cleaned by using distilled water placed in the ultrasonic device and then the same ball was returned but this time using pure alcohol which interacts with the materials and removes them and finally The bases are dried by blowing them with air and then wiping them using fine fabric.

After setting the glass bases and targets, the pulsed laser sedimentation stage (PLD) begins, where the pressure value inside the discharge chamber is mbar (2.5 x 10^{-2} mbar) for the purpose of contributing to the ionization of the material. Where the laser beam falls on the target surface at an angle (45°) with the target surface and the substrate is placed in front of the target and parallel to its surface as shown in Fig.1, bearing in mind that the distance between the target and the base is sufficient so that the base holder does not obstruct Falling laser beam.

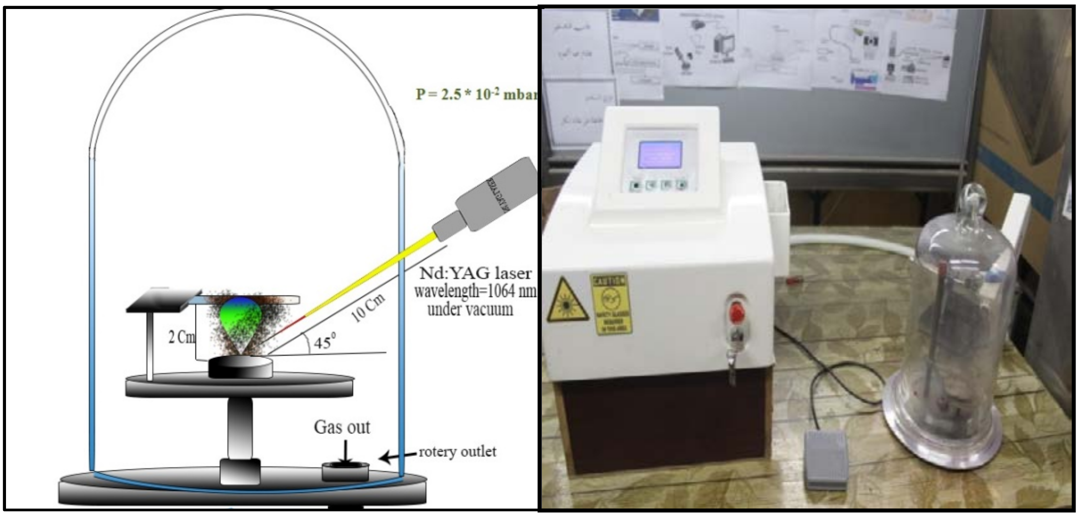

Fig.1: Parts of the PLD system.

Results and discussion

The results of the X-ray diffraction technique (λ=1.5406Å) showed that all prepared cadmium oxide films (pure and Doped) with magnesium (0.1, 0.3, 0.5) were polycrystalline in cubic phase. There are maine peaks located at (33), (38.2), (55.2) degree corresponding to the directions [111], [200] and [220], the preferred direction was along [111] for crystal growth as shown in Fig.2, this is consistent with what was stated in the published research [11]. Also, the results of X-ray diffraction have shown lack of effect it is clear to the vaccination ratios used on the nature of the crystal structure of pure membrane material (CdO). This can be seen by the X-ray diffraction model of the pure material membrane (CdO), Fig.2. When comparing the pure membrane with the grafted membranes, it turns out that the distinctive peaks of the vaccination ratios used were the same and for both types of prepared films (pure and doped), and this confirms that adding impurities in a small percentage may not cause visible change in the crystal structure of the vaccinated substance [12].

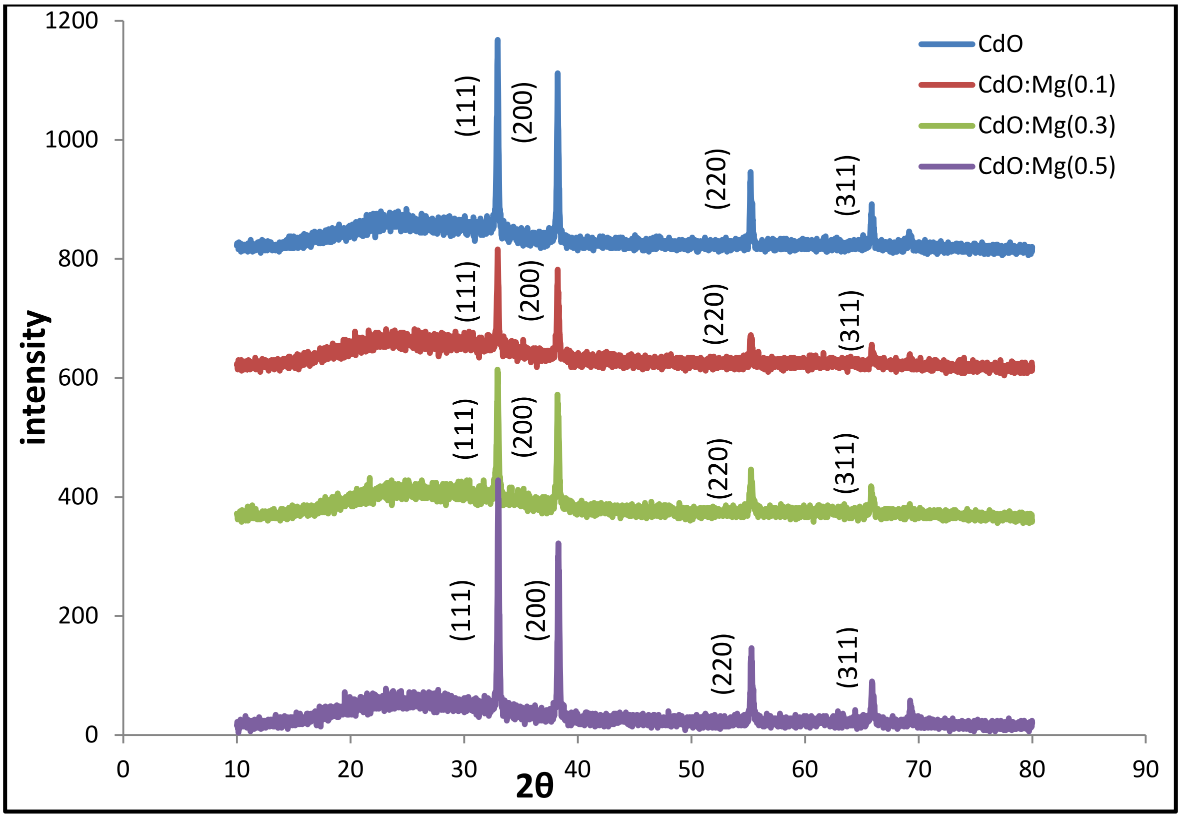

Fig. 2: X-ray diffraction pattern for CdO: Mg films.

From Fig.2, it becomes clear how the intensity of the first peak with a distinctive direction [111] began with a gradual decrease with an increase in the proportions of vaccination taken up to the ratio (0.3) the reason is that the impurity material worked to create its own atomic levels within the crystal lattice of the tainted substance, Consequently, the levels of each of the two substances do not disperse the X-rays falling on them in the same phase, and this causes a destructive interference, so the resulting amplitude of the dispersed wave will be less.

It was calculated the rate of grain size (C. S) of films prepared (Table 1) using the (Scherrer equation) [13] showing the increase of grain size to increase the proportion of the used:

$$D = \frac{0.94\,\lambda}{B_{FWHM}\,\cos\theta} \qquad (1)$$

D is average grain size and (θ) Brag angle.

Table 1: Structural parameters of (CdO: Mg) films obtained from (XRD) examination.

material	2θ (Deg.)	FWHM (Deg.)	C.S (nm)	d_{hkl} Exp.(Å)	d_{hkl} Std.(Å)	hkl
CdO	**32.9681**	**0.17010**	**48.52**	**2.71473**	**2.7120**	**1 1 1**
CdO:Mg(0.1)	**32.9804**	**0.16900**	**48.83**	**2.71374**	**2.7120**	**1 1 1**
CdO:Mg(0.3)	**32.9765**	**0.16820**	**49.06**	**2.71406**	**2.7120**	**1 1 1**
CdO:Mg(0.5)	**33.0318**	**0.14400**	**57.31**	**2.70964**	**2.7120**	**1 1 1**

Fig.3 shows three-dimensional (AFM) images of the cadmium oxide films inlaid with magnesium in proportions (0.1, 0.3, 0.5) and deposited on the bases of glass using the pulsed laser precipitation method that showed an increase in the average diameter of the particles and a decrease in both the surface roughness rate and the mean square root of the films (CdO: Mg) and that the increased vaccination (Mg) greatly affects the surface morphology of the samples as the surface roughness decreases with increasing the vaccination ratio.

It can be shown that the increase in the average diameter of the particles and the decrease in both the surface roughness and the mean square root of films (CdO: Mg) indicate that steroids worked to increase the crystalline symmetry and decrease the surface roughness of the membrane, as shown in Table 2, and this corresponds to what was stated in published research [14, 15]. There is a good agreement between the results of AFM and XRD in relation to increasing the granular size after vaccination, but the average granular size measured by (AFM) is greater than the average granular size measured by XRD, and the reason for this is because (AFM) measures the size of The granules on the surface of the films, while the (XRD) measures the size of the granules inside the films The granules are larger at the surface of the membrane than they are in the pain.

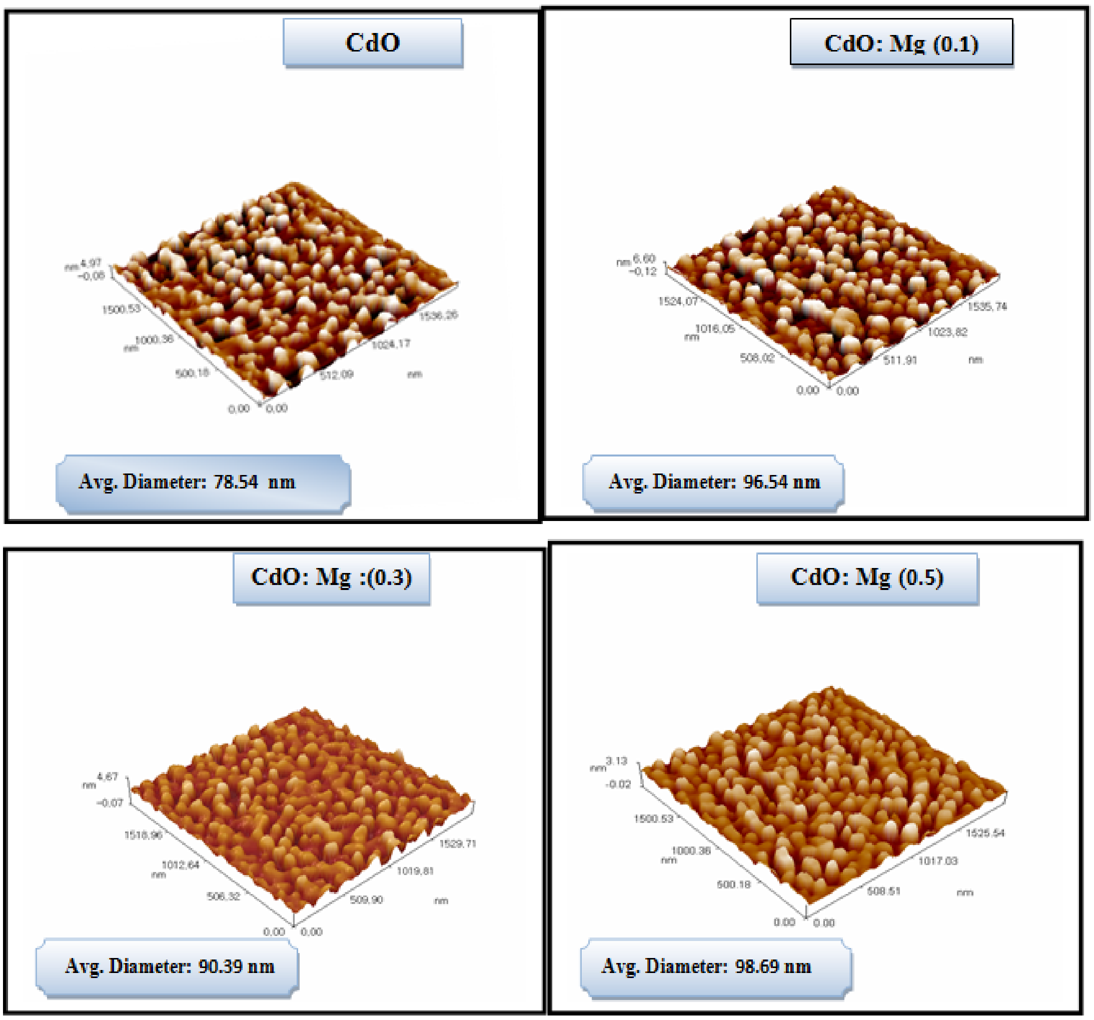

Fig.3: Three-dimensional images of (CdO: Mg) films and of various distortion ratios.

Table 2: Structural parameters of (CdO: Mg) membranes Obtained from the AFM examination.

material	Average diameter (nm)	Average roughness (nm)	Root mean square (nm)
CdO	78.54	1.26	1.46
CdO: Mg(0.1)	96.54	1.62	1.88
CdO: Mg(0.3)	90.39	0.408	0.495
CdO: Mg(0.5)	98.69	0.501	0.618

Fig.4 shows the transmittance spectrum as a function of the wavelength of pure cadmium oxide films that are impregnated with magnesium. In general, the wavelength of the electromagnetic radiation falling on the films material is increased.

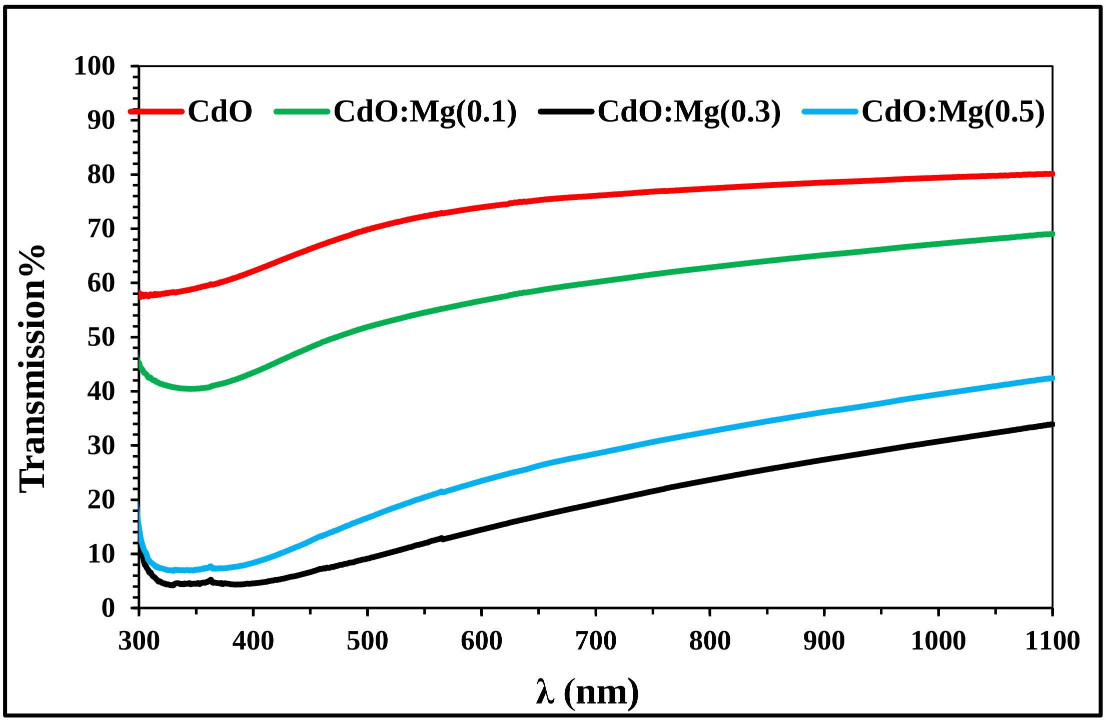

Fig.4: Transmittance spectrum as a function of the wavelength of pure CdO grafted films (Mg).

It is also noted from Fig.4 that the transmittance spectrum quickly begins with a gradual decrease with an increase in the percentage of distortion taken, due to impurities atoms and the accompanying formation of local levels within the prohibited energy gap between the valence and conduction beams and consequently an increase in absorption and a decrease in transmittance. The highest transmittance was for pure cadmium oxide films, which amounted to about (72%) for the wavelength ranges within the visible range (400-800 nm). and the low permeability to less than

(30%) at the rate of stimulants (0.3) makes it suitable for the manufacture of solar cells.

Fig.5 shows the relationship between the absorption coefficient (α) and the photon energy (hυ), where it was found that the values of the absorption coefficient are greater than ($\alpha \geq 10^4$), and this is what the studies mechanism [16, 17] reached, which indicates the high probability of occurrence of direct electronic transition [18]. The results showed that the increase in the doping ratio led to a clear increase in all the absorption coefficient values for the pre-vaccination state, especially at low photon energies, as the primary absorption edge toward the low photon energies crept due to the distortion resulting in the formation (generation) of donor levels within the energy gap and near the conduction beam led to the absorption of photons with low energies and thus to a clear increase in the values of the absorption coefficient.

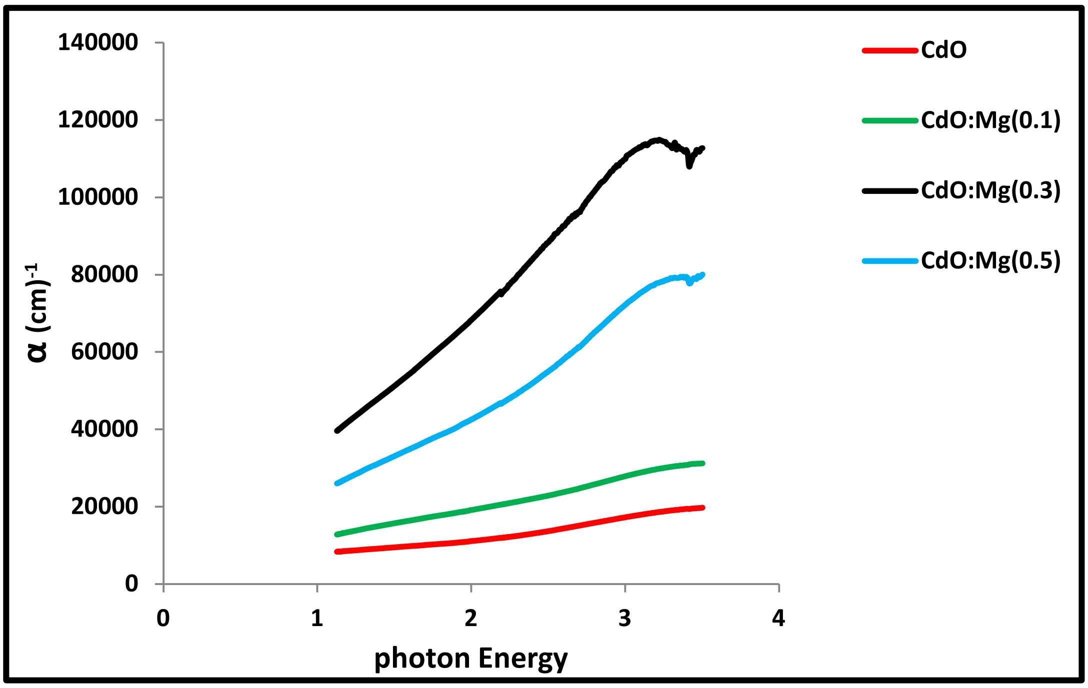

Fig.5: Change of absorption coefficient with photon energy for a pure CdO-magnesium-impregnated membrane.

The optical energy gap is of great importance in determining the extent of the possibility of using the thin films prepared in the manufacture of hybrid joints, reagents and solar cells, where the graphical relationship between ($\alpha h\nu^2$) was drawn as a function of the photon energy ($h\nu$), as in Fig.6 where The intersection of the straight part of the curve intersects with the photon energy axis (($\alpha h\nu$) $^2 = 0$) representing the value of the direct visual energy gap.

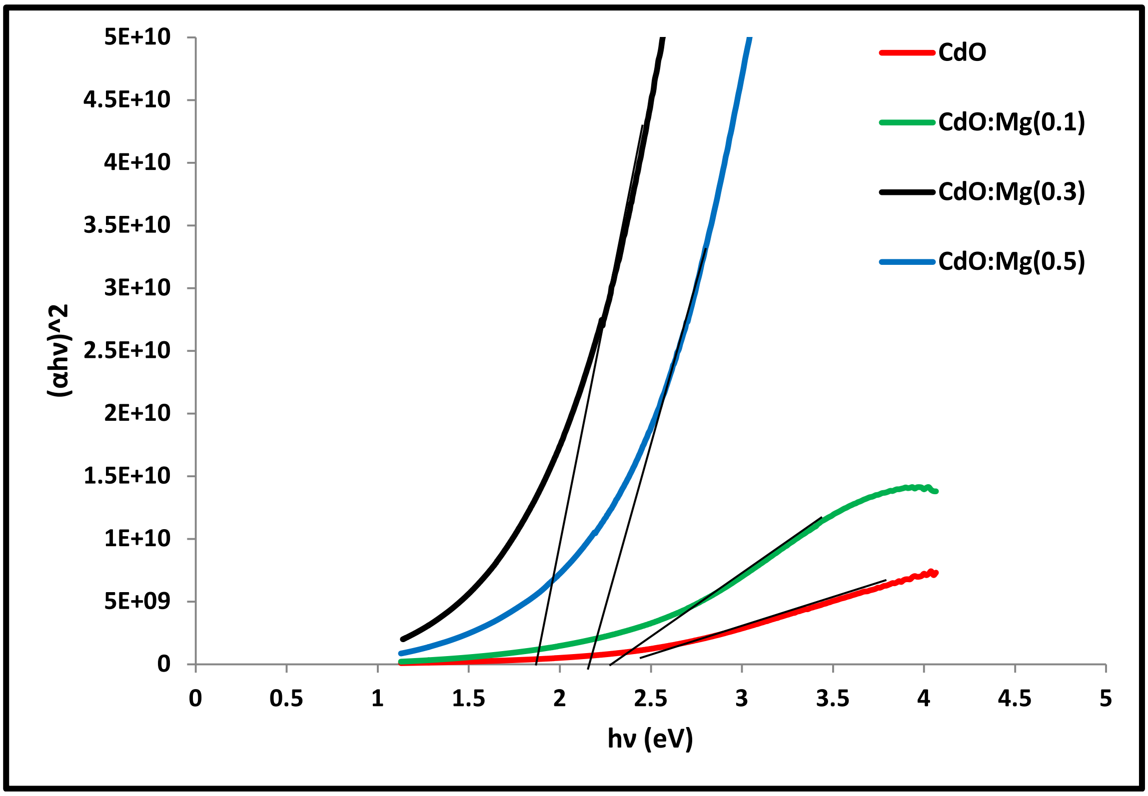

Fig.6: Represents a pure optical power gap with magnesium tainted by different vaccination ratios.

Through the results reached, we find that the energy gap for the permissible direct transmission of a membrane (CdO) is equal to (2.4 eV), and then the value of the absorption coefficient is equal to ($\alpha \geq 10^4$) which confirms that the energy gap is a direct gap and this result is consistent with the results of published research. Within different preparation techniques [19, 20], and that the increase in vaccination rates leads to a decrease in the energy gap and this decrease results from an improvement in the crystal structure and an increased granular size except for the proportion of vaccination (0.5). We note a slight increase in the energy gap caused by improper distribution of impurities and that the energy gap values indicated are shown in the Table 3.

Table 3: The values of the optical energy gap of pure (magnesium-doping) CdO films.

Sample	**Eg (eV)**
CdO	2.4
CdO : Mg (0.1)	2.3
CdO : Mg (0.3)	1.9
CdO : Mg (0.5)	2.2

Conclusions

Cadmium oxide undoped and doped with magnesium films were of a multi-crystalline composition and the addition of impurities in a few proportions did not affect the nature of the crystal structure and through synthetic tests it was found that the increase in vaccination ratios led to an increase in the granula r size as well as the results of the visual tests show that the transfer of electrons from the valence band to a band The conduction was a direct electronic transmission permitted and the increase in the rates of vaccination led to a decrease in the energy gap prohibited.

References

[1] L. Eckcrtov, “Physics of Thin Films”, Plenum Press New York and London, (1977).
[2] H.G. Lazem, Journal of Missan Researches, (2006) 2-4.
[3] A. JT. Varkey and A. F Fort, Thin Solid Films, 239, 2 (1994) 211-213.
[4] C. A. Hampel and Gessner G. Hawley, "The Encyclopedia of Chemistry", 3 rd Edition, (1973) P. 169.
[5] C. A. Hampel, Rare Metals, Handbook, (1954) 87-103.
[6] J. Belingham, W. Philips, C. Adkins, J. Phys, Condens, Matter, 2 (1990) 6207- 6221.
[7] R.S. Rusu, J. of Optoelectronics and Advanced Materials, 7, 2, April (2005) 823-828.
[8] H. Tabet-Derraz, N. Benramdane, D. Nacer, A. Bouzidi, M. Medles, Sol Energy Mat. Sol., 73, 3 (2002) 249-249-259.
[9] F. C. Gandarilla, A.M. Acevedo, O. Vigil, M.H. Garduno, L. Vaillant, G.C. Puente, Mater, Chem., Phys., 78, 3 (2003) 840-846.
[10] P. Shindov, Electronics, 22-24 September (2004) 1-4.
[11] CI. Zuniga-Romero, G. Torres-Delgado, S. Jimenez-Sandovall, O. Jimenez and R. Castanedo, Modern Physics Letters, B15 (2001) 726-729.
[12] R. Maity, K. K. Chattopadhyay, Sol. Energy Mater. Sol. Cells, 90, 5 (2006) 597- 606.
[13] S .Kathirvelu, Indian J. of Fibre and Textile, 3 (2009) 267-273.
[14] F. Atay, I. Akyuz, S. Kose, E. Ketenci, V. Bilgin, J. Mater. Sci. Mater. Electron, 22 (2011) 492-498.
[15] M. Vigneshwaran, R. Chandiramouli, B.G. Jeyapakash, D. Balamurugan, Journal of Applied Sciences, 12, 16 (2012) 1754-1757.
[16] Hassan Karami, J. Electrochem. Sci., 5 (2010) 720-730.
[17] J. C. Manifacier, J. P. Fillard, J. M. Bind, Thin Solid Films, 77 (1981) 67-80.
[18] C. C. Ling, S. Fung, C. D. Beling, and Weng Huimin, Physical Review, 64, 7 (2001) 075201.
[19] C. H. Bhosale, A.V. Kambale, Materials Science and Engineering, B122 (2005) 67-71.
[20] Amrut S. Lanje, Indian Journal of Pure and Applied Physics, 49 (2011) 234-238.