# Study the Effect of Irradiation on Structural and Optical Properties of (CdO) Thin Films that Prepared by Spray Pyrolysis

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**Received in : 5May 2015, Accepted in :23 June 2015**

## Abstract

In this research, the study effect of irradiation on structural and optical properties of thin film (CdO) by spray pyrolysis method, which deposited on glasses substrates at a thickness of (350±20)nm , The flow rate of solution was 5 ml/min and the substrate temperature was held constant at 400˚C.The investigation of (XRD) indicates that the (CdO) films are polycrystalline and type of cubic. The results of the measuring of each sample from grain size, micro strain, dislocation density and number of crystals the grain size decreasing after irradiation with gamma ray from(27.41, 26.29 ,23.63)nm . The absorbance and transmittance spectra have been recorded in the wavelength range (300-1100) nm in order to study the optical properties. the optical band gap for (CdO) decreasing after irradiation with gamma ray from(2.4, 2.35, 2.25)eV with increasing time irradiated, while extinction coefficient, refraction index,the optical conductivity increase after irradiated with gamma ray with increase irradiation time . $Cs^{137}$ is used to obtain Gamma ray with energy( 662)KeV, activity( 4.3)ci , the irradiation time (1-3)week .

**Keywords**: thin film CdO ,irradiation.

# Introduction

Cadmium Oxide is one of the promising transparent conducting oxides (TCOs) from to group of semiconductors [1] and its important material for the development of various technologies of soiled state devise, panel display, optoelectronic components, thermally insulating alas, etc.[2].Cadmium oxide is a transparent oxide the in visible and NIR spectral region. It is n-type semiconducting[3].Therefore it is used in many industrial productions like solar cells, smart windows, flat panel display optical communications, photo-transistors, IR-detectors, storage batteries, ceramic glasses and other optoelectronic applications[4-5]. A variety of methods has been used to prepare thin films of cadmium oxide such thermal evaporation metal organic, chemical bath deposition[6],silar deposition technique[7], rapid thermal oxidation (RTO) of Cd[8],successive ionic layer adsorption and reaction (SILAR) method[9],etc.

The effect of radiation onto films represents linear energy transfer (Kev) which is proportional to the square shipment and inversely with the square speed. Due to their small size and light weight have contribute to the current development the filed of electronic digital in addition to the development of space. The effect of irradiation on thin filmsis that it improves the behavior of these membranes where found the optical properties values increased with increasing irradiation dose and that the value of the energy gap less result generate extra energy levels between the valence and conduction bands[10].

Abdulmajed et.al.[11]was studied prepartion of the subjected to Gamma –ray for (5,10)min and(24)h with energy (0.662)MeV. The results, irradiation leads to decrease in energy gap value.

Assmaa[10] study effect of radioactive dose foe Alpha- practical, which energy (5.49)MeVon optical properties of(CdO)which prepared by spray pyrolysis. with doses of values (135,410,1100,5500)rad.The results showed decreasing in energy gap and changes in other properties with absorbed dose.

Majidet.al.,[1] studied thin films of CdO and 9 % Mg doped CdO doped have been prepared using spray pyrolysis technique. The deposited thin films were exposed to γ - rays. We have studied the transmission, absorptions and absorption coefficient as a function of photon energy before and after irradiation.

The aim of this study is fabrication thin film by spray pyrolysis and study effect irradiation Gamma-Ray with different times on structural and optical properties of (CdO) thin films.

# Experimental

Cadmium Oxide (CdO) films were prepared on glass substrates by spray paralyses technique. The spray solution used of 0.1 M of high purity cadmium acetate dissolved in 100 mil distilled water and add two drops Acetic acidin 15 min. The atomization of the solution into a spray of fine droplets was carried out by the nozzle, with the help of compresses air as carrier gas. The flow rat of solution was 5 ml/min ,spraying time was 10 sec lasted by 2 minutes to avoid excessive cooling and the substrate temperature was held constant at 400 ˚C using a chrome – alumel thermocouple with the help of a digital millimeter supplied by Pasco. The nozzle to substrate distance was (30) cm and the diameter of nozzle was 0.3 mm. The substrates were cleaned by alcohol and distilled water before coating. Film thickness is determined by the weight – difference method ( t=M/ρA) where A, is the area of the film, M its mass, t its thickness and ρ its density (8.15 g/cm $^{3}$). The structural of CdO film was obtained by X- ray diffraction (SHIMADZU Japan) XRD600,wave length 1.5418 A˚ and the optical transmission absorbance of the films were obtained in Ultraviolet/ Visible/ near infrared (200-1100)nm using (UV-visible 1800 spectra photometer) . $Cs^{137}$ used to obtained Gamma ray with energy( 662) KeV , activity ( 4.3)ci, the irradiation time(1-3)week.

cadmium oxide are formed on the substrate surface according to the following reaction [12][13]

$$Cd(CH_3COO)_2 + 3H_2O \xrightarrow{Heat} CdO \downarrow + CH_4 \uparrow + 4H_2 \uparrow + 3CO_2 \uparrow ............... (1)$$

## Results and Discussion

Fig. 1 shows the X-ray diffraction (XRD) of CdO thin film ,which appear some peaks at $2\theta=33.104^o$ ,$38.39^o$, $55.38^o$ the most peak at $33.10^o$ corresponds to (hkl) (111) with cell constant a=4.68A$^o$ and d=2.703A$^o$ .It clearly shows the CdO thin film is a polycrystalline structure and type of cubic, this result is agrees with[11]. The intensity from films has been increased after the process irradiation and became sharper due to crystallinity.

The calculated value of the structural parameters, FWHM, interplanar spacings, grain size, strain and number of crystals determined with the use of the following formulas and using the (ASTM) cards- CdO-00-005-0640:

1-The strain($\varepsilon$) [14]:

$\varepsilon= \beta\cos\theta/4$............(2)

$\beta$ the full width at half maximum of (111) peak of XRD pattern, and $2\theta$ is the Bragg angle.

2-Dislocation density($\eta$): [15]

$\eta=1/ (G.s)^2$…………………………………….(3)

G.s:The crystallites size of the grains in the films is estimated using the Sherer formula [16] :

$G.s=K \lambda/\beta\cos\theta$……………………………….(4)

where K is a constant taken to be 0.94, $\lambda$ the wavelength of X-Ray used ($\lambda$=1.54 Å). 4-Number of Crystals ($N_O$)[17]:

$N_O=t/ (G.s)^3$…………(5)

5- the interplanar spacing(d)[18]**:**

Using the Miller indices of these planes, the lattice parameters a=b =c of the unit cell are evaluated according to the relation:[18]

$d=a/(h^2 +k^2+l^2)^{1/2}$……………………(6)

where d is the interplanar spacing, and (hkl) are the Miller indices.

These ruslts are shown in table 1and2.

The decreases of grain size with increase of time irradiation may be attributed to the improvement of growth crystalline that leads to crystallinity and increases of strain and dislocation density with increase time irradiation that leads to increases structural defect

Fig. 2 shows the relation between absorbance and photon energy, we found the increase in absorption with the increase of photon energy,and increase with increase time irradiation. because irradiation may increase the number of charge carriers which increases the absorption that is films [19].

Fig. 3 shows the relation between transparent and photon energy, we had found decrease with increase of photon energy.

Fig. 4 shows the relation between the absorption coefficient ($\alpha$) and photon energy, was calculated using the formula[20]:

$\alpha=2.303A/t$………………………(7)

Where A is the optical absorbance, increasing absorption coefficient value with increase of irradiation time in depended on absorbance and the absorption edge shifted toward long wavelength region.

$\alpha h\nu=B(h\nu-E_g)^r$ …………………..(8)

Eg energy gap ,r is constant debend on kind transparent.

Fig. 5 shows the relation between$(\alpha h\nu)^2$and photon energy, we had found the values energy gap decreased from(2.4-2.35-2.25)eV with increase time irradiation with γ - rays due to the increase of the density of localized states in the band gap, which causes a shift to lower values this results agree with results [1],[10],[11].

Fig. 6 shows the relation between extinction coefficient and photon energy . It was found that the increasing at extinction coefficient value with increase time irradiation because of increasing absorption coefficient value with increase of irradiation time in depended on relation (7)and relation(9)[21].

$K=\frac{\alpha\lambda}{4\pi}$ ………………(9)

Where k is the extinction coefficient which is related to the absorption coefficient and the wavelength.

Fig. 7shows the relation between refractive index and photon energy,during our showing to curves we notice that the behavior of curves is the same behavior before and after irradiation refractive index is increasing with increasing of photon energy until it arrives peak at photon energies (2.2-2.6) eV ,then it began to decrease, with increasing it these value decrease with increasing time irradiation reflective index is calculated from relation: [22]

$n =[\frac{4R}{(R-1)2}-K^2]^{1/2} -\frac{(R+1)}{(R-1)}]$…………(10)

Where R:The reflection which calculated from the relation: [18]

$R + T+ A = 1$ ………………………………. (11)

Fig. 8 shows the relation between optical conductivity and photon energy,the optical conductivity increase with increasing time irradiation with γ - rays .

The optical conductivity was calculated using the relation[23]

$\sigma =\frac{\alpha n\, c}{4\pi}$…………..(12)

where c:the velocity of light in space.

## Conclusion

1. CdO thin film is a polycrystalline structure , the dominant orientation (111)
2.increase intensity with increase irradiation time .
3. after irradiated with gamma ray increase irradiation time refers to the increase in absorption value and decrease in transparent value.
4. the values energy gap decreased with increasing irradiation time.
5. the optical conductivity increase after irradiation with increase irradiation time with γ - rays.

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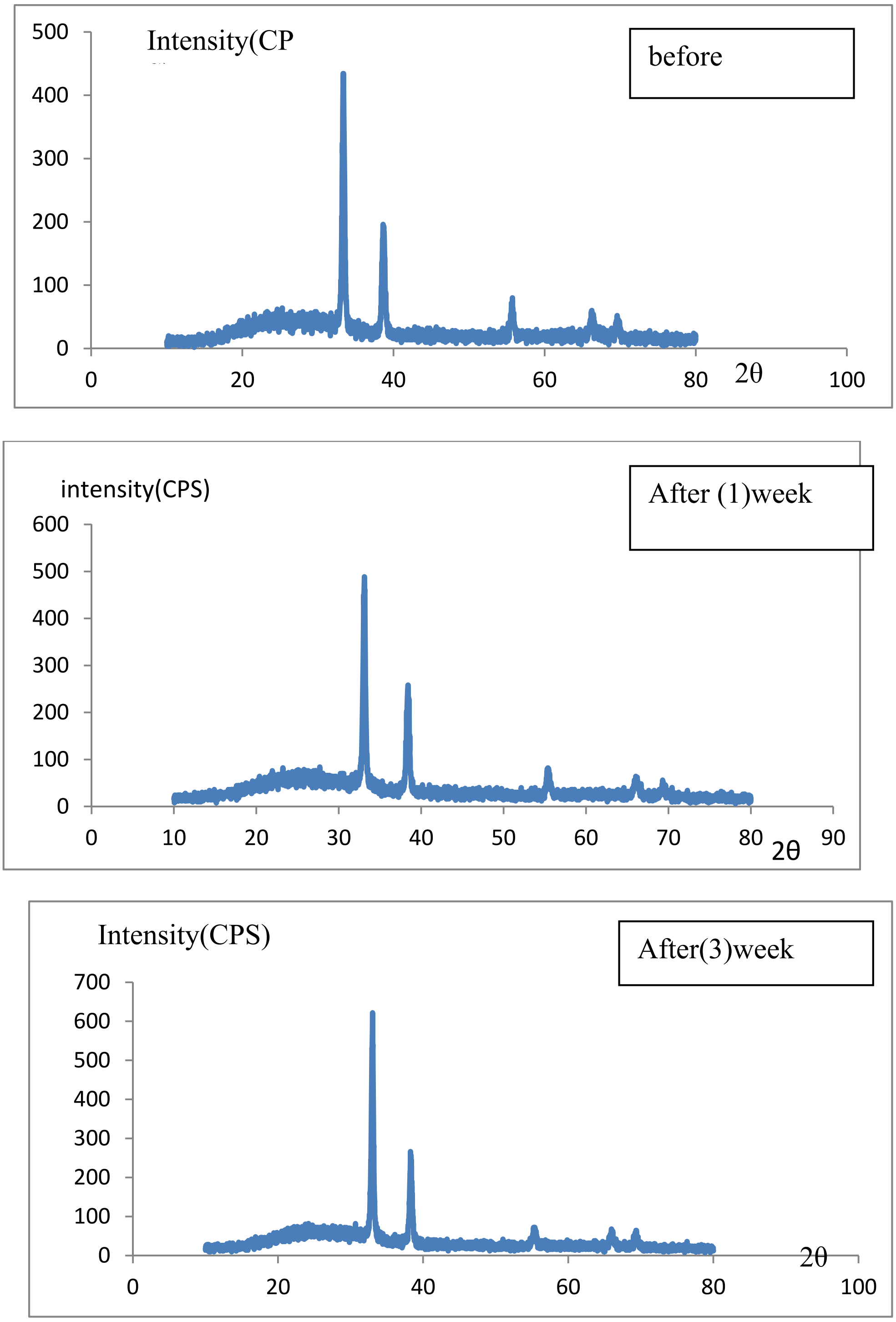
**Table No.(1): Comparison of structural parameters with (ASTM) cards**

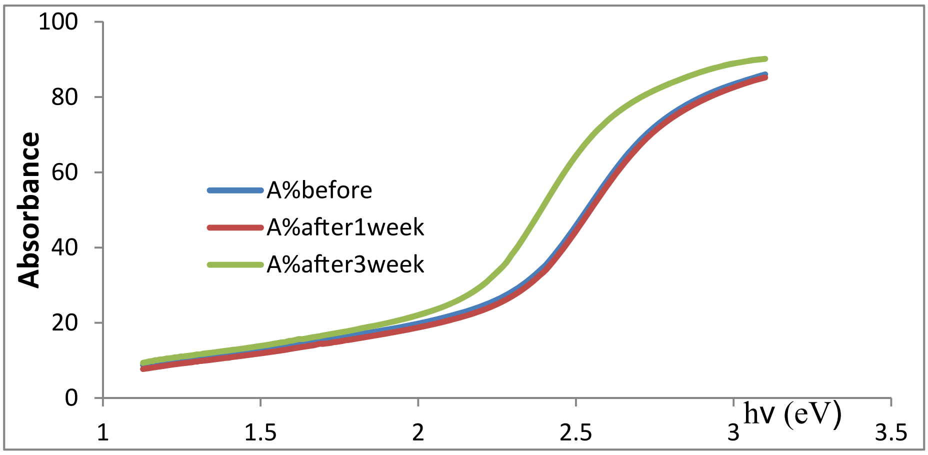
| Sa | 2θ(XRD) | 2θ(ASTM) | d(XRD)A° | d(ASTM)A° | a(XRD)A° | a(ASTM)A° | hkl |
|---|---|---|---|---|---|---|---|
| Before | 33.0236 | 33.0013 | 2.71029 | 2.7120 | 4.694 | 4.69 | (111) |
| | 38.3148 | 38.2849 | 2.3473 | 2.3490 | 4.6946 | | (200) |
| | 55.3193 | 55.258 | 1.6593 | 1.661 | 4.693 | | (220) |
| after(1week) | 33.1044 | | 2.7036 | | 4.682 | | (111) |
| | 38.3926 | | 2.3427 | | 4.685 | | (200) |
| | 55.386 | | 1.6751 | | 4.688 | | (220) |
| After(3week) | 33.3773 | | 2.68238 | | 4.646 | | (111) |
| | 38.6686 | | 2.32663 | | 4.653 | | (200) |
| | 55.6659 | | 1.64983 | | 4.666 | | (220) |

**Table No. (2): Comparison of structural parameters, FWHM, grain size, strain and number of Crystals**

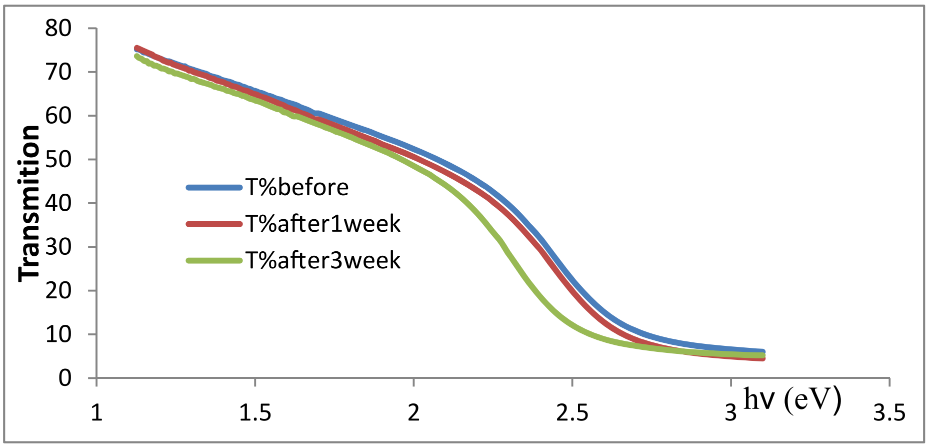
| Sa.(CdO) | t(nm) | $T_s$. | G.S (nm) | $\delta*10^{-3}$ | $\eta*10^{-3}$ $(nm)^{-2}$ | $N_o*10^{-3}$ $(nm)^{-2}$ | FWHM (deg) | FWHM (rad) |
|---|---|---|---|---|---|---|---|---|
| Before | 350 | 400 | 27.41 | 1.32 | 1.33 | 16.99 | 0.3158 | 0.0055089 |
| After(1week) | | | 26.29 | 1.37 | 1.45 | 19.26 | 0.3292 | 0.0057427 |
| After(3week) | | | 23.63 | 1.53 | 1.79 | 26.83 | 0.3666 | 0.006395 |



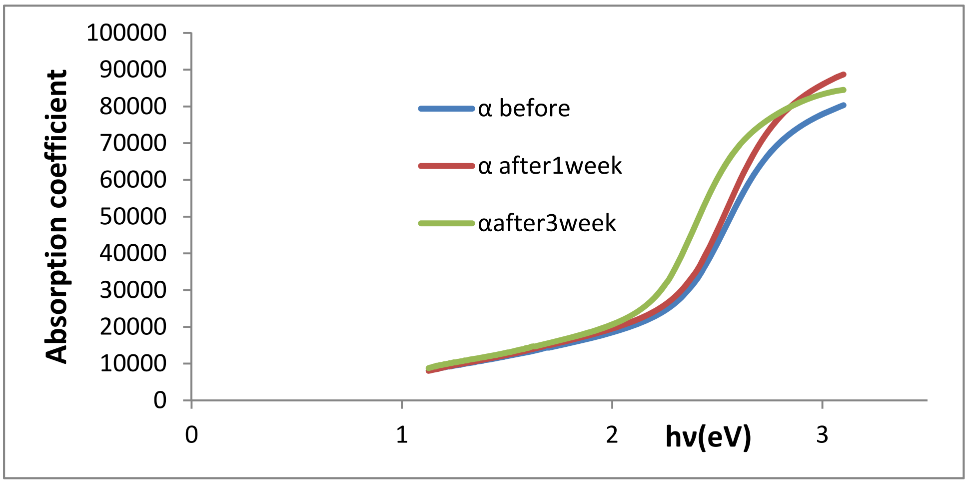

**Figare No.(1) Shows the X-ray diffraction (XRD) for the CdO before and after (rad.)(1,3)week**



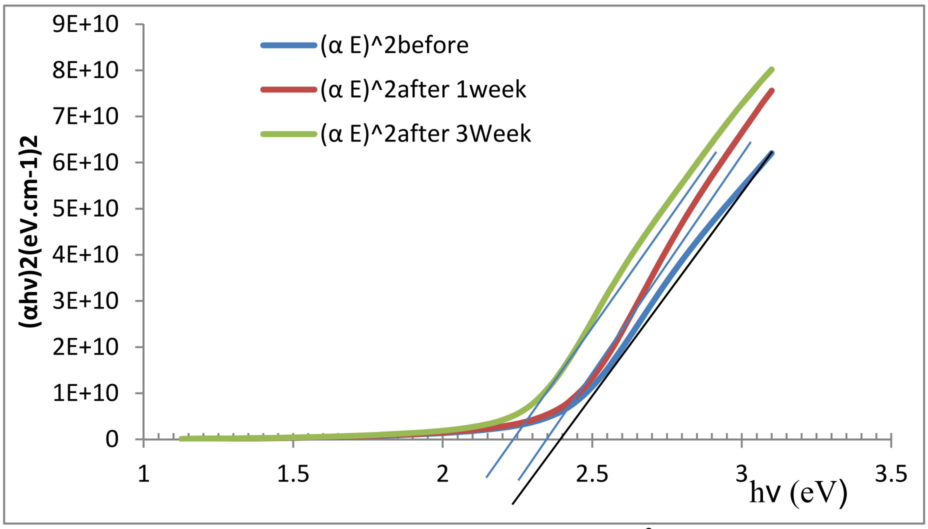

**Figare No.(2) shows the relation between absorbance and photon energy**



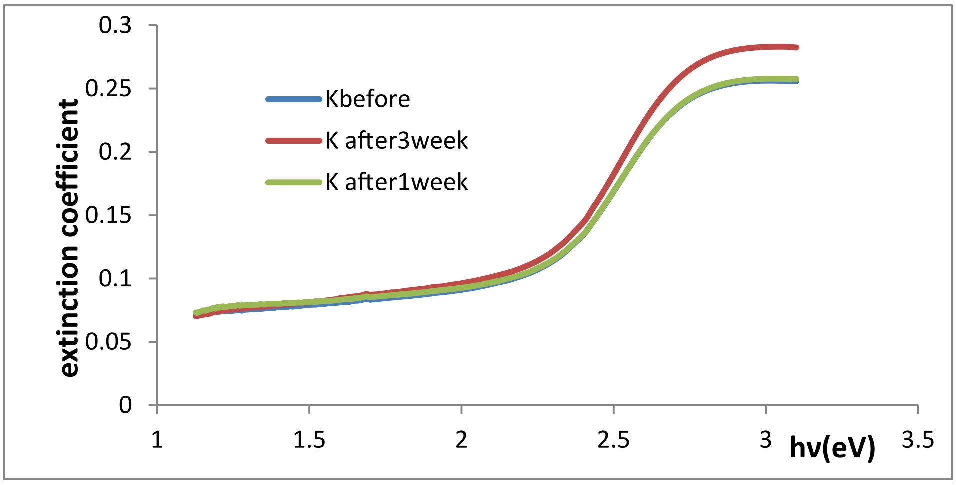

**Figare No.(3) shows the relation between transmition and photon energy**



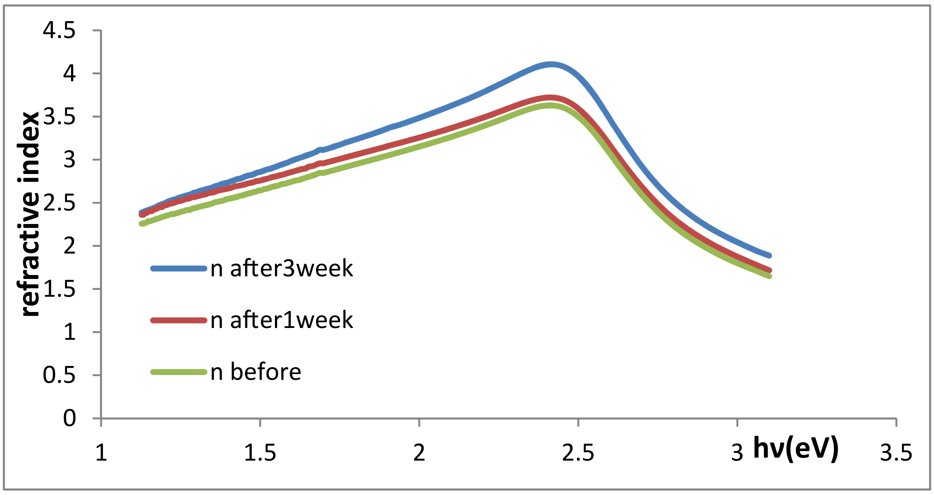

**Figare No.(4) shows the relation between absorption coefficient and photon energy**



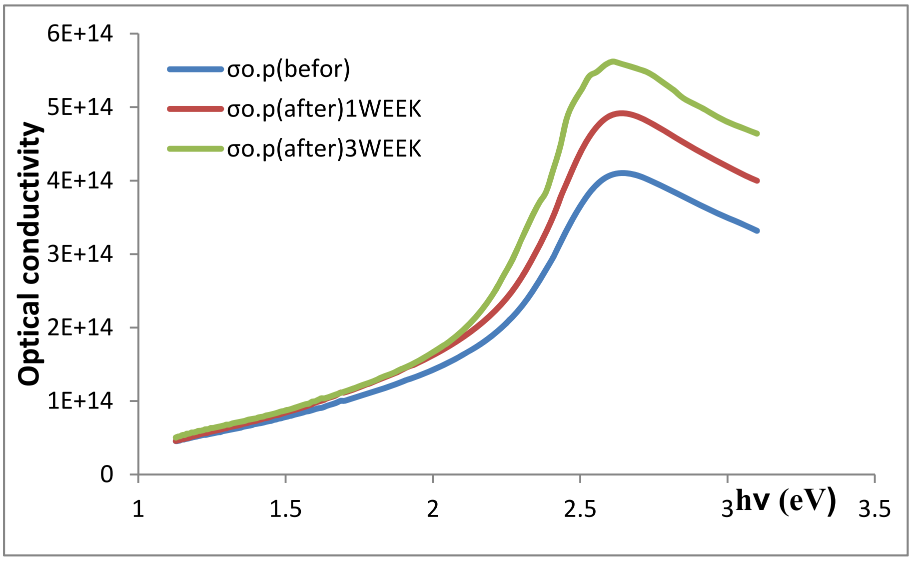

`Figare No.(5) shows the relation between$(\alpha h\nu)^2$and photon energy




Figare No.(6) show the relation between extinction coefficient and photon energy




Figare No.(7) shows the relation between refractive index and photon energy




**Figare No.(8) shows the relation between optical conductivity and photon energy**

# دراسة تاثير التشعيع على الخواص التركيبية والبصرية لاغشية اوكسيد الكادميوم الرقيقة المحضرة بطريقة الرش الكيميائي الحراري

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**استلم في:٥ايار ٢٠١٥، قبل في:٢٣حزيران ٢٠١٥**

## الخلاصة

في هذه البحث تم دراسة تاثير التشعيع على الخواص التركيبية والبصرية لاغشية اوكسيد الكادميوم المحضرة بطريقة الرش الكيميائي الحراري على قواعد زجاجية وبسمك (350±20)nm , ومعدل الرش 5 ml/min ودرجة حرارة القاعدة $400\ ^\circ C$ وباستخدام تقنية حيود الاشعة السينية وجد ان الاغشية ذات تركيب متعدد التبلور ومن النوع المكعب قد وجد كل من الحجم الحبيبي وتشوه البلورة وكثافة الانخلاعات وعدد الطبقات وقد وجد ان الحجم الحبيبي يقل من (27.41, 26.29 ,23.63)nmبعد التشعيع باشعة كاما.سجل طيف الامتصاصية والنفاذية ضمن مدى الاطوال الموجية (300-1100) لغرض دراسة الحواص البصرية وقد وجد ان فجوة الطاقة بعد التشعيع باشعى كاما تقل بزيادة زمن التشعيع من (2.4, 2.35, 2.25)eV بينما ازداد كل من معامل الخمود ومعامل الانكسار والتوصيلية البصرية تزداد بزيادة زمن التشعيع، المصدر المشع$Cs^{137}$ استخدم للحصول على اشعة كاما ذو طاقة 662KeV وبفعالية (4.3)ci وكان زمن التشعيع اسبوع وثلاثة أسابيع

**الكلمات المفتاحية:** اغشية رقيقة، اوكسيد الكادميوم، تشعيع.