Effect Gamma Radiation of CdTe Thin Films Deposited by Thermal Evaporation

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Abstract
The effect of 0.66 µeV gamma radiation on the structural and optical properties of the CdTe thin films prepared by thermal evaporation at thickness 350nm, The samples were irradiated with time (50 h and 79h) at room temperature. The absorption spectra for all the samples were recorded using UV-VIS spectrometer in order to calculate the energy gap, refractive index and others parameter . The optical energy gap was found decrease from (1.9 to 1.67) eV.

Key word: optical properties, gamma radiation, thin films, structural properties.

Introduction

Cadmium Telluride (CdTe) is a semiconductors, and Its II – VI group. CdTe band gap ≅ 1.54 eV for direct and high absorption coefficient (> 10^4), that means a direct band gap [1,2,3]. CdTe is more applicable such as solar cell material, electro – optical devices, radiation diodes (LED_s) and infrared optical window [2-4]. Several deposition methods such as spray pyrolysis, electro deposition, sputtering and metal organic chemical vapor deposition[4-6].

The effect of irradiation on thin films improves the behavior of films, saluting the radiation incident the films represents a linear energy transmitted rat commensurate directly proportional to the square of the consignment and inversely with the square velocity [7]. Considered CdTe one of the most affected by the radiation, especially gamma ray at room temperature as its high averge atomic number, high resistivity, large band gap energy and good charge transport [3]. The aim of the paper is to study effect of different times of gamma ray on the optical and structural properties of the CdTe films.

Experimental

Thermal evaporation method was used to prepare the CdTe thin films Which deposited on the glass substrate, after cleaned with distilled water. Put powder CdTe in boot molybdenum on the distance 12 cm from the substrate at room temperature under pressure $3*10^{-5}$ mbar . the films thickness was determined by using weight method from the equation: [3]

$$t = \frac{\Delta m}{\rho A} \text{ ....(1)}$$

Where t is thickness, Δm is different between the weight and the weight substrate before and after the film deposition,ρ is density of the material deposition (gm/cm^3) and A is substrate area film (cm^2). All films had nearly (350 $\pm$5) nm.

A $^{137}C_s$ radionuclide with activity 0.5 µm Ci was used for exposing the samples to gamma radiation (0.66 µeV) at room temperature. A set of irradiation doses was achieved by changing the exposure time (50 hour and 79 hour). CdTe crystalline structure pattern XRD was examined using SHMADZU XRD -6000 diffractometer. The absorption measurement was recorded using (UV-Visible 1800 spectra photometer) in the range of wave length (300 -1100) nm.

Results and Discussion

X-ray pattern of CdTe thin films exhibits polycrystalline nature and a major diffraction peak corresponds to (111) orientation, that the peak intensity increase with the increase in the film radiation time. The intensity of the (220) peak is extremely low in comparison with the (111) peak, it is possible to think that, the gamma energy and time used are high enough to displace which transport atom in lattice[8]. Also this fig. (1) shows the increase in intensity with increase radiation time may be resulting from grain growth.

The relation $a = d\sqrt{h^2 + k^2 + l^2}$ can used to clouted lattice parameter (a), where (d) is the atomic spacing value and $h, k \; and \; l$ are the miller indices [9].

The grain size (F) for CdTe thin films is calculated using Scherrer's formula [10, 11]:

$$F = \frac{C\lambda}{\beta \cos \Theta} \text{.................................(2)}$$

Where the constant C is the constant (0.94), λ is the wavelength of X-ray (1.5406 A° for Cu K_α), Θ is the Bragg's angle and **β** is the full width at half maximum.

The dislocation density (δ) has been evaluated from Williamson and Smallmans formula [12]:

$$\delta = \frac{1}{F^2} \text{ ....(3)}$$

All these parameters given in table (1), where observed the grain size and dislocation density increase after radiation (at 50 h), but they decrease (at 75 h), due to the released defect in the lattice.

The spectra of optical transmittance, as shown in figure (2) where the transmition is observed as a function of wave length within the range (400-1100)nm, decrease with increasing radiation time. That means increase of the crystalline of films. The optical band gap of samples could be described by equation [12, 15]:

$(\alpha h\nu) = D(E - E_g)^m$ ………………………….(4)

Where α is the absorption coefficient, D is constant, E_g is the energy gap and(h)is Planck 's constant where is (1/2) allowed direct transition, and (m) is equal to 2 for allowed in direct transition. The term E in Eq. (4) represents the photon energy which can be calculated from the equation: [16]

$E = h\nu = \frac{1240}{\lambda\,(nm)}$ ………………………………..(5)

Where h is the plank constant, ν is the incident photon frequency, and λ is the photon wavelength. Fig.(3) shows the value energy gap, where the energy gap value depends on the radiation dose where it decreases from (1.95eV) for unradiated CdTe thin flim to (1.67 eV) for irradiated film with time (79 h).“ This result may be explained on the basis of the high dose radiation to introduce energy levels in the forbidden gap which causes radical changes in the carries concentration .These new levels may be accepted at the top of the V.B or donor levels below the C. B, This in term decreases the energy required to transport the charge carrier required to transport the charge carries from the V. B to the C. B„ [2].

Fig. (4) shows the behavior of refractive index, where It was calculate by using the equation [17]:

$n = \sqrt{\frac{4R}{(1-R)^2} - K^2} - \frac{(1+R)}{(1-R)}$……………………………………(6)

Where R is reflectance and K is the extinction coefficient. and we can calculate (n) of a semiconductor by using Herve – Vandamne relationship :[18]

$n^2 = 1 + \left(\frac{A}{E_g+B}\right)^2$ …………………………………(7)

Where A and B are constants as A=13.6 eV and B= 3.4 eV. Fig. (4) shows the increasing in (n) value happened at highest radiation dose, indicated that the irradiated films become less transparent. See table (2).

The extinction coefficient (K) was obtained from the relation: [19]

$K = \frac{\alpha\lambda}{4\pi}$ ……………………………………………..(8)

Fig.(5) shows the dependence of (K) on the wavelength with different times radiation. It is that the behavior of K increases with increasing time radiation.

The real part of dialectric constant which represents the polarization (ε_1) and imaginary part of dielectric constant (ε_2) can be calculated from the equation: [20]

$\varepsilon_1 = n^2 - k^2$……………………………………(9)

$\varepsilon_2 = 2nk$……………………………………………(10)

The dependence of (ε_1) and (ε_2) on (λ) is shown in Figs. (6) and (7), it was concluded that the variation of (ε_1) mainly depend on the value of (n^2) because the smaller value of (K) compared with (n^2), while the imaginary part of dielectric constant (ε_2) mainly depends on (K) values which are related to the variation of (α).

Conclusion

CdTe thin films have been deposited by the thermal evaporation technique in the increase of the period of exposure to irradiation gamma. It was found that the optical properties were affected by the exposure to gamma radiation, such as optical energy gap values which showed an degrease as radiation dose was increased. From the result above, it can be used CdTe thin films in industrial application.

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Table (1) Structural parameters of CdTe thin films before and after radiation.

radiation time (hour)	2Θ degree	Spacing (d) A°	FWHM(β) deg.	hkl	Lattice constant (a) A°	Grain size (F) nm	Dislocation (δ) Lines/cm^2
0	39.2997 23.7695	2.29071 3.74034	0.15140 0.16800	111 220	6.47846 6.4769	50.1 52.7	3.9713 3.261
50	23.6822 39.2781	3.75393 2.29192	0.2228 0.2275	111 220	6.5019 6.4770	49.7 51.8	4.0338 3.72
79	23.7582 39.3113	3.75668 2.29422	0.18820 0.22000	111 220	6.5067 6.4890	59.4 54.5	2.833 3.36

Table (2) Optical energy gap and reactive index of CdTe thin films before and after radiation.

radiation time (hour)	n eq. 7	E_g (eV)
0	2.75	1.95
50	2.79	1.80
79	2.68	1.67

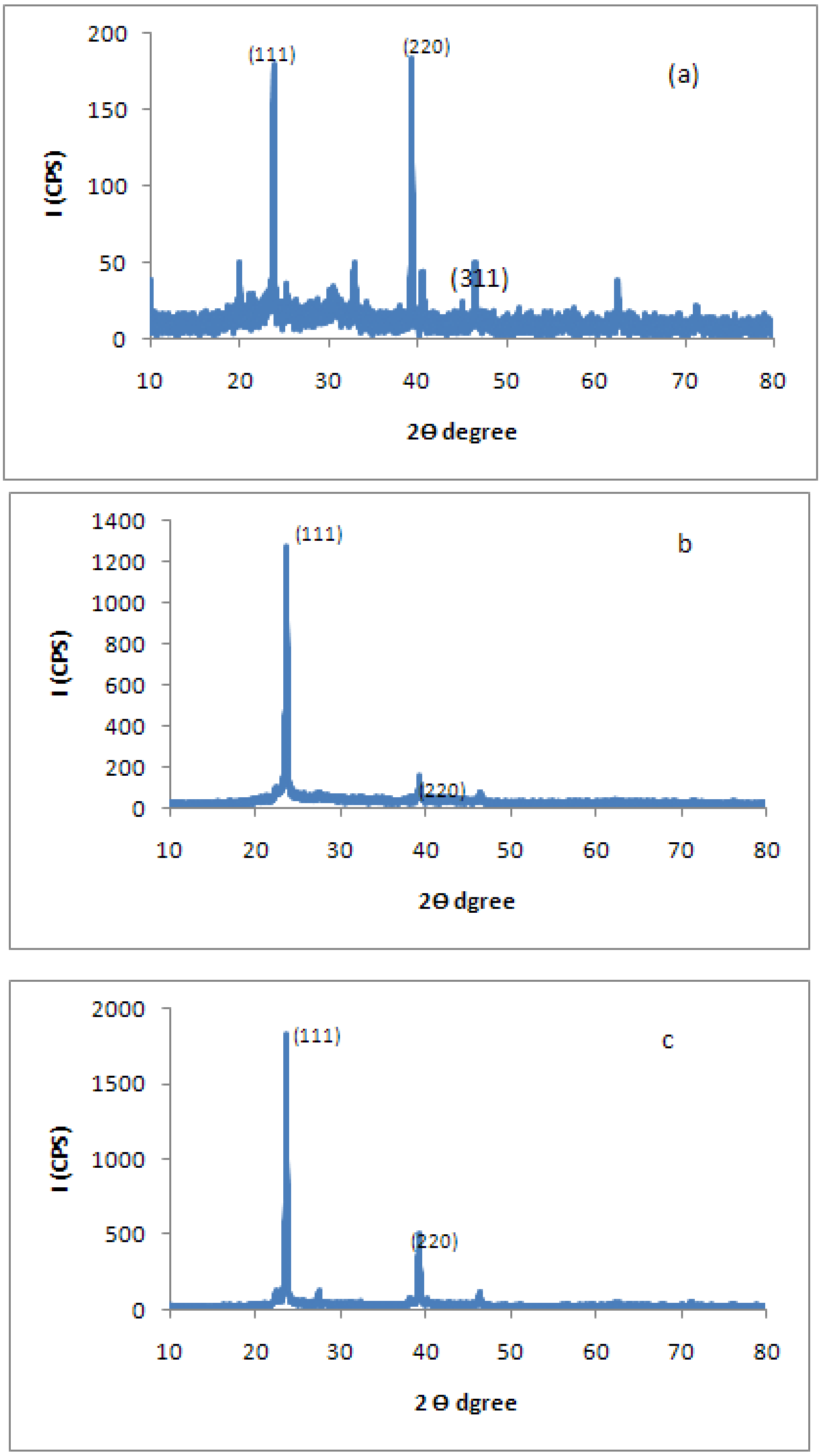


Figure.(1) X- ray diffraction of CdTe thin films at different radiation time.

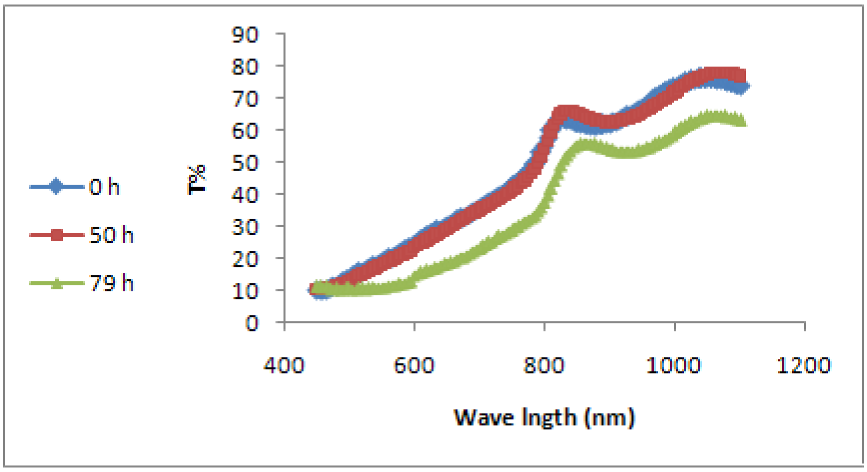
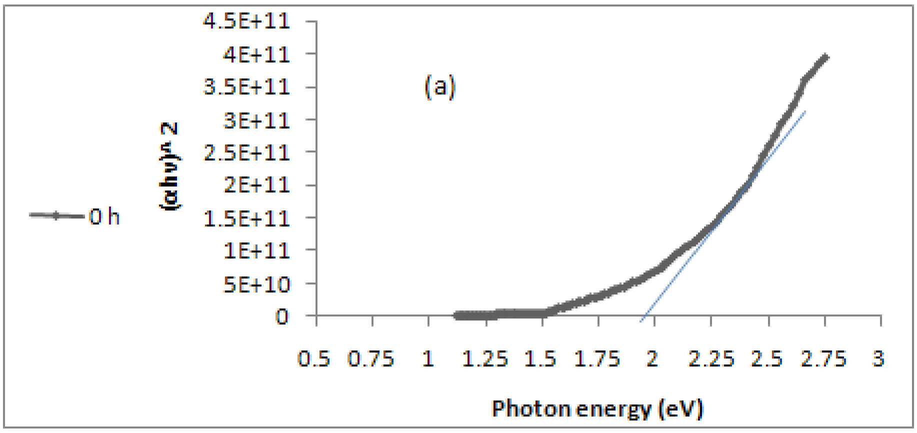


Figure.(2) Transmittance of CdTe thin films at different tradition time.



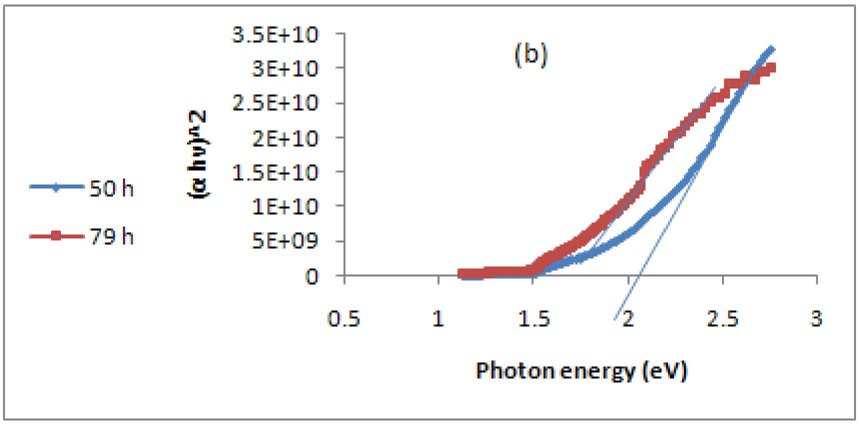


Figure. (3) Energy gap of CdTe thin films at different tradition time.

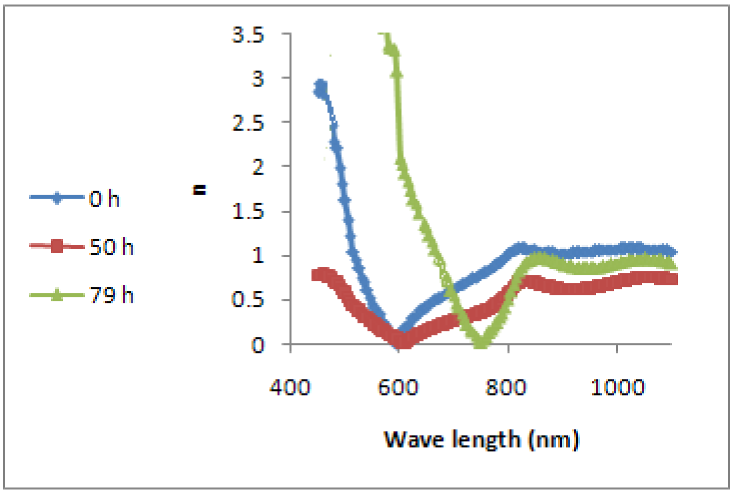


Figure. (4) Refractive index of CdTe thin films at different tradition time.

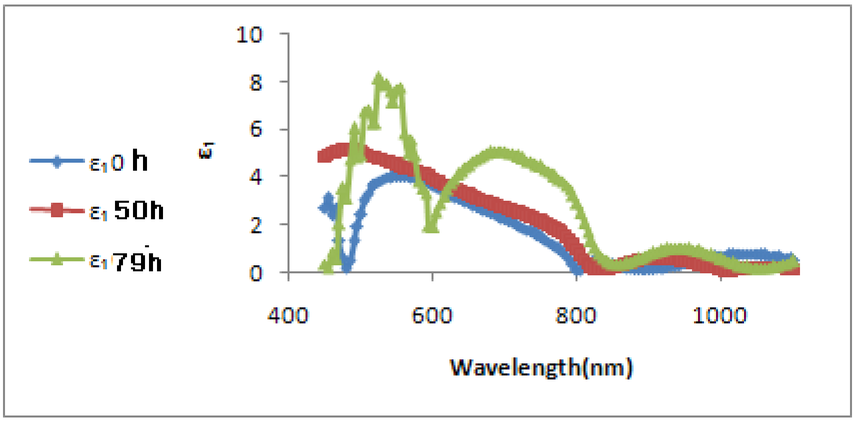


Figure.(5) Extinction coefficient of cd te thin films at different tradition time

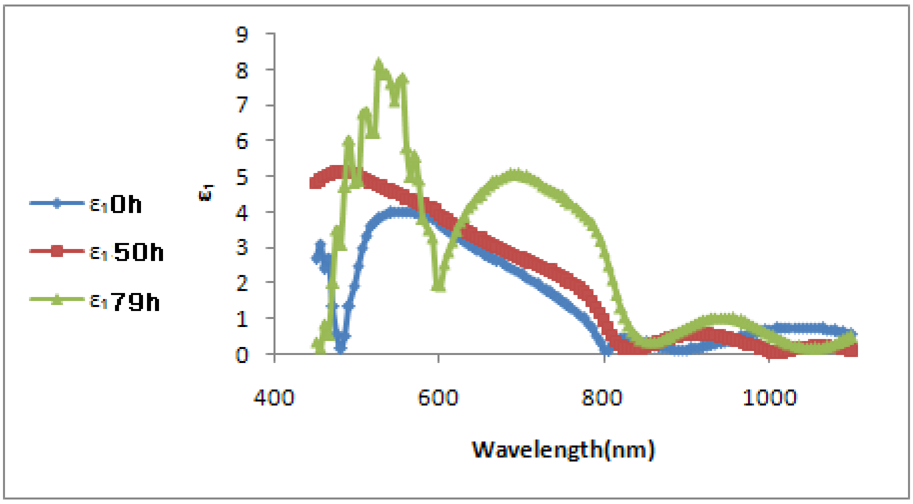


Figure. (6) Real dielectric constant of CdTe thin films at different tradition time.

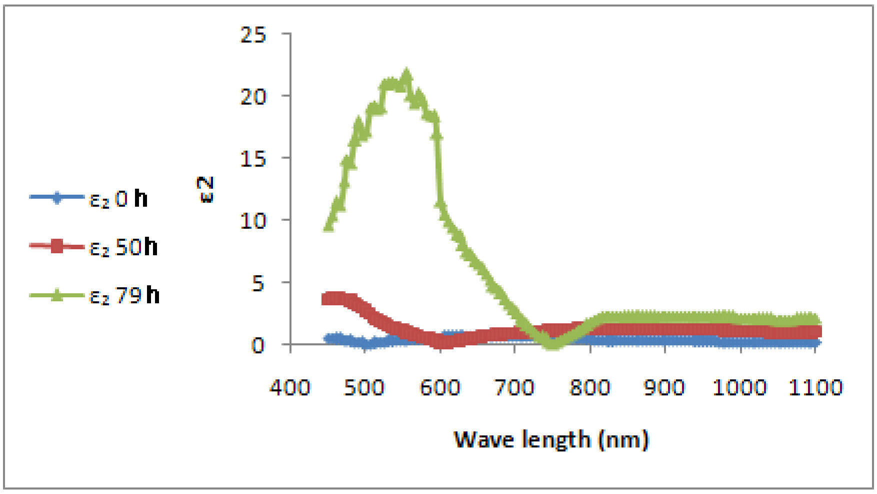


Figure. (7) Imaginary dielectric constant of CdTe thin films at different tradition time.

تأثير اشعة كاما في اغشية كادميوم تالورايد المرسبة بطريقة التبخير الحراري

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الخلاصة

تم دراسة تأثير اشعة كاما بطاقة 0.66 μeV في الخواص البصرية لأغشية CdTe المحضرة بطريقة التبخير الحراري باستعمال 350nm,شععت العينات بزمنين (50 ،79) ساعة بدرجة حرارة الغرفة. سجل طيف الامتصاصية لجميع النماذج باستعمال مطياف UV-VIS لحساب فجوة الطاقة البصرية ، معامل الانكسار وبعض العوامل الأخرى، ووجد أن فجوة الطاقة البصرية تقل من (1.9 إلى 1.6) eV .

الكلمات المفتاحية :- الخواص البصرية ، أشعة كاما، الأغشية الرقيقة، الخواص التركيبية.