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Effects of Gamma Radiation on Optical and Structural Properties of Cadmium Telluride Thin Films

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ABSTRACT

Cadmium Telluride (CdTe) thin films were prepared by thermal evaporation technique in the vacuum of about 3×10^{-3} mbar .using commercial glass substrates. The CdTe thin films were the effect gamma (γ) radiation on the grain size with dose 0.5µCi and membrane surface of treated films before and after to exposure period to gamma radiation and characterized by X-ray diffraction (XRD) results showed that the films are polycrystalline structure with hexagonal lattices and had preferred growth of grains along the (002) crystallographic direction. Atomic Force microscopy (AFM) and optical microscopic recognized. The optical band gap of thin films was found to allow direct transition with energy gap of 1.7 eV.

Keywords. Cdte Thin Film; Structural and Optical Properties; AFM, Nonstructural and Gamma Radiation Effect.

تأثير اشعة جاما(γ) على الخواص التركيبة والبصرية لأغشية الكادميوم تيلورايد (CdTe)

الخلاصة

حُضّرت أغشية الكادميوم تيلورايد بتقنية التبخير الحراري في الفراغ 3×10^{-3} ملي بار. باستخدام قواعد زجاجية. تم دراسة تأثير اشعة جاما (γ) بجرعة 0.5µCi على الحجم الحبيبي وعلى سطح الغشاء قبل وبعد التعرض لأشعة غاما (γ) لفترات زمنية مختلفة وخصائص الاغشية المحضرة باستخدام حيود الأشعة السينية (XRD) ، ، فحص المجهري البصرية (UV-VIS) ومجهر القوة الذرية (AFM) , حيث أظهرت النتائج حيود الأشعة السينية أن الأغشية كانت متبلورة كما أظهرت أن الاغشية كانت ذات تركيب سداسي، وافضل نمو الحبوب على طول الاتجاه (002) للبلورات. وأظهرت صورمجهر القوة ذرية (AFM) المجهر الضوئي له. وجد ان فجوة الطاقة للأغشية الكادميوم تيلورايد للانتقال المباشرة (1. 7) الكترون فولت.

INTRODUCTION

Cadmium telluride (CdTe) is an important group II–VI semiconductor with a direct band gap of 1.5 eV at room temperature. CdTe has long been known as an interesting semiconductor with application such as in gamma ray detection [1], Extensive research was done in the last two decades on CdTe thin films, mainly due to its potential applications, particularly in the field of polycrystalline thin film solar cells and also large area electronic devices like field effect transistors, radiation detector, optical thin film filters, nonlinear integrated optical devices, light emitting diodes (LEDs) and laser heterostructures for emission in the infrared spectral range [2]. The absorption edge in CdTe is very sharp due to its direct energy band gap and thus efficiency of absorption of light is very high around 90%. The maximum theoretical efficiency reported for CdTe solar cells is 29%. Whereas the conversion efficiency of CdTe solar cell was reported up to 16.5% [3], the conversion efficiency, crystallites size, optical properties and conduction phenomena in CdTe thin films are some open-ended problems demanding extensive research. Recently structural and optical properties of thermally evaporated CdTe polycrystalline thin films were reported [4], however the work on important parameters like nucleation of grain size, microstructures and how to affect various properties of polycrystalline CdTe thin films is still to be done[5]. The most used techniques to obtain these films are organometallic chemical vapour deposition[6],closed spaced sublimation [7], molecular beam epitaxy[8], electrode position[9] and sputtering [10].The results of relationships of (V_H) and(I) Show the p-type behavior of charge carries of the prepared CdTe thin films deposited by s thermal evaporation technique n on glass substrates .

EXPERIMENTAL

Preparation of CdO Thin Experimental

The CdTe thin films were Blazers evaporation grade CdTe (99.999%) using a molybdenum boat, under a vacuum of 3×10^{-3} mbar on glass substrates. Thicknesses of the prepared thin films were measured by a device (MINITEST – 3000) technique . The structure of the films studied by using X-ray diffract meter [X-ray diffraction data file] [N 1997 JCPDS prevalent. Japan] , Atomic Force Microscope (AFM) studies were thin film grown on glass substrates and optical properties using spectrophotometer[UV-VIS spectrum (Optima Sp – 300 Plus)]. Samples are placed in a chamber containing gamma radioactive source (^{137} Cs) MeV γ, for one week to two weeks.

RESULTS AND DISCUSSION

Structural Properties

A. The results of optical microscopic examination

The optical microscopic examination (Nikon- Japan) of CdTe thin film shows the effect of the membrane surface by gamma radiation, note that the greater of exposure period of gamma radiation it became more holes and defects as shown in Figure (1: a, b and c).

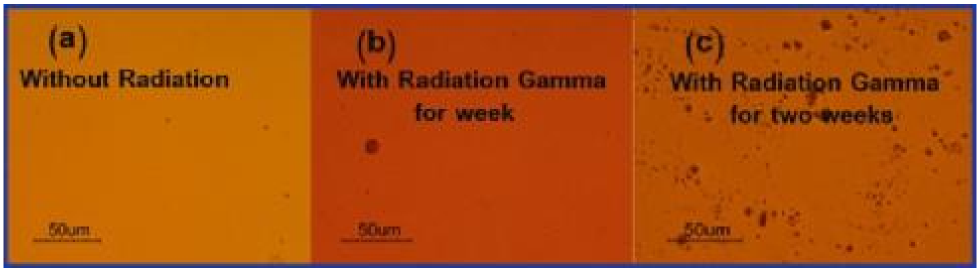

Figure (1) : Image of CdTe thin films without γ-irradiaton, b: Image of CdTe thin films with γ-irradiaton for week and c: Image of CdTe thin films with γ-irradiaton for two week.

B. Atomic Force Microscope (AFM)

The grain sizes of the CdTe thin films were selected by using the (AFM) technique, as shown in Figures (2: a, b and c) the effect of gamma radiation on the grain size, where we note the greater the period of exposure to gamma radiation increased the granular size of the membrane, because the absorption of energy by the grain leads to temperature high, there for will be increasing in membrane grain sizes. Gamma rays caused holes and clearly show when increasing the period of exposure to radiation as show in in Figures(2 : b and c). They are also calculated (Sa,Sq,Ssk,SKu,Sy and Sz) for the samples before and after irradiation by (AFM) technique.

Amplitude parameters: CdTe without gamma
Sa(Roughness Average) 0.656 [nm]
Sq(Root Mean Square) 0.877 [nm]
Ssk(Surface Skewness) 0.748
Sku(Surface Kurtosis) 6.06
Sy(Peak-Peak) 9.53 [nm]
Sz(Ten Point Height) 9.44 [nm]

Amplitude parameters: CdTe γ-irradiation one week
Sa(Roughness Average) 0.824 [nm]
Sq(Root Mean Square) 1.33 [nm]
Ssk(Surface Skewness) 3.29
Sku(Surface Kurtosis) 40
Sy(Peak-Peak) 22.6 [nm]
Sz(Ten Point Height) 18.2 [nm]

Amplitude parameters: CdTe γ-irradiation two weeks
Sa(Roughness Average) 1.14 [nm]
Sq(Root Mean Square) 2.14 [nm]
Ssk(Surface Skewness) 2.34
Sku(Surface Kurtosis) 32.5
Sy(Peak-Peak) 34.4 [nm]
Sz(Ten Point Height) 26.1 [nm]

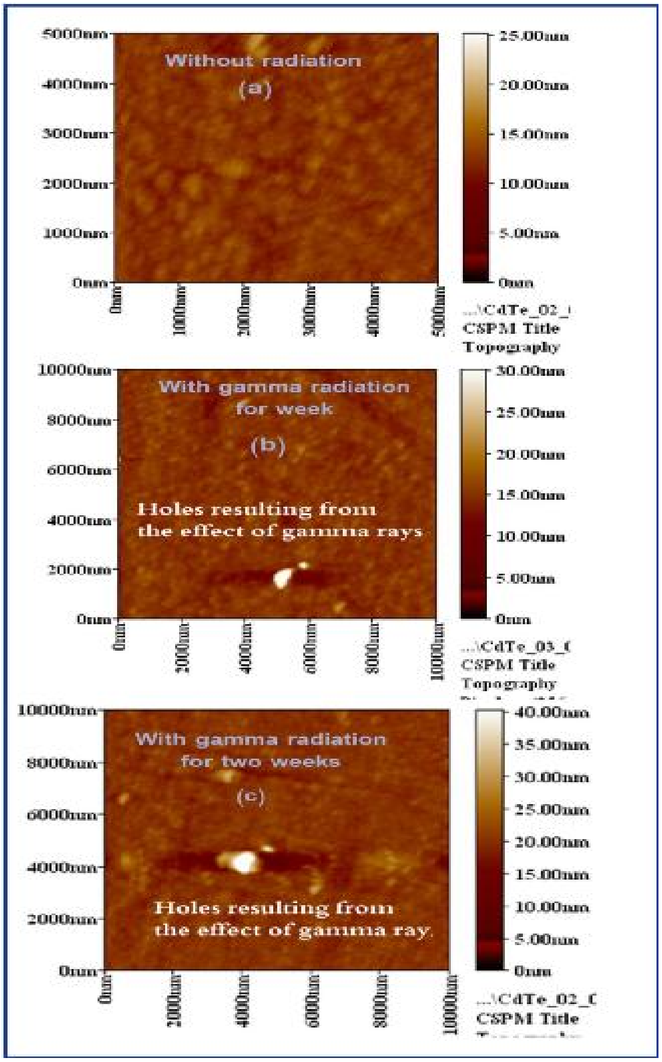

Figure (2) Atomic force microscope (AFM) Image of CdTe thin film a: without ɤ-irradiation, b: without (ɤ) irradiation for week and c:withoutɤ-irradiation Image of CdTe thin film withoutɤ- irradiation for two weeks.

C.X – Ray Diffraction (XRD)

X-ray diffraction (XRD) patterns were obtained for CdTe thin films deposited on glass substrates. The spectrum of CdTe thin film exhibits sharp peaks at *2Θ* equal to 23º.71, 39º.31 and 46º.61 which corresponds to diffraction from (002), (11 0) and (3 1 1) planes of the hexagonal phase, respectively These are in good agreement with the peaks are appear diffraction hexagonal phase formation as compared with s standard[X-ray diffraction data file [N 1997 JCPDS prevalent. Japan].Figure 3 shows diffraction patterns a clear (002) preferred orientation,. According to the XRD results, the intensity of peaks is changed indicating the radiation does changed the structure of thin film, it is possible to think that, the gamma energy and dose used are high enough to displace which transport atom from its lattice. On the other hand, the for a long period of exposure to gamma radiation. The increase in intensity may be resulting from grain growth .The increasing in the period of exposure to gamma radiation would appear to be related to the larger grain size, as discussed in the previous section. The average size of crystallite is estimated by Scherer's formula [11]:

$$D = K \lambda / \beta \cos\theta \quad \ldots \quad (1)$$

D: is the grain (G.S) **,** θ: is the Bragg's angle, K: is a constant (0.94),
λ: is the wavelength of Cu Kα =1.54060 ºA =0.154060 nm
β :is full width half maximum (FWHM) of the preferential plane CO_2 because of the

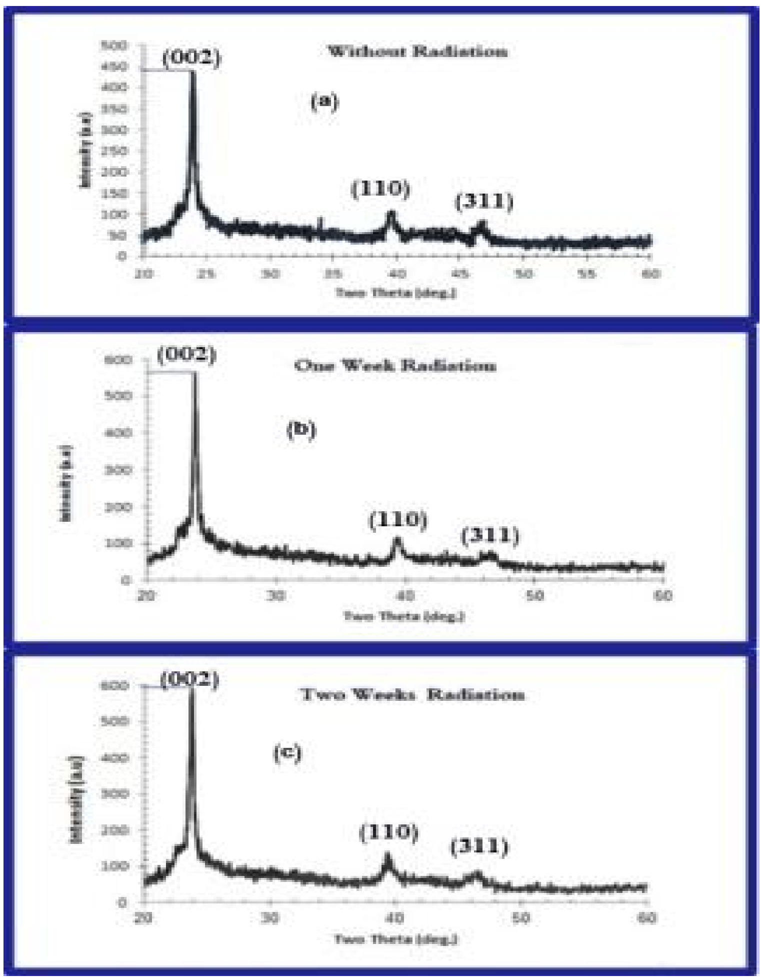

Figure (3) XRD patterns of a: deposited reference films without ɤ-irradiation b: deposit reference films without ɤ-irradiation after one week c: reference films without ɤ-irradiation after two week.

OPTICAL ANALYSIS

Optical absorbance spectra of the films are measured in the wavelength range of 200-900 nm by used Spectroscope. Figure (4) shows the effect of gam radiation on absorption spectra of CdTe films, note that the absorbance increases with the increase of the period of exposure of radiation doses in range (1 – 2 weeks). This could be due to the increase of the crystalline of these films with the irradiation dose period increase as shown in Figure (4). In order to deduce the optical band gap of the studied samples, the spectral dependence of absorption coefficient on the photon energy could be described by the following equation [12]:

$$(\alpha\, h\upsilon) = A\,(h\upsilon - Eg)^{p} \qquad \dots (4)$$

where $h\upsilon$ is the photon energy, A is a parameter that depends on the transition probability, α is the absorption coefficient, Eg is the optical band-gap energy and the exponent p depends on the type of the optical transition between the valence and conduction band; direct or indirect optical transitions. The simplest way to determine From Figure 4 .The direct optical energy band-gaps was determined; it is clear that direct energy band-gaps increase with increasing of the period of exposure of radiation doses in range (1 – 2 weeks). This can be explained that. This excessive energy leads to the formation of short-range order [13] or creation of localized energy states in the normally forbidden energy gap. Whenever gamma radiation interacts with the thin film, induced defects will be formed and the density of the localized states increases resulting in increase in the energy gap as show in Table (1).

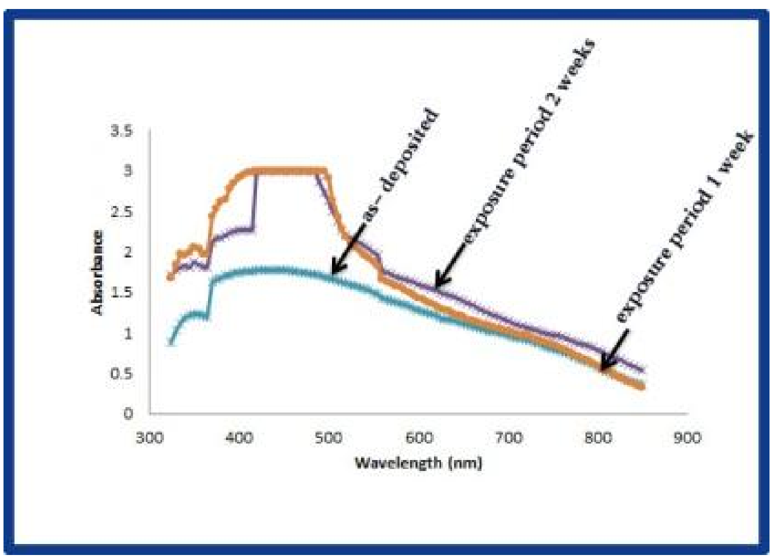

Figure (3) typical optical absorption spectra for CdTe thin films, Corresponding to different values of the exposure period of reference Films with ɤ-irradiation after one week.

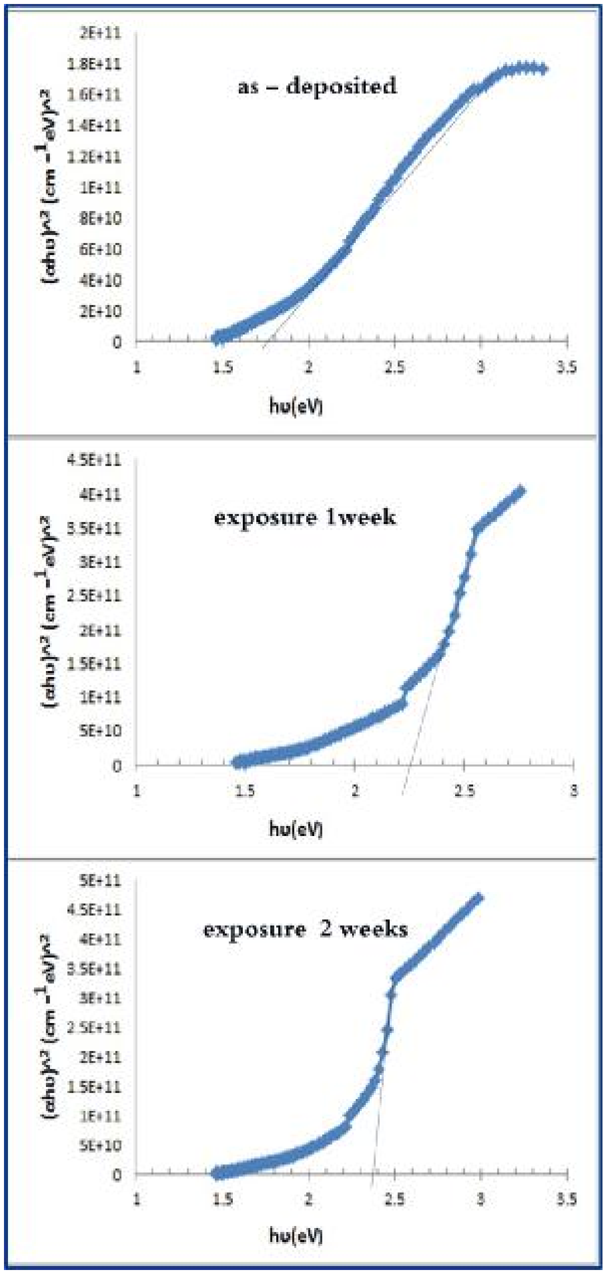

Figure (4) Plots of $(ahv)^2$ vs hv for CdTe thin films, corresponding to different values of the exposure oeriod of gamma radiation dose.

Table (1) Optical band gap (Eg) values for CdTe thin films with exposure period of gamma radiation dose.

CdTe	Eg (eV) direct
As - deposited	1.7
exposure period 1week of gamma radiation	2.25
exposure period 2weeks of gamma radiation	2.4

CONCLUSIONS

CdTe thin films have been deposited by the thermal evaporation technique in the vacuum, According to the XRD results, the intensity of peaks are increasing with increase of the period of exposure to irradiation gamma. The AFM results showed The grain size increase with increasing of period of exposure to irradiation gamma. Spectrum absorption increase after exposure the thin film to irradiation gamma doses. The shift of the adage band toward higher photon energy for the exposure period to irradiation gamma.

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