Radiation Effect on the Optical& Structural Properties of CdTe: Zn thin Films

Suad I. Issa
Dept.of Physics/College of Education For Pure Science (Ibn Al- Haitham)/
University of Baghdad

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Abstract

The Films of CdTe:Zn were prepared on a glass by using vacuum vapor deposition technique .The x-ray diffraction pattern revealed that the films have polycrystalline with FCC structure and the preferred orientation was along (111) plane.

The films were exposed to a low dose of gamma ray.(5μCi for 30 days) Transmission and absorptance spectra were recorded in the range of (400-1100) nm before and after irradiation. It was found that irradiation has a clear effect on the optical and structural properties which include the transmition and absorption spectra, extinction coefficient, refractive index, and the energy gap.

Keywords: CdTe thin films , Vacuum Evaporation , XRD

Introduction

CdTe has emerged as a promising thin film material for a number of reasons. Thin films of CdTe are usually p-type semiconductors, but can be made both p-type and n-type.[1] Its 1.5eV direct band gap is nearly ideal for terrestrial energy conversion. It has a very high absorption coefficient, meaning that relatively thin layers can be used to make functional devices.[2]

CdTe is an important II -VI semiconductor material, which is very useful for a variety of electro-optical devices and solar energy conversion [3-4]. The theoretical limit of conversion efficiency for polycrystalline CdTe is 29%.[5] By 1982, Kodak researchers Tyan and Perez-Albuerne had produced the first cell with 10% efficiency.[2]

Having a large exciton Bohr diameter (15.0 nm), and its high absorption coefficient ($\tilde{}10^5$ cm^{-1}) [4]. There are some rearranged reports about the deposition methods available for the preparation of CdTe thin films such as close spaced sublimation (CSS), physical vapor deposition (PVD), vacuum evaporation, vapor transport deposition (VTD), closed space vapor transport, electrodeposition, screen printing, spray pyrolysis, metalorganic chemical vapor deposition (MOCVD), and RF sputtering.[6]The aim of the work is to study effect of X-ray and gamma ray on the optical and structural properties of the CdTe:Zn films.

Experimental

CdTe thin films were deposited on to well-cleaned glass substrates by physical vapor deposition technique. The samples under study were prepared using the following deposition parameter: the source (evaporator), substrate distance was (10cm) , source temperature was 300K ,and the films were deposited under a pressure of 3×10^{-5} mbar[7-8]. the films thickness was determined by the weight method from the equal :

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

where:

t : thickness

Δm: different between the weight and the weight substrate before and after the film deposition.

ρ: density of the material deposition (gm/cm^3)

A: substrate area (cm^2).

All films had nearly about or equal to thickness (500nm). The optical and absorption measurement were recorded using one beam (UV-Visible 1800 spectra photometer) in the 400-1100 wavelength. The thin film CdTe:Zn with two percent deposited 2% was radiation by gamma ray from CO^{60} 5μci within 30 days, after that the transmition and absorption spectra were recorded and we studied the effect of radiation on the optical and structural properties.

Structural properties

The prepared sample CdTe:Zn thin films on thin glass slides substrates reveal that the nature of the structures of films were polycrystalline and typed cubic [9].Applying Brag's Law using (hkl Miller indices) these faces are in agreement with (ASTM) standards card as well as previous studies[10-11] .Figures (1),(2) show the x-ray diffraction spectra (CdTe:Zn) before and after irradiation .Fig(1) clarifies strong diffraction peaks at (23.5˚,25.5˚) it is before irradiation and Fig(2) clarifies strong diffraction peaks only at(23.5˚) after irradiation .

Results and Discussion

By studying optical properties (transmission and absorption spectra, refractive index dispersion) of CdTe:Zn films, information can be obtained about energy band-gap , characteristics of optical transitions , etc.[5] The optical transmission spectra before irradiation as a function of wavelength in the range of (400-1100)nm is shown in Fig(3) for CdTe:Zn

The ratio of deposition was 2% it is obvious from the Figure that CdTe:Zn has a larger transmittance for wavelength 270 nm. The CdTe:Zn film after irradiation is decreased with transition which indicates the increment with absorbance. The absorbance of the films as a function of wavelength is presented in Fig(4) the absorbance spectra before irradiation is increased with wavelength and after irradiation decreased with absorbance in visible range (500-700)nm. The extinction coefficient k was calculated from the relation [12].

$$k = \frac{\alpha \lambda}{4\pi} \qquad (2)$$

Where:

α: Absorption coefficient.

λ: wavelength for the incident light.

It could be noticed that k before irradiation increases in 2.9eV and after irradiation is decreased and it is shown in Fig (5). The refractive index was calculated from the relation [13]

$$n = \left[\frac{(1+R)^2}{(1-R)^2} - k^2 + 1\right]^{1/2} - \frac{1+R}{1-R} \qquad (3)$$

Where:

R: Reflectance and calculated with the relation [14]

$$R = 1 - A - T \qquad (4)$$

Figure (6) depicts the variation of refractive index with photon energy for films. Therefore the refractive index decreases after irradiation from (20.1) to (9.2) and shift in energy gap from a value of (1.8eV) to a value of (1.6eV).

Fig (7) and Fig (8) clarifies the relation between $(\alpha h\nu)^2$ and hν. The relation between absorption α and the incident photon energy hν can be written as [15]

$$\alpha h\nu = C_1 (h\nu - E^i_g)^2 \text{ ,indirect transition} \qquad (5)$$

$$\alpha h\nu = C_2 (h\nu - E^d_g)^{1/2} \text{ ,direct transition} \qquad (6)$$

where

C_1 and C_2 are constants

E^i_g is the indirect transition band gap energy

E^d_g is the direct band gap.

The

$(\alpha h\nu)^2$ are plotted against the photon energy (hν) the intercept point with the energy axis gives the edge of the allowed direct transition. It has been observed that direct band gap energy increased before irradiation was (1.6eV) and the value of the after irradiation decreased to (1.58eV).

Conclusions

It was found that irradiation has a clear effect on the optical and structural properties by studying optical properties (transmission and absorption spectra , refractive index dispersion) of CdTe:Zn films.

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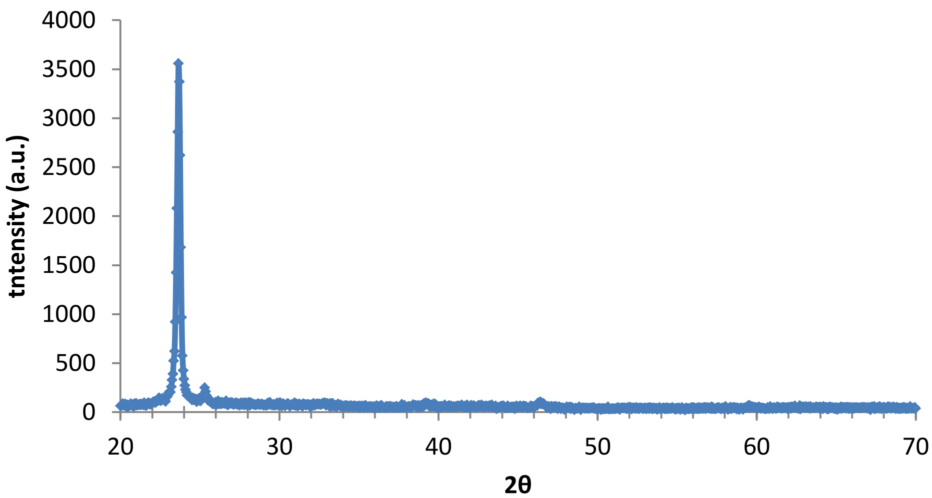

Fig (1): X-ray diffraction before irradiation

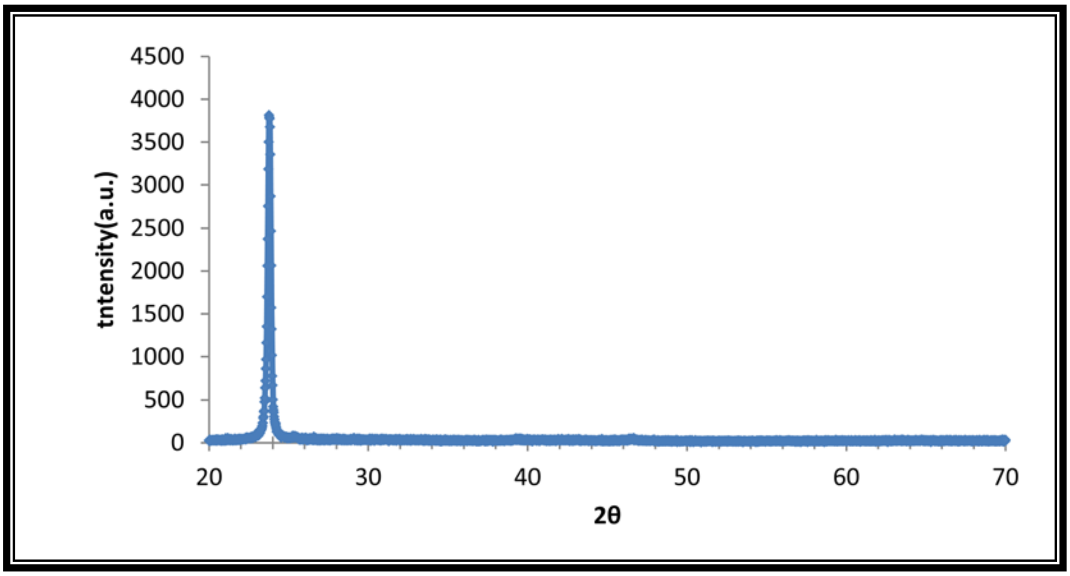

Fig (2): X-ray diffraction after irradiation

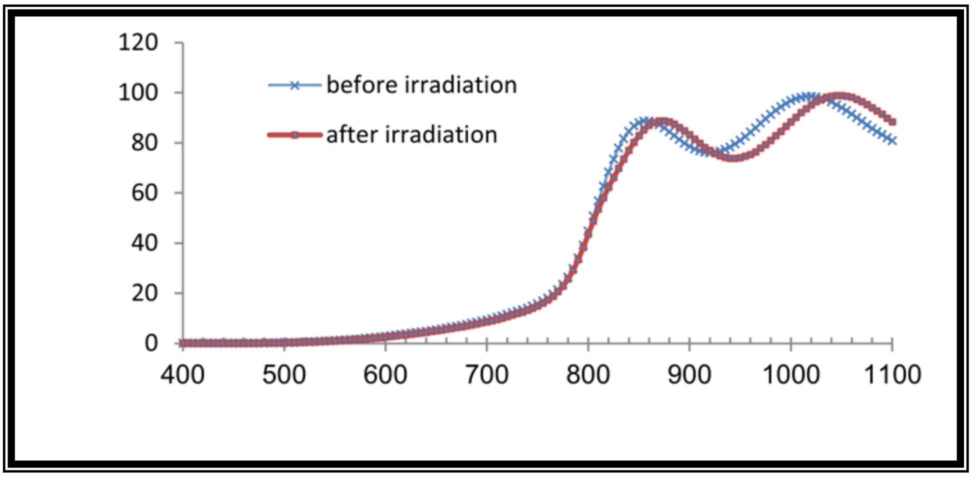

Fig. (3) :Transmittance as a function with wavelength

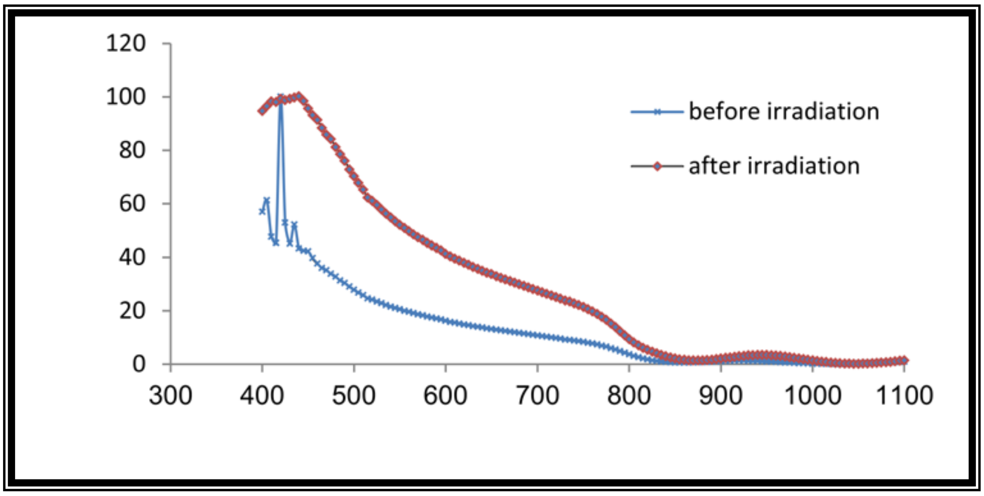

Fig. (4): Absorbance as a function with wavelength

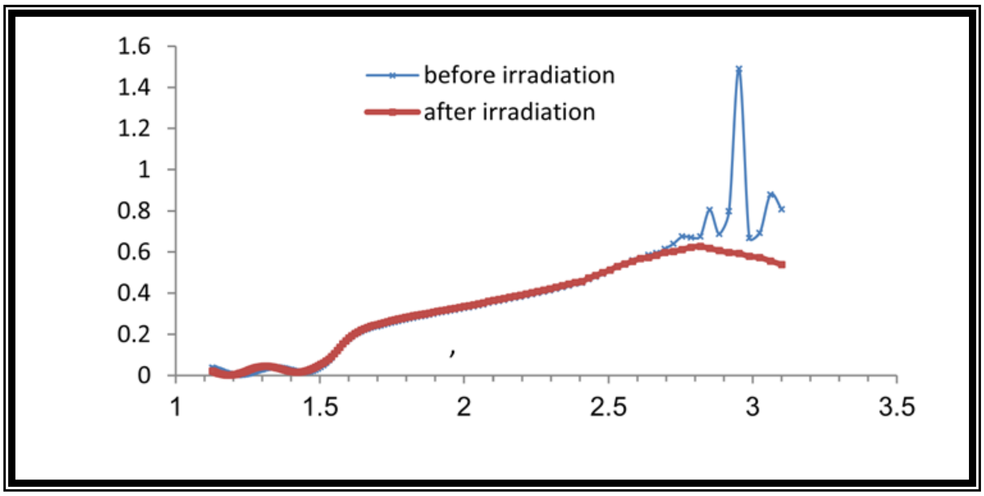

Fig. (5): Extinction coefficient as a function of photon energy

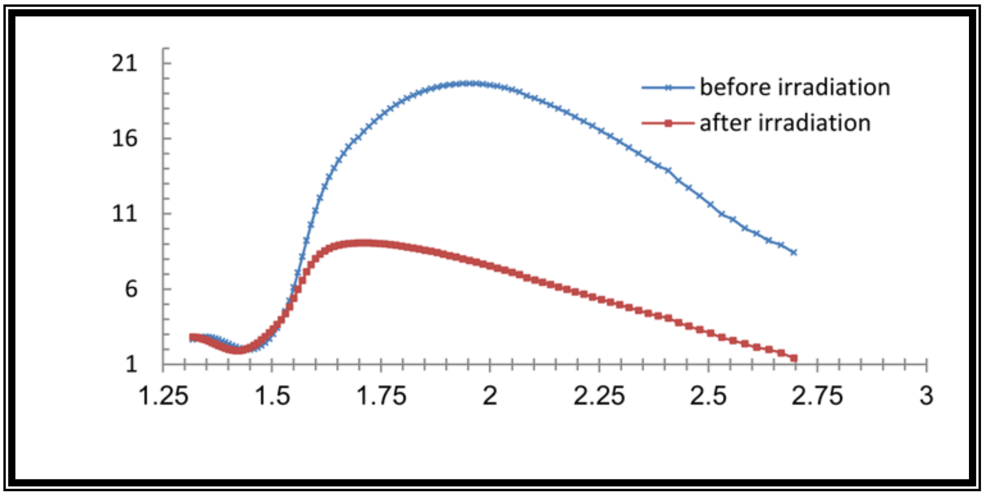

Fig. (6) Refractive index as a function of photon energy

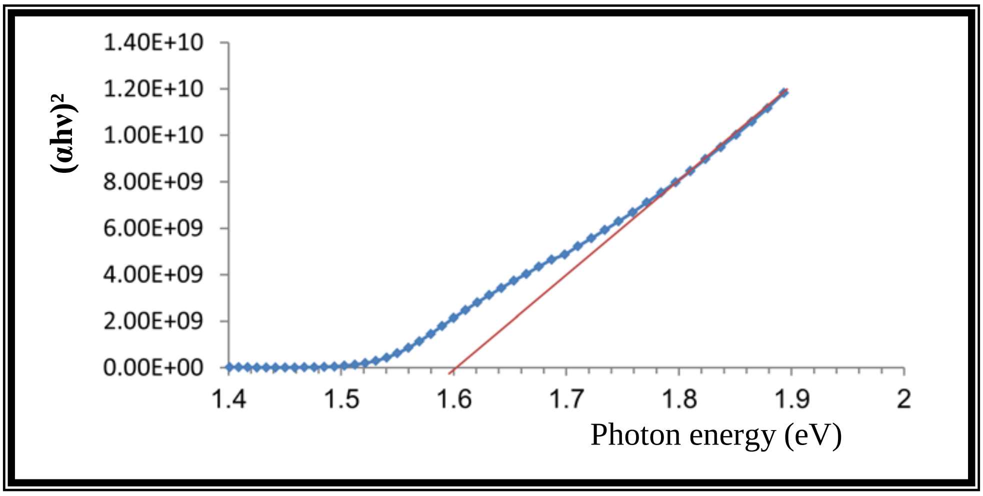

Fig. (7) (αhν)² as a function with photon energy (before irradiation)

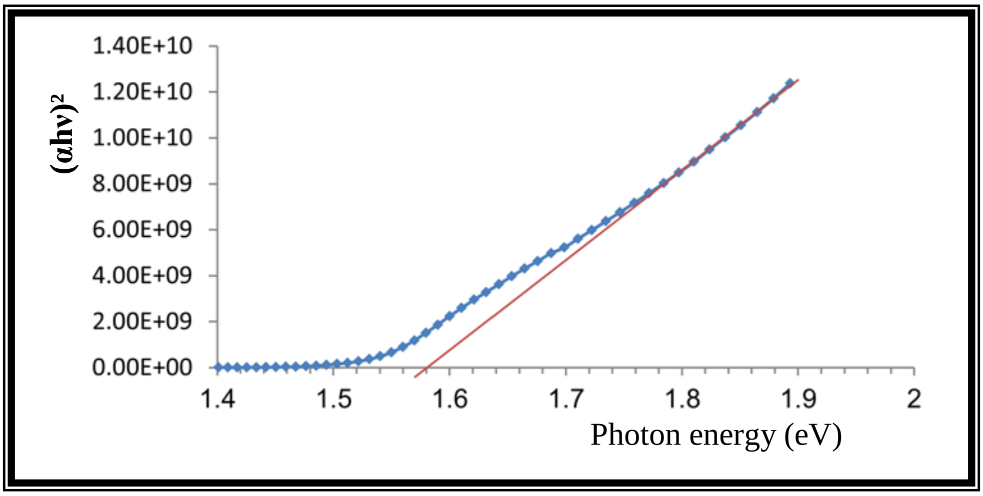

Fig. (8) (αhν)² as a function with photon energy (after irradiation)

تاثير التشعيع في الخواص البصرية والتركيبية لاغشية تيلرايد الكادميوم المشوبة بالزنك

سعاد عمران عيسى
قسم علوم الفيزياء /كلية التربية للعلوم الصرفة (أبن الهيثم) / جامعة بغداد

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الخلاصة

حضرت اغشية تيلرايد الكادميوم الرقيقة المشوبة بالزنك باستخدام تقنية التبخير الحراري في الفراغ على قواعد من الزجاج. ظهر من طراز حيود الاشعة السينية للاغشية المشوبة قبل التشعيع انها متعددة التبلور وامتلاكها تركيب مكعب FCC وباتجاهية (111) عُرِّضت هذه الاغشية لجرعة من اشعة كاما 5μCi مدة 30 يوماً، سجل طيف النفادية والامتصاصية من مدى nm(400-1100) لهذه الاغشية قبل التشعيع وبعده. لقد وجد ان التشعيع قد اثر وبشكل واضح في الخواص البصرية والتركيبية والمتضمنة طيفي النفادية والامتصاصية، معامل الخمود، معامل الانكسار، وفجوة الطاقة المحظورة.

الكلمات المفتاحية: أغشية CdTe النقية ، التبخير الفراغي ، حيود الاشعة السينية