Effects of gamma irradiation on optical properties of CdS thin film

تاثير اشعه كاما على الخواص البصريه لفلم كبريتات الكادميوم

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Abstract

The effect of gamma-ray radiation on the optical properties of CdS thin film .Thin film were prepared by sol Gel technique .The investigated thin films of 1µm thickness are then irradiated by 25 kGy doses of ^{137}CS(Half time 28 years) gamma rays. The optical properties of prepared film have been studied using UV-VIS spectrophotometer in the wavelength range 300 nm-1100 nm. Optical constants, such as absorption, extinction coefficient , refractive index ,real and imaginary type of dielectric constant are calculated. The prepared films were found to be of direct energy gap found to be in the range of 2. 4eV before radiation and 2eV after radiation .
Keywords: Thin films; CdS; Gamma irradiation; sol Gel; Optical properties.

الخلاصه

تم دراسه تاثيرالتشعيع باشعه كاما على الخواص البصريه لغشاء كبريتيد الكادميوم بسمك ا مايكرومتر والذي شعع باشعه كاما من مصدر السيزيوم 137 بجرعه kGy 25 (عمر النصف 28 سنه) .ودرست الخصائص البصريه للغشاء المحضر في المنطقه المرئيه – فوق البنفسجيه UV-VIS من الطيف الكهرومغناطيسي من خلال تسجيل طيف الامتصاصيه للغشاء المحضر في مدى الاطوال الموجيه nm (300-1100) ودرست الثوابت البصريه للغشاء المحضر كمعامل الامتصاص، معامل الخمود، معامل الانكساروثابت العزل بنوعيه الحقيقي والخيالي لنفس الطيف ،وكذلك تم ايجاد فجوه الطاقه للفلم المحضر وكانت قيمه فجوه الطاقه 2الكترون فولت بعد التشعيع و 2.42 الكترون فولت بعد التشعيع .

Introduction

Nanostructured materials are defined as materials that their diameters have dimensions in the range of 1 to 100 nm. While conventional materials have grains varying in size from 100 micron to several millimeters. The particular mechanical, magnetic, electronic and other physical properties of nanomaterials are in focus of the actual scientific and technological research [1, 2]. Nanoparticles semiconductor is an exciting materials whose optical and electronic properties can be manipulated by changing their size or composition. Semiconductors like (CdSe, CdS, ZnS, or ZnSe) with size of a few nanometer exhibit a broad excitation by all wavelengths, high brightness, narrow and symmetrical emission, and excellent photostability. In addition, the semiconductor can be used in photovoltaic devices, photodetectors, and as fluorescent biological labels [3].

Cadmium Sulfide (CdS) is a semiconductor material with a bandgap of 2.42 eV [4,5]. The importance of CdS nanoparticles thin film has experienced a fast rising, mainly due to its applications in piezoelectric, laser materials, and photovoltaic cells [5]. In addition, CdS nanoparticles have critical applications in solar cells, optoelectronic and electronic devices [6].The interest in the nonlinear optical properties of nanometer-sized semiconductor crystals, especially semiconductors have become a subject of intensive research for their extraordinary properties compared to their bulk counterparts. Semiconducting materials in the nanostructured form offers the possibility of possessing large optical nonlinear response. Such unusual properties may have technological applications such as optical-switching devices and light emitters[7]

Experiment

For the deposition of CdS thin film by sol gel dip coating solutions have been prepared Cadmium Sulfide –CdS was dissolved in Dilute sulfuric acid was added to solution under stirring , which was continued for half hour.. The prepared solution deposition of thin film. The dip coating coating technique was used to deposited thin film using above sol. The spin-coating technique was used to prepare thin films using the above sol on to glass substrates. The substrates were rotated at a speed of 500 rpm for 30 sec. After deposition annealing of the film is necessary in order to remove solvent and residual organics and film destification. So the film have been post annealed in air at 120 ^{0}C.

The Optical properties of thin films deposited by method has been studied by using double beam spectrophotometer After that the film is exposing to gamma radiation using a source of cesium The film has been exposing to radioactive cesium-137 source and the duration of the irradiation of the film 2 minutes , the amount of dose 25 KGy and was half-life of the sourceis 28 year, The distance between the film and irradiated source 1 cm as show in figure (1). It was study the effect of radiation on the optical properties of thin film .

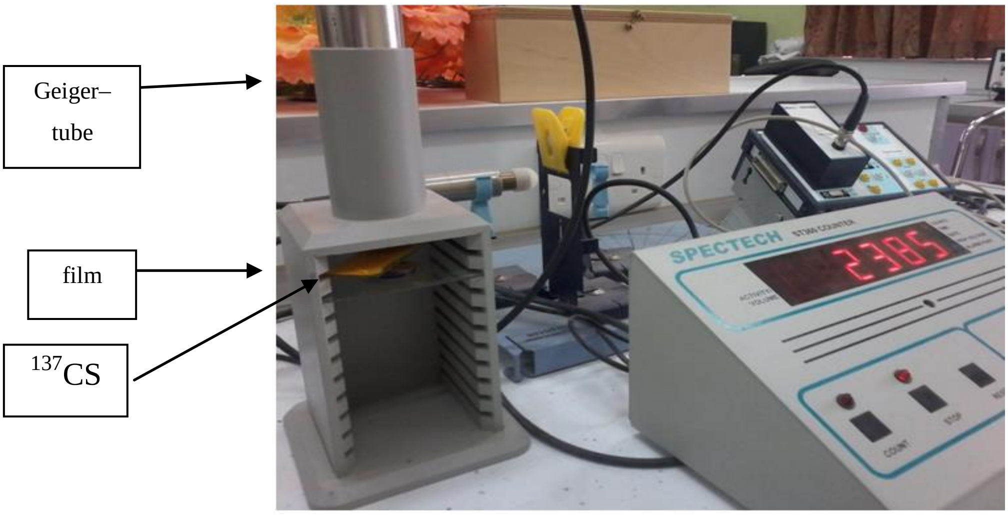


Figure (1) gamma irradiation process

Results and discussion

Optical Analysis

Optical analysis of CdS samples deposited on glass were performed using UV-Vis and Photoluminescence spectroscopies. These two characterization techniques are generally used for bandgap determination and purity approximation respectively. UV-visible spectroscopy was performed in room temperature and at a region from 200 nm to 1000 nm. The UV-Vis spectrum of CdS deposited glass is after that The film was exposed irradiation gamma study absorbance spectrum after irradiation shown in Figure (2).

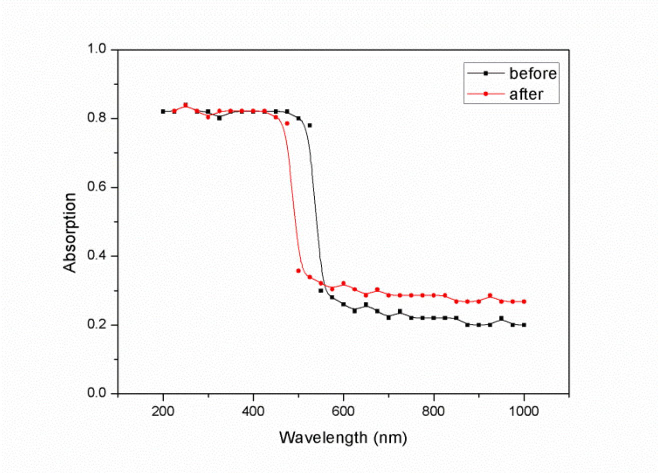


Figure (2) Optical absorption spectra of CdS film before and after irradiation

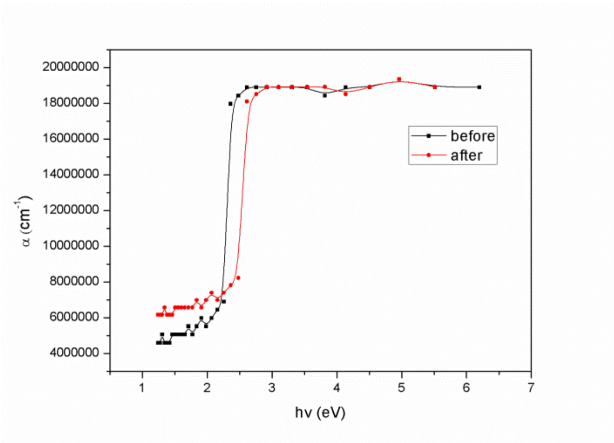
from where it is seen that the absorption increases with irradiation dose which is attributed to the production of defect levels. It is seen in figure 2 that the absorption edge shifts to higher wavelengths with increasing implantation dose suggesting a decrease in the optical bandgap.

well as the absorption coefficient was calculated from equation[8]

$$\alpha = 2.303 * \frac{A}{t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where t is the thickness A is absorbance

also calculate the energy hv there was a relationship between the absorption coefficient and energy of both cases before and after irradiation, as shown in Figure (3)



Figure(3) The absorption coefficient as afunction of photon energy of CdS thin film before and after irradiation

Note figure3 of the find absorption coefficient as a function of photon energy change of membrane cadmium sulfide (CdS) before and after irradiation the absorption coefficient increased after irradiation and this because of the decrease in the energy gap and the optical alignment of the atoms,

It was the refractive index calculation of the equation[8]

$$n = \frac{(1+R^{1/2})}{(1-R^{1/2})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

extinction coefficient from equation [9]

$K = \alpha\lambda/4\pi$……………………………(3)

The relationship between the refractive index and the incident photon energy shown in figure(4)

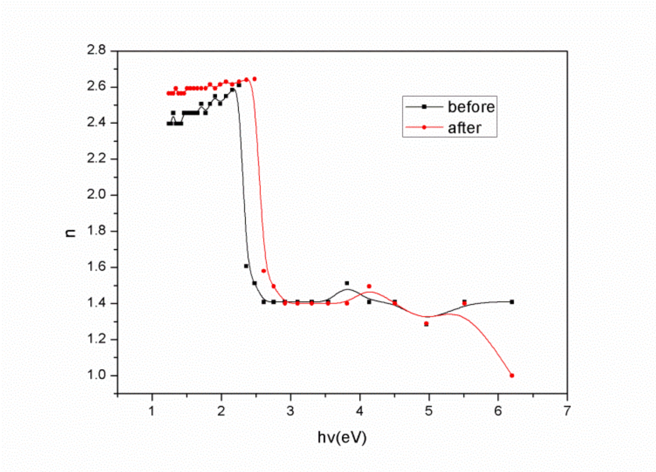


Figure (4) the refractive index as a function of photon energy incident of CdS film before and after irradiation

The change in refractive index as a function of photon energy for membrane cadmium sulfide (CdS) thin film before and after irradiation observe that the refractive index values after irradiation lower than it is before irradiation.

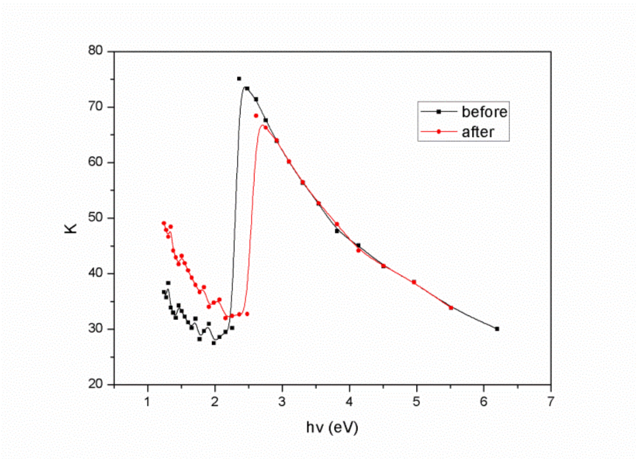


Figure (5) explains extinction coefficient as a function of photon energy of CdS film before and after irradiation

And found that the before and after radiation is observed that the value of the extinction coefficient of after irradiation larger than it is before irradiation.

Optical Energy Gap

The optical energy gap in which, the minimum of the conduction band and the maximum of the valence band,The relation between the optical energy gap, absorption coefficient and energy hυ of the incident photon is given by [10] [11]:

$\alpha (h\nu) = B(h\nu - Eg)^{r}$ ………… (4)

where Eg is the optical energy gap; α is the absorption coefficient; B is a constant; and r is an index which can be assumed to have values of 1/2, 3/2, 2 and 3, depending on the nature of the electronic transition responsible for the absorption. r = 1/2 for allowed direct transition, r = 3/2 for forbidden direct transition and r = 3 for forbidden indirect transition, and r = 2 refers to indirect allowed transitions.

The optical band gap has been obtained from the plot of $(\alpha h\nu)^2$ against $h\nu$ (Figure 6) via extrapolating the straight line portion of the curve to intercept the energy axis. The band gap energy obtained as intercept on $h\nu$ axis were found to be in the range of 2. 4eV before radiation and 2eV after radiation .The value of energy band gap of the film obtained using the absorption spectra are closer to the bulk band gap (2.42eV) .

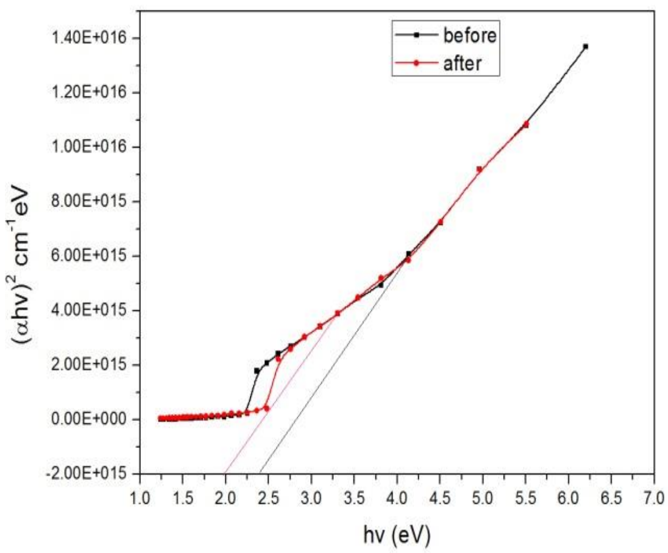


Figure (6) $(\alpha h\nu)^2$ as a function of photon energy $(h\nu)$ for films CdS before and after radiation

Note figure 6 of the gamma rays we find the effect on the amount of energy gap and led to the decline.

And also it was reflective film calculation of the equation[12]

$R = 1 - A - T$………………………………. (5)

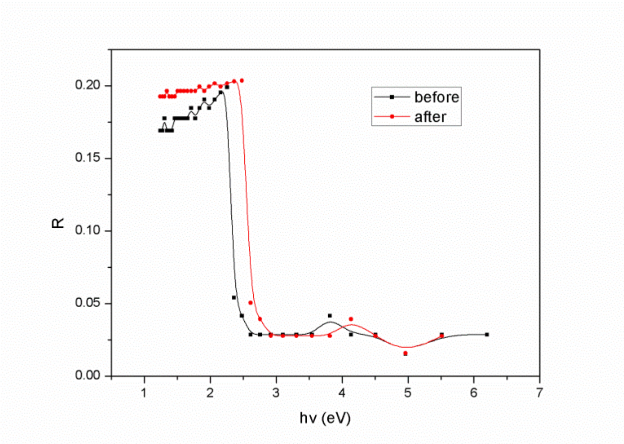


Figure (7) The reflectivity as a function of photon energy before and after irradiation from the figure(7),we find that the reflectivity lower slightly after irradiation because the irradiation effect on the brightness of the the films became coarse non-glossy.

also it calculation of the real part dielectric constant by the equation[13,14]

$\epsilon_r = n^2 - K^2$……………………………..(6)

imaginary part of dielectric constant by equation [13,14]

$\epsilon_{\mathrm{i}} = 2nK$…………………………………*(7)*

Find photon energy incident relationship as in Figures(8,9)

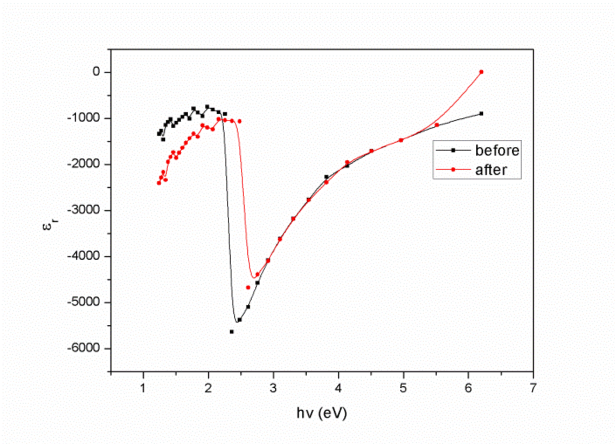


Figure (8) The real part the dielectric constant as a function of photon energy of CdS films before and after irradiation

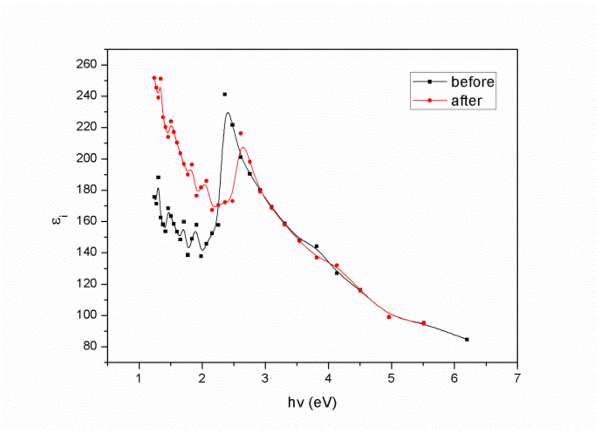


Figure (9) The imaginary part the dielectric constant as a function of photon energy of CdS films before and after irradiation

It is clear from those Figures 8,9 that both the real and the imaginary parts for cds film are increased after irradiated by gamma ray, From this figure we can deduce that the values of the real part are higher than those of the imaginary part ,the real part of the dielectric constant behavior nearly similar for all the range of the wavelength spectrum to that of the refractive index because of the real part depends mainly on refractive index according o the equation (6), while the imaginary part depend on extinction coefficient values which are related to the variation of absorption coefficient, we can see from Fig.(9) the imaginary part value decrease with increasing irradiation at lower photon energy followed increase this values with increasing irradiation at higher photon energy and the peak shift to higher photon energy. The dielectric behavior of the polymer is due to the presence of an appreciable number of defects in the form of chain scission, cross-linking, discontinuity, bending, breaking of bonds, etc. in the molecular chains. Upon irradiation, the increasing defects results in the formation of a greater number of dipoles in the polymer matrix that governs its dielectric properties.

Conclusion

The effect of irradiation on the electrical and optical properties of a-CdS thin films before and after gamma irradiation was carried out and the following conclusions are drawn:The optical properties are influenced by irradiation. The absorption coefficient decreases, the same behavior for the optical energy gap E_{opt} shifted to lower energy and the values of E_c.This change may cause a shift in the Fermi level leading to the reduction in optical band gap from 2.4 eV to 2 eV. The energy gap less after irradiation of what is before irradiation and time-mounting. It can be explained by the decrease in the energy gap fallacy that irradiation led to the creation of flat donor within the energy gap near the delivery package, and that the presence of these levels increases the likelihood that the absorption of photons with wavelengths long, thereby reducing the fallacy energy gap.

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