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Influence of gamma radiation on optical properties of CdS thin films prepared by chemical bath technique

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Abstract

We have studied the effect of gamma irradiation on the absorption spectra and the optical energy gap of CdS thin films deposited by chemical bath technique method on glass substrate. Transmittance spectra have been recorded in order to determine reflectivity, absorption coefficient , kind of transition .The optical constants such as refractive index , extinction coefficient , real and imaginary part of dielectric constant have also been studied , it was seen that all the parameters under investigation affected by gamma irradiation.

Key words: Cds thin film, optical properties, chemical bath technique, and irradiation effect.

الخلاصة:

تم دراسة تاثير اشعة كاما على طيف الامتصاص وفجوة الطاقة البصرية للغشاء الرقيق كبريتيد الكادميوم المرسب باستخدام تقنية الحمام المائي الكيميائي على قواعد زجاجية .سجل طيف النفاذية والامتصاصية وذلك لغرض تحديد الانعكاسية, معامل الامتصاص و نوع الانتقال .كذلك تم دراسة الثوابت البصرية متمثلة بمعامل الانكسار ومع امل الخمود والجزء الحقيقي والخيالي من ثابت العزل الكهربائي ,ولقد وجد ان جميع المعلمات التي تمت دراستها تاثرت بأشعة كاما .

Introduction

Studies on the changes in optical properties of thin films irradiated with ionizing radiations yield valuable informations regarding the electronic processes in these materials. Ionization occurs and charged species, are formed. It is believed that ionizing radiation causes structural defects (called color centers or oxygen vacancies in oxides) leading to their density change on the exposure to γ-rays.[1] Thin film of cadmium sulphide solar cell has for several years been considered to be a promising alternative to the more widely used silicon devices.[2] Thin CdS films deserve attention because their expected gap emission lies very close to the highest sensitivity of the human eye. Thus, one might assume that CdS thin films are an appealing host for photonic devices [3].This material was prepared by several methods including evaporation, sputtering, chemical bath deposition (CBD), spray, molecular beam epitaxy (MBE) , and metal organic chemical vapour deposition (MOCVD)[4-9] . Among them, (CBD) and spray pyrolysis method is best suited for thin film deposition because of simplicity, convenience, least expenses to produce uniform, adherent and reproducible large area thin films for solar related applications [9]

The aim of this work is to study the effect of Gamma irradiation on optical properties of CdS thin films.

Experimental details

The deposition process of CdS thin films were done on commercial glass slides with 1mm thick and 2.5 ∗ 7.5 cm2 size. Before the deposition they were cleaned by detergent solution then washed by deionised water and finally they were cleaned by using ethanol solution. Every two samples should be put with their back sides facing each other so as to insure that the growth of the film well be done on one side of each glass substrates. The deposition arrangement consisted of a water bath on a hot plate. We used a 250 ml borosilicate glass flat bottom baker for the process. The aqueous solutions of the reaction were 0.1 M cadmium chloride, $CdCl_2$, 1 M thiourea, $CS(NH_2)_2$, 0.7 M ammonium chloride, NH_4Cl, and 2 M ammonium hydroxide, NH_4OH. 50 ml of NH_4Cl and 50 ml of NH_4OH were dispensed into the baker and 50 ml of $CdCl_2$ was added in drops to prevent $Cd(OH)_2$ formation in the solution. Substrates were placed vertically into the baker and heated in the water bath to 85 °C. 50 ml solution $CS(NH_2)_2$ was slowly dropped into the preheated solution in the baker. The deposition process time was 120 minute with 300 nm thick. A 137Cs gamma – rays used to irradiate the thin films under Investigation for seven days.

Results and discussion

In Figure (1) the optical transmittance (T%) and optical reflectance (R) spectra of Unirradiated and irradiated CdS films are shown.

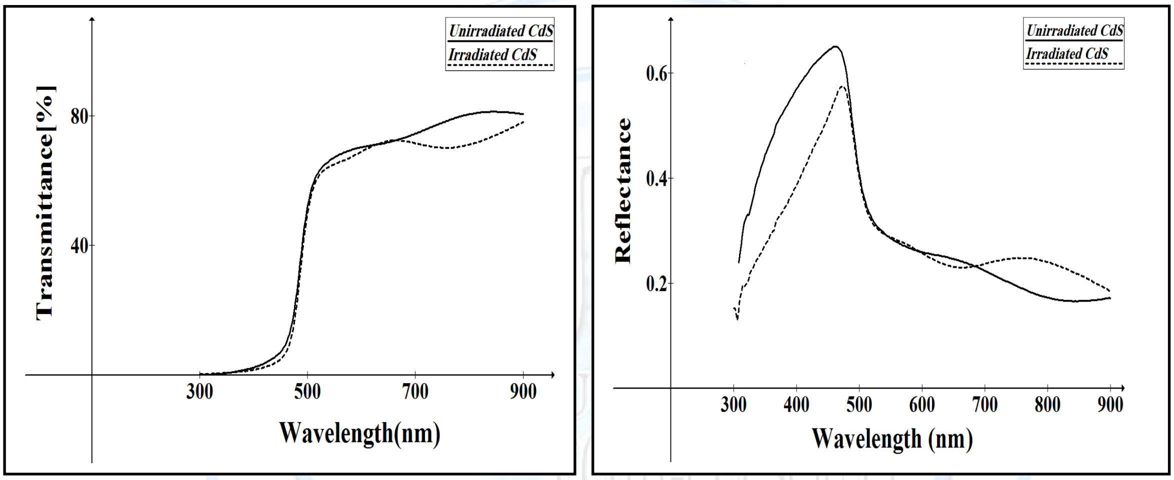

Figure (1) (a) Transmittance [%] versus Wavelength. (b) Reflectance versus Wavelength

Unirradiate film shows high transmittance compared to irradiated one, this might be attributed to the increased roughness of the irradiated thin films contributed to the drastic decrease of optical transmittance [11] The average transmittance for both films are approximately 80% in the visible region of the spectra above 500 nm , making them possible to be used as window layers in solar cells . It is observed that the transmittance (for both curves) decreases at the spectral region of fundamental absorption. In this region the incoming photons have sufficient energy to excite electrons from the valence band to the conduction band and thus these photons are absorbed within the material to decrease the transmittance. [12]

The variation of absorption coefficient α with photon energy is shown in Figure (2). Both films show higher absorption on the shorter wavelength side, this is attributed to increase the defect states which lead to increase absorption coefficient.

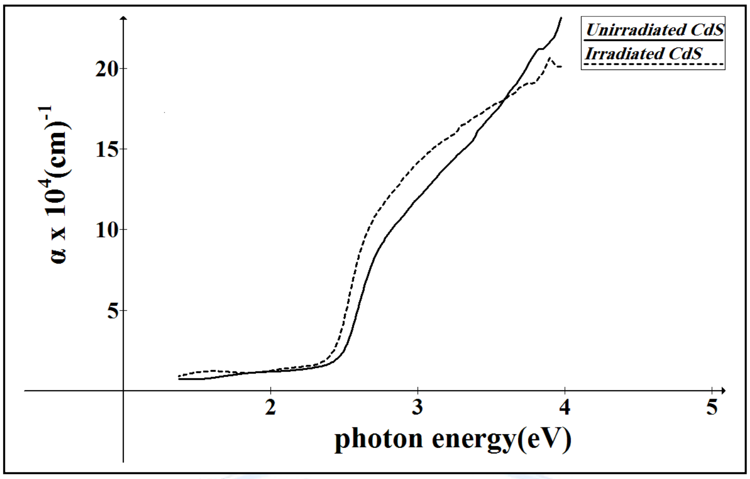

Figure (2): Absorption Coefficient as a function of Photon energy (eV).

The energy band gaps of these films were calculated with the help of the absorption Spectra. To determinate of the energy band gap, we plotted (αhf)2 versus (photon energy) using the relation.[13]

αhf= const.(hf-Eg)n

Where Eg is the band-gap energy. Eg could be obtained from the intercept of (αhf)2 vs. hf for direct allowed transitions, as shown in figure(3).

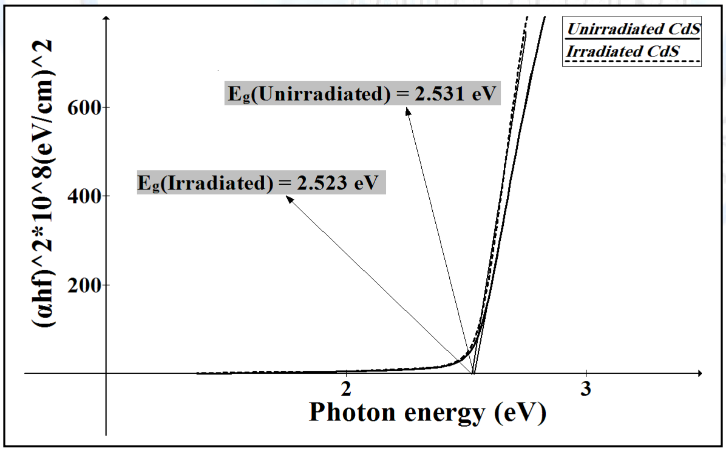

Figure (3): Band gap E_g estimation for CdS films.

The optical band gap was shifted from 2.531 eV to 2.523 eV due to irradiation. Gamma doses cause the breaking of bonds, leading in turn to the increase of dangling bonds and of defects, as well as the trapping of the generated carriers. This may be the cause for the increase in band tail width, and then decrease energy gap. Refractive index is one of the fundamental properties for an optical material, because it is closely related to the electronic polarizability of ions and the local field inside materials. The evaluation of refractive index of optical material is important for many applications especially in optical devices, (n0) decreases with irradiation as shown in figure (5) as a result to reflectance decreasing with irradiation. Extinction Coefficient (K0) represents the imaginary part of complex refractive index and it can be defined as the amount of energy losing as a result of interaction between the light and the charge of medium [14] ; figure (6) shows the (k0) as a function of Photon energy, the behavior of (k0) is :

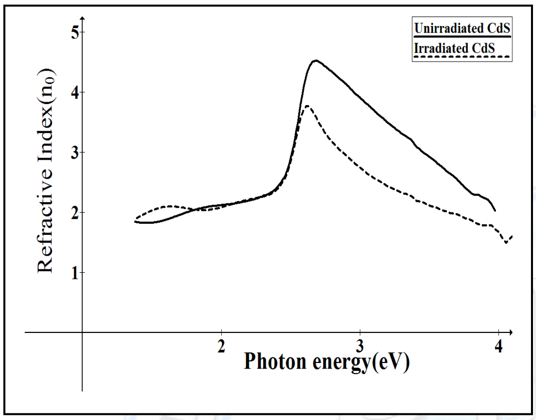

Figure (5): Refractive Index vs. Photon energy.

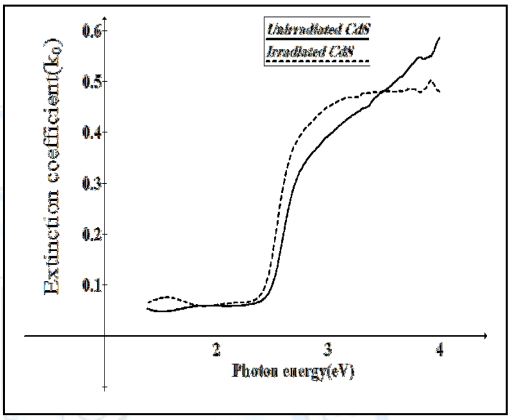

Figure (6): Extinction coefficient vs. Photon energy.

(K0)CdS (unirradiated) < (K0)CdS (irradiated) ; because it has smaller absorption coefficient . The dielectric constants consists of real part (εr) and imaginary part (εi) ,the variations of them with photon energy were determined and shown in figure (7) and (8).

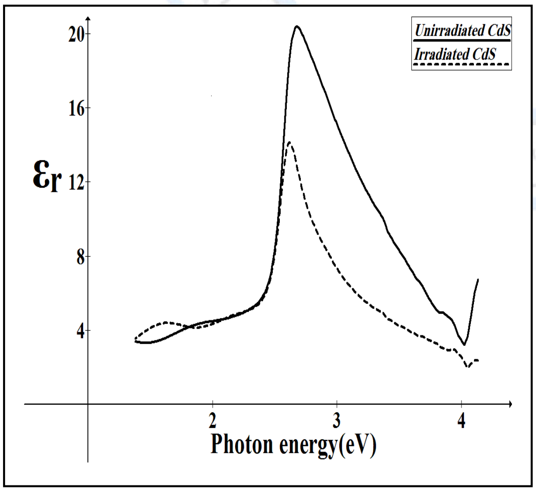

Figure (7): ε_r as a function of photon energy

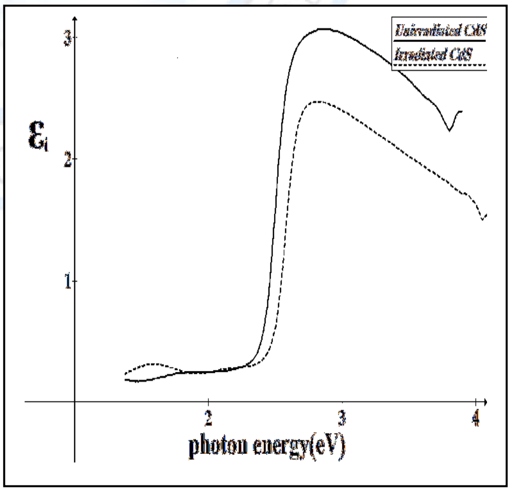

Figure (8): ε_i as a function of Photon energy

Conclusions

The effects of irradiation by gamma ray on CdS thin film are:

1 Decreasing the energy gap from 2.531 eV to2.523 eV ,

2 Increasing the absorption coefficient and extinction coefficient,

3 (ε_r), (εi) decreased after irradiation.

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