

Effect of Gamma Irradiation on the Optical Properties of Mg doped CdO Thin films deposited by Spray Pyrolysis

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ABSTRACT

Thin films of CdO and 9 % Mg doped CdO doped have been prepared using spray pyrolysis technique. Transmission and absorption spectra were recorded in order to estimate these films. The deposited thin films were exposed to γ - rays. We have studied the transmission, absorptions and absorption coefficient as a function of photon energy before and after irradiation. The optical constants such as: reflectance, extinction coefficient, refractive index, real and imaginary parts of the dielectric constant and the electrical conductivity were calculated also.

Keywords: TCOs, thin films, optical properties, doping film, gamma radiation.

1. INTRODUCTION

Cadmium oxide is one of the promising transparent conducting oxides (TCO_s) from II to VI group of semiconductors which has a great potential use for optoelectronic devices [1]. Cadmium oxide is a transparent oxide the in visible and NIR spectral region. It is n-type semiconducting [3-6] characteristics of a band gap between 2.2 and 2.7 eV [1,2] and a high electrical conductivity (10^{-2} - 10^{-4} Ω ·cm) [2,3].

Therefore, it is used in many industrial productions like solar cells, smart windows, optical communications, flat panel display, photo-transistors, and other optoelectronic applications [3,4,7,8]. Moreover, CdO has many applications other than (TCO_s), for example, it can be used as a heat mirror due to its high reflectance in the infrared region and high transparency in the visible region, gas sensors, low-emissive windows, and thin-film resistors [8].

Different techniques were used to piepare CdO such as sol-gel, DC magnetron sputtering, radio-frequency sputtering, spray paralysis, chemical vapor deposition, chemical bath deposition , and pulsed laser deposition have been used to deposit CdO thin films [8-13].

The aim of this work is to show the effect of gamma rays on the optical properties of Mg doped CdO.

2. EXPERIMENTAL WORK

Thin films of cadmium Oxides CdO and (CdO : 9 % Mg) have been prepared by chemical pyrolysis method. The spray pyrolysis was done by using a laboratory designed glass atomizer, which has an output nozzle about 1 mm. The films were deposited on preheated glass substrates at a temperature of 673 K, the starting solutions were achieved with an aqueous solution of 0.1 M $[(\text{CH}_3\text{COO})_2\text{Cd}\cdot 2\text{H}_2\text{O}]$ and $[(\text{CH}_3\text{COO})_2\text{Mg}\cdot 4\text{H}_2\text{O}]$ (from Fluka company German) and a total volume of 100 ml was used in each deposition, with the optimized conditions corresponding the following parameters: Spraying rate 5 ml/min, spraying time was 10 sec lasted by 2 minutes to avoid excessive cooling. The carrier gas (filtered compressed air) was maintained at a pressure of 10^5 Nm^{-2} , distance between the nozzle and substrate was about $29 \text{ cm} \pm 1 \text{ cm}$. Films were irradiated by gamma ray form Cs-137 (0.4.9 μCi) for 30 days, sample thickness of the deposited films was measured using gravimetric method which, was found to be around 400 nm. Optical transmittance and absorbance were recorded in the wavelengths range (300-900) nm using UV-Visible spectrophotometer (UV/VIS-1650 u probe Shimadzu) [14].

3. RESULTS AND DISCUSSIONS

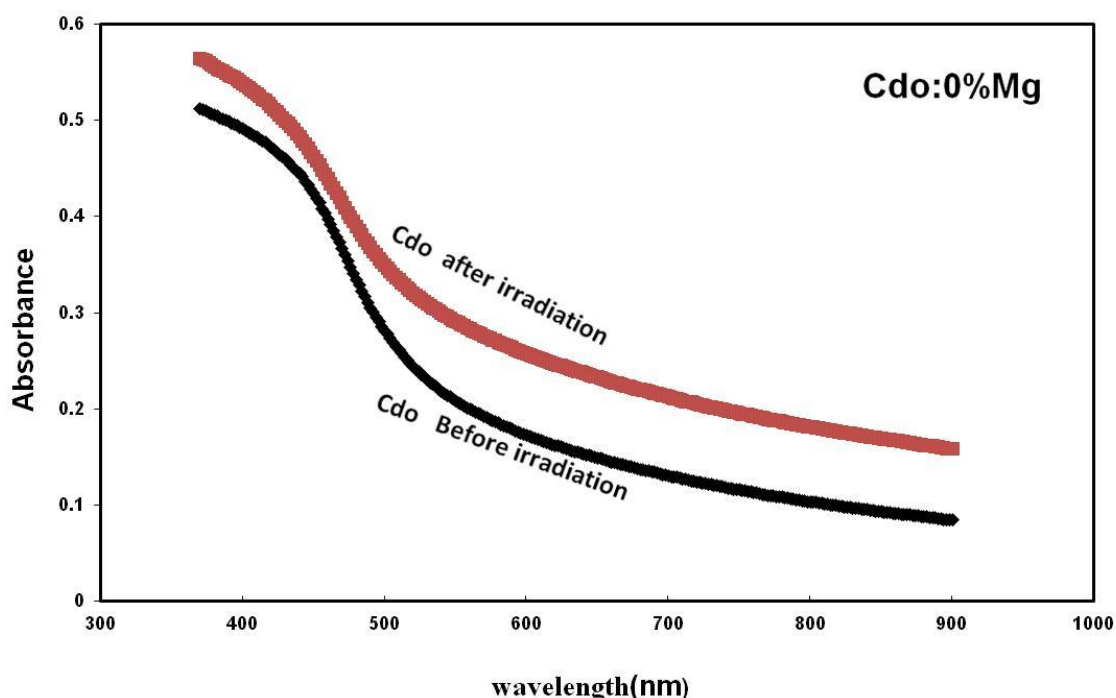


Fig. 1. Absorbance versus wavelength of CdO thin films.

The Absorbance (A) spectra of CdO and (CdO : 9 % Mg) films before and after irradiation were shown in Fig. 1 and Fig. 2, the absorbance of films decreased as the wavelength increase, and we see that the value of the absorbance of CdO films after the

irradiation is less than its value before irradiation for all values of the wavelength, but the absorbance (CdO : 9 % Mg) films increased after irradiation in comparison with its value before irradiation, because irradiation may increase the number of charge carriers which increases the absorption that is films, and we see there that the lambda cut off for (CdO : 9 % Mg) films shifted toward long wavelengths region (red shift) [15].

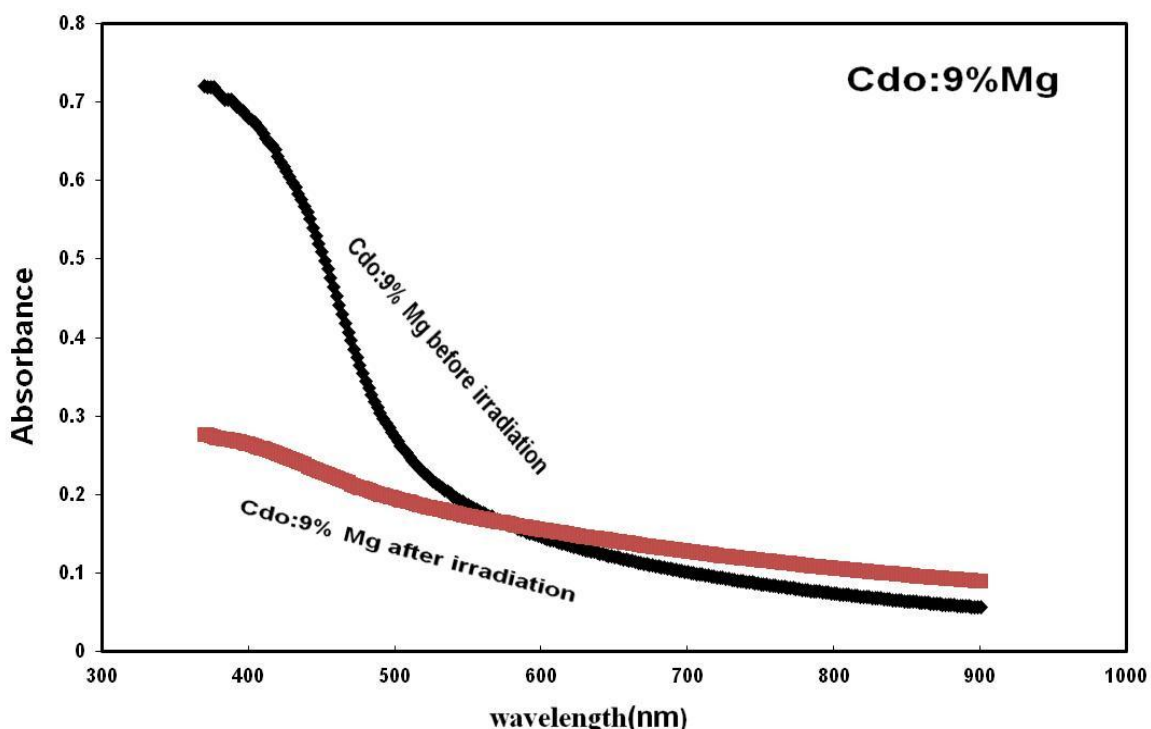


Fig. 2. Absorbance versus wavelength of (CdO : 9 % Mg) thin films.

The absorption coefficient (α) is related to the energy band gap E_g and the photon energy $h\nu$ and could be calculated using the following relation [15]:

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

where (A) is the absorption and (t) is the film thickness. Fig. 3 and Fig. 4 Shows the dependence of the absorption coefficient (α) on the photon energy for films before and after irradiation.

It can be seen from the Figures that the absorption coefficient for the films increased after irradiation and the absorption edge shifted toward long wavelength region.

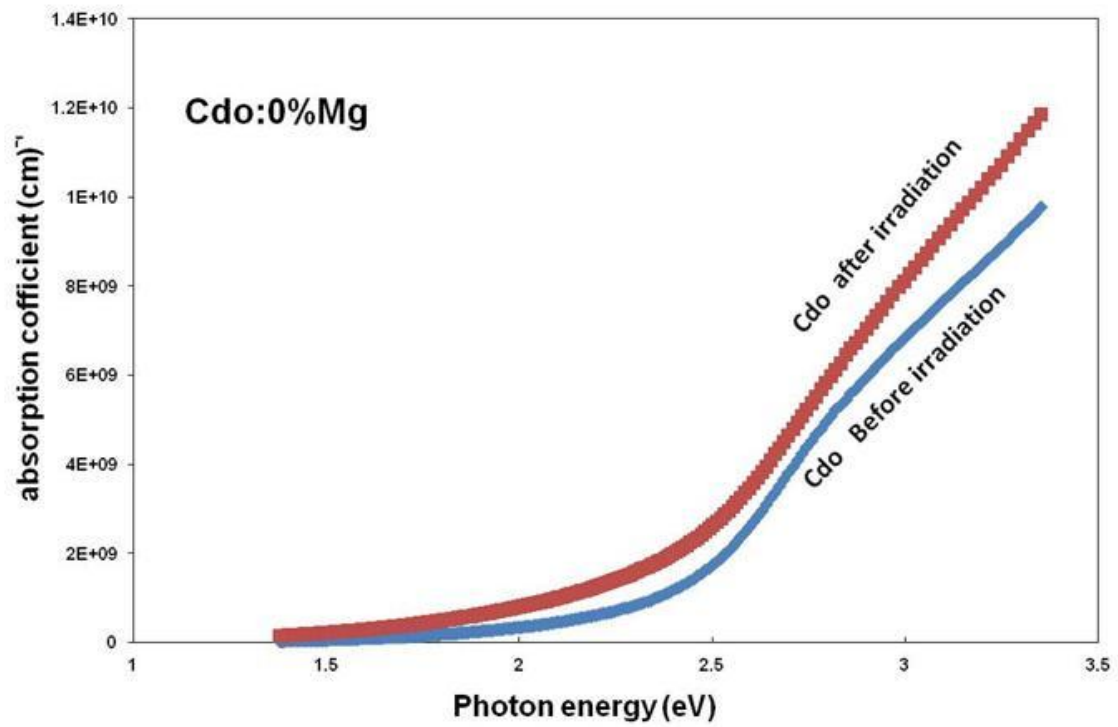


Fig. 3. Absorption coefficient versus photon energy of CdO thin films.

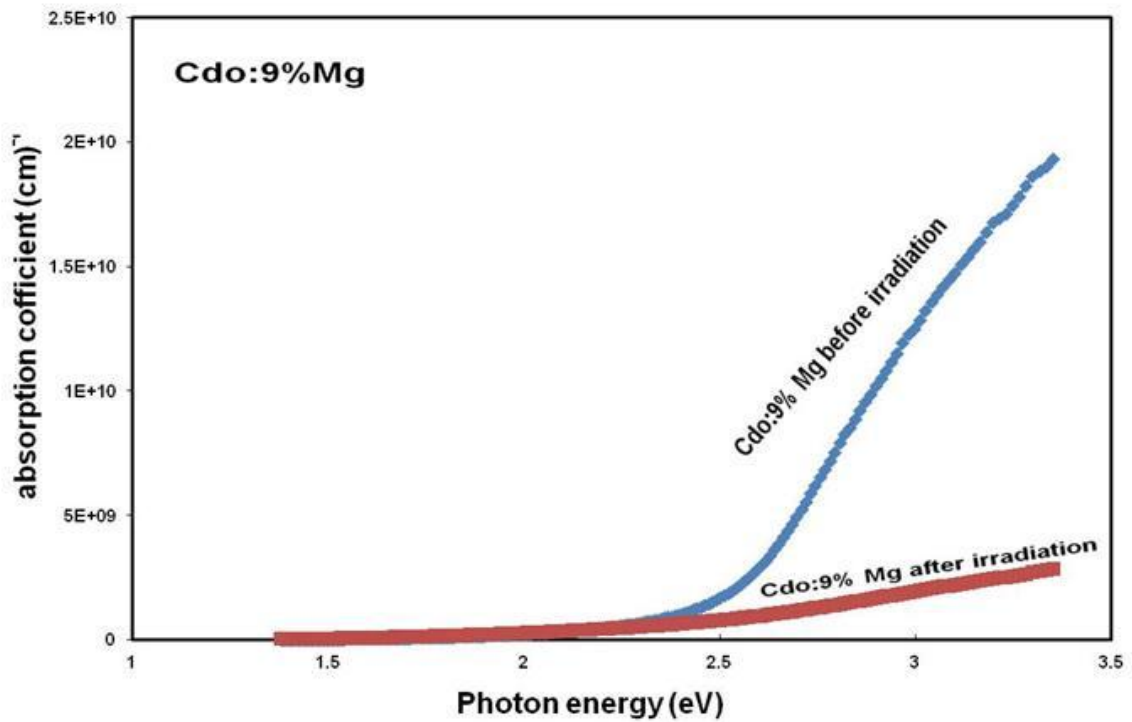


Fig. 4. Absorption coefficient versus photon energy of (CdO : 9 % Mg) thin films.

The extinction coefficient (k) can be determined by using the relation [16]:

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

where α is the absorption coefficient and λ is the wavelength of the incident photon. The behavior of extinction coefficient k is similar to that of the absorption coefficient. In the Fig. 5 that the extinction coefficient increases after Irradiation by gamma ray, but In the Fig. 6. That the extinction coefficient decreases after Irradiation by gamma ray.

The refractive index can be determined from the reflectance (R) and K uses the relation [17]:

$$n = \left(\frac{1+R}{1-R} \right) + \sqrt{\frac{4R}{(1-R)^2} - K^2} \quad (3)$$

Fig.7 shows the variation of the refractive index with irradiation for CdO. The refractive index of these films is slightly increased after irradiating by gamma ray. Fig. 8 shows the variation of the refractive index with irradiation for (CdO : 9 % Mg) films. The refractive index of these films is decreased after irradiating by gamma ray.

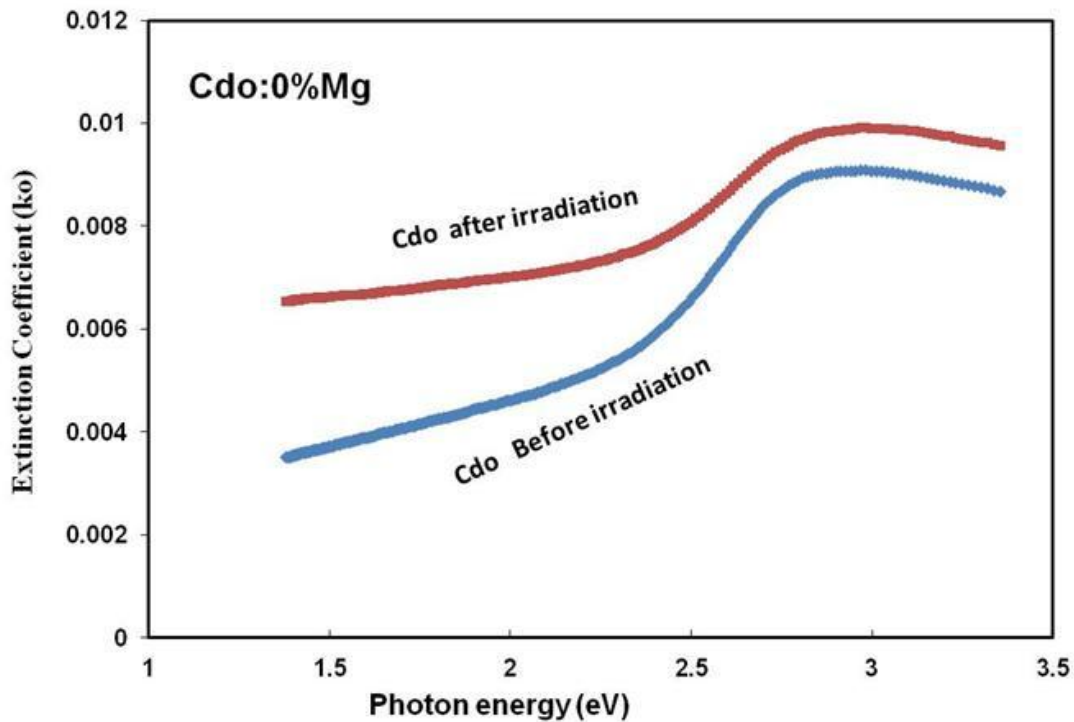


Fig. 5. Extinction coefficient versus photon energy of CdO thin films.

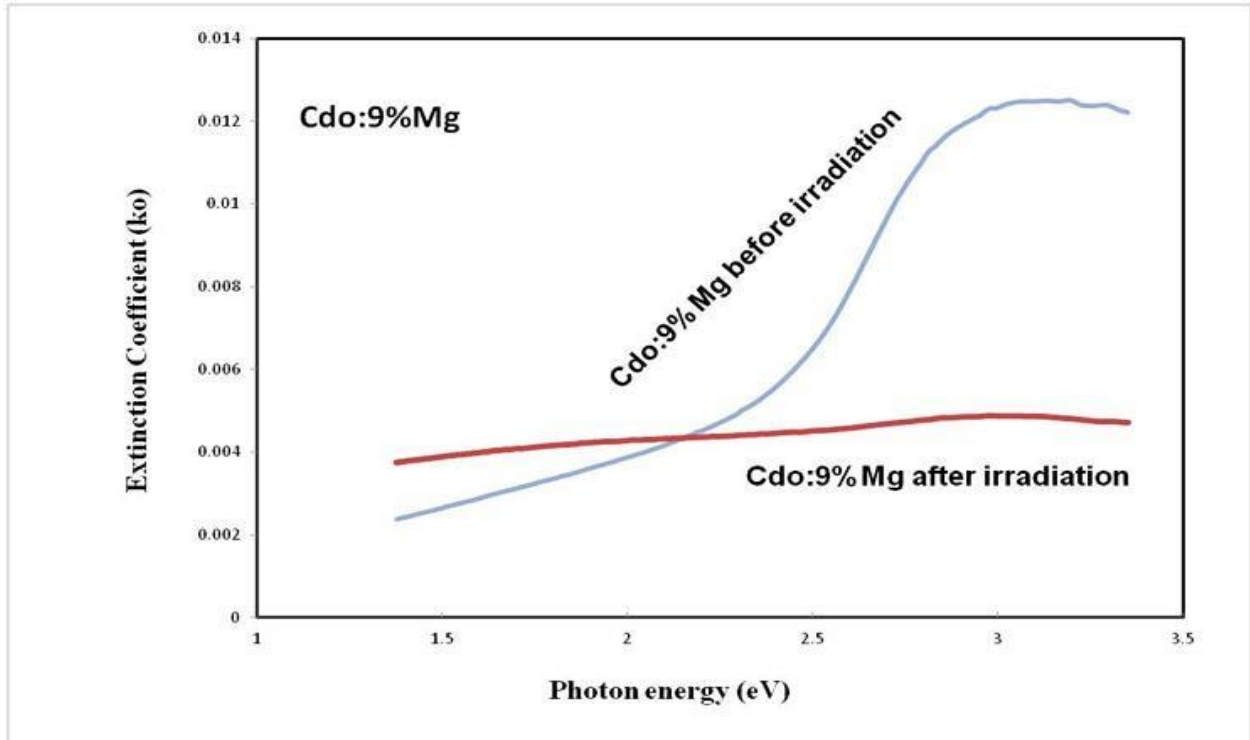


Fig. 6. Extinction coefficient versus photon energy of (CdO : 9 % Mg) thin films.

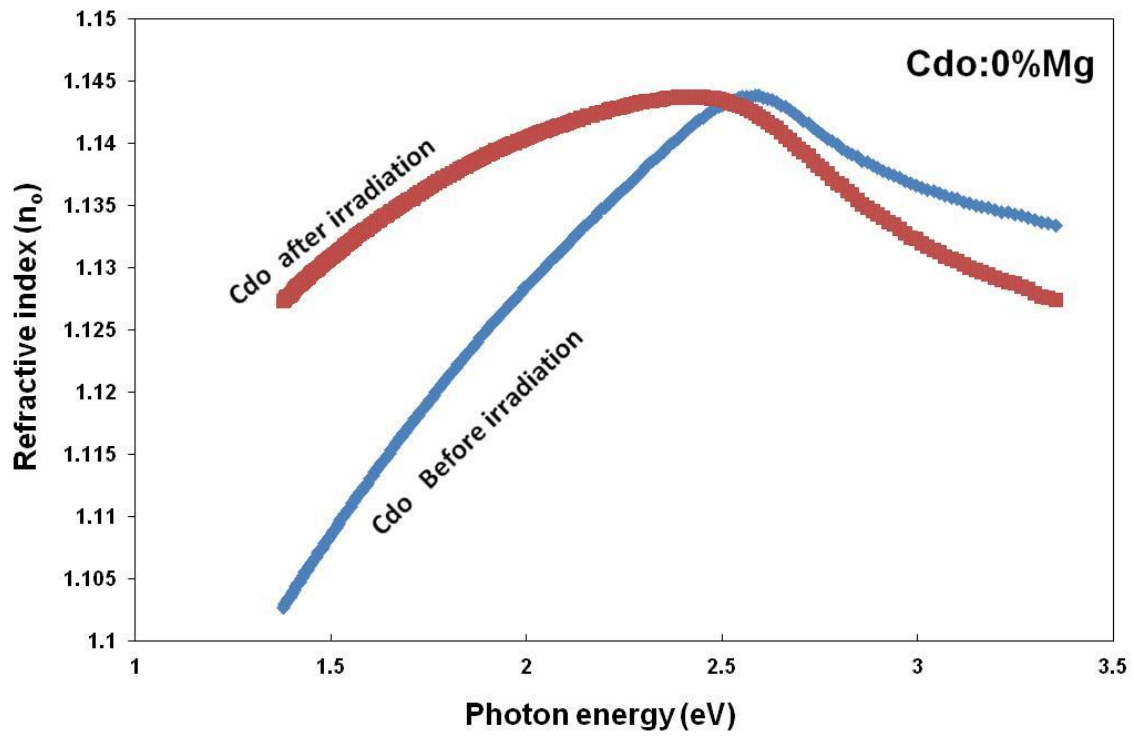


Fig. 7. Refractive index versus photon energy of CdO thin films.

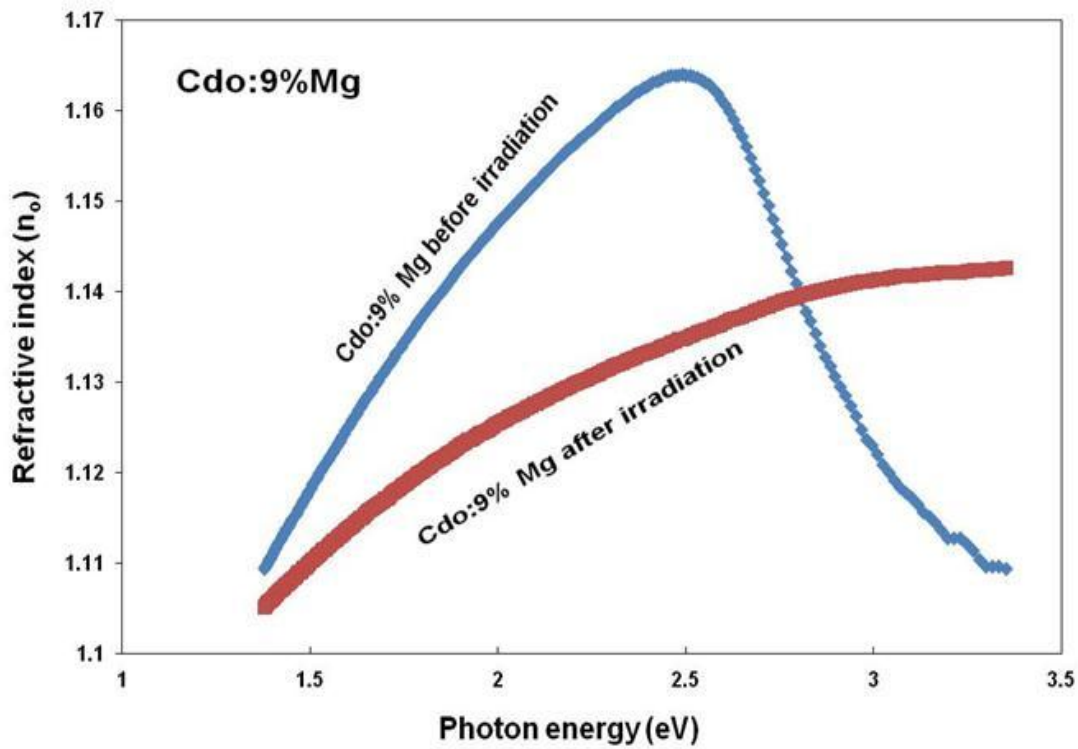


Fig. 8. Refractive index versus photon energy of (CdO : 9 % Mg) thin films.

The real ϵ_1 and imaginary ϵ_2 parts of the dielectric constant were obtained using the formula as [18]:

$$\epsilon_1 = n^2 - k^2 \quad (4)$$

$$\epsilon_2 = 2nk \quad (5)$$

The variation in the real (ϵ_1) of the dielectric constant and imaginary (ϵ_2) was seen in Fig. 9 and Fig. 10 for CdO films before and after irradiation while the values of the doping films are shown in Fig. 11 and Fig. 12.

It is clear from those Figures that both the real and the imaginary parts for CdO film are increased after irradiated by gamma ray, also the values of the real part are higher than those of the imaginary part, From Fig. 11 and Fig. 12 both the real and the imaginary parts for (CdO : 9 % Mg) film are decreased after irradiated by gamma ray, also the values of the real part are higher than those of the imaginary part.

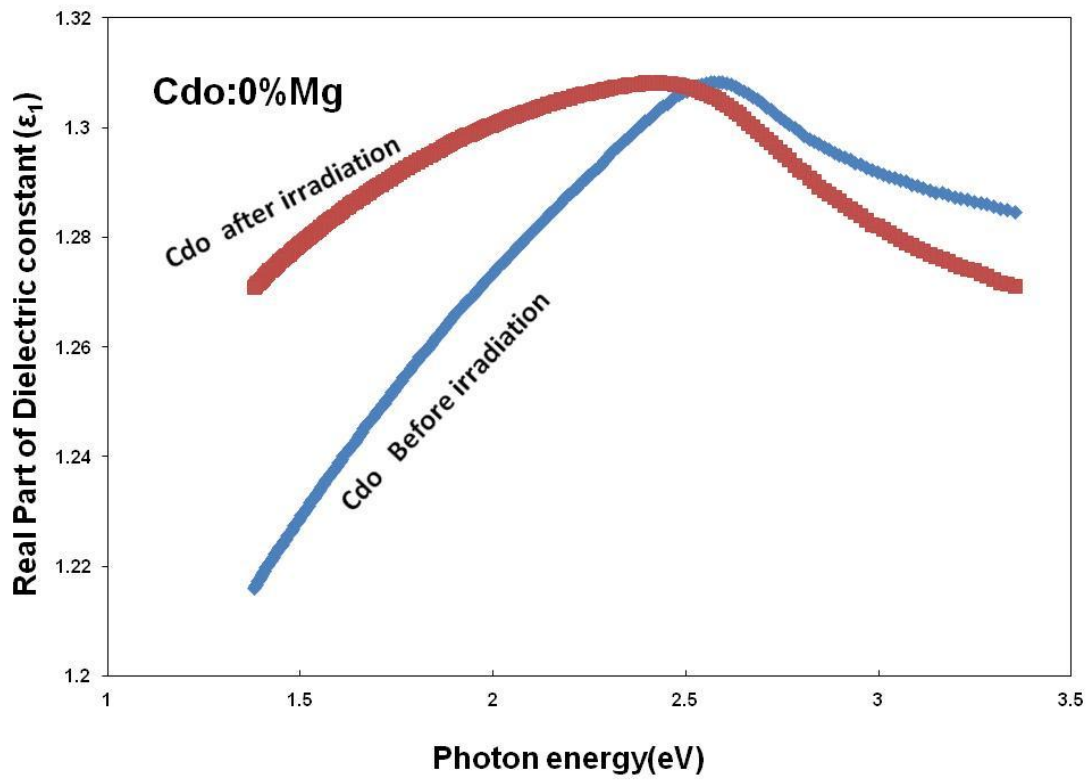


Fig. 9. Real part of dielectric constant versus photon energy of CdO films.

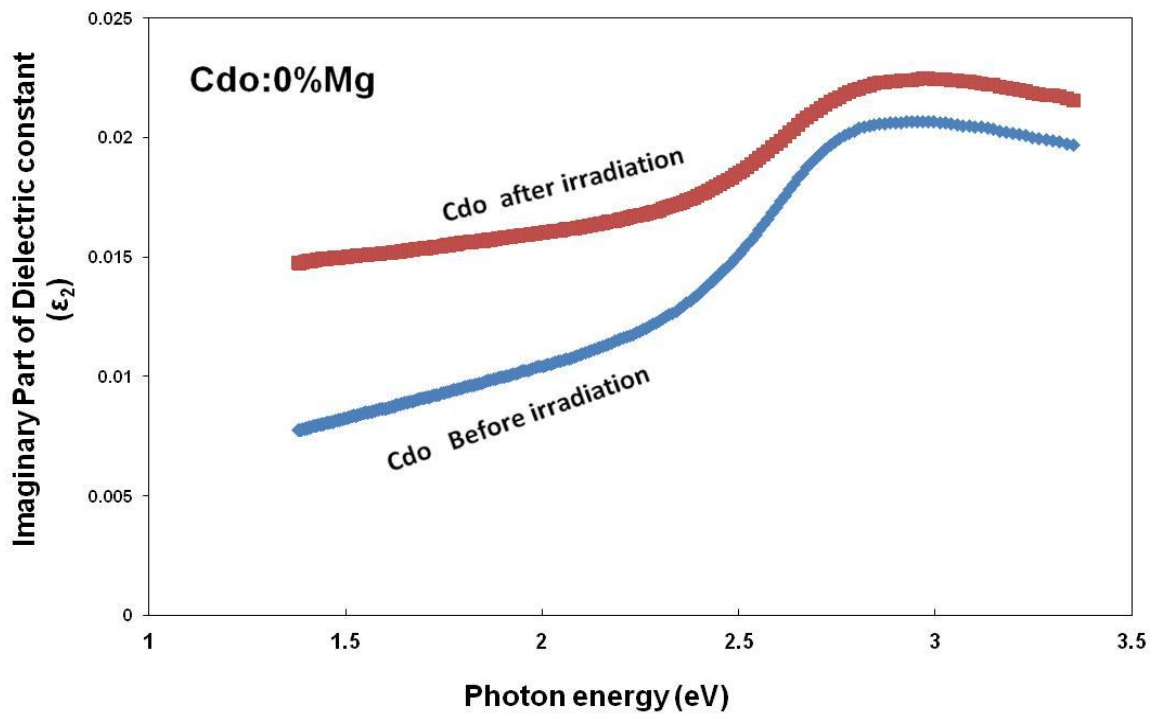


Fig. 10. Imaginary part of dielectric constant versus photon energy of CdO films.

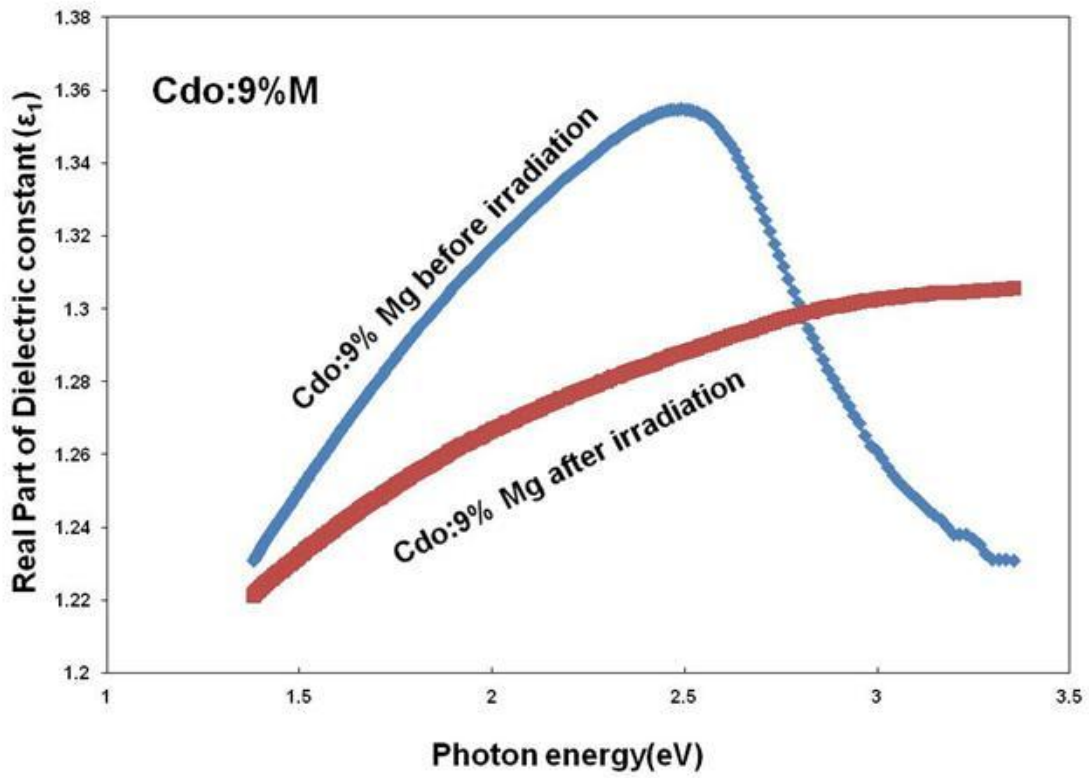


Fig. 11. Real part of dielectric constant versus photon energy of (CdO : 9 % Mg) films.

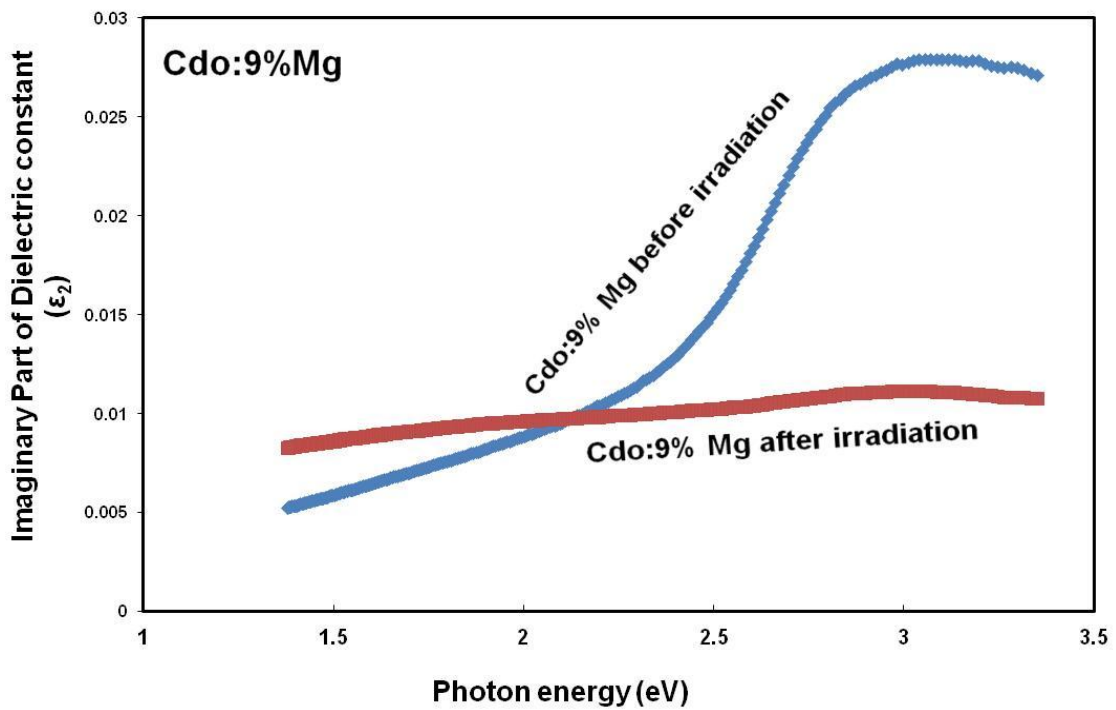


Fig. 12. Imaginary part of dielectric constant versus photon energy of (CdO : 9 % Mg) films.

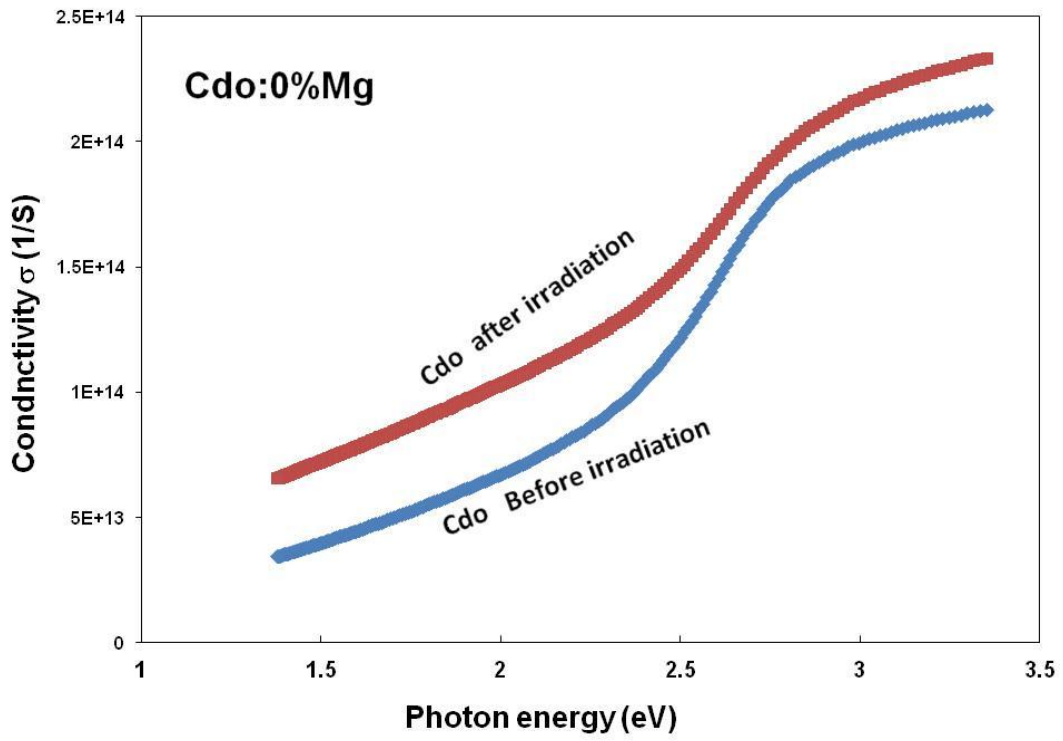


Fig. 13. Optical conductivity versus photon energy of CdO thin films.

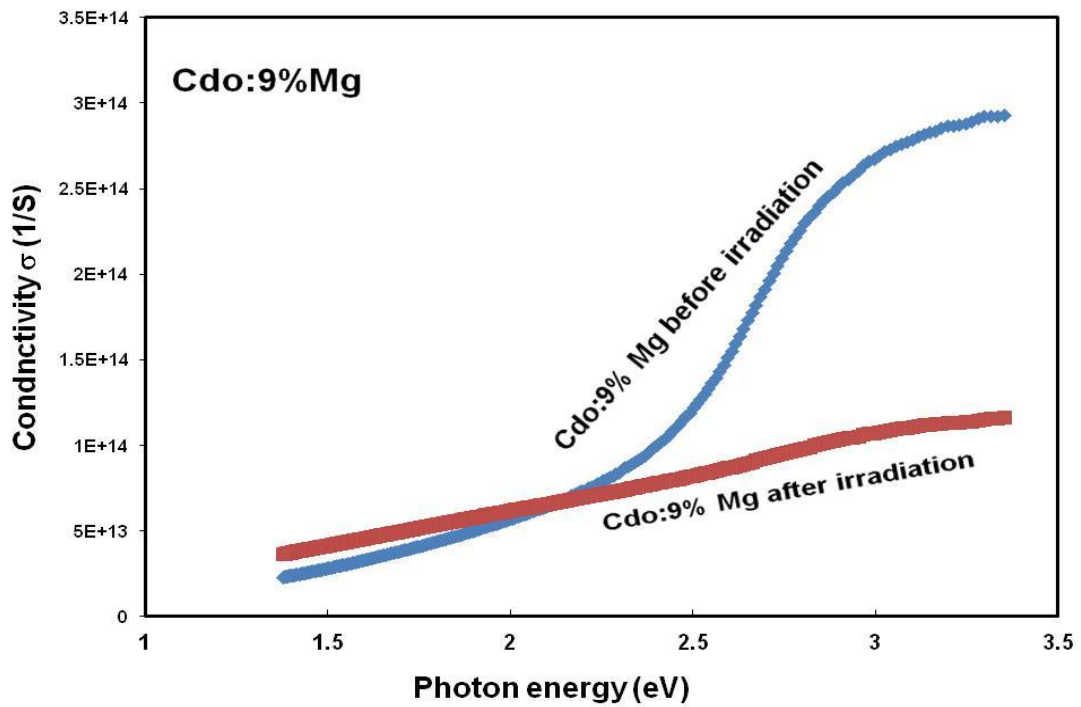


Fig. 14. Optical conductivity versus photon energy of (CdO : 9 % Mg) thin films.

The optical conductivity was calculated using the relation [19]:

$$\sigma = \frac{\alpha n c}{4\pi} \quad (6)$$

where (c) is the velocity of light.

Fig. 13 shows the variation of optical conductivity with the photon energy of CdO films, the optical conductivity increases after irradiated with gamma ray. But from Fig. 14 the variation of optical conductivity with the photon energy of (CdO : 9 % Mg) films, shows that the optical conductivity decreases after irradiated with gamma ray.

4. CONCLUSIONS

CdO films were fabricated by spray pyrolysis technique using an aqueous solution of cadmium acetate and Mg acetate. The films were deposited onto glass substrates at temperature of 673 K. The effect of γ ray irradiation on the optical properties has been investigated. The absorption coefficient for the CdO films increased after irradiation and the absorption coefficient for the (CdO : 9 % Mg) films decreased after irradiation and can conclude that γ – irradiation was effecting all the parameters under investigation and show a healing effect with a low dose to increase the degree of crystallinity

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