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Effect of Laser Radiation on Optical Properties of CdO Thin Films

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Abstract: CdO thin films were prepared by chemical spray pyrolysis technique. The study of laser radiation was held in this research in order to estimate the influence of laser on the optical parameters of CdO thin films. The transmittance was increased after laser radiation in comparison with its values before irradiation. While the absorbance, shows a trend of increasing in the low wavelength region and increasing in the high wavelength region. The value of the optical energy gap was increased after irradiation. All the rest optical constants under investigation were affected by laser radiation showing decrement on their values.

Keyword: CdO thin films, laser radiation, optical energy gap, refractive index.

1. Introduction

Transparent conducting oxides TCO's have been widely studied in the last decade due to their application in many fields [1-6]. Cadmium oxide is one of the most important TCO's compound due its favourite properties such as, wide band energy gap approximately 2.4-2.7 eV depending on preparation conditions, n-type semiconductor with relatively high conductivity, show a high optical transparency in the visible range, cubic crystal structure, high density (8150 kg/m^3), extraordinary luminescence characteristics [7-10]. In accordance to these properties, CdO has entered many important applications including solar cells, optoelectronics devices, gas sensor, photocatalytic activity, reduce toxicity in environment and photodiodes [11-17]. Variety techniques have been used to deposit CdO thin films such as electron beam evaporation, RF magnetron sputtering, sol-gel spin coating, chemical precipitation, pulsed laser deposition and chemical spray pyrolysis [18-23]. The aim of this work is to study the effect of laser exposure on the CdO and the optical properties of CdO thin films deposited by spray pyrolysis.

2. Experimental Details

Thin films of cadmium oxide were prepared by simple, low cost, chemical spray pyrolysis technique. 0.1 M of $CdCl_2$ supplied from Alpha Chemika India was used as a source of cadmium diluted in 100 ml deionized water in order to obtain an aqueous solution, few drops of hydrogen chloride was added to obtain the starting solution free from any undissolved residue. The preparation conditions were shortened by using nitrogen gas as a carrier gas, distance between substrate and nozzle was fixed at 28 cm, substrate temperature was maintained at 400°C during the deposition process, spraying rate is 4 ml/min, spraying time is 8 s followed by 2 min waiting time to preclude any immoderate cooling. Gravimetric method was used to calculate the film thickness, which was in the range of 300 ± 30 nm. Laser exposure was achieved by using Q-switched Nd-YAG pulsed laser operated at 1064 nm, pulse duration 9 ns and the energy was 560 mJ. Optical absorbance and transmittance was carried out through double beam spectrophotometer supplied from (Schimadzu Japan) in the wavelength range (380- 800 nm) to calculate the optical parameters of CdO thin films before and after exposure by laser.

3. Results and Discussion

Fig. 1 depicts the relation between transmittance and wavelength, it can be noticed that the values transmittance beyond 460 nm after exposure to laser was increased in comparison with its values before exposure. This phenomenon could be attributed to the improved in crystallinity due to laser exposure, which acts as an annealing to recrystallize the CdO thin films. Fig. 2 shows the dependence of absorbance as a function of wavelength of CdO

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thin films before and after irradiation with laser. It can be clearly seen that the transmittance was increased after irradiation with laser in the short wavelengths, then intersects with the curve before irradiation near 480 nm, which represent the absorption edge and assure that the irradiation does not highly affect the optical energy gap. After 510 nm the curve tend to decrease after irradiation in comparison with its value before irradiation.

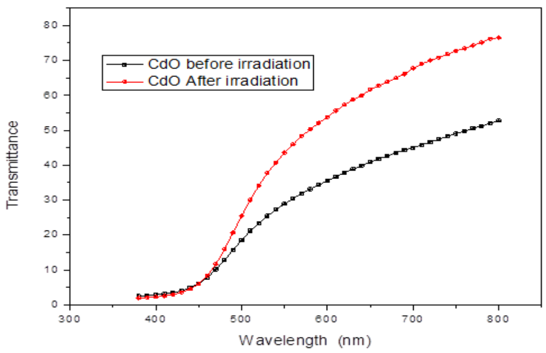

Fig. 1 Transmittance versus wavelength of CdO thin film before and after irradiated by laser.

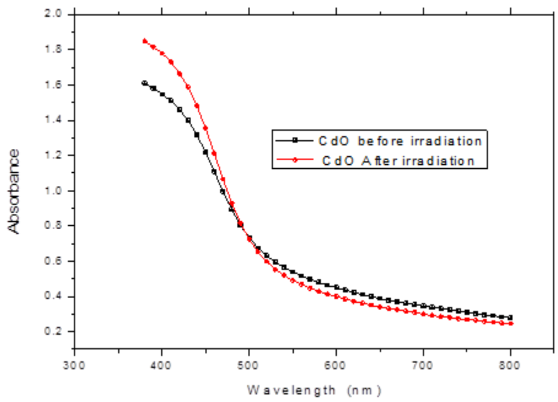

Fig. 2 Absorbance versus wavelength of CdO thin film before and after irradiated by laser.

The optical band gap is obtained from Tauc's model from the following relation [24]:

$$\alpha h\vartheta = A\,(h\vartheta - E_g)^n \qquad (1)$$

Where $h\vartheta$ is the photon energy, A constant , α is the absorption coefficient in cm^{-1} , E_g is the optical energy gap and n determining kind of transition for direct allowed and forbidden transitions which is n is equal to ½ and 2/3 respectively, for indirect allowed and forbidden transitions n is equal to 2 and 3 respectively. Fig. 3 shows the relation between $(\alpha h\vartheta)^2$ as a function of photon energy . From this figure one could estimate the optical energy gap which was around 2.46 eV and 2.5 eV for CdO thin films before and after irradiation by laser respectively. The increases of the optical energy gap could be attributed to the increasing in the average crystallite size due to laser radiation.

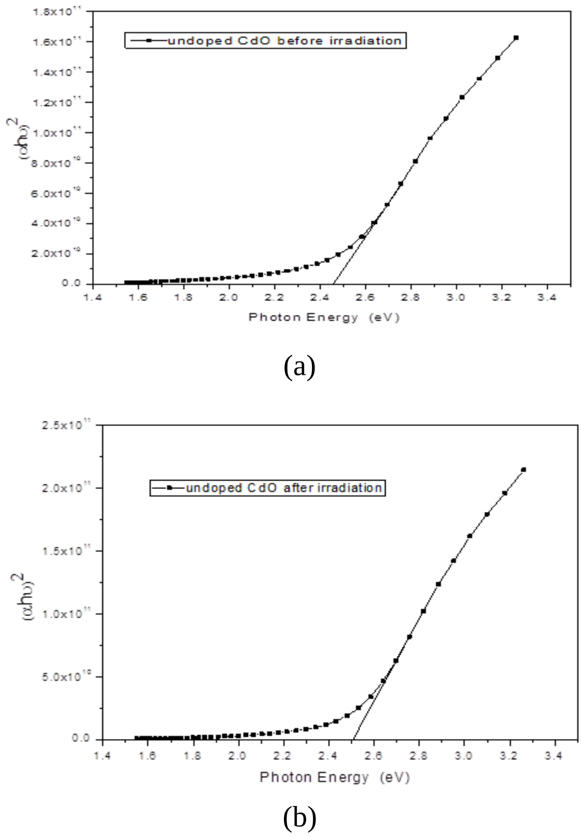

Fig. 3 $(\alpha h\vartheta)^2$ versus photon energy of CdO thin film (a) before and (b) after irradiated by laser.

The refractive index n could be calculated utilizing the following relation [25]

$$n = \left(\frac{1+R}{1-R}\right) + \sqrt{\frac{4R}{(1-R)^2} - k^2} \qquad (2)$$

Where R represents the reflectance, which was calculated from the absorbance and transmittance data utilizing the conservation law, k is the extinction coefficient and can be estimated from this relation [26].

$$k = \frac{\alpha\lambda}{4\pi} \qquad (3)$$

The dependence of refractive index on wavelength is shown in Fig. 4. It can be seen that that the refractive index was decreased after laser radiation for all the values of wavelength, showing a peak shift toward high wavelength (red shift).

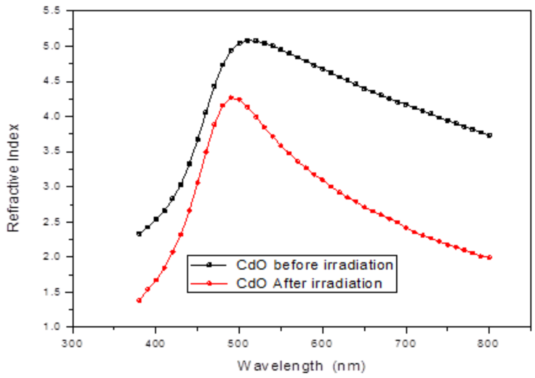

Fig. 4 Refractive index versus wavelength of CdO thin film before and after irradiated by laser.

Fig. 5 depict the relation between extinction coefficient and wavelength of CdO thin films before and after laser radiation. The same behaviour was noticed in Fig.2 for the absorption coefficient due to the extinction coefficient that depends on the value of absorption coefficient.

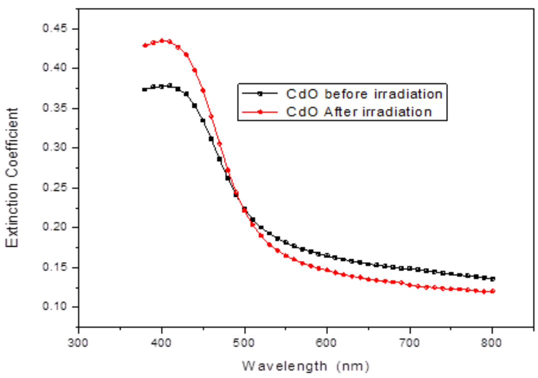

Fig. 5 Extinction coefficient versus wavelength of CdO thin film before and after irradiated by laser.

The real ε_r and imaginary parts of the dielectric constant are related to refractive index and extinction coefficient values through the following formulas [27]:

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

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

Fig. 6 and Fig. 7 depicts the relation between real and imaginary parts of dielectric constant of CdO thin films before and after irradiated by laser. The same trend was noticed for both real and imaginary parts that their values after irradiation were decreased. The values of the real part were higher than the value of the imaginary parts according to their dependence of refractive index.

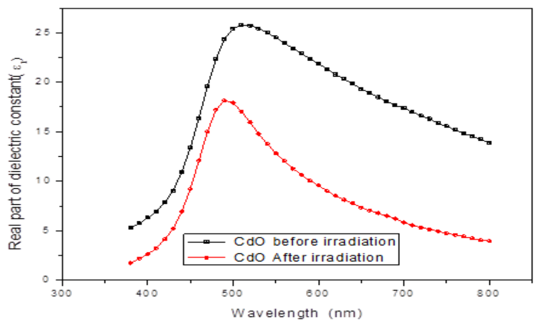

Fig. 6 Real part of dielectric constant versus wavelength of CdO thin films.

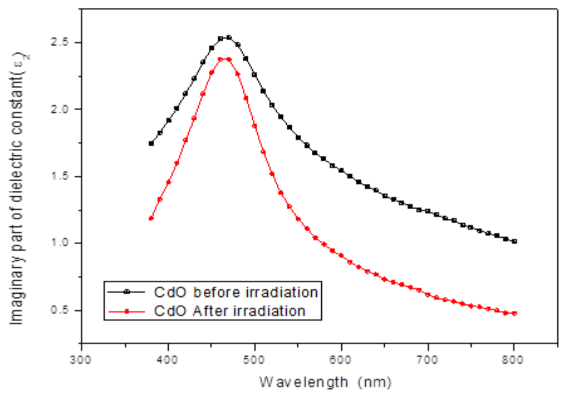

Fig. 7 Imaginary part of dielectric constant versus wavelength of CdO thin films.

4. Conclusion

CdO thin films were prepared successfully by spray pyrolysis technique. The optical energy gap and the transmittance were increased after laser radiation, in this case we can conclude that the laser worked like annealing temperature to enhance the crystallization of thin films.

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