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CdO thin films Grown by Chemical Spray Pyrolysis and Effect of Substrate type on its Optical Properties

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ABSTRACT

Cadmium oxide (CdO) thin films were formed by chemical spray pyrolysis technique for different substrate type (glass, quartz, ITO). Absorption spectra were recorded from UV-Visible spectrophotometer in the range of 300-900 nm. The absorbance increased when the glass substrate replaced to quartz or ITO substrate, also this behavior for absorption coefficient and extinction coefficient. While the refractive index tack unstable behavior. The energy gap decreased from 2.4 eV for CdO thin film deposited on glass substrate to 2.36 eV for CdO thin film deposited on ITO substrate.

***Keywords*:** CdO, Thin Film, Optical properties, energy gap

1. INTRODUCTION

Cadmium oxide (CdO) is a good transparent conductive material because their high transparency coefficient in visible region, high electrical conductivity and high optical transmittance in the visible region of solar spectrum along with a moderate refractive index [1]. Cadmium oxide attracted the attention of researchers in recent years for their potential use in various applications.

Cadmium oxide is one promising transparent conducting oxides (TCOs) from II to VI group of n-types semiconductors which has unique chemical and physical properties [2]. Recently, semi-conducting, thin films of various oxide materials like ZnO, SnO_2 and CdO etc. have shown significant results as regard to gas sensing properties [3-6], solar cells, windows, flat panel display, photo transistors etc. [7-8].

CdO thin films have been deposited by techniques such as dc magnetron sputtering [9], spray pyrolysis [10], chemical bath deposition [11], SILAR [12], pulsed laser deposition [13], sol-gel dip coating [14], etc.

The optical properties of CdO thin films prepared by chemical spray pyrolysis method and effect of substrate type of these films are studied.

2. EXPERIMENTAL PROCEDURES

Thin films of CdO deposited on different types of substrate at a constant temperature 400 ºC by chemical spray pyrolysis technique. A solution of 0.1 M of $Cd(COOCH_3)_2 \cdot 2H_2O$ (supplied from Sigma-Aldrich Chemicals) was used as precursors prepared by dissolving in double distilled water.

The nozzle was at a distance of 28 cm from the substrate during deposition. The carrier gas was compressed air and deposition rate was 2 ml/min. Thickness was calculated from the gravimetric method to be 300 nm. UV-Visible spectrophotometer in the range 300-900 nm was used to determine some of optical properties.

3. RESULTS AND DISCUSSION

The optical absorption spectra (using UV-Visible spectrophotometer) was used to study the optical properties of CdO thin films, which prepared by chemical spray pyrolysis method with different substrate type, as plotted in Fig. 1. From this figure, it can notice that the absorbance decreased with increasing wavelength (decreasing photon energy), and increased when the glass substrate replaced to quartz or ITO substrate, this attributed to the arrangement of the atoms.

The optical absorption coefficient (α) of CdO thin films in the fundamental absorption region for various substrate types were calculated using the equation [15]: $\alpha = (\ln T^{-1})/t$, where T is the transmittance and t is the film thickness. The plots of absorption coefficient are presented in Fig. 2. This figure shows the increases of α when the glass substrate replaced to quartz or ITO substrate.

Fig. 3 represent the variation of extinction coefficient with wavelength of CdO thin films for various substrate types. From this figure, it can notice that the extinction coefficient increased when replacing the glass substrate to quartz or ITO substrate for the CdO prepared thin films.

The refractive indices for all prepared films are, however, followed unstable behavior with increasing wavelength within the infrared region as shown in Fig. 4. The maximum peak of refractive index of the films at the wavelength of 350 nm. Refractive index unchanged with replacing substrate (glass, quartz, ITO glass) at the wavelength 500 to 900 nm.

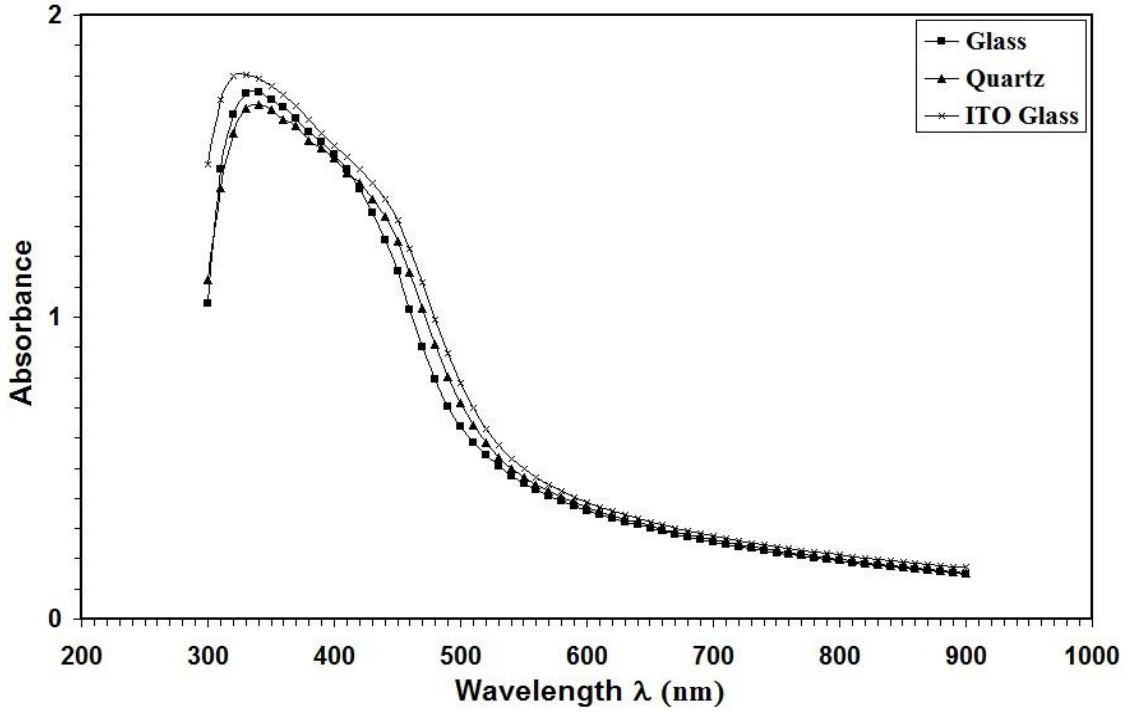

Fig. 1. Absorbance spectra of CdO thin films for various substrate types.

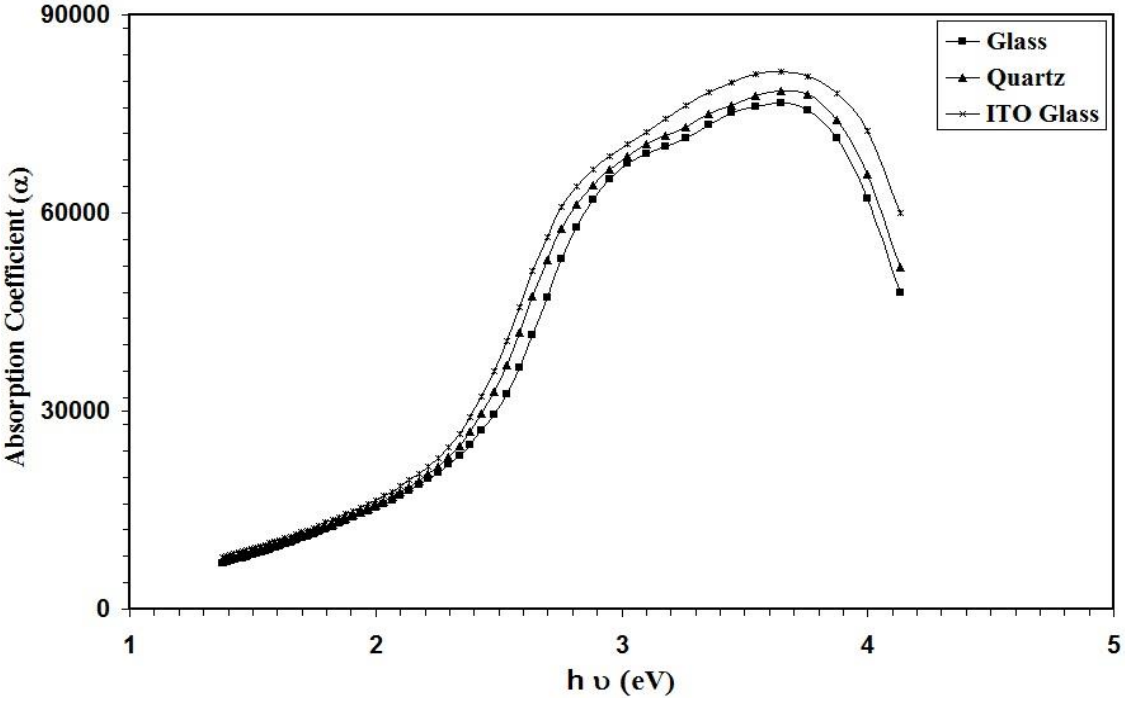

Fig. 2. Absorption coefficient of CdO thin films for various substrate types.

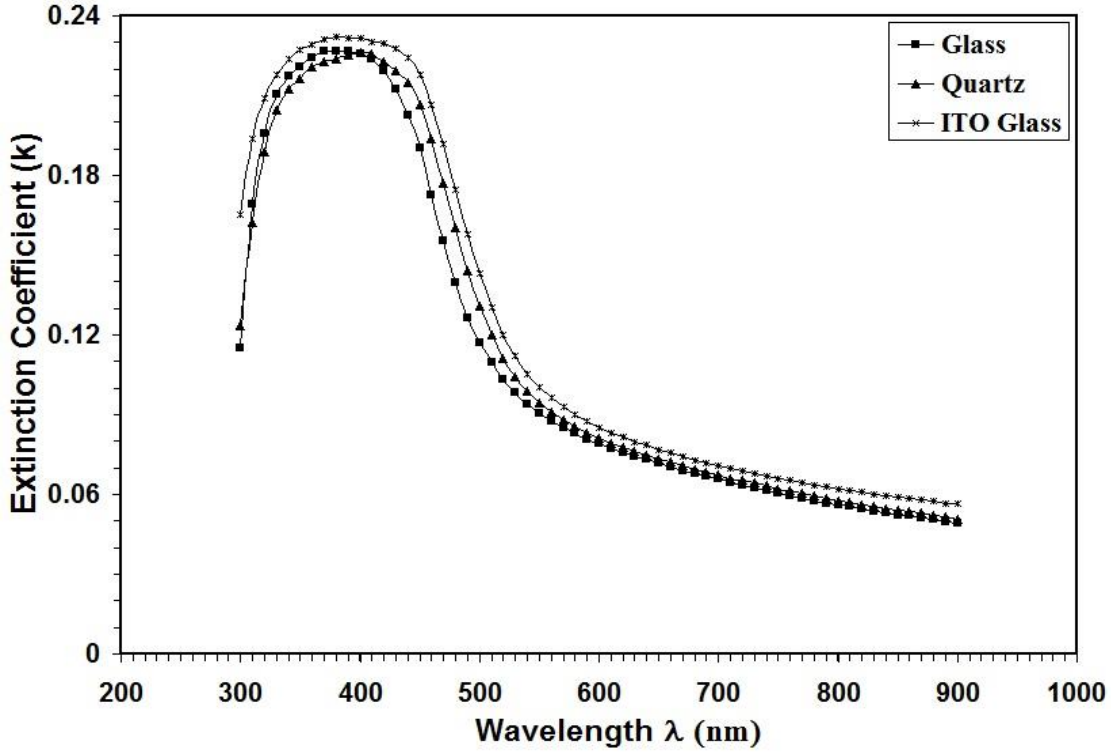

Fig. 3. Extinction coefficient of CdO thin films for various substrate types.

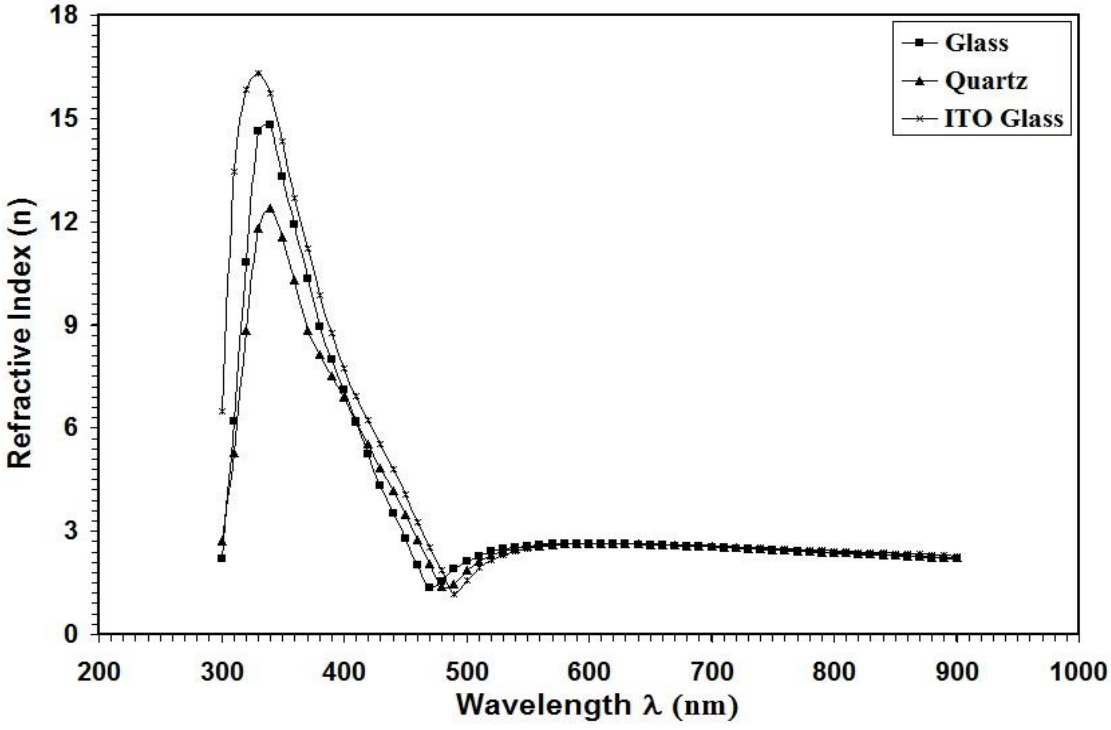

Fig. 4. Refractive index of CdO thin films for various substrate type.

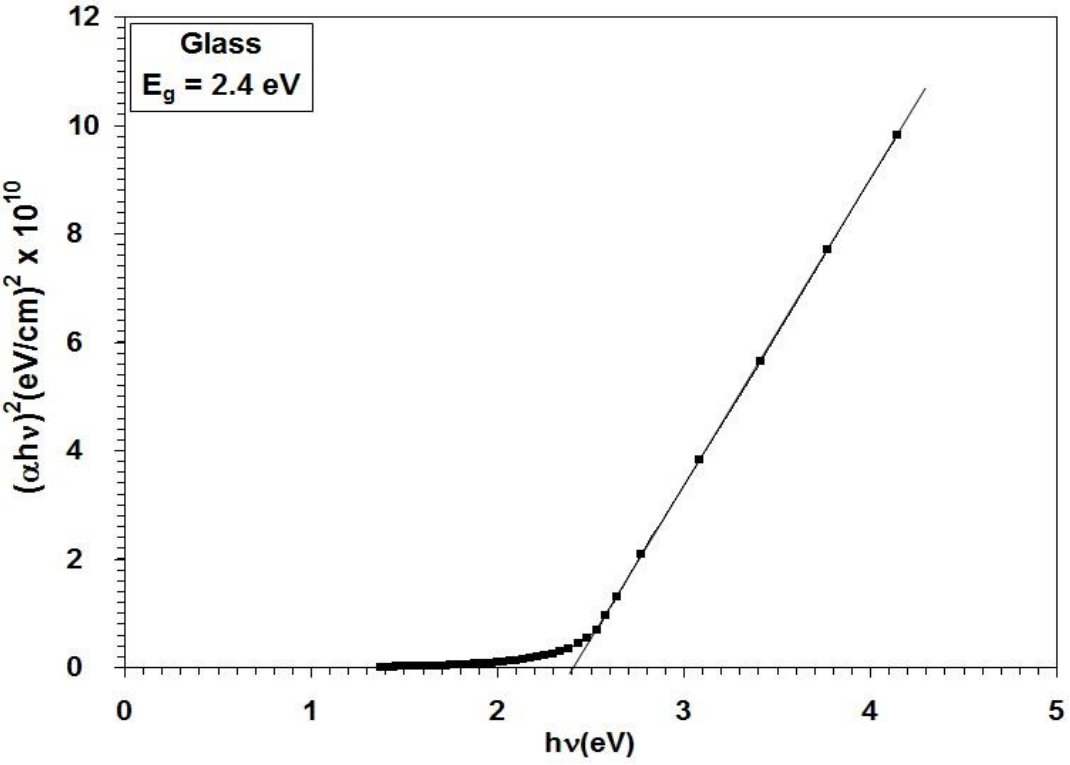

Fig. 5. Variation of $(\alpha h\upsilon)^2$ versus photon energy of CdO thin film deposited glass substrate.

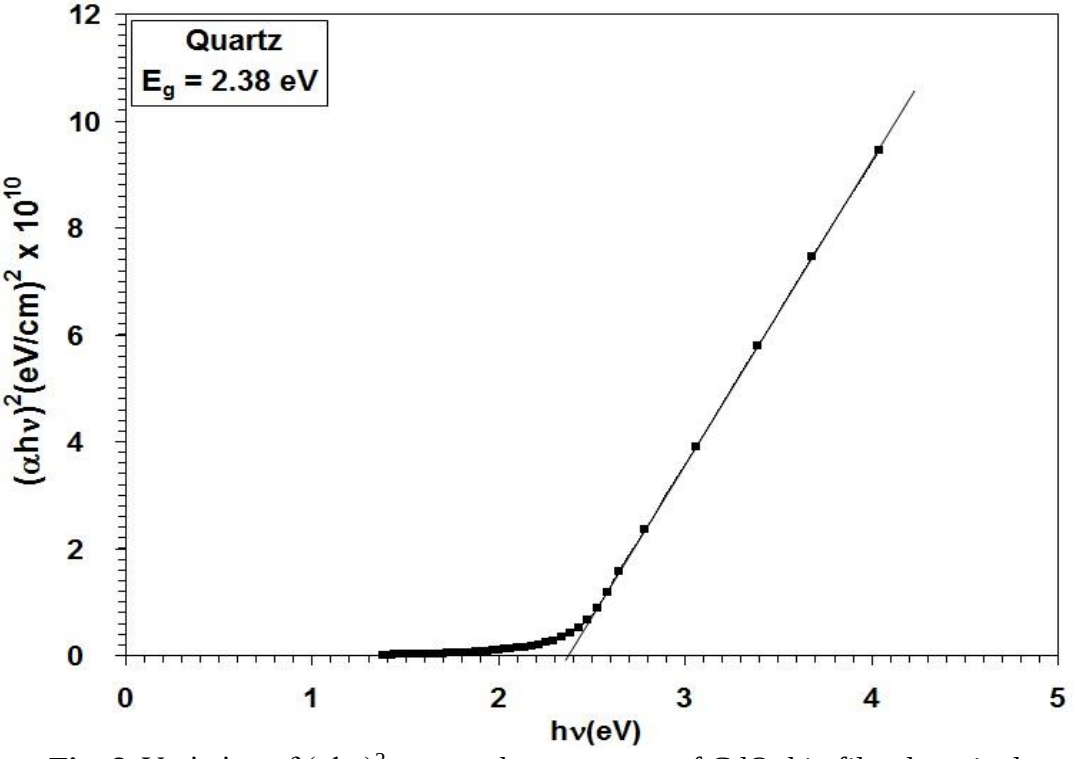

Fig. 6. Variation of $(\alpha h\upsilon)^2$ versus photon energy of CdO thin film deposited on quartz substrate.

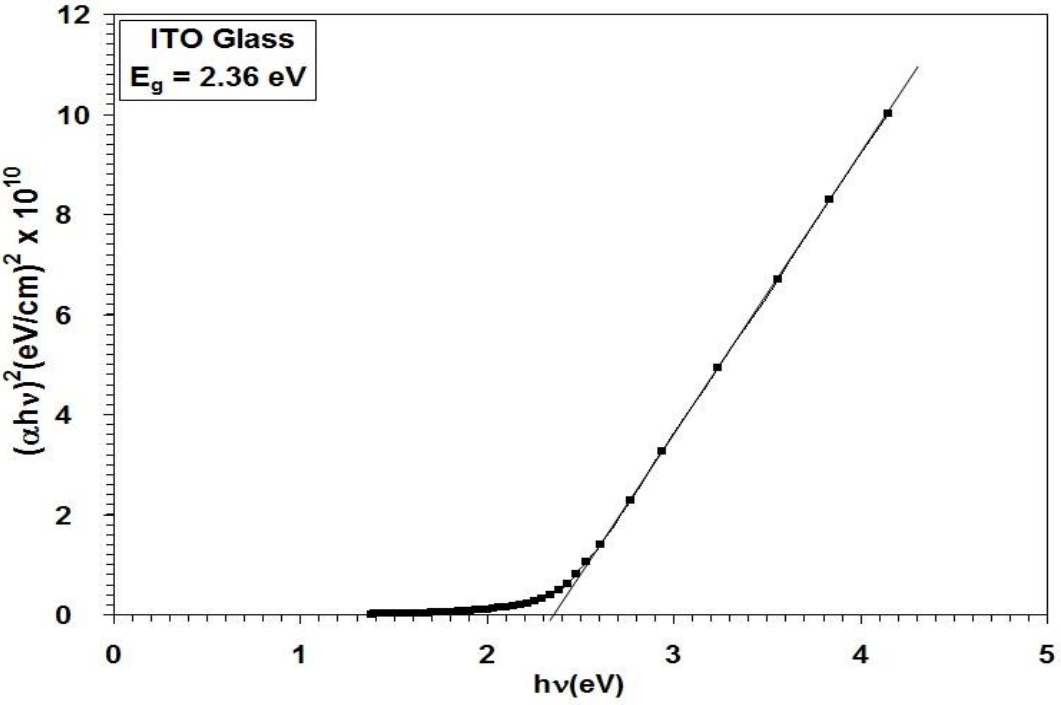

Fig. 7. Variation of $(\alpha h\upsilon)^2$ versus photon energy of CdO thin film deposited on ITO glass substrate.

The optical band gap (E_g) of the films was determined from the equations reported by Pankove [16]:

$$(\alpha h\upsilon)^{1/2} = A\,(h\upsilon - E_g)^{1/2}$$

Where: hυ is the photon energy and A is a constant.

For CdO films which has a direct band gap, a linear fit is obtained by plotting $(\alpha h\upsilon)^{1/2}$ versus hυ [17]. The value of E_g was determined from the intercept of the line fit to the line rportion of the curve with the x-axis as shown in Figs. 5-7. From these figures it can notice that the energy gap are decreased when replacing the glass substrate to quartz or ITO substrate for CdO prepared thin films.

4. CONCLUSION

Cadmium oxide (CdO) thin films were formed by chemical spray pyrolysis technique, the increase of absorbance caused by replacing substrate type, and also the absorption coefficient and extinction coefficient. The refractive index unchanged with replacing substrate (glass, quartz, ITO glass) at wavelength 500-900 nm. The energy gap decreased from 2.4 eV to 2.3 eV for replacing substrate type.

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