International Journal of Nanoelectronics and Materials

In Press, Accepted Manuscript – Note to users

Oblique Angle Deposition of Cadmium Oxide Film on Quartz Substrate

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ABSTRACT

The oblique angle configuration has emerged as an invaluable tool for the deposition of nanostructured thin films. In this article, we use this technique to investigate the optical properties of cadmium oxide nanostructure. Cadmium metal was deposited normally (θ=˚0) and obliquely at different angles (50º and 70º) by using vacuum evaporation technique on a quartz substrate, then oxidized in air at 773K for the 1:30 hour.The absorbance and transmittance spectrum have been investigated by using UV-Visible spectrophotometer in the range300-1100nm. The optical energy gap (Eg), refractive index (n), extinction coefficient (k), real dielectric constant (εr) and imaginary dielectric constant (εi) have been determined.

`**Keywords**: CdO thin films, Oblique incident, OAD technique.

1. INTRODICTION

In recent years, researchers have focused on cadmium oxide (CdO) due to its applications, specifically in the field of optoelectronic devices such as solar cells [1,2] photo transistors and diodes, transparent electrodes, gas sensors [3,4]. CdO is an type semiconductor with a rock-salt crystal structure(F.C.C) and possesses a direct band gap of (2.2-2.5) eV [5]. Various techniques have been employed to prepare (CdO) thin films such as spray pyrolysis [6] sputtering [7] solution growth[8] the activated reactive evaporation [9] pulsed laser sputtering [10] and sol-gel method [11].The glancing angle deposition (GLAD) technique is the extension of the commonly used oblique angle deposition (OAD) in a thin film deposition community which has been practiced for many years [12]. In the state of obliquely deposited thin films, it is noticed forms like high-density rod or needles, separated by low-density voids [13].And so the film density less than the material density in its bulk and the film density decrease with increasing deposition angle [14]. The oblique deposition produces columnar structures due to the shadowing effect and random fluctuations during film growth [15]. The shadowing effect favors the growth of longer nanorods that causes the decrease in the number density of nanorods [16]. The objective of this work is examining the effect of deposition angle on the optical properties of cadmium oxide films prepared oblique thermally evaporated of cadmium metal thin films.

2. EXPERMINTAL PART

Cadmium metal thin films were normally and obliquely deposited onto a quartz substrate at different angles by thermal evaporation technique (Thermionic Laboratory, IncGerman). The Pisces of quartz substrates 2 x 2cm^2, were washed with acetone and ethanol for 15 minutes in ultrasonic treatment (Transistor/UL Transonic T-7) respectively, rinsed using deionized water, and then dried with nitrogen gas. The cadmium metal was placed in tungsten (W) boat in a vacuum chamber at a pressure of$7x10^{-5}$Torr. The distance between source and substrate was kept 15cm. All the cadmium films were annealed in a furnace type (KSL-1100X) at temperature 773 K for 1:30hour to produce cadmium oxide. The absorbance and transmittance spectrum have been investigated by using UV-Visible spectrophotometer in the range (300-1100) nm. The optical energy gap and the optical factors have been determined.The film thickness is measured by optical interferometer method. The method is based on the interference of the light beam reflected from the thin filmsurface and substrate bottom. He – Ne Laser 632.8 nm is used and the thickness is determined using the formula [17].

$$d = \frac{\Delta x}{x} \cdot \frac{\lambda}{2} \quad (1)$$

Where: x is the fringe width, Δx is the distance between two fringes and λ is the wavelength of the laser light.

3. RESULT AND DISCATION

3.1 THICKNESS RESULT

The thickness of cadmium oxide films shown in table 1 below. It is clear,that the deposition film thickness decreases with increasing deposition angle and this results agreement with paper [18]. This is due to shadowing effect and geometrical consideration in the oblique deposition, also increasing the deposition angle will decrease the deposited materials per unit area.

Table 1. Film Thickness Of (Cdo) Thin Films Deposited At Different Angles.

Deposition angle (Deg)	T(K)	Film thickness (nm)
0°	773	348
50°		316
70°		275

3.2 TRANSMITANCE

Figure1 shows the relation between cadmium oxide transmittance and a wavelength at different deposition angles at oxidation temperature 773 K for the 1:30 hour. It has been mentioned, it delivers a high average transmittance in visible and near IR regions (window effect) of CdO thin films and increases with increasing wavelength for all deposition angles. This may be ascribable to the enhancement in the crystallinity of the cadmium oxide crystallites; this improvement is in the films structure and surface homogeneity. It is also clear, that the deposition angle increasing has a clear effect on the transmittance decreasing, this is resulted from roughness increasing for film surface that gained by the columnar growth increasing with needles like structure and rods. This result agrees with the reference [19].

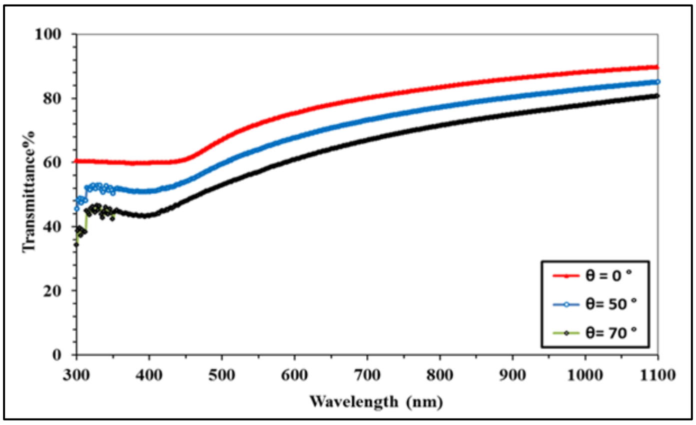

Figure 1. The relation between transmittance and wavelength for different deposition angles of CdO thin films.

3.3 ABSORBTION COEFFICENT

Cadmium oxide (CdO) has many attractive properties like high transmission coefficient, large energy band gaps in the visible spectral domain and notable luminescence characteristics [20].Figure2displays the relation between the absorption coefficient (α) and the wavelength of CdO thin films deposited at different angles. It has been noticed the low value (α) increased with the increasing wavelength in the spectrum range (300-500) nm than the slightly decreasing. Also, it's clear that the absorption coefficient increases with the increasing deposition angle.The absorption coefficient value depends on absorptivity and theoretically, its relation is inverted with the film thickness as in the equation (2)[21].

$$\alpha = \frac{2.303 \times A}{t} \quad (2)$$

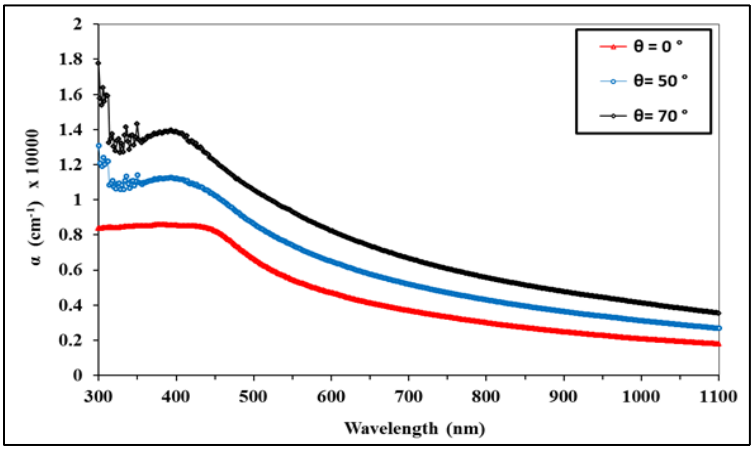

Figure 2. The relation between absorption coefficient and wavelength for different deposition angle of (CdO) thin films prepared at oxidation temperature 773 K.

3.4 ENERGY GAP

The usual technique in which the value of (Eg) can be determined, involves a plotting graph of $(\alpha h\nu)^r$ versus photon energy (hν), if an appropriate value of (r) is used to linearize the graph, then the (Eg)value will be given by intercepting the (hν) axis when $(\alpha h\nu)^r = 0$ [21].Figure 3 displays the relation between (αhυ) 2 and photon energy (hυ) of the CdO films deposited at angles and oxides at 773 K for one and half hour. It has been noticed that when the deposition angle increased, the band gap value increased. The oblique angle deposition led to increasing in the film crystallites and decreasing in the structural defects which led to increases in the energy band gap. There is also an increase in the band gap that is related to film thickness decreasing in the oblique deposition, where the oblique deposition angle,led to the changes that the structure of (CdO) film. Hence this effectiveness can be useful for some devices, like optical memory applications [22].In the table (1), these results and their observation are listed, it's clear also increase in deposition angle a slight increase in the optical band gap (direct band gap).

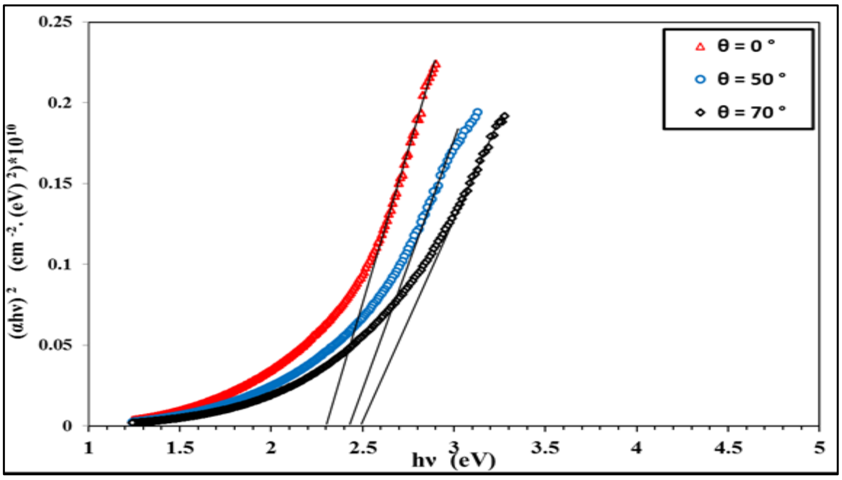

Figure 3. The relation between $(\alpha h\upsilon)^2$ with $(h\upsilon)$ for (CdO) films deposited at different angles and prepared at oxidation temperature 773 K.

Table 2. Shows The Direct Allowed Energy Gap For (Cdo) Thin Films Deposited At Different Angles.

Deposition angle (Deg)	T(K)	Energy Gap (eV)
0°	773	2.30
50°		2.43
70°		2.50

3.5 REFECTIVE INDEX

The ratio between the light velocities in a space with its velocity in the material is called the refractive index. The refractive index values (n) have been calculated by using an equation3[21] shows below.Figures 4, shows the variations in refractive index with the wavelength for spectrum range (300-1100) nm of CdO films deposited at angles. It's clear from the figure that the refractive index value slightly increased towards longer wavelengths with increasing deposition angle. This is may be due to decreasing in the defect and dislocation with increasing incident angle.

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

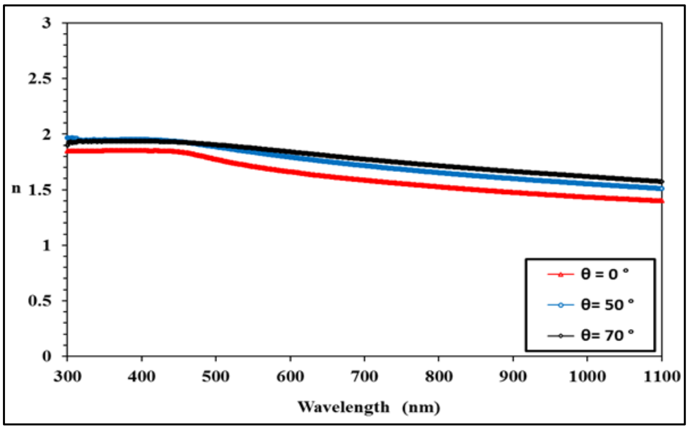

Figure 4. The relation between the refractive index and wavelength for (CdO) films deposited of different deposition angles and at temperature 773 K.

3.6 EXTINCTION COEFFICIENT

The extinction coefficient (k) is directly related to the light absorption then to the absorption coefficient (α) as in the equation 4[21]. Figure 5explains the relation between extinction coefficient (k) of (CdO) thin films deposited at different angles and oxides at 773 K with the wavelength. It's clear from a figure below that the extinction coefficient value is low and increases with the deposition angle increasing for the wavelength range (300-500) nm. These variations caused by crystal structure variation due to the deposition angle and this is, in turn, has an effect on the absorption coefficient (α) on which (k) value depends on the reasons that are mentioned in the absorption coefficient subject [21].

$$K = \frac{\alpha\lambda}{4\,\pi} \tag{4}$$

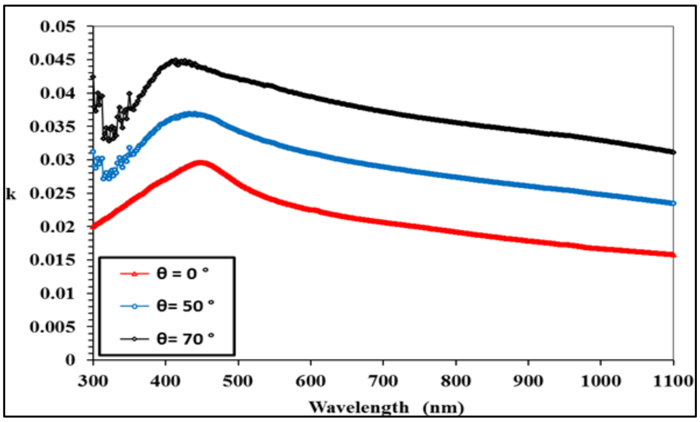

Figure 5. The relation between extinction coefficient and wavelength for CdO films at deposition angles.

3.7 DIELECTRIC CONSTANT

Complex dielectric constant (ε) consists of real dielectric constant (εr) and imaginary dielectric constant (εi) where the real part is the normal dielectric constant and the imaginary part is the absorption related to free carriers [23] and measured by using the relations (5) [21]. Figures 6display the relation between (εr,εi) and wavelength for normal and the oblique (CdO) films. It has been noticed that the low value (εi) increased with the increasing deposition angle in the spectrum range (300-500) nm then the slightly decreasing. The differences that take place in (εi) depend on the (n and k) variation because of their relation .While in figure 7, below it can be observed that the graph is fixed value of (εr) for the wavelength range (300-500) then slightly decreased with increasing wavelength. The value account of (εr) depends on (n and k), so consequently, all the variations are due to the variation of (n and k) [23].

$$\left.\begin{aligned} \varepsilon_r &= n^2 + K^2 \\ \varepsilon_i &= 2\,n \end{aligned}\right\} \quad (5)$$

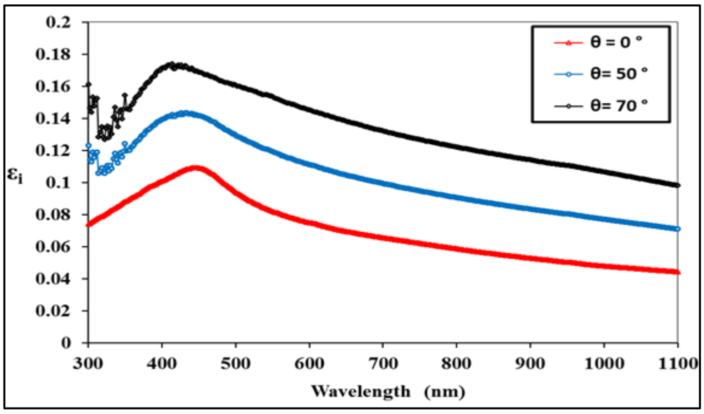

Figure 6. The relation between the dielectric constants (εi) and wavelength for CdO films deposited at different angles and temperature 773K.

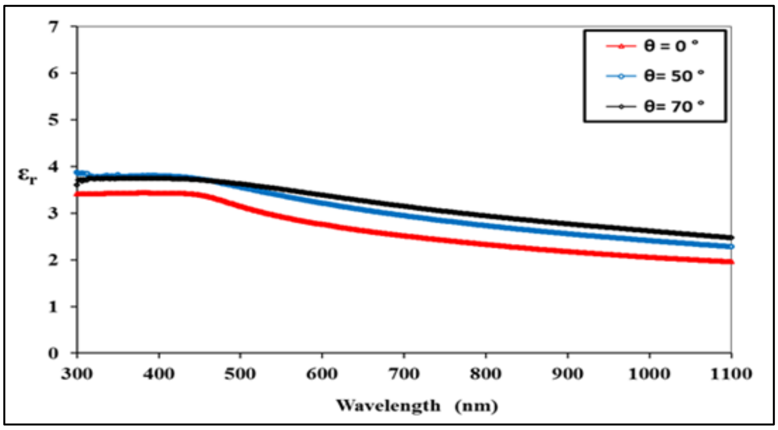

Figure 7. The relation between the dielectric constants (εr) and wavelength for CdOfilms deposited at different angles.

4. CONCLUSIONS

We have presented an experimental study of the prepared cadmium dioxide (CdO) thin films using oblique angle deposition (OAD).Optical properties show, transmittance decreased with increasing deposition angle and increased in the optical bandgap. Also, it's clear that the greatest effect of oblique angle on the refractive index (n), extinction coefficient (k), real dielectric constant (εr) and imaginary dielectric constant (εi).

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