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Enhancement of CdO Film Via Li Additive: Structural and Optical Properties

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Abstract:

Chemical spraypyrolysis technique was used to prepare thin film of pure nanostructured CdO and nanostructured Li-doped CdO with volumetric concentration of (1 and 3.%). By using XRD, the prepared films on glass substrate have been studied and found to be cubic structure.Through the use of UV-Visible spectrophotometer we have determined the optical parameters like transmittance and optical constants. The optical energy gap of CdO was decreased from 3.92 eV for pure CdO film to 3.8 eV for the CdO:3%Li film.

Keywords: *CdO:Li thin film, chemical spray pyrolysis, energy gap ,structural and optical.*

I. INTRODUCTION

The technologies of thin film have an importance role specifically in the field of optical coating, microelectronics, integrated optics and superconductors [1]. The transparent conducting oxides (TCOs) like CdO, ZnO, InO, TiO2 و , were extensively studied in optoelectronic devices,[2]. Cadmium oxide (CdO) attracted the attention of researchers in recent years for their potential use in various applications [3]. The CdO is an II-VI semiconductor, it is an n-type with a simple cubic structure with a direct band gap of 2.3 eV [4-5], low resistivity, high optical transmittance in visible region [6], high density (8150 Kg/m^3) [7], and high melting point (900-1000 °C) [8]. Many techniques that used to prepare CdO film like SILAR method [9], solvothermal method [10], chemical bath deposition[11], chemical spray pyrolysis (CSP) [12]. In the present work, Chemical spray pyrolysis was used to obtain the CdO films with various Li content, From structural and optical properties it can candedate the films in many applications acording to its structure and optical properties.

II. EXPERIMENTAL

Chemical pyrolysis (CdO) and thin film of CdO and Li-doped CdO with volumetric concentration of (1 and 3%) were prepared on a glass substrate at preheated to 400 oC by using CPS method. The structural properties of the CdO:Li was studied by (X-Ray) Diffractometer, and scans are performed between 2θ values of 20o and 70o. The optical absorption spectra are

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registered between 300-800 nm of wavelength using Shimadzu UV-Visible Spectrophotometer at room temperature. AFM (AA 3000 Scanning Probe Microscope) was utilized to study deposited thin films surface.

III. RESULTS AND DISCUSSION

The structure of CdO: Li films with a variety of contents of Li is determined by X-ray diffraction (XRD). The diffraction angle which is investigated with the intensity of peaks is determined as in the Fig.1. From the figure, the predominant peak is (111) corresponding to the 2θ = 33° corresponding to the polycrystalline CdO film with other peaks that are determined. The crystallite size (D) of CdO:Li thin films were determined via scherrer formula [13,14]:

$$D = \frac{k\lambda}{B\cos\theta} \qquad (1)$$

where k is a constant (0.9), λ (0.154 nm) represent the x-ray wavelength used, B is FWHM, and θ is the angle of Bragg's diffraction. The crystallite size has been decreased from 65.83 nm of the pure CdO film to 48.70 nm of the film CdO:3% Li indicate that the deposited film were nanostructured.

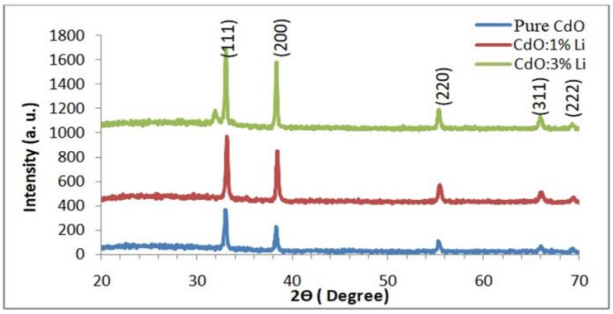

Figure 1: XRD pattern of CdO film with various content of Li.

Fig. 2 disply the Atomic force microscope images of a) CdO b) CdO:1%Li c) CdO:3%Li films. From the figure, the films seem homogenious because there is no craks and pinhole, and smoth because the ten hight point ranged from 1.73 nm to 6.87 nm. The roughness average S_a is increased with the increasing of Li content, also the root mean square S_q. The AFM data are listed in Table 1.

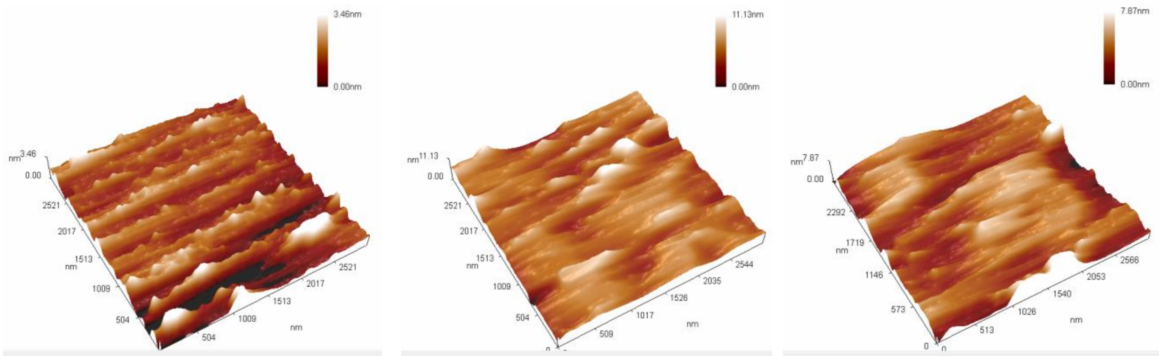

Figure 2 illuatrate the Atomic Force Microscope (AFM) images.

Table 1: AFM data of CdO:Li films

Film	(Sa) (nm)	(Sq) (nm)	Ten point height (Sz) (nm)
CdO	0.48	0.65	1.73
CdO:1%Li	0.99	1.3	2.58
CdO:3%Li	0.98	1.23	6.97

The transmittance (T) can determined from the relation (2),which depends on the absorption (A)[15]:

$$T = 10\text{-}A \qquad (2)$$

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Fig.3 illustrates transmittance spectra of pure and CdO:Li thin films against wavelength. From the figure, the transmittance has been decreased with the increasing of Li doping, this is caused by adding of Li including electrons in the outer orbits, which can be absorb the incident photons make these films more absorber and less transmittance.

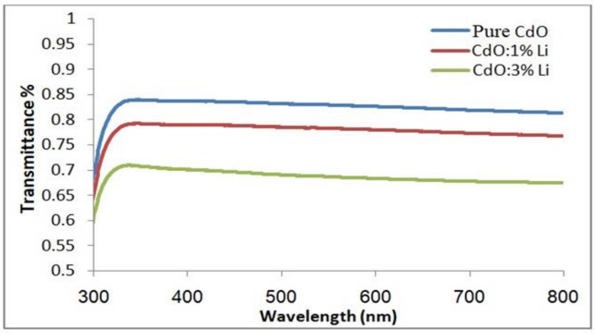

Figure 3: Transmittance spectra of CdO film with various content of Li.

The absorption coefficient (α) can be obtained from the following formula [15]:

$$\alpha = \frac{2.303A}{t} \qquad (3)$$

where A and t are the absorbance and thickness of film respectivily.

The absorption coefficient (α) of pure and CdO:Li thin films versus wavelength were presented in the Fig.4. The α helps to have a knowledge about kind of transition. The values of α of the prepared films (CdO:Li) (Fig.3) refer to the direct transition ($\alpha > 10^4$) cm^{-1}[16].

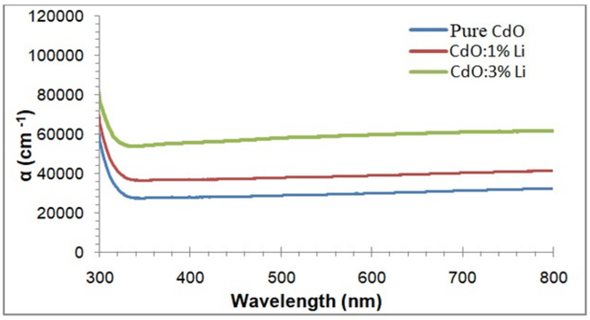

Figure 4: Absorptioncoefficient of CdO film with various content of Li.

The energy gap (E_g) of pure and CdO:Li thin films can be determined from the relation [16]:

$$\alpha h\upsilon = A(h\upsilon - Eg)^n \qquad (4)$$

where hυ represents the photon energy and A is a constant, for a direct transition n = $\frac{1}{2}$ or $\frac{2}{3}$ [17]. The value of energy gap can determined from he plot $(\alpha h\upsilon)^2$ and hυ as in Fig.5. The values of E_g were decreased from 3.92 eV for pure CdO film to 3.8 eV for the CdO:3%Li film.

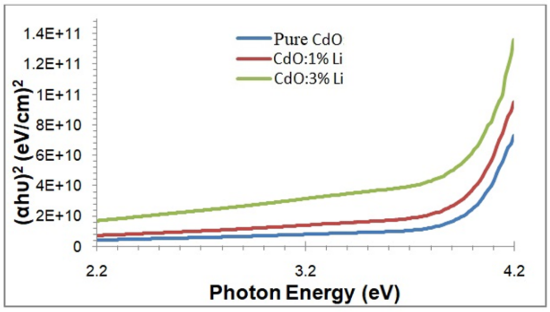

Figure 5: $(\alpha h\upsilon)^2$ versus photon energy of CdO film with various content of Li.

Fig.6 represent the link between extinction coefficient and wavelength. The extinction coffecient (k) can be calculated from the relationship [18]:

$$k_o = \frac{\alpha\lambda}{4\pi} \qquad (5)$$

where α represents the absorption cofficient.

From the figure, the k_o increases with the increasing of wavelength. In addition, the k_o increases with the increasing of Li concentration in CdO:Li films.

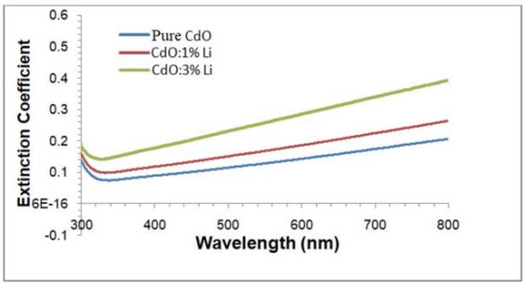

Figure 6: Extinction coefficient of CdO film with various content of Li.

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The variations of refractive index (n) with wavelength of CdO:Li films which were approximately estimated are illustrated in Fig.7. From the figure, it is clear that n behaviour is decreases with increasing wavelength; where as the increase with Li concentration can be noticed. At higher wavelength, the CdO:Li films illustrated refractive index approaching to be constant.

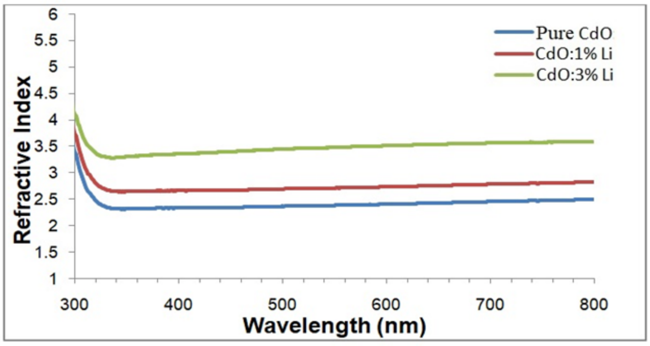

Figure 7: Refractive index of CdO film with various content of Li.

The real (ε_i) and imagenary (ε_r) dielectric constants , which was calculated from the relationships [19]:

$$\varepsilon_i = n^2 - k^2 \qquad (6)$$

$$\varepsilon_r = 2nk \qquad (7)$$

where k is extinction cofficient. The imagenary dielectric constant was illustrated in Fig.8.

The complex dielectric constant for a wavelength range between 300-800 nm, is important standard for the choosing of fabricated films for different applications. The general behaviour of the prepared films increased with the increasing of Li doping in the CdO:Li films, refer to the increase of electrical polarization.

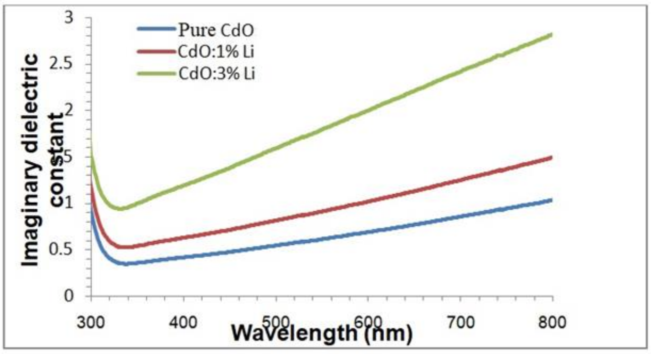

Figure 8: The imaginary dielectric constant of CdO film with various content of Li.

IV. CONCLUSIONS

The structure of polycrystalline CdO:Li films, which was prepared using chemical spray pyrolysis on glass substrate which are examined by XRD. From UV-Visible spectrophotometer, the absorbance and transmittance spectra are determined. Absorbance increased with the increasing of Li doping, while transmittance decreased. The optical energy gap decreased with the increasing of Li doping to be 3.8 eV for the CdO:3%Li film. The optical constants also determined.

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