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STURCTURE IDENTIFICATIOIN AND OPTICAL PROPERTIES OF SPIN COATED Cu DOPED CdO THIN FILMS

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Abstract

Pure CdO and Cu (1 mol%, 2 mol%, 3 mol% & 4 mol%) doped CdO thin films on glass substrate were successfully fabricated by using the spin coating technique. The samples were annealed at 500˚C for 1 hour. The films structures were studied by X-ray diffraction (XRD). From the XRD analysis, lattice parameters, unit cell volume and crystallite size of the samples are calculated. Also XRD studies reveal that pure CdO and Cu doped CdO thin films are showed cubic structure with maximum peak (111) planes. Furthermore, the XRD data, dislocation density and microstrain are also evaluated. From the optical properties, absorption coefficient and the band gap energy of the samples are calculated.

Keywords: Cu doped CdO thin films, crystallite size, optical band gap E_g, Spin coating method

Introduction

Cadmium oxide (CdO) is n-type semiconductor used as a transparent conductive material prepared as a transparent conducting film back. Cadmium oxide has been used in applications such as photodiodes, phototransistors, photovoltaic cells, transparent electrodes, liquid crystal displays, IR detectors and anti reflection coat [Cai Z et al 2004, Jang J et al 2007, John X et al 2005 and Paul A et al 2008]. The wide band gap properties of semiconductors, like CdO, are of interest particularly for applications such as solar cells and transparent electrodes. Cadmium oxide (CdO) one of these important semiconductors oxide which has high optical properties. According to these properties it has vast applications. Where it show high transparency in the visible region of solar spectrum and has high electrical properties which were represented low ohmic resistance. Although it is difficult to obtain simultaneously a high transmission coefficient, thin films have been carried out. In this work pure CdO and Cu doped CdO films were deposited on glass substrate by using the spin coating technique. The electrical, structure and optical properties were studied.

Experimental

Pure CdO and Cu (1 mol%, 2 mol%, 3 mol% & 4 mol%) doped CdO thin films are synthesized by solid state reaction method, using high purity (99.9 % reagent grade) CdO and Cu powders. There powders were weighed on the basis of stoichiometric composition. The resultant, stoichiometric composition of the pure CdO and Cu (1 mol%, 2 mol%, 3 mol% & 4 mol%) doped CdO powders were ground by agate mortar to obtain the homogeneity. The mixed powders were annealed at 500˚C for 1 hour. The glass slides were cleaned by acetone, HCl and deionized water. Pure CdO and Cu (1 mol%, 2 mol%, 3 mol% & 4 mol %) doped CdO were mixed with 2-methoxyethanol solution by using sol-gel method. And then these pastes were coated on glass substrates by using spin coating technique and annealed at 500˚C for 1hour. The structure of prepared films were characterized by X-ray diffraction (Rigaku Multiflex, Japan)

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with CuK_α source (λ =1.54056 Å). The optical transmittance of the samples was recorded using UV-Vis spectrophotometer.

Results and Discussion

XRD patterns of the CdO and Cu doped CdO thin films on glass substrates were shown in Figure 1(a~ e). Well defined peaks at (111), (200), (220), (311) and (222) planes at respected 2θ values. This indicates that all samples are polycrystalline and matched the characteristics peaks due to the cubic structure.

The lattice constants “a” and unit cell volume “V” for the cubic phase structure are determined by the relation,

$$\frac{1}{d^2} = \frac{h^2 + k^2 + l^2}{a^2} \text{ and } V = a^3$$

where d and (hkl) are interplanar distance and Miller indices, respectively. The lattice constant a and the unit cell volumes are calculated as given in Table 1. They match well with the standard JCPDS data card. In order to determine the variation of crystallite size with increasing Cu doping, the size of the crystallites oriented along the (111) plane is calculated by using Scherrer’s formula,

$$D = \frac{0.9\lambda}{\beta\cos\theta}$$

where, β, θ and λ are the broadening of the diffraction line measured at half its maximum intensity in radians, the diffraction angle, and the X-ray wavelength, respectively. The calculated values of crystallite size are given in Table 1. Dislocation density and microstrain are also calculated are given in Table 1.

The optical transmittance (T%) spectrum of CdO and Cu doped CdO thin films on glass substrates was taken in the wavelength range 400-1100nm. Figure 2 (a ~ e) shows the variation of optical transmittance with the wavelength of thin films. The fundamental absorption corresponding to the optical transition of the electrons from the valence band to the conduction band can be used to determine the nature and value of the optical band gap E_g of the films.

The optical absorption coefficient (α) was calculated from transmittance using the following relation,

$$\alpha = \frac{1}{d}\log\left(1/T\right)$$

where, T is the transmittance and d is the thickness of the films. The films under study have an absorption coefficient (α) obeying following relation for high photon energies (hν)

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

where E_g is the optical band gap of the films and A is a constant. A plot of variation of $(\alpha h\nu)^2$ versus hν is shown in Figure 3 (a ~ e). Eg is evaluated using the extrapolation of the linear part. The intercept on energy axis gives the value of band gap energy.

Table 1 The structural properties of pure CdO and Cu doped CdO thin films on glass substrate

Samples	***Maximum peak***	***Lattice constant "a"(Å)***	***Unit cell volume "V" (nm)^3***	***Crystallite size "D" (nm)***	***Dislocation density "δ" ×10^{14} (m)$^{-2}$***	***Strain "ε"×10^{-4}***
Pure CdO	(111)	4.6958	0.1035	93.0846	1.1541	3. 7238
Cu (1mol%) doped CdO	(111)	4.6939	0.1034	65.2360	2.3498	5.3134
Cu (2mol%) doped CdO	(111)	4.6956	0.1035	93.0848	1.1541	3.7238
Cu (3mol%) doped CdO	(111)	4.6943	0.1035	66.2791	2.2764	5.2298
Cu (4mol%) doped CdO	(111)	4.6961	0.1036	111.951	0.7979	3.0962

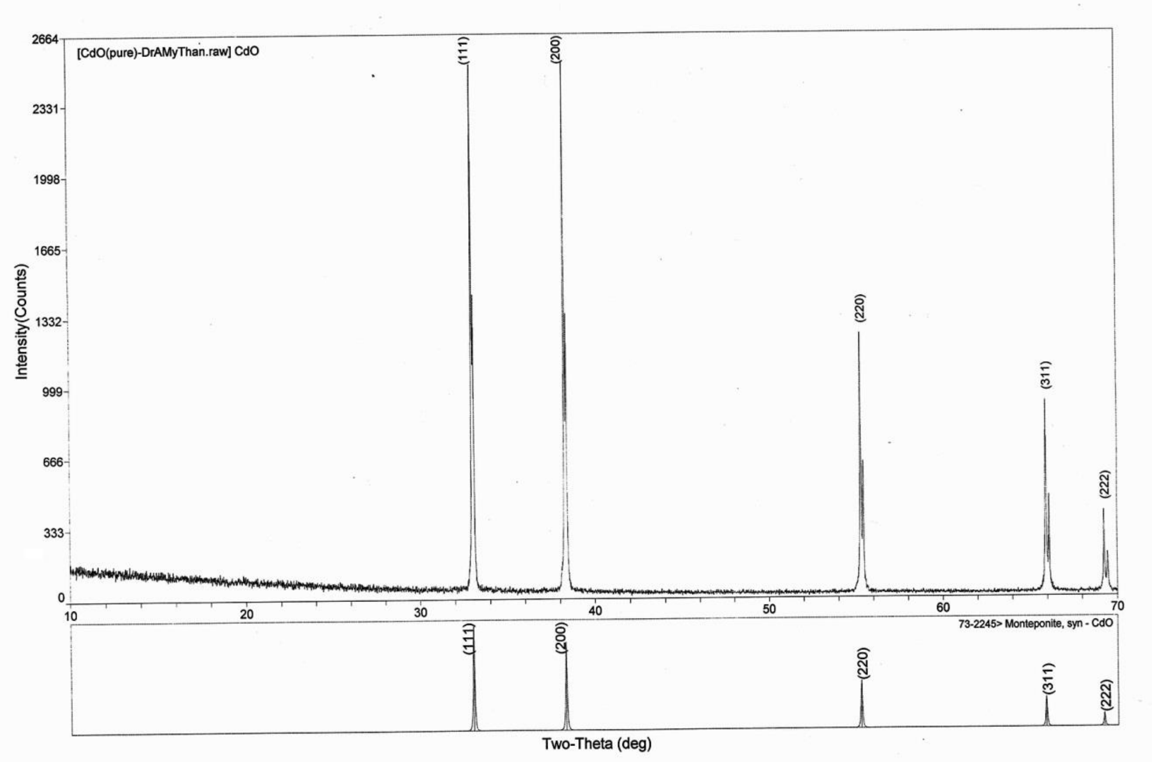

Figure 1(a) XRD pattern of pure CdO thin film on glass substrate

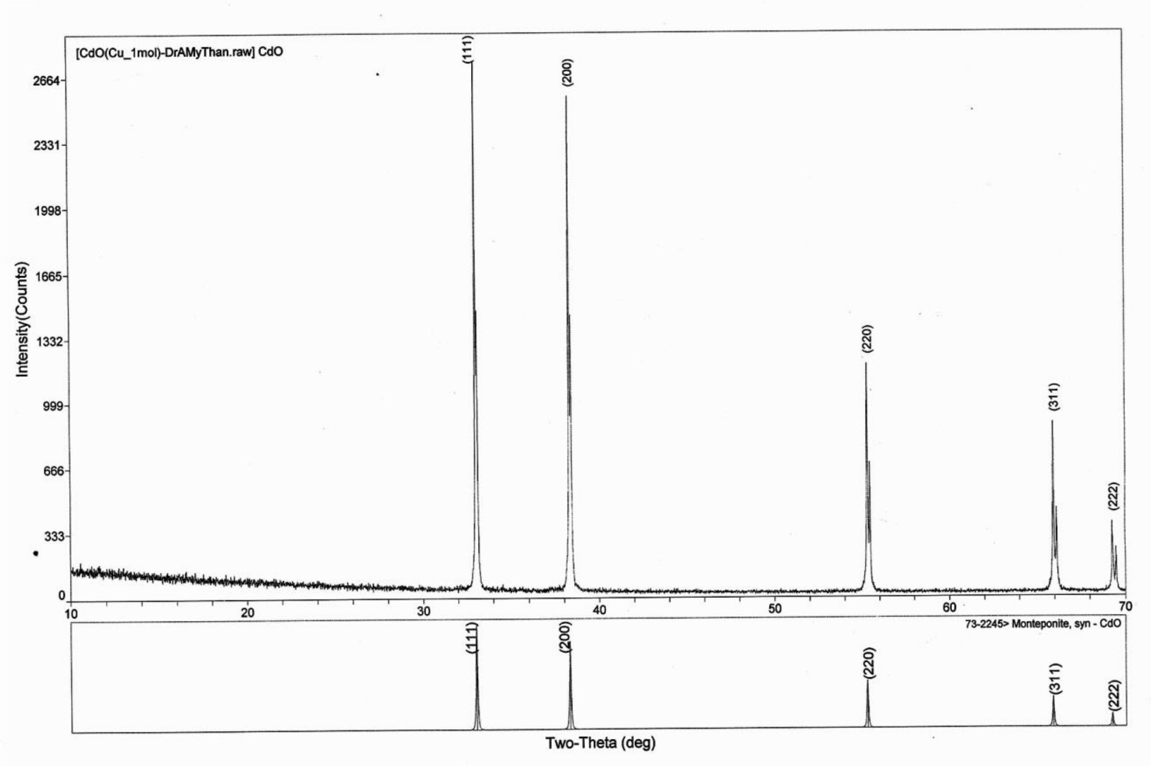

Figure 1(b) XRD pattern of Cu (1 mol%) doped CdO thin film on glass substrate

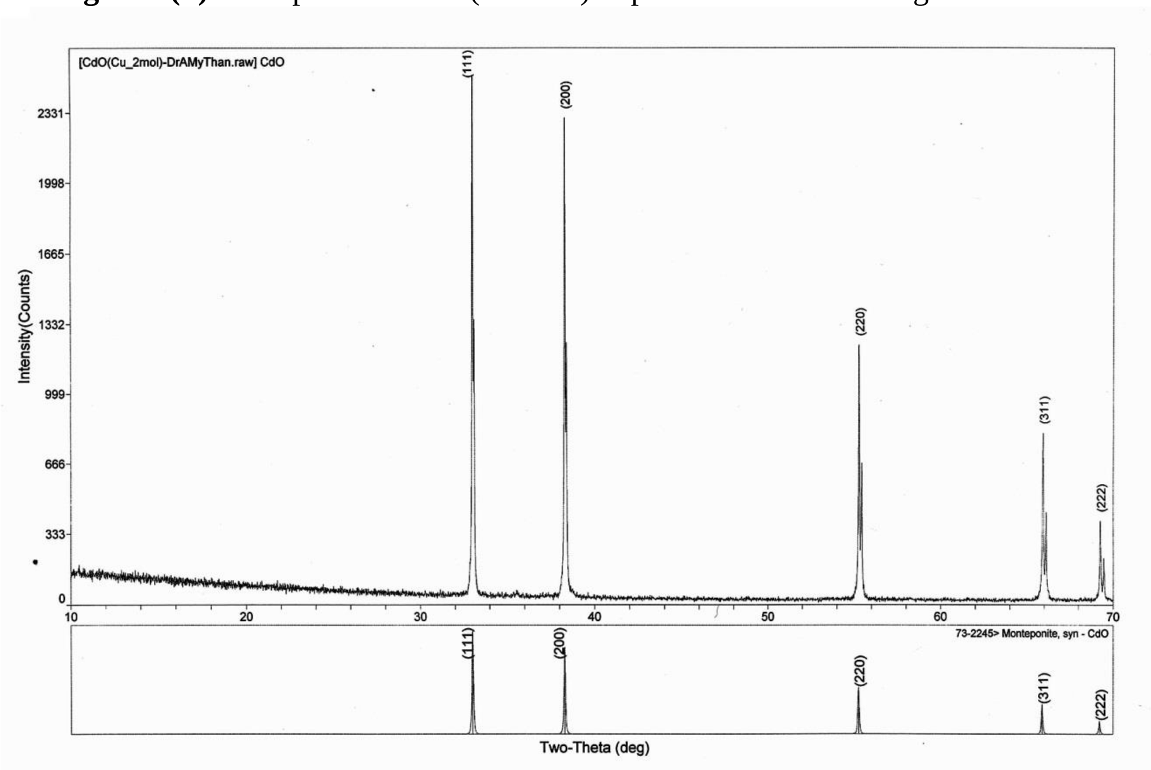

Figure 1(c) XRD pattern of Cu (2 mol%) doped CdO thin film on glass substrate

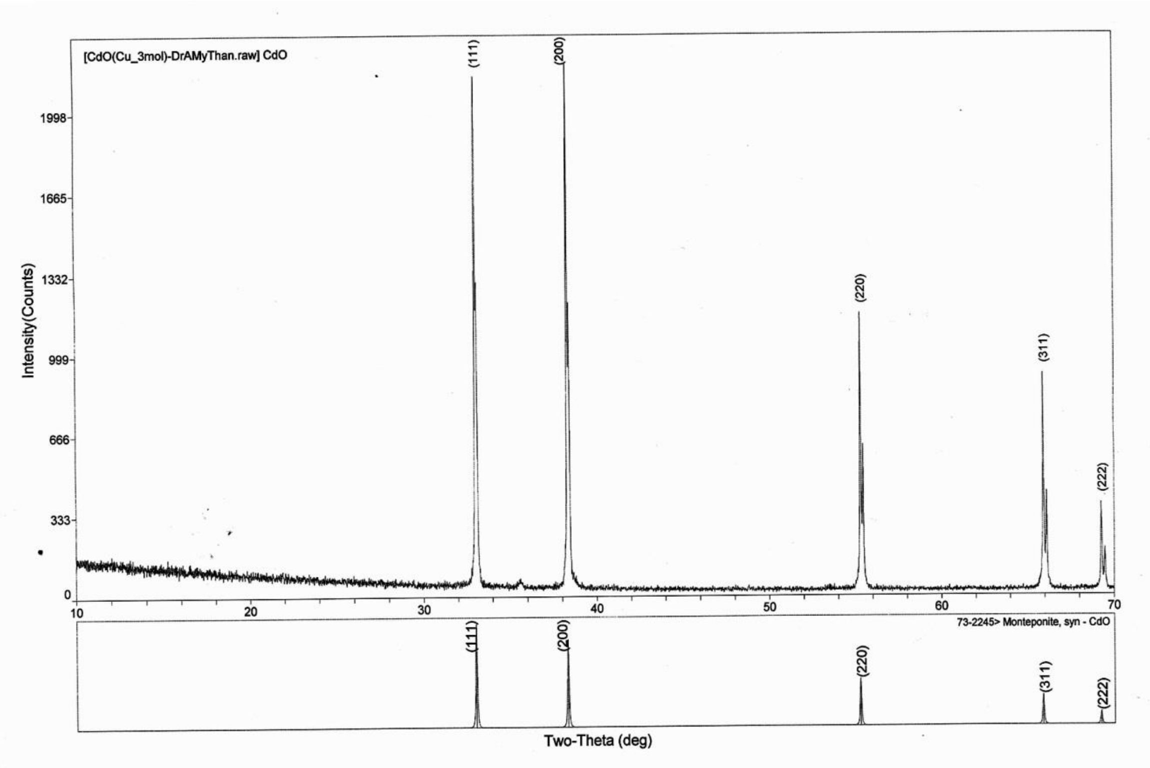

Figure 1(d) XRD pattern of Cu (3 mol%) doped CdO thin film on glass substrate

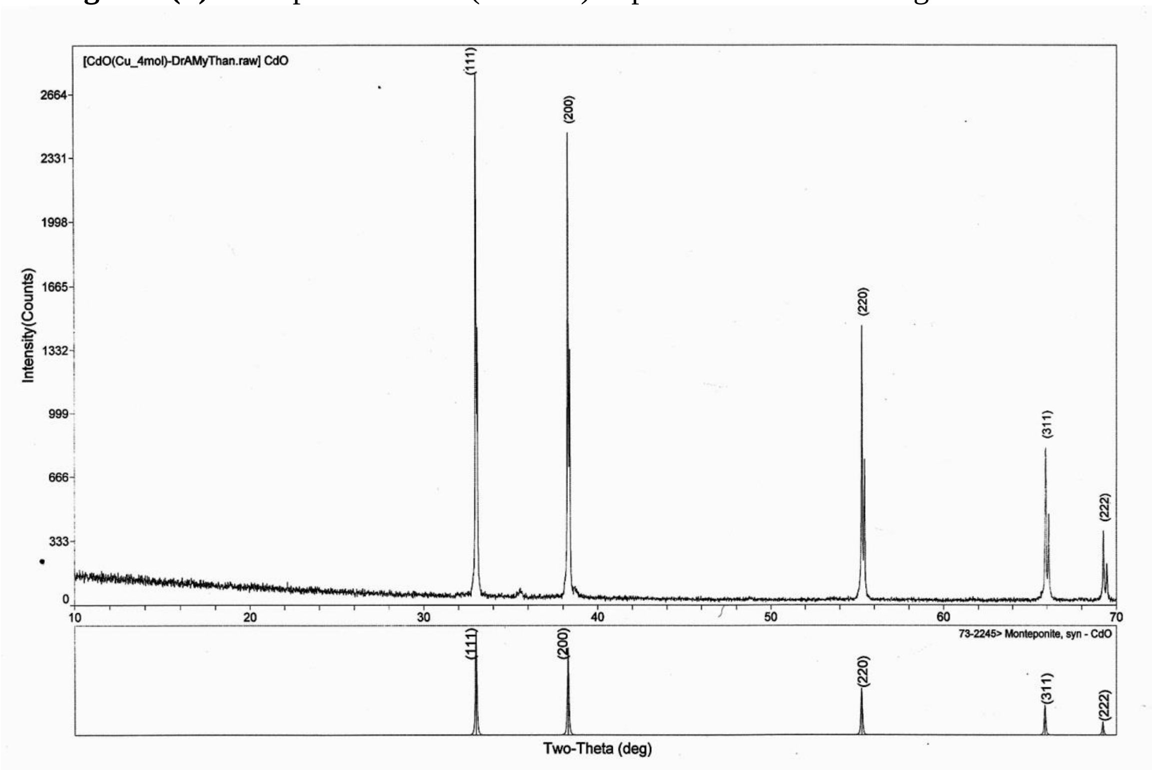

Figure 1(e) XRD pattern of Cu (4 mol%) doped CdO thin film on glass substrate

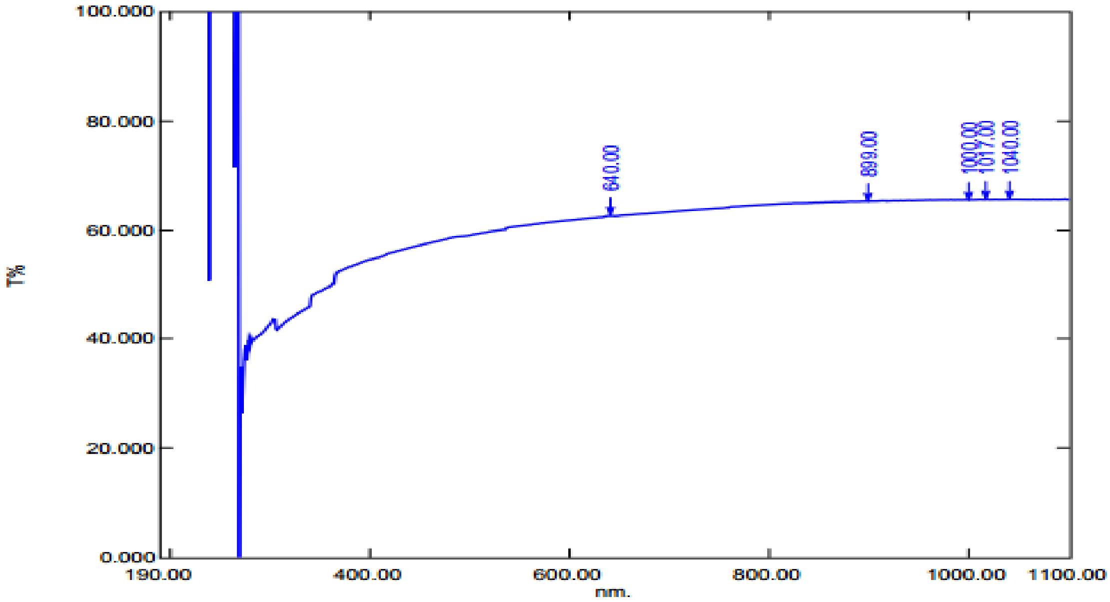

Figure 2(a) Optical transmittance (T) spectra of pure CdO thin film on glass substrate

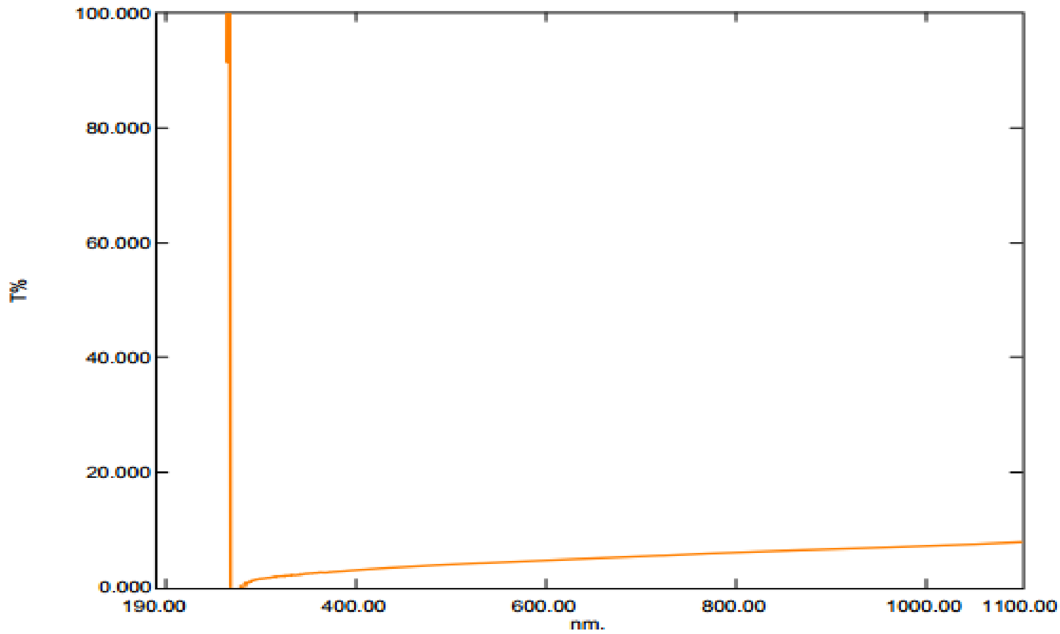

Figure 2(b) Optical transmittance (T) spectra of Cu (1 mol%) doped CdO thin film on glass substrate

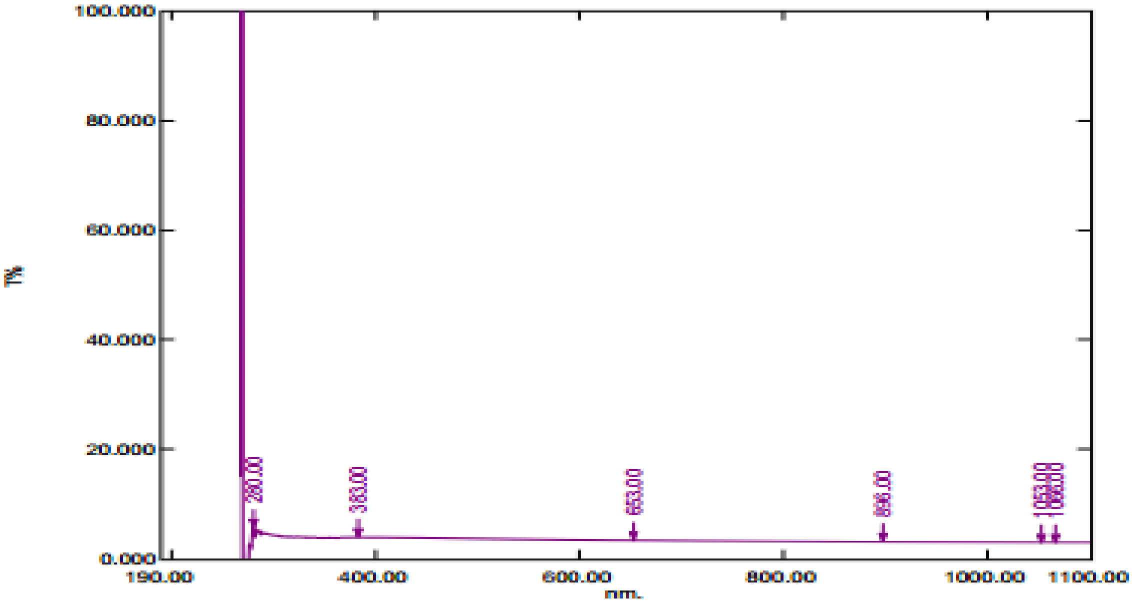

Figure 2(c) Optical transmittance (T) spectra of Cu (2 mol%) doped CdO thin film on glass substrate

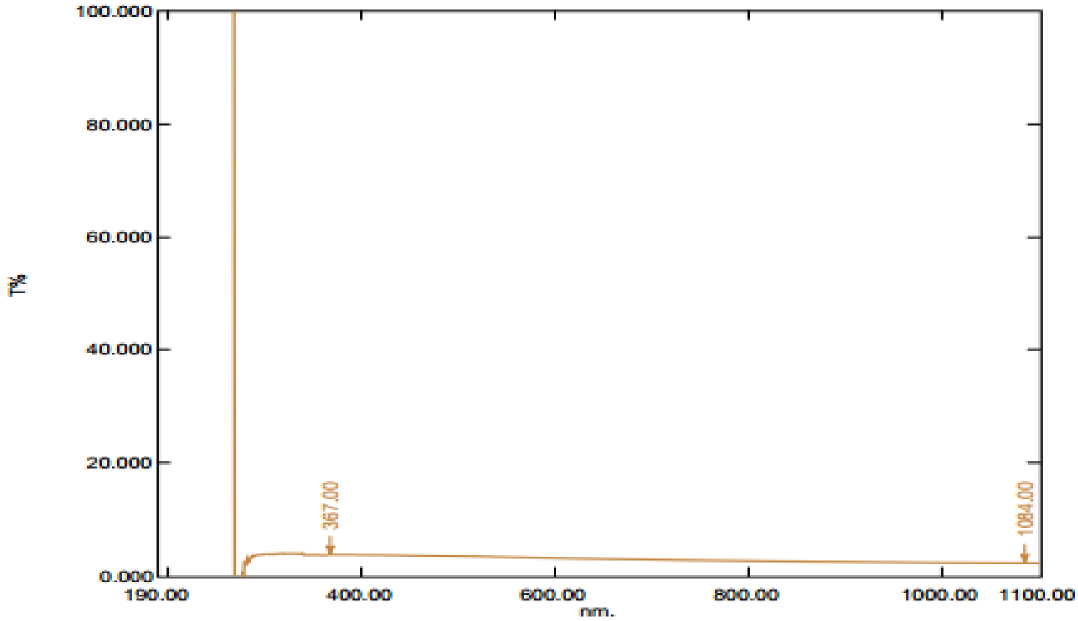

Figure 2(d) Optical transmittance (T) spectra of Cu (3 mol%) doped CdO thin film on glass substrate

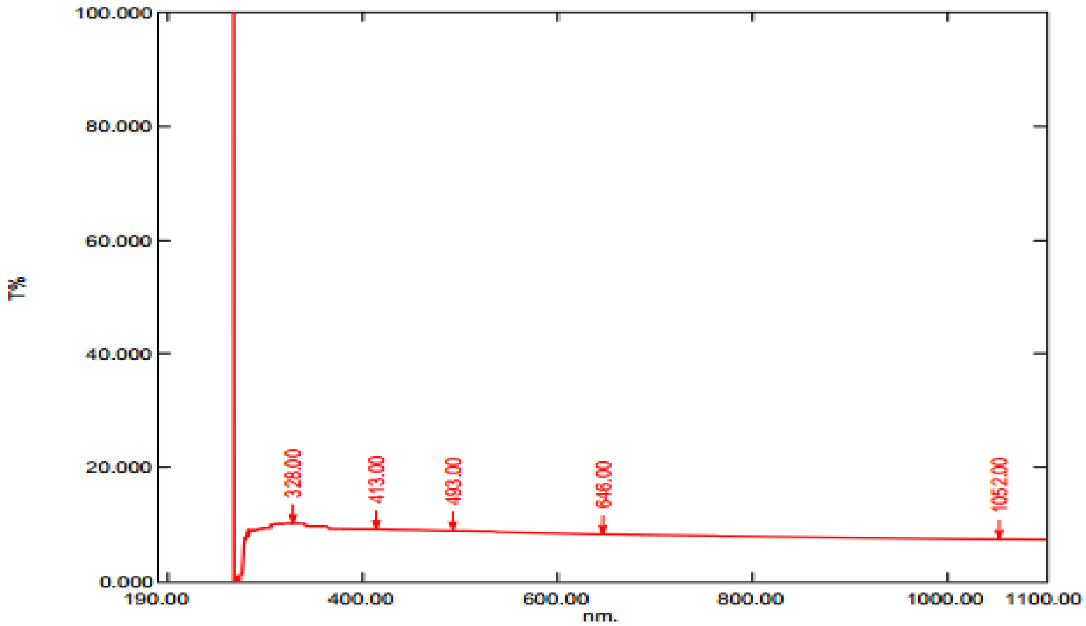

Figure 2(e) Optical transmittance (T) spectra of Cu (4 mol%) doped CdO thin film on glass substrate

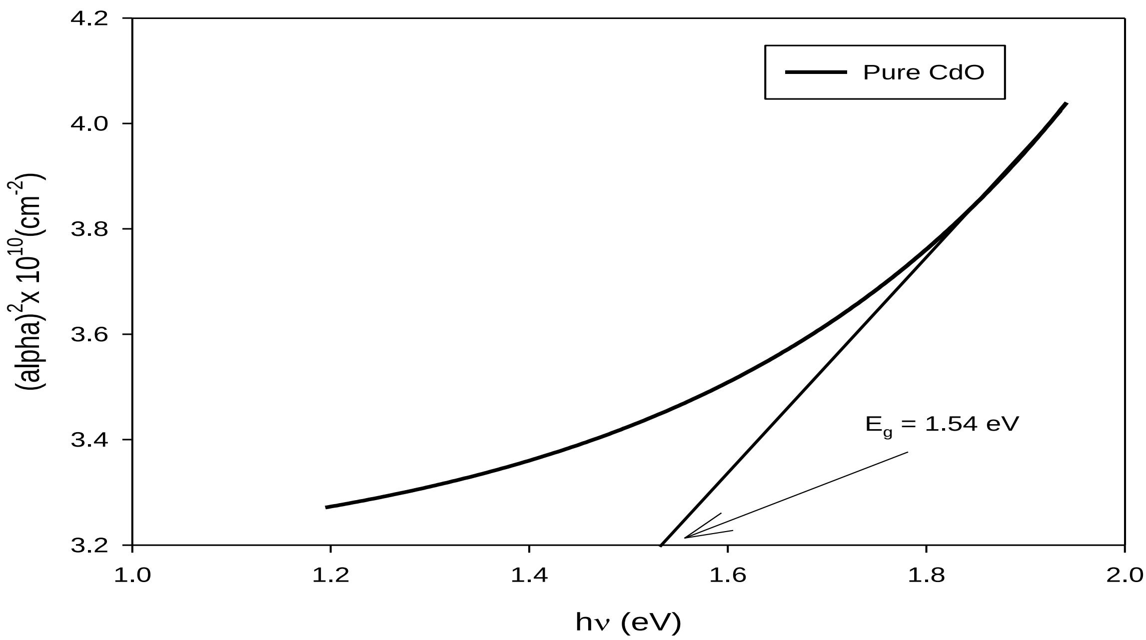

Figure 3(a) Plot of α^2 versus hν curve of pure CdO thin film on glass substrate

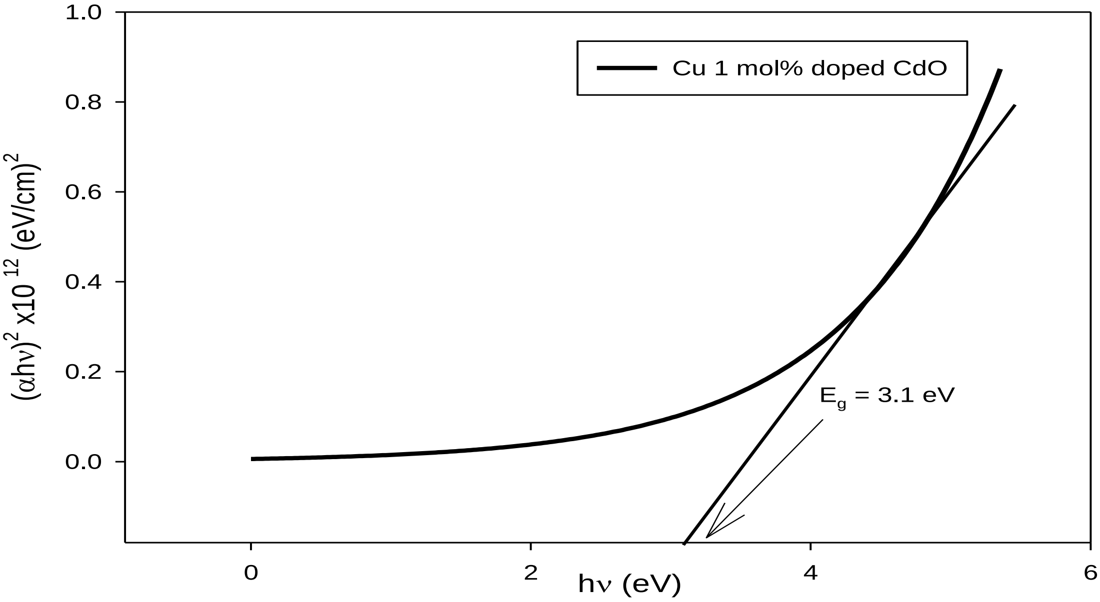

Figure 3(b) Plot of $(\alpha h\nu)^2$ versus hν curve of Cu (1 mol%) doped CdO thin film on glass substrate

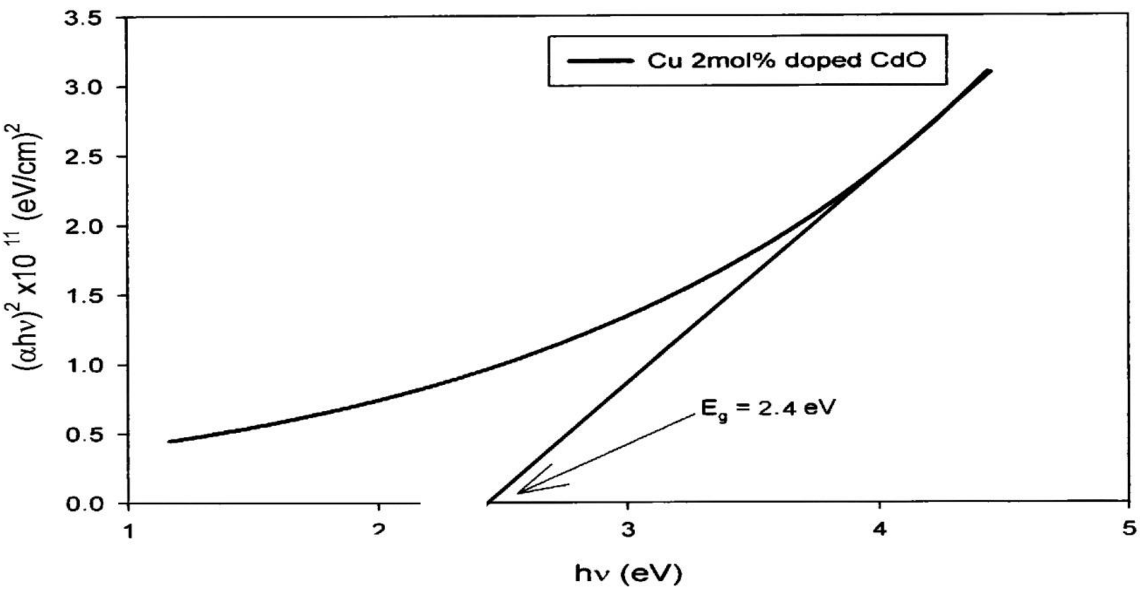

Figure 3(c) Plot of $(\alpha h\nu)^2$ versus hν curve of Cu (2 mol%) doped CdO thin film on glass substrate

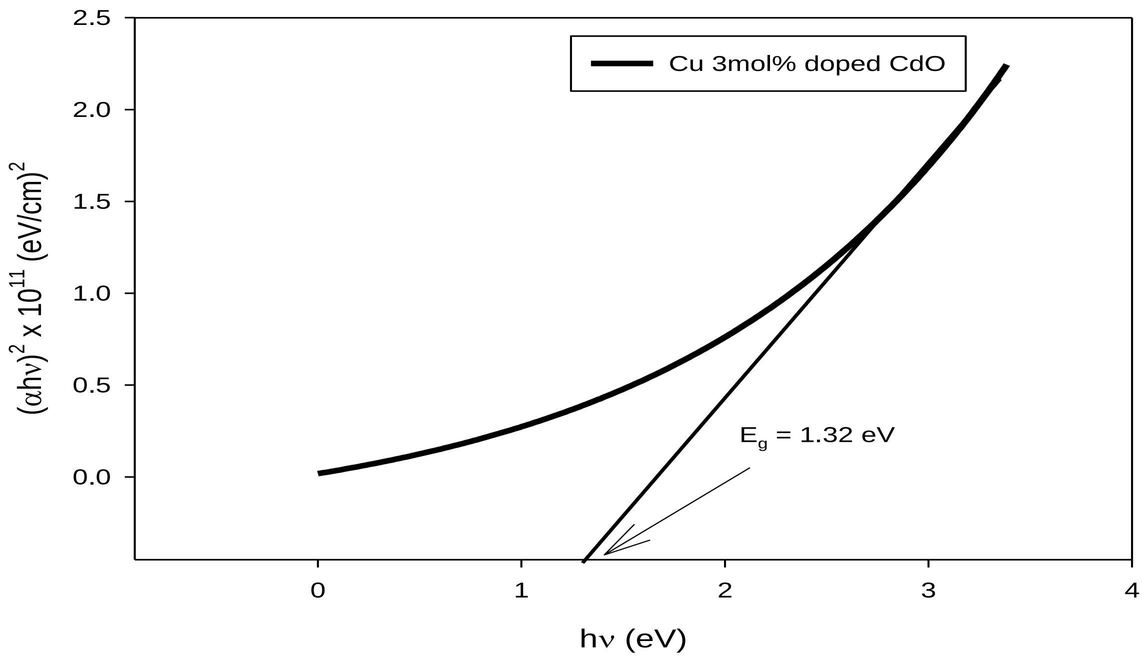

Figure 3(d) Plot of $(\alpha h\nu)^2$ versus hν curve of Cu (3 mol%) doped CdO thin film on glass substrate

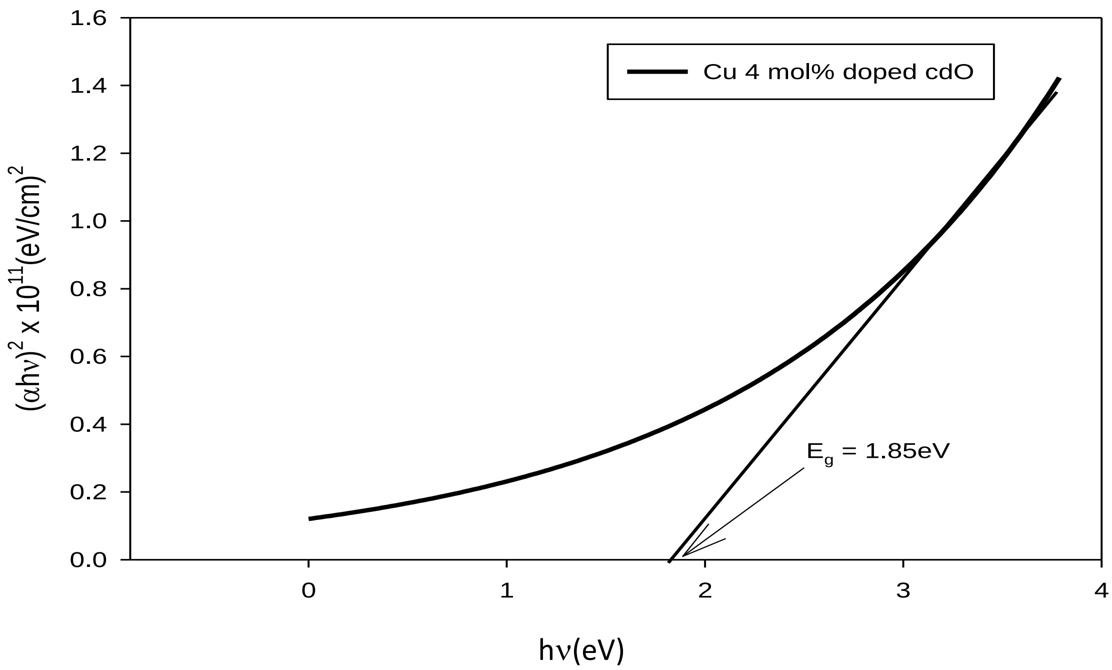

Figure 3(e) Plot of $(\alpha h\nu)^2$ versus hν curve of Cu (4 mol%) doped CdO thin film on glass substrate

Conclusion

The pure CdO and Cu doped CdO thin films on glass were prepared by using sol-gel and spin coating method. The Cu doped concentration changed from 1mol% to 4 mol%. XRD patterns of all samples is found to have a better polycrystalline nature oriented along the (111), (200), (220), (311) and (222) planes at 33.012˚, 38.305˚, 55.290˚, 65.927˚ and 69.260˚ respectively. The average crystallite size of all samples is found to be 85.927 nm. The optical band gap of the samples, measured by employing a UV-Vis spectrophotometer, observed that at 1.32 eV to 3.1 eV. The doped CdO with Cu improved the photoconductive gain.

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