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The effect of the concentration ratio of Cadmium oxide on the optical properties for Titanium dioxide films

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Abstract: *In this work, CdO - doped TiO_2 thin films with different concentrations (0.0%,0.1%, 0.3%, 0.5% and 1%) have been prepared by pulse laser deposition method on glass substrates and annealed in air at 500º K. The effects of CdO-doping on the optical properties of the TiO2 thin films were studied by UV–visible spectroscopy.The prepared films were characterized by X-ray diffraction. The XRD pattern of the films show a polycrystalline film, with tetragonal structure for TiO2 and formation of Anatase phase and many peaks(101), (004) and (200) were appear when increasing of CdO concentration a new peak is appearedfor CdO , for concentration of (0.1 %,0.3%, 0.5% and 1%) of CdO for intensities of (111) ,(200), (220) and (311) with cubic structure. The optical band-gap was also studied from the optical transmittance for the as grown and annealed samples. As expected, the band-gap changes between that for pure CdO and that for TiO_2.*
Keywords – *Optical properties; CdO thin films; PLD, XRD analysis, doped thin films*

I. Introduction

PLD is one of the most promising techniques for the formation of complex oxide hetero-structures, super-lattices, and well controlled interfaces [1]. This technique generally enables the deposition of highly dense film and has proven its efficiency in growing oxides of complex stoichiometry. Transparent conducting oxide (TCO) thin films have been widely used in solar cells applications. CdO and TiO_2 have high transparency in the visible region of the electromagnetic spectrum and show n-type conductivity, mainly due to oxygen vacancies. With a ranging band gap of 2.2-3.2 eV [2], CdO present the advantage of a low resistivity with respect to the high values obtained for TiO2, but this exhibits a higher transparency, having a band gap around 3.2 eV. It is known that it is difficult to obtain simultaneously a high transmission coefficient in the visible region and good conductivity qualities [3], however a ternary compound which combines these properties in a controlled way may allow the optimization of the window layer. For many years, transparent conductive oxidelayers have been studied extensively because of a widerange of technical applications, for instances as transparentelectrodes in photovoltaic and display devices [4], sensors[5] and so on. Cadmium oxide (CdO) is n-typesemiconductor that crystallizes in the rocksalt structure(FCC) and presents an optical ban-gap of about 2.2 eV [6].The CdO films exhibit high transmission in the visible andUV ranges and has high conductivity. These films havebeen used as transparent contact in CuInSe2 [7] and Si [8]solar cells.

II. ExperimentalWork

An experimental setup for a typical PLD system is shown in fig. 1. The targets with compositions $(TiO_2)_{1-x}(CdO)_x$ (x = 0.00, 0.1, 0.3, 0.5,and 1.0 %) were synthesized via solid state reaction method. For this purpose, the required proportions of TiO2 and CdO in powder form having purity level 99.99% were mixed together and grinded properly. The thin films were deposited on single crystal silicon (1 0 0) substrates using Nd:YAG laser (=1064 nm, τ=9 ns,and El = 700 mJ). Nd:YAG laser was focused on to the target surface at an angle of 45˚,was placed parallel to the target material at distance of 2 cm. The base pressure $4x10^{-2}$ mbar was created inside the PLD chamber using rotary pump. A DC Stepper motor was used to rotate and translate the target material during deposition for uniform ablation from the target surface, which helped to avoid the crater formation on the target‟s surface. laser pulses were incident on each target to irradiate them during the thin film deposition, and the temperature of the substrate surface was kept at 500 k for all depositions. Post deposition annealing

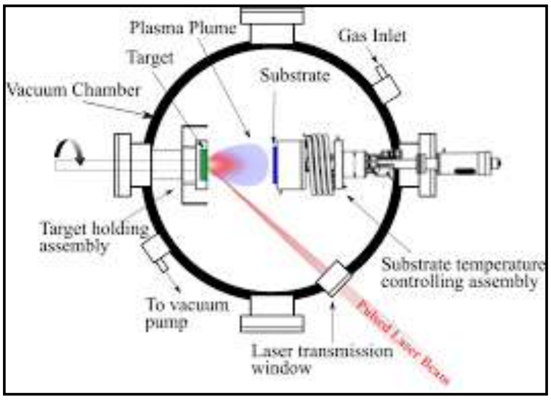

Fig. 1 Schematic diagram of Experimental Setup

III. Results And Discussion

The XRD of $(TiO_2)_{1-x}(CdO)_x$ thin films deposited on glass substrate prepared by PLD. Fig.(2) shows that the XRD patterns of $(TiO_2)_{1-x}(CdO)_x$ thin films after annealed to temperature of 500 K it can observed that the films show a polycrystalline film, with tetragonal structure for TiO2 and formation of Anatase phase and many peaks (101), (004) and (200) were appear when increasing of CdO concentration a new peak is appeared for CdO , for concentration of (0.1 %,0.3%, 0.5% and 1%) of CdO for intensities of (111) ,(200), (220) and (311) with cubic structure, which agree with (ASTM) card.

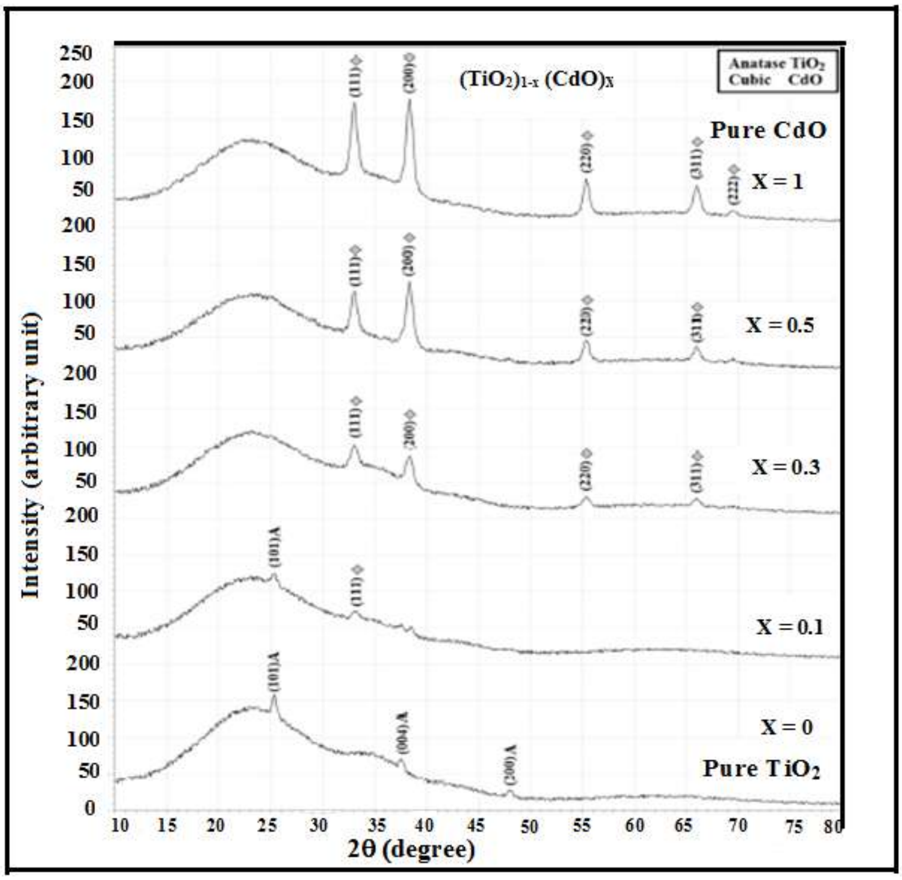

Fig.(2) X-Ray Diffraction for $(TiO2)_{1-x}(CdO)_x$ Thin Films at 500 k

The optical properties of (TiO2)1-x(CdO)x films grown on glass substrate which involve the transmittance, absorption coefficient, the optical energy gap and Refractive index Were studied the effect of the CdO content on optical properties of (TiO2)1-x(CdO)x films prepared by (PLD) were investigated.

Fig. (3) Shows the transmission spectrum as a function wavelength have been determined using UV-Visible transmission spectrum in the spectral range (320-1100) nm. It can be observed from this Fig(3) that the transmission spectrum shifts to longer wavelengths with increasing of different concentrations ratios. It is obvious that the transmission increases with increasing of annealing temperature and this may be due to improving the crystallite size which means a decrease in the reflection and absorption that occurs due to increase of annealing temperature. in the other hand increases in the absorbance and this is due to create levels centers inside the energy which is considered as traps centers leads to increase in the absorbance. The behavior of the transmission spectra is opposite completely to that of the absorption spectra.

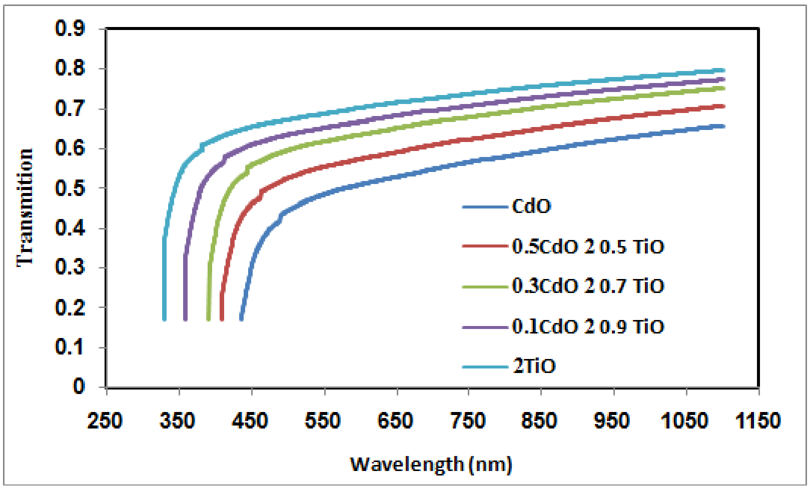

Fig.(3): The transmission spectra of $(TiO2)_{1-x}$ $(CdO)_x$thin films annealed at Ta = 500 k

The absorption coefficient α was determined from the region of high absorption at the fundamental absorption edge of the film. The variation of the absorption coefficient versus the wavelength. It can be observed from this Fig(4) that the absorption coefficient shifts to longer wavelengths with increasing of different concentrations ratios of CdO at annealing temperatures (T_a) equal to 500 k of the $(TiO_2)_{1-x}(CdO)_x$.

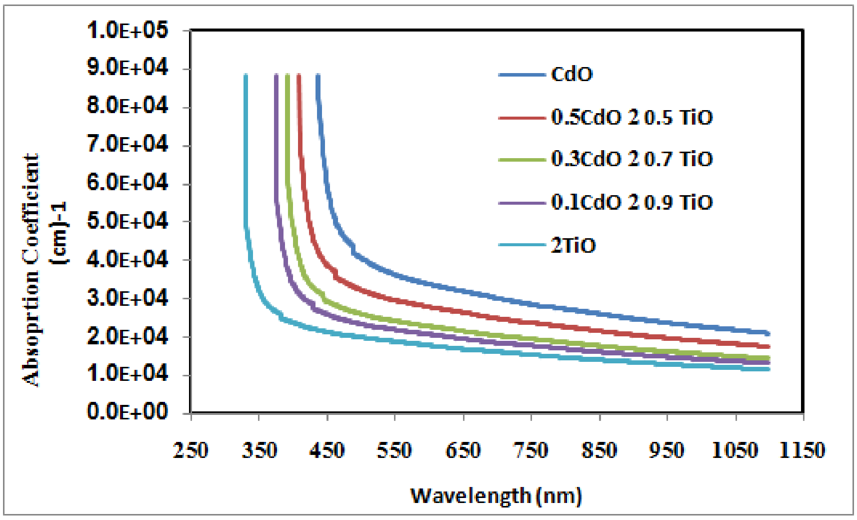

Fig.(4) : Variation of absorption coefficient as a function of wavelength for$(TiO2)_{1-x}$ $(CdO)_x$ films at Ta = 500 k

The direct optical energy gaps value (E_g^{opt}) for **of $(TiO2)_{1-x}$ $(CdO)_x$** films have been determined. A plot of $(\alpha h\upsilon)^2$ versus hυ for **of $(TiO2)_{1-x}$ $(CdO)_x$** with with increasing of different concentrations ratios of CdO at annealing temperatures (T_a) equal to 500 k of the $(TiO_2)_{1-x}(CdO)_x$ is shown in Fig.(5).The plot is linear indicating the direct band gap of the films. Extrapolation of the linear of the line to the hυ axis gives the band gap.The value of the optical energy gap decreases with increasing of different concentrations ratios of CdO at Ta = 500 k.The optical energy gap values (E_g) for **of $(TiO2)_{1-x}$ $(CdO)_x$** films have been determined by using Tauc equation which is used to find the type of the optical transition by plotting the relations $(\alpha hv)^{1/2}$versus photon energy (hv) and select the optimum linear part. It is found that the relation for r =1/2 yields linear dependence. The extrapolation i.e. E_g , of the portion at (α=0). The value of optical energy gap decrease with increasing of different concentrations ratios of CdO at Ta= 500 k for all samples.

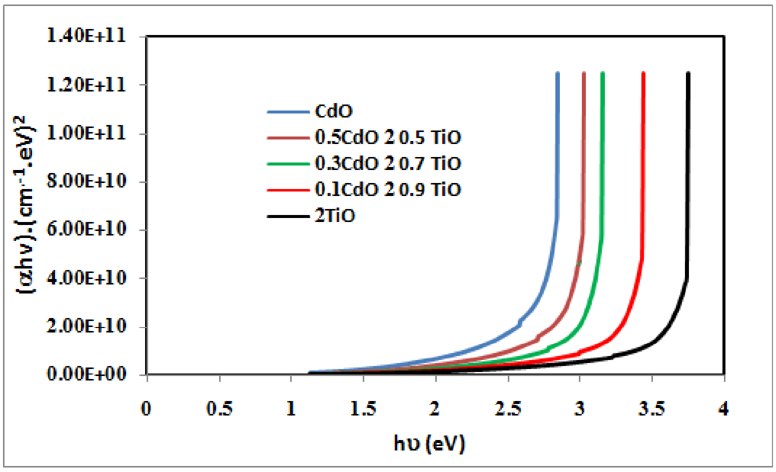

Fig.(5) :$(\alpha h\nu)^2$ as a function of hν for $(TiO2)_{1-x}$ $(CdO)_x$ films at Ta = 500k

Fig (6) Shows the variation in refractive index with wavelength for **$(TiO2)_{1-x}$ $(CdO)_x$** films in the wavelength range of(320-1100)nm for annealing temperature (500)k and with increasing of different concentrations ratios of CdO .It is observed that the refractive index, in general ,increases slightly with increases of concentration .This result can be explained by an increases in the density of the film due to better packing and increased crystalline.

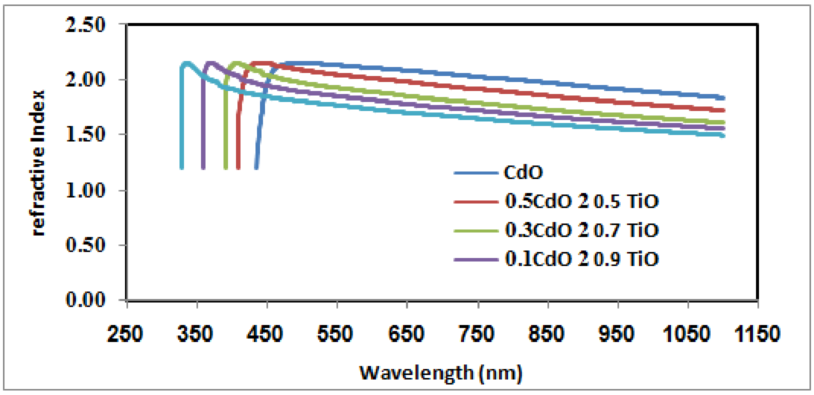

Fig.(6) :Variation of Refractive Index as a function of wavelength for $(TiO2)_{1-x}$ $(CdO)_x$ films at Ta = 500 k

IV. Conclusion

This study focused on the effect of concentration ratio of CdO on phase transformation and optical properties of the $(TiO_2)_{1-x}(CdO)_x$ thin films. The XRD pattern of the films show a polycrystalline film, with tetragonal structure for TiO2 and formation of Anatase phase and many peaks when increasing of CdO concentration a new peak is appearedfor CdO , for concentration of (0.1 %,0.3%, 0.5% and 1%) of CdO for intensities of (111) ,(200), (220) and (311) with cubic structure. while optical properties of thin films it can observedshifts to longer wavelengths with increasing of different concentrations ratios of CdO at annealing temperatures (T_a) equal to 500 k

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