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Influence of Cadmium ion on the Structural and Optical properties of ZnO Nano structures by sol gel method

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ABSTRACT

CdO/ZnO was fabricated by the sol-gel method. The effects of annealing process on the microstructure, transparent properties, and morphology of ZnO films were studied. The film was heated at 400°C for 5hours and the obtained samples were crushed to prepare a fine powder and taken into annealing process the temperature is constant at 700°C. The process will be preceded with different ratio. XRD results show that the different peak values in various chemical composition. In SEM image shows the nano cluster nano particles. In EDAX represents the nano composite which is to identify the compositions. UV- Absorption spectroscopy it is observed that there is a slight shift in absorption edge at 410nm towards longer wavelength side.

Introduction

Metal oxide semiconductor films have been widely studied and have received considerable attention in recent years due to their optical and electrical properties. It is a wide-band gap oxide semiconductor with a direct energy gap of it about 3.37eV. It is an anticipated manufacturing technology that allows through, inexpensive control of structure of matter by working with atoms.

Zinc Oxide (ZnO) is emerging as a material of interest for a variety of electronic applications. It can be used in a large number of areas, and unlike many of the materials with which it completes, ZnO chemically stable, easy to prepare and non toxic. At present the most widely published application for ZnO is an ITO replacement for displays and photovoltaic panels, where ZnO could lower costs of transparent conductors. The scope of the present work is to synthesis of CdO and ZnO nano particles are synthesized by pyrolysis method. Pyrolysis is a developed technology, treats and destroys semi volatile organic compounds (SVOVs), fuels, and pesticides in soil. Pyrolysis is not effective in either destroying or physically separating inorganic from the contaminated medium.

Experimental procedure

Sample preparation

In this work the starting solution consists of ethanol-water in equal ratio and dissolve 2gm Zinc nitrate, 2gm Cadmium nitrate and 8g Poly Vinyl Alcohol. The mixture is heated to 60◦C to form a homogeneous sol solution. The obtained sol is slowly heated to evaporate the solvent and form a hard homogenous gel. The pyrolysis of the final gel is performed at temperature of 400◦C for 5hours. Then during pyrolysis process the PVA poly metric network is slowly burnt through the outer surface zinc and cadmium nitrate salts were simultaneously culminated and converted into the CdO-ZnO nano composite. The obtained samples were crushed to prepare a fine powder and taken into annealing process the temperature is constant at 700◦C.

The amount of Zn $(NO_3)_2$, Cd $(NO_3)_2$, PVA, ht composition of the mixed solvent and the pyrolysis temperature were optimized by the "one at a time method". In this method, the gel network rigidity controls the morphology and particle size of the synthesized sample to make a uniform nano structured CdO-ZnO composite. In the gel structure, cadmium and zinc salts were homogeneously dispersed among polymeric network. Because of gel network rigidity, the dispersed ions in the gel network cannot alter their positions. Therefore, during the pyrolysis of the gel's outer layer, the zinc and cadmium ions of the burnt layers combine with each other to create the double salts of $Cd(NO_3)_2$ and $Zn(NO_3)_2$ which also react to yield CdO-ZnO nano composites. The chemical equation is as follows:

$$Cd(NO_3)_2 + Zn(NO_3)_2 \rightarrow CdO,ZnO + 4NO_2$$

In this method amount of Zn $(NO_3)_2$, Cd $(NO_3)_2$, PVA used. The solvent composition and the pyrolysis temperature have an effect on the composition, morphology and particle size of the sample. Similarly the same process will be preceded with different ratio. Zinc nitrate 1g, Cadmium nitrate 3g, PVA 8g the ethanol and distilled water is (50:50). Vice versa Zinc nitrate 3g, Cadmium nitrate 1g, PVA 8g, but ethanol and distilled water as equal ratio.

Characterizations

The prepared ZnO-CdO nanostructure were characterized by X-Ray diffraction(XRD),X ray diffraction pattern was recorded on diffractometer (Miniflex model, Rigaku, Japan) using Cu kα radiation with a wave length λ=1.541A° at 2θ values between 20° and 80°C. Scanning electron microscope (SEM), Optical absorption spectra and energy dispersive spectroscopy (EDAX) measurements. The optical absorption spectra of the films were measured in the wave length range of 300-450 on a shimazu UV-2450 spectrophotometer.

X-ray diffraction analysis

The crystallite sizes of the nano crystalline *CdO/ZnO* film is estimated using Scherrer's formula

$$D = K\lambda / \beta_{2\theta} \cos\theta,$$

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where the constant K is taken to be 0·94, λ the wavelength of X-ray used which is CuKα radiation (λ = 1·54 Å), and β the full width at half maximum of the diffraction peak corresponding to [111] plane.the structure of the CdO/ZnO are shown in fig(1). The structure was in Hexagonal and cubic, it is clearly matches with the spectrum of standard JCPDS cards of ZnO & CdO numbered 361451, 05-0640 respectively. The average crystal size for various samples has been estimated using Scherrer formula and is presented in Table 1.

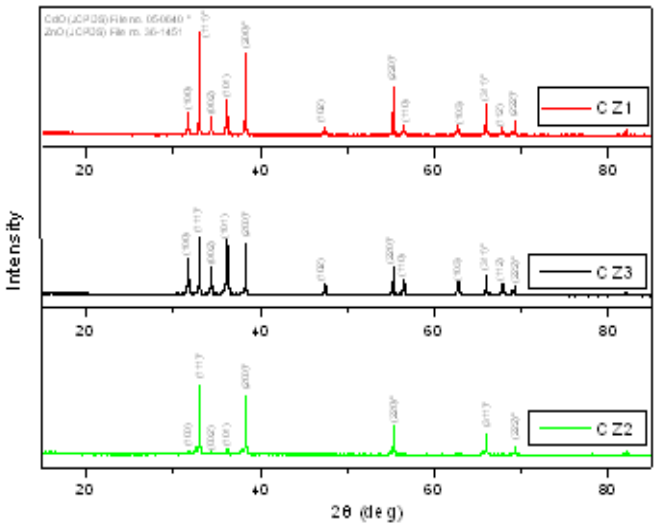


Fig 1. X - Ray Diffraction Analysis of Cdo-Zno Nanocomposites

Surface morphology

The scanning electron microscope images of the sample which synthesized in the optimum conditions in three magnifications of 27000 Fig. (2a), 43000 Fig. (2b) and 10000 Fig. (2c). As it is seen in Fig.10 (b) the optimum sample has a nanostructure in a cluster shape. Each the clusters are aggregate of grains linear nano cluster has been formed from several grains with 68.67 nm to 102.11 nm.

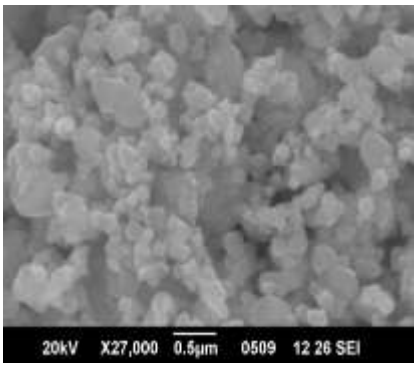


Fig 2a. SEM image in magnification of 27000

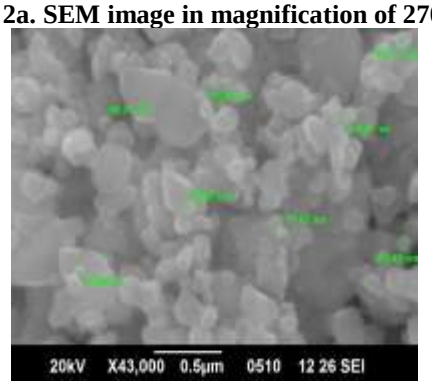
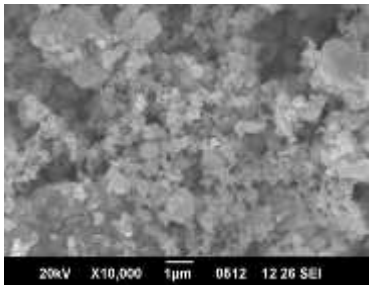


Fig 2b. SEM image in magnification of 43000X



Fig(2c) EM image in magnification of 10000X

EDAX analysis

The EDX analysis results are show in Fig(3). The CdO content in the surface layers of the nanocomposites was insignificant. It should be mentioned that the EDX method only analyzes the surface of particles, therefore, in each nanocomposite bead (grains of linear nanoclustes); CdO forms the core and is then covered by ZnO. Some of these samples were analyzed by XRD which results confirmed the EDX analysis results. The results showed that the cadmium and zinc contents of the samples were the same as their initial concentrations in the sol. It is confirmed that ZnO covering the CdO seed.

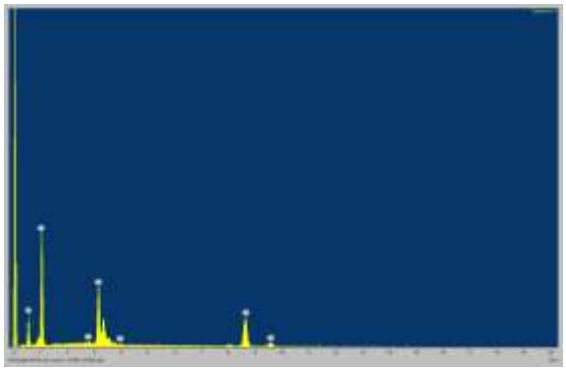


Fig 3. Energy-dispersive X-ray spectroscopy

UV-Vis absorbance spectroscopy

The UV-Visible spectrum is the CdO/ZnO composites are in the wavelength range from 300 nm to 450 nm. It is observed that there is a slight shift in absorption edge at 410 nm towards longer wavelength side. At content of Zn increases absorption is decreased and there is a reverse in absorption value while Cd content increases was showed in fig (4).

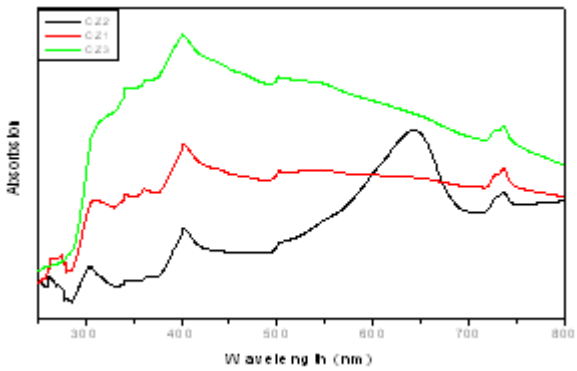


Fig 4. UV-Vis absorbance spectroscopy

Conclusion

PVA based Sol-gel Pyrolysis method can be a useful method to synthesized the CdO-ZnO nanocomposite.

❖ X-ray analysis reveals annealed CdO-ZnO is about Hexagonal and cubic structure.

❖ Surface morphological studies have been carried out that the CdO-ZnO is clusters in aggregate of grains.

The average crystal size for various samples has been estimated using Scherrer formula and is presented in Table 1

Samples	2θ (degree)	FWHM (β) (radian)	(hkl)	Crystalline Size (nm)
CZ1	33.01129	0.0012	(111)	72.53
	36.16278	0.0021	(101)	69.42
	38.30655	0.0013	(200)	112.86
	55.30144	0.0023	(220)	104.3
	65.94229	0.0015	(311)	110.14
CZ2	33.0428	0.0012	(111)	120.51
	38.3374	0.0013	(200)	112.88
	55.3307	0.0015	(220)	104.33
	65.9721	0.0016	(311)	103.27
CZ3	31.7181	0.0023	(100)	62.77
	33.0227	0.0012	(111)	120.47
	34.3766	0.0023	(002)	63.08
	36.1982	0.0028	(101)	52.07
	38.3157	0.0013	(200)	112.8
	55.3055	0.0016	(220)	97.86

In EDX represents the nanocomposite which is to identify the compositions.

❖UV-Absorption spectroscopy it is observed that there is a slight shift in absorption edge at 410 nm towards longer wavelength side.

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