Structural and optical properties of ZnO-CdO nanocomposite using electrodeposition method.

Zehraa. N. Abdul-Ameer*, Ibrahim. R. Agool

Physics department/ Science college

Almustansiriah University, Baghdad, Iraq.

*E-mail address: zehraanajim@gmail.com

Keywords: ZnO, CdO, nanocomposite, electrodeposition.

ABSTRACT. ZnO, CdO, ZnO-CdO nano composite were prepared using electrochemical deposition the prepared samples were characterized using X-ray diffraction and the photoluminescence spectroscopy (PL) to get the surface morphology leading to calculation of optical energy gap. the grain size determined by Scherrer's equation (22-25)nm. through the calculation of E_g , it was noticed a red shift behavior in ZnO manner due to addition of CdO content

1.INTRODUCTION:

ZnO is a well-known II–VI semiconductor; it has a direct band gap in the ultraviolet range (3.37 eV) and a large exciton binding energy (60meV), which made it has a great application prospect due to its extrusive physical properties. With the help of the discovery of carbon nanotubes, nanostructures and nanomaterials have attracted great interest in the recent years. Zinc oxide nanostructures have become attractive building blocks for devices application in light-emitting diodes, solar cells, sensors, field emitters, and piezoelectric devices in recent years [1–6]. Cadmium oxide (CdO) is a well known II– VI semiconductor with a direct band gap of 2.2 eV (520 nm) and has developed various applications such as its use in solar cells, transparent electrodes, photodiodes, and sensors. There are numerous reports on the synthesis of the nanostructure ZnO-CdO through the usage of different methods including the electrodeposition [7], vapor phase transport [8], reactive sputter [9] and spray-pyrolysis-techniques [10] .

2.MATERIALS AND METHOD

Electro-deposition cell was used for preperation of ZnO, CdO, and their composite using Pt cathode and Indium tin oxide (ITO) as anode. 10mM of $Zn(NO_3)_2$ were added to 100 ml of Double deionized water Using the electro-deposition cell with 23 DC voltage for 30 min and the same process was done for preparation of CdO from cadmium nitrates and their 50ZnO:50CdO composite in the same molarity (10mM). all the samples were sintered at 600 °C for 6 hours.

Fig(1): Electrodeposition system.

3.STRUCTURAL STUDIES

X-ray diffraction spectra:

X-ray diffraction (XRD) pattern of ZnO, CdO, and their composites was used to determine the nature of the film and the structural characteristics of the materials used using lab XRD Shimadzu of Measurement Condition X-ray tube of target CuK α , voltage 40.0 (kV), current 30.0 (mA) the average grain size of the sample have been estimated using Scherrer's equation :

$$D = 0.94\lambda / \beta \cos\theta \quad (1)$$

Where λ is the wavelength ($\lambda = 1.542 \text{ \AA}$) (CuK α), β is the full width at half maximum (FWHM) of the line, and θ is the diffraction angle. the XRD parameters for pure ZnO ,pure CdO ,and their composite are shown infigure (2) where hkl parameters are indicated on each peak .structural properties for 5the same samples under study are summarized as in table (1).

4.THICKNESS MEASUREMENT

Interferometer method was used to measure ZnO, CdO , and their composites using light beam reflection from film surface and substrate bottom .He-Ne Laser (632.8)nm was used to find thickness from formula:

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

Where x is fringe width, Δx is the distance between two fringes. He-Ne Laser (632.8)nm.

5.OPTICAL PROPERTIES

The transmittion spectrum of pure ZnO ,pure CdO ,and their composition were measured using shimadzu spectrometer (2000) of range (190-1100)nm as shown in fig(3) to determine the optical properties of our samples .Photoluminescence were studied at room temperature using ELICO company spectrofluorometer covering 300-900 nm wavelength range ,have been used ZnO, CdO , and their composites.Using E_g values that were estimated for each case as in table(1).While

Photoluminescence were tested for the samples using excitation wavelength of 320nm as shown in fig (4).

6. RESULTS

Fig(2):XRD structures for: a- pure znO b- pure Cdo c-50znO:50cdO .

Fig(3): Shows optical properties of ZnO Pure, Cdo pure & ZnO-CdO nanocomposites.

Table(1): Structural properties of ZnO Pure, Cdo pure & ZnO-CdO nanocomposite

	ZnO pure	CdO pure	50ZnO:50ZnO
Eg(eV)	3.1	2.2	2.95
d_{hkl} (nm)	0.288	0.27	0.29084
β (deg)	0.355	0.2965	0.36820
D (nm)	22.6	27.2	21.7
ε (* 10⁻³ lines⁻² m⁻⁴)	1.49	1.24	1.55

Fig(4): Shows Fluorescence versus wavelength for (a) ZnO pure (b) CdO pure (c)50 ZnO:50CdO

7. RESULTS AND DISCUSSION

Fig. 2 shows XRD patterns of the ZnO nanoparticles fabricated by the electrochemical deposition method. All the diffraction peaks can also be well indexed to the hexagonal phase ZnO reported in JCPDS. The results indicate that the products consisted of a pure phase. The average crystalline size (D) of the nano-sized ZnO particles can be estimated to be about 22.6 nm. The figure shows XRD structures for pure ZnO, pure CdO, 50ZnO: 50 CdO and .from the pattern can be noticed that preferential crystal orientation at $2\theta = 36.5^\circ$ for ZnO which exhibits (100), (101), (102), (103), (201) characteristic peaks of wurtzite hexagonal structure with average grain size (20)nm. While CdO pattern shows (111), (200), (220) with preferential crystal orientation at $2\theta = 33.6$ with average grain size (25)nm with cubic structure.

The XRD data of ZnO-CdO nanocomposite showed major diffraction peaks at $2\theta = 31.7, 36.2, 38.224, 52.5^\circ$ due to existence of Cd species in ZnO samples according to ICDD card the intensity of (100), (101) remains unchanged with increment of CdO content while remarkable increment in preferred growth in (220), orientations with increase of CdO concentration and (103) orientation due to ZnO concentration.

The results showed from figure(2) that there is a change in range of optical band gap from 3.1 eV for ZnO to 2.7 for CdO respectively leading to red shift for ZnO-CdO nanocomposites which was 2.95 eV with the increase of CdO content and could be attribute to the existence of some Cd phase

at the interphase of the nanocomposites. the violet emission is due to transition occurring from Zn interstitials (Zn_i) to the valence band while the green emission arises due to recombination of photo-generated hole and singly ionized oxygen. as it is well known that CdO has at least one indirect optical transition below the direct absorption edge at nearly 2.4 eV [11]. the weak PL peaks can be due to this indirect transition nature of the CdO structure. Therefore the PL peaks were noted to be close to ZnO [12].

8. CONCLUSIONS

Electrodeposition method can be used as a useful method to synthesize the CdO, ZnO & their nanocomposites. structural and optical properties have been studied for ZnO-CdO nanocomposites with a little decrease in E_g due to excess in CdO concentration. PL measurements indicates that the ZnO-CdO nanocomposites contain defects. The decrease in E_g indicates an improvement of the quality of the film due to the annealing out of the structural defects.

References

- [1]. Sun, J. L. Zhao et al., "Ultraviolet and visible electroluminescence from n-ZnO/SiO_x (n,p)—Si heterostructured light-emitting diodes," *Applied Physics Letters*, 2008, vol. 93, no. 1, Article ID 013506, 3 pages.
- [2]. Hsu, H., Yi, X., Djurić, A., and Chan, "ZnO nanorods for solar cells: hydrothermal growth versus vapor deposition," *Applied Physics Letters*, 2008, vol. 92, no. 13, Article ID 133507, 3 pages.
- [3]. He, H., Ho, H., and Chen, C., "Polymer functionalized ZnO nanobelts as oxygen sensors with a significant response enhancement," *Nanotechnology*, 2009, vol. 20, no. 6, Article ID 065503.
- [4]. Hui, Z., Ning, D., Bingdi, C., Dongshen, L., and Deren, Y., "Carbon nanotube-ZnO nanosphere heterostructures: low temperature chemical reaction synthesis, photoluminescence, and their application for room temperature NH₃ gas sensor," *Science of Advanced Materials*, 2009, vol. 1, no. 1, pp. 13–17, 2009.
- [5]. Yu, H., Wang, Li, N. et al., "MOVPE growth of AlGaIn/GaN superlattices on ZnO substrates for green emitter applications," *Journal of Crystal Growth*, 2008, vol. 310, no. 23, pp. 4904–4907.
- [6]. Fan, Lee, W., Hauschild, R. et al., "Template-assisted large-scale ordered arrays of ZnO pillars for optical and piezoelectric applications," *Small*, 2006, vol. 2, no. 4, pp. 561–568, 2006.
- [7]. Trinchì, A. Y., Li, X., Włodarski, W., Kaciulis, S., Pandolfi, L., Russo, S. P., "Investigation of sol-gel prepared Ga-Zn oxide thin films for oxygen gas sensing" J. Duplessis and S. Viticoli, *Sens Actuators A*, 2003, 108.
- [8]. Yu, K., Zhang, Y., Xu, R., Jiang, D., Luo, L., Li, Q., Zhu, Z. and Lu, W., "Vapour phase transport mechanisms with controlled size porous silicon substrates process" *Solid State Commun*, 2005, 133, 43–47.
- [9]. Jeong, B. S., Budai, J. D. and Norton, D. P., "Thin Solid Film", 2002, 422, 166–169.
- [10]. Keshmiri, S. H. and Rokn-Abadi, M. R., "Enhancement of drift mobility of ZnO transparent conducting films by hydrogenation process" *Thin Solid Film*, 2001, 382, 230–234.
- [11]. Ashfari, B., Kumano, H., Suemune, I., Seong, "Single crystalline rocksalt CdO layers grown on organic molecular beam epitaxy" *Appl. Lett.*, 2001, 79, 470–472.
- [12]. Lin, B., Fu, Z., Jia, Y., "Green luminescent center in undoped zinc oxide films deposited on silicon substrates" *Appl. Phys. Lett.* 2001, 79, 943–945.
- [13]. Al-Jawad, S. M., Al-Aogili, H. K., "Investigation of optical and electrical properties of chemically deposited nano-crystalline CdO thin film" *J. Education College, Iraq*, 68, 2011.

-
- [14]. Galicia.D.M.,Perez.R.C.,Sandoval.O.J,Sandoval.S.J.Romero.CI.Z."High transmittance CdO thin films obtained by sol-gel method "thin solid films 2000,371,105-108.
- [15]. Salman.K.S." Physical Properties of Nanostructure SnO_2 Thin Films Growth on Al_2O_3 Substrate by Pulsed Laser Deposition , " Eng and Tech journal,2014 ,32,5.
- [16]. Sule.E.E."Photovoltaic Performance of ZnO Nanorod and ZnO : CdO Nanocomposite Layers in Dye-Sensitized Solar Cells (DSSCs)" International Journal of Photoenergy ,Volume 2013, Article ID 436831, 6 pages.
- [17]. Sahu.N., Duchaniya.R.K."Synthesis of ZnO-CdO Nanocomposites "Journal of Materials Science & Surface Engineering 2013, Vol. 1 (1), pp 11-14.
- [18]. Yang .L.L."Synthesis and Optical Properties of ZnO Nanostructures" Linköping Studies in Science and Technology Licentiate ,2008,Thesis No.1384.
- [19]. Kumar.M"Zinc Oxide Nanostructures Synthesized by Oxidization of Zinc" thesis Bachelor of Technology In Metallurgical & Materials Engineering ,2010.