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Structural Properties of (ZnO- CuO) Doped Fe Thin Films

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Abstract: (ZnO- CuO)_{1-x}:Fe_x (x=6,8 and 10%) the thin films (for the same percentage of ZnO- CuO) were deposited on a glass substrate at 300 °C by Chemical Spray Pyrolysis(CSP) technique. X-ray diffraction (XRD) shows that the increasing of Fe leads to decrease the crystalline size. Energy gap values of the doped thin films are larger than undoped thin films. These values are increase with increase of weight ratio doping. The range of energy gap values was within the range (2.6 -3.15) eV. The morphological surfaces properties have been studied using Scanning Electron Microscope (SEM) which reveals a homogeneous flowers structure of the films.

Keyword: structural properties, ZnO- CuO, Chemical Spray Pyrolysis

1. Introduction:

Zinc oxide (ZnO) is the type n, and has a gap in the range between (3.37-3.7) eV [1, 2]. ZnO films can be prepared using chemical bath technique [3, 4]. For enhancing the efficiency of ZnO film in optoelectronic devices, doping was used in fabrication, Fe doped ZnO has been manufactured for optical properties because Fe is well - known optical emitter [5]. Also Fe is used as a doping element for magnetic and electrical properties [6, 7]. Testified showed that ZnO_{0.9} Fe₂O₃_{0.05} CuO_{0.01} at above R.T. was larger than that ZnO samples without Cu [8, 9]. Furthermore, Fe and Cu anesthetized ZnO in R.T. magnetic magnetism in the samples is due to secondary phase Zn Fe₂O₃ [8, 10]. The choice of (CSP) technique in this work comprises advantages such low cost and covering large area coating related with other techniques.

2. Experimental work:

Pure Coupled ZnO- CuO and ZnO-CuO doped Fe thin films were prepared by (CSP) technique as shown in table (1):

Table (1): physical parameters of prepared thin films

Material	Molecule weight (g/mol.)	Molarity(mole/liter)
ZnCl ₂	172.3166	0.1
CuCl ₂ .2H ₂ O	170.48	0.1
FeCl ₃	162.21	0.1

Initially ZnCl₂ and CuCl₂.2H₂O were dissolved in the purified water with equal weight ratio using magnetic stirrer at 60 °C for ten minutes, after that different weight ratio of Fe (6, 8, and 10)% were additional to the solution. Glass substrates were cleaned by HCl, acetone and distilled water. The solution was sprayed on glass substrates which heated at 350 °C to obtain the films.



3. Results and discussion

3.1. Structural properties:

Figure (1) illustrates XRD analysis for coupled (ZnO/CuO), ((ZnO/CuO)_{0.94}:Fe_{0.06}), ((ZnO/CuO)_{0.92}:Fe_{0.08}), and ((ZnO/CuO)_{0.9}:Fe_{0.1}), the increasing of doping leads to decrease the crystallite size (D) calculated by Scherrer's equation ^[11,12] as shown in Table (2) until the ((ZnO/CuO)_{0.92}:Fe_{0.08}) concentration :

$$D = \frac{k\lambda}{\beta_D \cos(\theta)} \quad \dots (1)$$

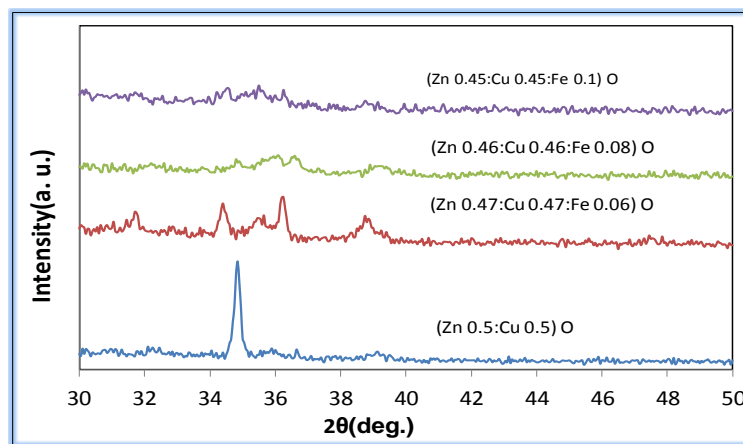


Fig (1) XRD of coupled and doped films

Table (2) shows XRD data of diffraction angle (2θ), angular full width at half maximum β (FWHM), lattice constants **a** and **c** calculated by eq.(2), interplanar spacing **D** and crystalline size calculated by eq.(1) for all samples.

$$\frac{1}{d^2} = \frac{4}{3} \left[\frac{h^2 + hk + k^2}{a^2} \right] + \frac{l^2}{c^2} \quad \dots (2)$$

Table (2): Structural parameters of ((ZnO/CuO)_{1-x}:Fe_x) thin films calculated by XRD

hkl	Samples	2θ (deg.)	d(nm)	β(FWHM) (deg.)	a(nm)	c(nm)	crystallite size (nm)
002	ZnO/CuO	34.57197	0.257197	0.2238	0.32107	0.51439	38.8
	6%	34.4179	0.260362	0.2955	0.32502	0.52072	29.4
	8%	34.7881	0.257676	0.6	0.32167	0.51535	14.5
	10%	34.4828	0.259887	0.3889	0.32443	0.51977	22.3
	ASTM	34.421	0.26033		0.32498	0.52066	
101	ZnO/CuO						
	6%	36.2299	0.247745	0.2725	0.32519	0.52100	32.1
	8%	36.1035	0.248583	1.3333	0.32629	0.52276	6.5
	10%	36.2332	0.247723	0.3929	0.32516	0.52095	22.2
	ASTM	36.252	0.24759		0.32498	0.52066	

The image of coupled (ZnO/CuO) nanostructure were obtained by (SEM VEGA3 TESCAN Czech Republic) Scanning Electron Microscope. figure (2) displayed the image of coupled (ZnO/CuO) thin film without doping in FeO . this figure shows the agglomeration of particles complete separation is not happened.

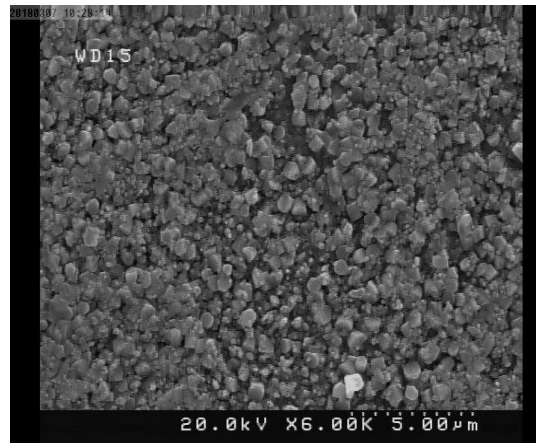


Fig (2) SEM image for coupled (ZnO/CuO)

Figure (3) shows the agglomeration of (ZnO/CuO):Fe with lowest doping weight ratio of FeO equal (6%).this image shows a great recognizing agglomeration material held together .

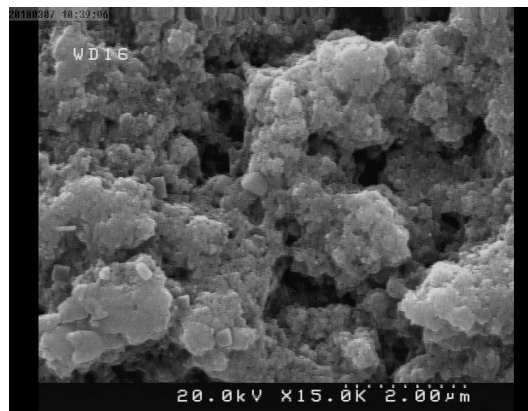


Fig (3) SEM image for ((ZnO/CuO)_{0.94}:Fe_{0.06})

Figure (4) shows the nanostructure with different particle size about (40) nm.

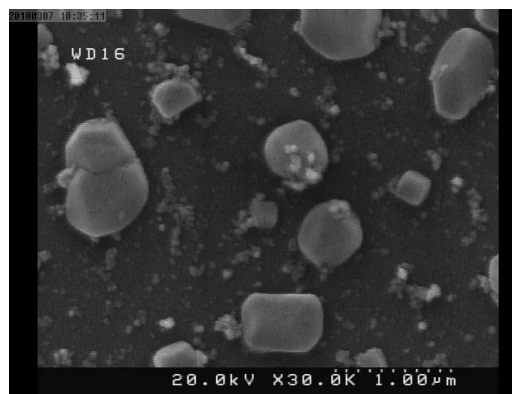


Fig (4) SEM image for ((ZnO/CuO)_{0.92}:Fe_{0.08})

Figure (5) shows the best nanostructure of (ZnO/ CuO): Fe thin film with weight ratio percentage doping (10%). The homogeneous of thin film can be observed clearly at nano range. The shape of thin films is Nanostructure similar to flowers.

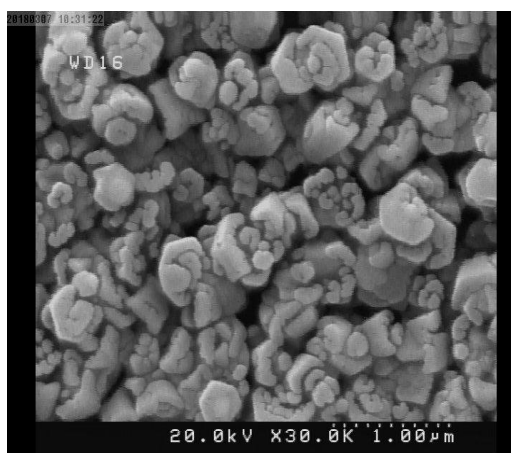


Fig (5) SEM image for ((ZnO/CuO)_{0.9}: Fe_{0.1})

4. Conclusion:

The characterization tests of thin films shows decreasing in grain size nanostructured of the prepared thin films with increase the concentration of FeO.. SEM investigations showed the good homogeneous flower structure of thin films in the maximum concentration of FeO.

References

- [1] S. M.Hatch, J. Briscoe and A. Sapelkin "Influence of anneal atmosphere on ZnO-nanorod photolumnescent and morphological properties with self-powered photodetector performance," Journal of Applied Physics, vol.113, no. 20,Articale ID 204501,2013 .
- [2] Z. Zeng, C. S. Garoufals, A. F. Terzis and S. Baskoutas, "Linear and nonlinear optical properties of ZnO/ZnS and ZnS/ ZnO core shell quantum dots: effect of shell thickness, impurity and dielectric environment," Journal of Applied Physics,vol. 114, no.2,Article ID 023510, 2013 .
- [3] J.-B. Lee, C. Park and J.-S.Park, "Physical Properties of RF- Sputtered ZnO Thin Films:Effect of Two-Step Deposition, Journal of the Korean Physical Society, Vol.50,No.4, pp. 1073-1078, 2007 .
- [4] E. H. Kim, D. H. Lee, B. H. Chung, H. C. Kim, Y. Kim ,and S. J. Noh, "Low-Temperature Growth of ZnO Thin Films by Atomic Layer Deposition, Journal of the Korean Physical Society, Vol.50,No.6, pp. 1716-1718, 2007 .
- [5] T. Rattana, S. Suwanboon, P. Amornpitoksuk, A. Haidoux and P. Limsuwan,"Improvement of optical properties of nanocrystalline Fe-doped ZnO powders through precipitation method from citrate-modified zinc nitrate solution," Journal of Alloys and Compounds,vol.480,no.2,pp.804-808, 2013 .
- [6] M.Benhaliliba,Y.S.Ocak,and A,Tab, "Characterization of coated fe-doped zinc oxide nanostructures," Journal of Nano- Electronic physics ,vol.5, no,3,2013
- [7] A.Sawalha,M.Abu Abdeen, and A. Sedky,"Electrical conductivity study in pure and doped ZnO ceramic system," physics B,vol.404,no.8-11,pp.1316-1320.2009

- [8] H.Liu,J.Yang ,Z.Hua, Y.Liu, L.Yang, Y.Zhang and J.Cao,"Cu-Doping Effect on Structure and Magnetic properties of Fe-Doped ZnO powders," Materials Chemistry and physics ,Vol.125,No.3 pp.656-659,2011.
- [9] S.J.Han, J.W.Song, C.H.Yang, S.H.park, J.H.parket and Y.H.Jeong,"A Key to Room-Temperature Ferromagnetism in Fe Doped ZnO:Cu," Applied physics Letters, Vol.81.No.22, p.4212, 2002.
- [10] J. Shim, T. Hwang, J. Park, S. J. Han and Y. Jeong, "Origin of Ferromagnetism in Fe- and Cu-Codoped ZnO " Applied ohysics Letters, Vol.86.No.8,2005.
- [11] J. L. Zhao," Highly (002) oriented ZnO film grown by ultrasonic spray pyrolysis on ZnO-seeded Si (100) substrate", J. Mater. Res., Vol. 21, No. 9, pp. 2185-2189, Sep. 2006.
- [12] P. Mitra and S. Mondal," Structural and Morphological Characterization of ZnO thin Films Synthesized by SILAR", Progress in Theoretical and Applied Physics, V ol. 1, 17-31, 2013.