Factors Affecting the Synthesis of Nano-Structure Materials

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Abstract

We have to study the factors affecting the synthesis of Co doping ZnO Nano powder with the sol – gel method to study the effect of quantity or doping concentration we fix the reaction base at pH = 9 and change the doping concentration the structural and morphology carried out with X-ray and SEM show hexagonal wurtzite nanoparticles for Zn 1-x Co x O for x = 0.01 and x = 0.05 and increase of the cell volume and lattice parameter with increase of x concentration ,the florescence spectroscopy at room temperature show peaks at ultraviolet for both concentration with read shift for x = 0.05. To study the effect of pH value we fix doping concentration at x = 0.05, SEM shows a spherical nanoparticle with size 38 – 52 nm for pH = 9 and hexagonal nanoparticles with size 42 – 52 nm for pH = 6. The florescence spectroscopy at room temperature exhibit that for pH = 9 there is no band observed in the ultraviolet region bands are around 380,420 and 475 nm. The Ultraviolet/Visible (UV) Spectroscopy exhibit decrease of the band gap energy with increase doping concentration and decrease with increase pH value. Copyright © VBRI Press.

Keywords: ZnO nanoparticles, Sol-gel method, Crystal structure, florescence spectroscopy.

Introduction

Zinc oxide is related to group II-VI compounded semiconductor doping with transition metals is a main nanomaterial in the electronic devices, solar cell and gas sensors manufacturing for its wide direct band gap (3.37 eV) and high excitation energy (60 m eV) [**1**] so if we control or guide factors affect its synthesis we do a quantum jump in the nanotechnology for that Zn 1-x Co x O has been synthesis using sol – gel method we study the effect of doping concentration the effect of pH value which detrained the reaction base if pH is smaller than 7 then the solution is acidic base and if it is greater than 7 it is a basic base. In both resultant Nano powder were characterized with X-ray, scanning electron microscope (SEM) and florescence spectroscopy using an excitation source of 275 nm at room temperature. We study the effect of temperature using TiO2 the Raman spectra at room temperature show anatate single crystal phase with modes at 396 cm-1, 516cm-1, 639cm-1 and unexpected mode at 447cm-1 associated with rutile phase this is because we heat near 400Cº and TiO2 make the crystal structure of rutile phase after 350Cº. Also S. Jurablu *et al.* [**2**] study the structure of ZnO nanoparticles with change of temperature with rat of 1Cº /min till 500Cº the SEM images show the hexagonal wurtzite phase has been changed to spherical phase with increasing the temperature. There is many other affects such as pressure, synthesis method and surrounding environment if we can take advantage of natural phenomena such as the heat of the sun in the desert, volcanic heat, rain, lightning power, wind power, pressure and the under-zero temperatures in winter to create an environment that urges matter in nature to form nano-material of its own then we encourage the reactions to nanostructures are induced to occur from surrounding environmental conditions with the lowest cost and the most quantity of materials produced.

Experimental

Materials

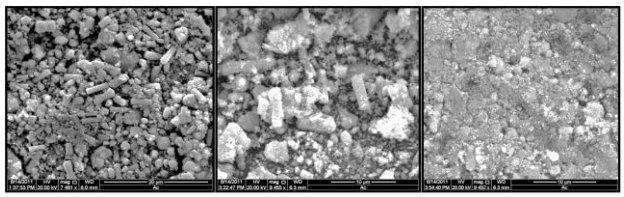
Cobalt nitrate $Co(NO_3)_2.6H_2O$ and zinc acetate dehydrate $(CH_3COO)_2 Zn.2H_2O$ have been dissolved in distilled water H_2O separately.

Material synthesis and reactions

The tow solutions mixed together to get 200 ml volume (ones with fixed molarity of 0.6 M in different values of x = 0.01 and 0.05, another with different values of molarity of 0.6 M and 0.9 M with fixed dope concentration of x = 0.05) then stirred then kept in an oven at 100 then ground and kept in a furnace at 400 ^{0}C for 12 hours.

Characterizations

The x-ray diffraction patterns recorded by Rigaku Minifex x–ray diffractometer in the 2θ range of 20^0 - 80^0, SEM images with Quanta FEG450, band gap calculated using UV/V Spectroscopy and fluorescence spectra are recorded using a Perkin Elimer LS55 Spectrofluorometer with excitation source of wavelength 275nm.



(a) (b) (c)

Fig. 1. SEM images (a) x =1% pH 6, (b) x =5% pH 6, (c) x =5% pH 9.

Results and discussion

X-ray diffraction pattern and SEM images **(Fig. 1)** for Zn 1-x Co x O for x = 0.01 and x = 0.05 and pH = 6 show hexagonal wurtzite nanoparticles but Zn 0.95 Co 0.05 O with pH = 9 show spherical nanoparticle, from XRD pattern we calculate particle size using Scherrer equation [**3**].

Particle size in nanometer = $k\lambda / \beta_{hkl} \cos\theta$

where k is a constant equal to 0.94, λ is the radiation wavelength = 1.54056 A° for Cu Ka radiation, βh k l is the full width at the half maximum and Θ is peak position. The cell volume is a2c sin θ where a and c are the lattice parameters. Using the Ultraviolet/Visible Spectroscopy the band gap Eg estimated by taking the intercept of the extrapolation to zero absorption with photon energy axis (**Fig. 2**). All results are tabulated in **Table 1**.

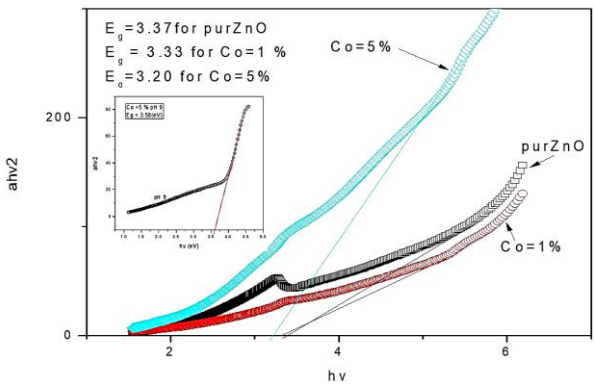


Fig. 2. Band gap calculation for Zn 1-x Co x O (pH 6) for x = 0.01 and x = 0.05, in the square Zn 0.95 Co 0.05 O (pH 9).

Table 1. The effect of doping concentration and pH value on the Structure Analysis.

Co Concentration (x) and pH value	Lattice parameters		Unit Cell volume (Å)^3	Crystallite sizes (nm) using Scherrer's equation	Band gap (eV)
	a (Å)	c (Å)			
X=0.01, pH 6	3.25	5.18	66.7	55.7	3.33
X=0.05, pH 6	3.33	5.24	87.4	41.3	3.20
X=0.05, pH 9	3.26	5.20	47.8	27.0	3.58

The fluorescence spectra using an excitation source of 275 nm (**Fig. 3**) for both 1 % and 5 % concentrations with pH = 6 show bands in the visible and ultraviolet regions at 307, 328, 335, 379 and 423 nm with a red shift in 335 nm band for x = 0.05. For 5% dope concentrations with pH = 9 bands are bands are around 380,420 and 475nm.with higher intensity (**Fig. 4**).

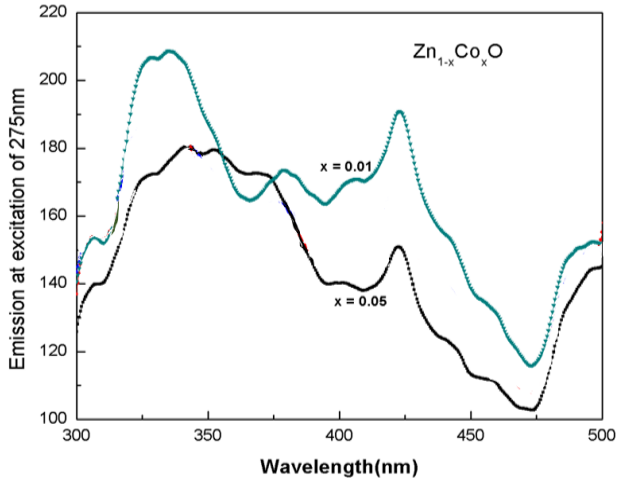


Fig. 3. Florescence spectroscopy of Zn 1-x Co x O using excitation of 275 nm at room temperature with different doping concentration.

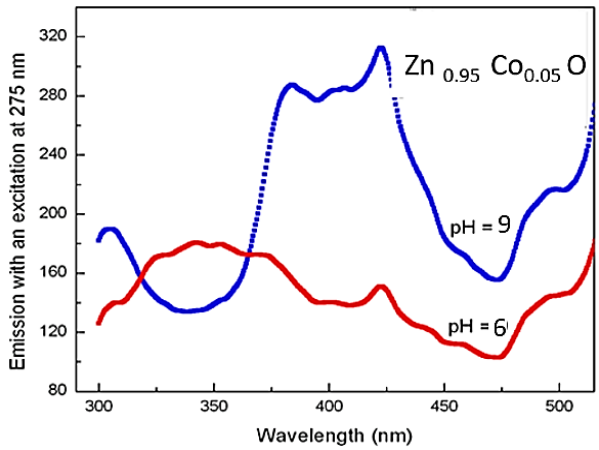


Fig. 4. Florescence spectroscopy of Zn 0.95 Co0.05 O using excitation of 275 nm at room temperature with different pH values.

Conclusion

The cell volume and lattice parameter increase with increase of doping concentration (so the band gap decrease) and decrease with increase of pH value (so the band gap increase) small shift to bands in fluorescence spectra occur with changing doping concentration and increase of pH value make it shift with higher intensity.

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Author's contributions

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