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Synthesis and Characterization of Pure and Co doped Zinc oxide

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Abstract

Present work is a study on synthesis and Characterization of pure ZnO and Co doped nanoparticles by using chemical co-precipitation method. We have doped pure ZnO with Co by 3% mole concentration. Structural and optical properties of these nanoparticles are analyzed by using XRD, UV-Visible spectroscopy. We found the crystallite size of range 20 nm to 30 nm.

Introduction

ZnO is a wide band gap (3.37 eV at room temperature) semiconductor of the II-VI semiconductor group. Nanosized particles of semiconductor materials have gained much more interest in recent years due to their desirable properties and applications in different areas such as catalysts [1] sensors [2] photoelectron devices [3,4] highly functional and effective devices [5]. Many methods have been used to synthesize ZnO nanoparticles such as sol - gel, electrochemical deposition, sonochemical, hydrothermal technique etc. In this work, we report the synthesis and characteristics of zinc oxide with Co nanoparticles obtained by using co-precipitation method. Synthesis and characterization of zinc oxide (ZnO) nanoparticles has found widespread interest during past few years due to their unique electro optical properties, which can be employed in devices such as ultraviolet (UV) light-emitting diodes (LEDs), blue luminescent devices, and UV lasers [6].

Experimental

Material to be used for synthesis the ZnO: Co nano particles are $ZnSO_4$.$7H_2O$, $CoSo_4$.$7H_2O$ (Cobalt sulfate), NaOH (Sodium Hydroxide), and DI (Distilled water). For keeping the size of particles in nano dimension the capping agent Ethileneglycol (EG) is used.

Result and Discussion

X-ray diffraction studies confirmed that the synthesized material was ZnO with wurtzite phase and the entire diffraction peak agreed with the reported JCPDS data (card No. 36-1451). No characteristic peaks were observed other than ZnO. The X- ray diffraction data were recorded by using Kα radiation (1.5406 A°). The average grain size was calculated with the help of Scherrer's equation using the FWHM of all peaks (Figure 1 & 2) show the XRD data for pure and Co doped ZnO nanoparticles.

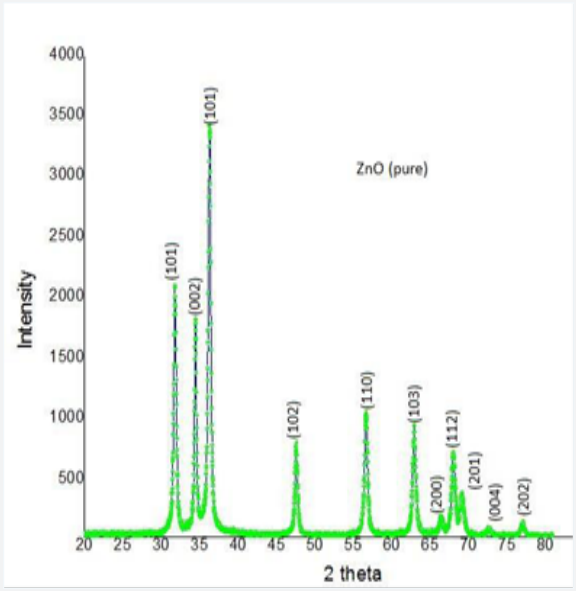

Figure 1: XRD spectra of ZnO.

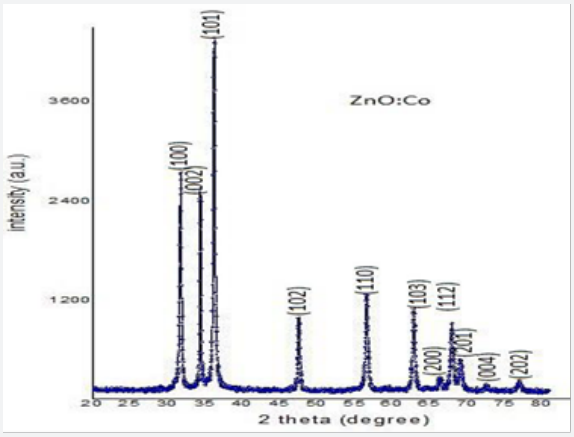

Figure 2: XRD spectra of ZnO: Co.

XRD

For calculating the particle size we used Scherer's formula it is given by

$$D = 0.9\,\lambda / \beta\,\mathrm{Cos}\theta$$

Where:

λ is a wavelength of x-ray (1.54 A0).

B is a FWHM (full width and half maxima)

By observing the above table it is cleared that the most prominent peak got for both samples at 101.

Average Strain

The average strain of quantum dots can be calculated by using Stokes-Wilson equation which is given below.

$$\mathrm{Strain}(\varepsilon) = \beta/4\,\tan\theta$$

Where: β is full width at half maxima (FWHM).

We have used the (101) reflexes of the x-ray diffraction profile to calculate the variations in the uniform strain as a function of ZnO and ZnO: Co nanoparticles and the results have been shown in figure.

Non Uniform Strain

It is denoted by (η). For study of non uniform strain changing with the particle size can be seen by using Hall equation which is given below.

$$\beta\,\mathrm{Cos}\theta/\lambda = 1/t + 2\eta\,\mathrm{Sin}\theta/\lambda$$

Where, 'λ' is the wavelength of x-ray used for scattering experiment and 't' is the particle size and β is the line broadening.

UV-Visible Spectroscopy

UV-spectroscopy is the technique which is used for finding the optical properties of material like band gap of material can be calculated by using this technique. But for calculating the band gap we use tauc equation [αhν = C (hν − Eg) 1/2]. Here α and C are the constant which depends on material. And Eg is the band gap of material and hν is the excited energy. The electronic states of spherical ZnO nanoparticles were carried out by UV–vis diffuse reflectance spectroscopy as shown in (Figure 3 & 4). The distinct sharp absorption at the band edge confirms that as-prepared ZnO have a crystalline nature [7].

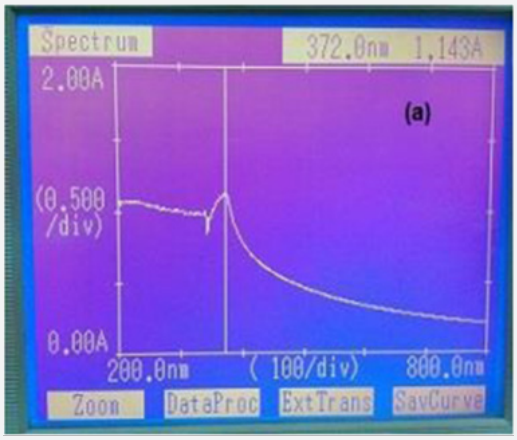

Figure 3: UV –visible spectra of ZnO.

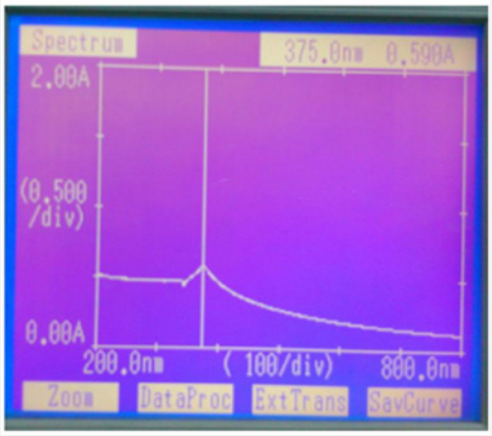

Figure 4: UV –visible spectra of ZnO: Co.

Conclusion

Both samples were prepared using co-precipitation method. The XRD analysis clearly indicates that pure phase of ZnO, and ZnO: Co is formed. Pure ZnO sample has the lowest grain size that is 22 nm, Co doped have 17nm respectively. Average strain is depends on the size of the particle as the size of the particle decrease strain is increases. Optical band gap is calculated using absorption spectra and it was found 2.65ev-3.02eV. Wavelength in UV-Vis spectra is shifted from lower to higher.

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