SYNTHESIS OF Sr DOPED ZnO BY USING CHEMICALLY MODIFIED ROUTE

A. U. Bajpeyee
Department of Physics,
Arts, Science and Commerce College, Kiran Nagar, Amravati, Maharastra

Abstract
Sr (Strontium) doped ZnO (zinc Oxide) has been synthesized from Strontium nitrate and Zinc Nitrate by using chemically modified route, the powders were calcined at 550ºC in two batches. The pellets were structured from powders and dilelectric studies have been carried out. Dielectric dispersion with frequency has been studied and noted. Average crystallite size calculated by Debye-Scherer equation is calculated and 50 nm.
Keywords: chemical route, nano-crystals, dielectric measurements.

1. Introduction

ZnO is a technologically important material exhibiting multifunctional properties for various applications in optoelectronic devices applications such as photonic, photovoltaic and electronic devices such as blue light emitting diodes (LEDs), lasers, UV detectors, transistors and solar cells [1-5]. In addition, ZnO exhibits attractive piezoelectric properties, which enable its applications as transducers, SAW, and BAW devices [6]. Among other major uses of ZnO, particularly in powder form, are pigments [7, 8], photocatalysts and UV absorbers [9, 10]. Advantages of ZnO in this application include broad absorption of the UV radiation both in UVA and UVB range, much better and can be used in sunscreens as UV filter [11]. Excellent UV absorption of ZnO can be also utilized in cosmetics, paints, varnishes, and plastics [12, 13]. Dielectric properties of Cerium doped Zinc oxide have been studied [14]. With the same connection here Strontium doped Zinc oxide and its structural and dielectric properties are presented.

2. Experimental

Commercially available chemicals of Merck (India) with 99.9% purity. $Sr(NO_3)_2$ (Strontium nitrate) and $Zn(NO_3)_3$ (Zinc nitrate) well crushed in mortar. Fresh distilled water is added in it to get homogeneous solution. The solution so obtained has been magnetically stirred at 70ºC temperature for 2 h. White solution so formed is then kept at 100ºC for 12 h and then allowed to cool naturally for 12 h. The powder so formed is crushed well for one hour to maintain uniformity. Powders were calcined at 550^0C and structurally characterized by XRD (Cu-Kα radiations). Pellets of the powders were prepared by 10 Ton KBr press machine in the laboratory and sintered at 1000ºC in air for 12 h at the cooling rate of 1^0C/min. to study and record room temperature dielectric measurements.

3. Results and Discussion

3.1 XRD Studies

Pick bar diagrams from XRD patterns of pure and doped ZnO powder sample is shown in Figure 1. Hexagonal phase has been observed for the powder, confirmed from standard JCPDS card file. It suggests nano-crystallite formation of pure and doped ZnO. The major peak positions are noted. Using formula (1), the average crystallite size has been calculated from the experimental XRD peaks of powders by using Debye-Scherer equation (1) for spherical powders [15].

$$\mathbf{D = \frac{K\lambda}{B\,Cos\theta}} \quad ----- (1)$$

Where, B is the full width at half-maximum intensity (FWHM in radians) of a peak at an angle θ; K is a constant (0.9) depending on the line shape profile; λ (1.542 A.U.) is the

wavelength of the X-ray source. The average crystallite size (D) was found to be 45 nm.

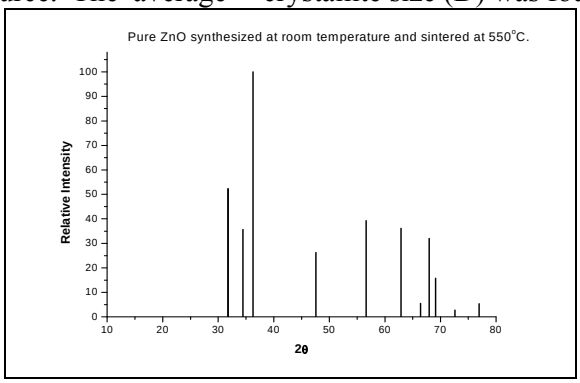

Fig. 3.1.1 XRD Graph of Pure ZnO synthesized at room temperature and calcined at 550ºC.

The XRD Graph of pure ZnO synthesized at room temperature and sintered at 550ºC shows well distinct peaks of the synthesized nanopowder which confirms the formation of single phase compound. The grain size for this compound is in the range from 39.6 nm to 54.6 nm, which clearly shows that the synthesized material is a nanopowder. The average Srystallite size is estimated to be 44.51 nm.

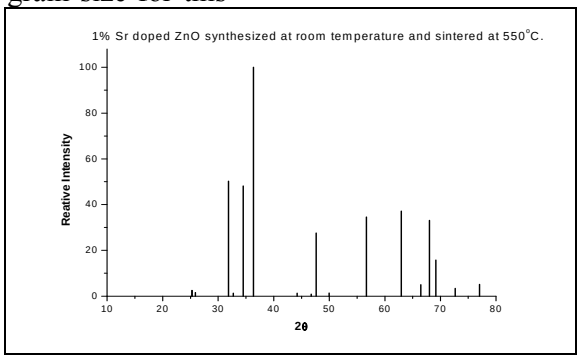

Fig. 3.1.2 XRD Graph of 1% Sr doped ZnO synthesized at room temperature and calcined at 550ºC.

The XRD Graph of 1% Sr doped ZnO synthesized at room temperature and sintered at 550ºC shows well distinct peaks of the synthesized nanopowder which confirms the formation of single phase compound. The dopant has been assimilated in ZnO. The grain size for this compound is in the range from 13.8 nm to 63.8 nm, which clearly shows that the synthesized material is a nanopowder. The average Crystallite size is estimated to be 50.39 nm.

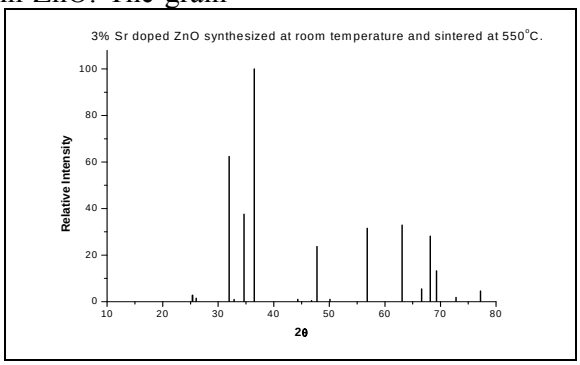

Fig. 3.1.3 XRD Graph of 3 % Sr doped ZnO synthesized at room temperature and calcined at 550ºC.

The XRD Graph of 3 % Sr doped ZnO synthesized at room temperature and sintered at 550ºC shows well distinct peaks of the synthesized nanopowder which confirms the formation of single phase compound. The dopant has been assimilated in ZnO. The grain size for this compound is in the range from 25.1 nm to 65 nm, which clearly shows that the synthesized material is a nanopowder. The average crystallite size is estimated to be 53.55 nm.

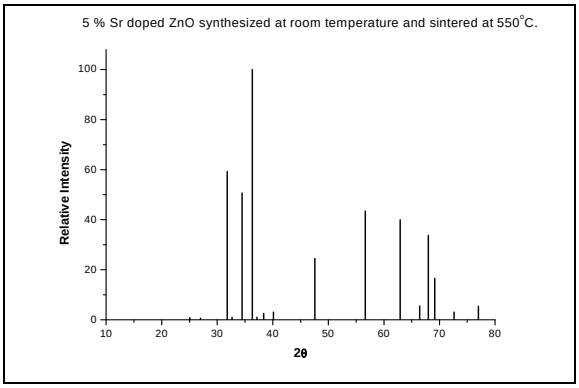

Fig. 3.1.4 XRD Graph of 5 % Sr doped ZnO synthesized at room temperature and calcined at 550°C.

The XRD Graph of 5 % Sr doped ZnO synthesized at room temperature and sintered at 550°C shows well distinct peaks of the synthesized nanopowder which confirms the formation of single phase compound. The dopant has been assimilated in ZnO. The grain size for this compound is in the range from 12.2 nm to 62.3 nm, which clearly shows that the synthesized material is a nanopowder. The average Crystallite size is estimated to be 50 nm.

3.2 Dielectric Studies

The following are the dielectric measurements of the Sr Doped ZnO nanopowders. These Dielectric studies are divided according to the percentage of doping, nano-powder synthesis temperature and sintering temperature.

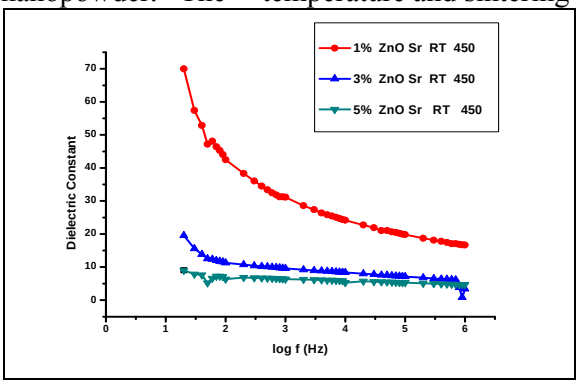

Fig.3.2.1. Dielectric studies of 1%, 3% and 5 % Sr Doped ZnO nanopowders synthesized at room temperature and calcined at 450°C.

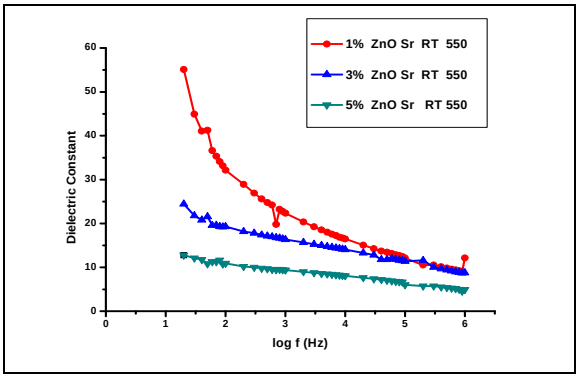

Fig.3.2.1. Dielectric studies of 1%, 3% and 5 % Sr Doped ZnO nanopowders synthesized at room temperature and calcined at 550°C.

The Fig.3.2.1 shows that dielectric constant ε decreases with increasing frequency, indicating dielectric dispersion with frequency. The dielectric dispersion with frequency shown by

the material is due to Maxwell-Wagner type interfacial polarization. The values of dielectric constant are decreasing with increased doping concentration. So doping concentration can be varied to keep the electrical properties according to our needs. If the doping concentration is further increased molecules may change from polar to non-polar.

The fig. 3.2.2 shows that dielectric constant ε decreases with increasing frequency, indicating dielectric dispersion with frequency. The dielectric dispersion is observed at room temperature (27^{o}C) with frequency. The dielectric dispersion with frequency shown by the material is due to Maxwell-Wagner type interfacial polarization. The large value of dielectric constant at low frequency is attributed to the presence of all types of polarization, whereas at higher frequencies the dominant contribution to dielectric constant is from electronic polarization only. Also dielectric constant shows variation with sintering temperature. The dielectric constant decreases with increased sintering temperature.

4. Conclusion

Successfully hexagonal wruitzit ZnO is synthesized by using chemical route. The average crystalline size calculated for it is 50 nm. Powders show decrement in dielectric constant with increasing frequencies, indicating dielectric dispersion with frequency.

Acknowledgements

SAIF-IIT, Mumbai and Panjab University (India) and CIC, ACS College, Kiran Nagar, Amravati for providing facilities.

References

[1] W. Y. Liang, A. D. Yoffe, Transmission spectra of ZnO single crystals, Phys. Rev. Lett., 20, 59 (1968).

[2] Look, D. C. Mater. Sci. Eng. B 2001, 80, 383.

[3] Ryu, Y. R.; Lee, T. S.; Lubguban, J. A.; White, H. W.; Park, Y. S.; Youn, C. J. Appl. Phys. Lett. 2005, 87, 153504.

[4] Carcia, P. F.; McLean, R. S.; Reilly, M. H. Appl. Phys. Lett. 2006, 88.

[5] Wang, X. D.; Zhou, J.; Song, J. H.; Liu, J.; Xu, N. S.; Wang, Z. L. Nano Letters 2006, 6, 2768

[6] Kadota, M. Jpn. J. Appl. Phys. Part 1 1997, 36, 3076.

[7] Ekambaram, S. J. Alloys and Compounds 2005, 390, L4.

[8] Johnson, J. A.; Heidenreich, J. J.; Mantz, R. A.; Baker, P. M.; Donley, M. S. Progress in Organic Coatings
2003, 47, 432.

[9] Li, D.; Haneda, H. Chemosphere 2004, 54, 1099.

[10] Byrappa, K.; Subramani, A. K.; Ananda, S.; Rai, K. M. L.; Dinesh, R.; Yoshimura, M. Bull. Mater. Sci.2006, 29, 433

[11] Reisch, M. S. Chemical & Engineering News 2005, 83, 18.

[12] Carr, D. S.; Baum, B. Modern Plastics 1981, July, 64.

[13] Ammala, A.; Hill, A. J.; Meakin, P.; Pas, S. J.; Turney, T. W. Journal of Nanoparticle Research 2002, 4, 167.

[14] Nidhi Sinha, et al., Ceramics International 2014, vol. 40 (8), 12337

[15] Z. Ru-Bing, Y. Chun-Sheng, D. Gui-Pu, Mater. Lett. 59 (2005) 1741