wjpmr, 2017,3(7), 128-131

SJIF Impact Factor: 4.103

WORLD JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.wjpmr.com

Research Article

ISSN 2455-3301

WJPMR

TEMPERATURE AND FREQUENCY DEPENDENT ELECTRICAL CHARACTERIZATION OF ZNO NANOCRYSTALS

Amit Kumar Bhunia*[1,2], S. Saha[1] and S. S. Pradhan[3]

[1]Department of Physics and Technophysics, Vidyasagar University, Midnapore -721102, India.
[2]Department of Physics, Government General Degree College at Gopiballavpur-II, Beliaberah, Jhargram-721517, India.
[3]Department of Physics, Midnapore College (Autonomous), Midnapore-721101, India.

***Corresponding Author: Amit Kumar Bhunia**
Department of Physics and Technophysics, Vidyasagar University, Midnapore -721102, India.

Article Received on 06/06/2017 **Article Revised on 27/06/2017** **Article Accepted on 18/07/2017**

ABSTRACT

The present study explore the electrical properties of pressure compacted pellets of zinc oxide nanoparticles powder synthesized by simple chemical method. The HRTEM images showed the formation of nanoparticles (NPs). The room temperature absorption spectra showed a strong peak at 365 nm due to excitonic formation. The photoluminescence spectrum of ZnO NPs showed a strong emission peak at 445 nm . The electrical properties of zinc oxide (ZnO) were studied within temperature range from 25^{0}C to 400 ^{0}C and in the frequency range from 1kHz to 100 kHz for ac electrical measurements.

KEYWORDS: ZnO NPs, UV-VIS spectrum, HRTEM, Dielectric Loss, Impedance.

INTRODUCTION

Zinc Oxide (ZnO) is a direct and wide band gap interesting material because of its potential usage in various technological applications such as transparent conducting electrodes, wavelength light-emitting, UV lasing, gas sensors, solar cells, laser systems, biomedical applicatios etc.[1,5]

ZnO has a excitonic energy of 60 meV in a Semiconductor. It crystallizes in a hexagonal wurtzite structure with lattice parameters of (a = 3.249 nm, c = 5.205 nm). It also exhibits many interesting properties, like magnetic properties, piezoelectricity.[6] ZnO has high chemical and thermal stability and is not easily oxidized in the atmosphere. The key technology for ZnO based optoelectronic devices is the fabrication of high quality ZnO materials and ZnO thin films. Various fabrication methods, such as physical and Chemical vapor deposition, pulsed-laser deposition, hydrothermal growth have already appeared in the literature to synthesized various types of ZnO nanostructures. Some of the Above mentioned methods have some drawbacks. Used precursors are unstable causing environmental hazards and require very high temperature, low pressure, control rate of carrier flow and many more. These methods are not cost effective also. We focused the fabrication of ZnO nanoparticles by a simple and cost-effective wet-chemical method. We next investigated their optical and electrical properties by using UV-VIS, PL, Capacitance, impedance, dielectric loss measurements. We focused our study to better understand the electrical properties for ZnO nanocrystals for various optoelectronic and other applications.

Experiment

We synthesized ZnO nanoparticles by chemical method. In a typical synthesis process 0.5M of Zinc Nitrate Hexahydrate was first dissolved in ethanol and kept as stock solution. 0.5M NaOH solution was added drop wise into the stock solution. The magnetic stirring was continued for 24 h. At the end of the reaction the white precipitate deposited at the bottom of the flux was collected, filtered, washed several times by de-ionized water and dried at 100^{0}C for further characterizations. X-ray diffraction was carried using Rigaku X-ray diffractometer system over $10^0 < 2\theta < 80^0$ using Cu-kα radiation of wavelength λ=1.54Å. Structural characterizations were also done by transmission electron microscopy images using JEOL JEM-2100F microscope with the accelerating voltage of 200 kV. For TEM study a very small amount of the powder sample was first dispersed in ethanol by ultra-sonication. A drop of that solution was taken on a carbon coated grid for TEM imaging. The room temperature emission spectrum was recorded in PERKIN ELMER LS- 55 with a Xenon lamp with the excitations of 335nm. The optical absorption spectra of the samples were taken by using Shimadzu- Pharmaspec-1700 UV-VIS, after ultrasonication of the samples in ethanol.

The dielectric properties of of the samples were measured using a HIOKI 3532-50 LCR Hi Tester. The capacitance (C) and the dissipation factor, D=tan (δ), and the phase angle (ϕ) of the parallel plate capacitor made by the pressed pellet (disc shaped) samples were directly measured in the frequency range 10 kHz to 100 kHz at different temperatures. The parallel plate capacitor was constructed by applying silver paste on both sides of the pressed pellets.

RESULTS AND DISCUSSION

UV-VIS spectroscopy
UV-VIS spectroscopy was carried out to study the optical property of the synthesised nanoparticles. The room temperature UV-VIS spectra of the ZnO NPs dispersed in ethanol is shown in figure 1. ZnO NPs shows a strong band at 365 nm due to excitonic transition at room temperature.[7] This absorption in the UV region shows one dimensional quantum confinement of carriers.[8] This absorption in the visible range of wavelength implies that there exist more defect energy levels in experimental synthesis conditions.

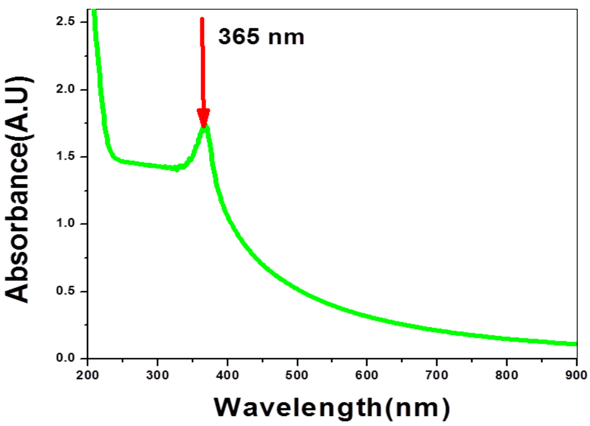

Figure 1: Absorption spectrum of ZnO NPS.

Emission Spectroscopy
Figure 2 shows the emission spectra of ZnO NPs. The ZnO NPs shows a strong emission band around 445 nm.[9] The emission band corresponding to 483 nm and 527 nm arise from the defects related to the nanocrystals. The different types of defects in ZnO nanocrystals are: Zn vacancy, O-vacancy, Zn-interstitial.

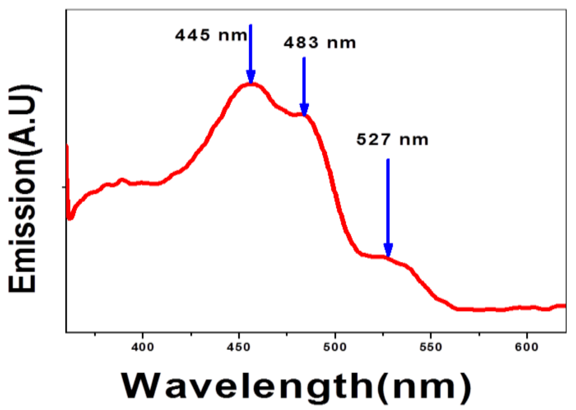

Figure 2: Emission spectrum of ZnO NPS.

HRTEM images
The HRTEM micrographs of zinc oxide nanoprticles are as shown in Figure 3(a) and 3(b). The TEM micrographs show ZnO NPs having average diameter of 19 nm. The corresponding SAED pattern indicates crystalline nature of the nanoparticles.[10,11]

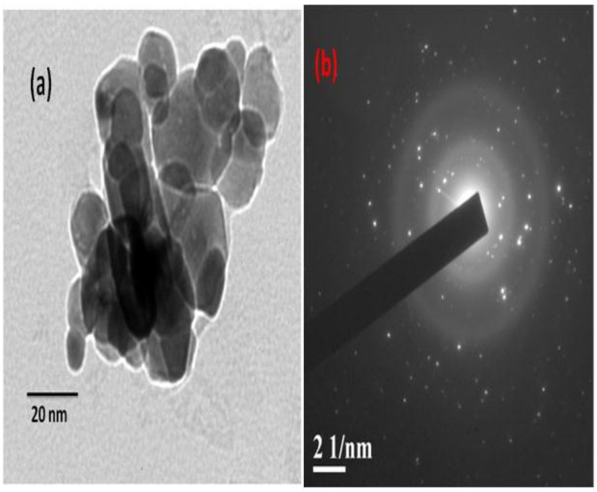

Figure 3: (a) TEM image of ZnO NPs; (b) SAED pattern.

X-ray diffraction (XRD)
The unit cell of the ZnO nano crystal was found to be hexagonal. The prominent diffraction peaks are (100), (002), (101), (102), (110), (103),(200),(112), and (201).[12,13]

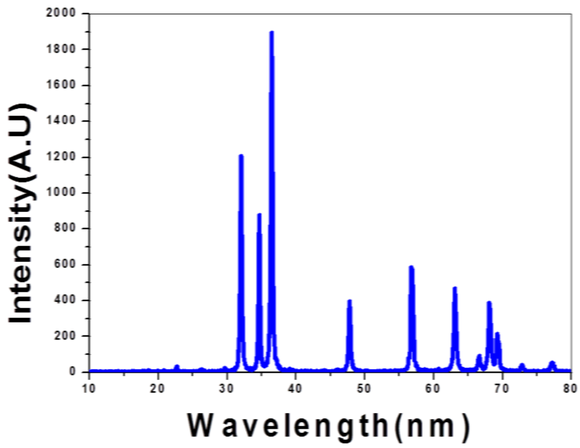

Figure 4: XRD pattern of the ZnO NPS.

Dielectric loss (D), Impedance and Capacitance
Figure. 5 shows the variation of dielectric loss (D) with temperature (25 ^{0}C-400^{0}C) at fourteen frequencies (1 kHz to 100 kHz). It is observed that the behaviour of dielectric loss increases with increase in temperature upto 150 ^{0}C for low frequency range(1 kHz- 10 kHz) and 211 ^{0}C for high frequency range (10 kHz to 100 kHz), then decreases, after 300^0 C it becomes increases . The increase in the dielectric loss (D) with temperature is due to small ferroelectric propertie of ZnO NPs. Here the ZnO NPs shows high dielectric loss for all low

frequencies (1 kHz- 10 kHzat) nearly 150 ^{0}C and for high frequency ranges (10 kHz to 100 kHz), it is nearly 212 ^{0}C . The high dielectric loss is due to randomness of the orientation of dipoles of the nano material. In the lower temperature range D shows a good agreement with other dielectric material.[14]

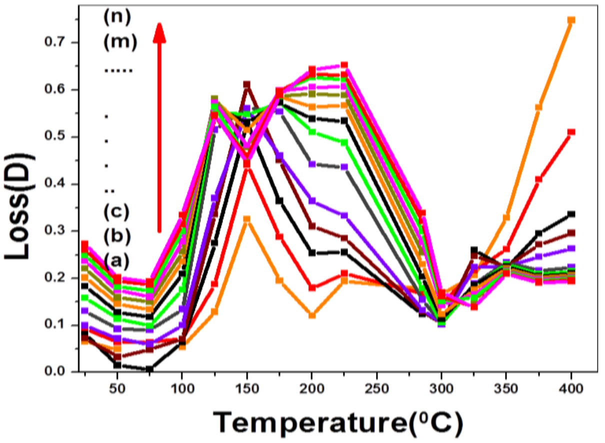

Figure 5: Variation of Dielectric loss of Nano ZnO pellet with temperature and at different frequencies (a) 10 Hz,(b) 100 Hz, (c) 1000 Hz,(d) 2500 Hz,(e) 5000 Hz,(f) 7500 Hz,(g)10000 Hz, (h)20000Hz,(i) 30000Hz,(j) 40000Hz,(k) 50000Hz,(l) 60000Hz,(m)70000Hz,(n) 80000Hz,(o)90000Hz, (p)100000 Hz.

Figure 6 shows the variation of impedance (Z) with temperature (250^{0}C–400^{0}C) for different frequencies (1kHz to 100 kHz). It has been found that the impedance at lower frequency is higher than that at the higher frequency with sharp decrease in impedance at 275 ^{0}C this is due to sharp increase in capacitance around 292^{0}C (Fig. 7) . The sharp peak is disappear after 7.5 kHz frequency.

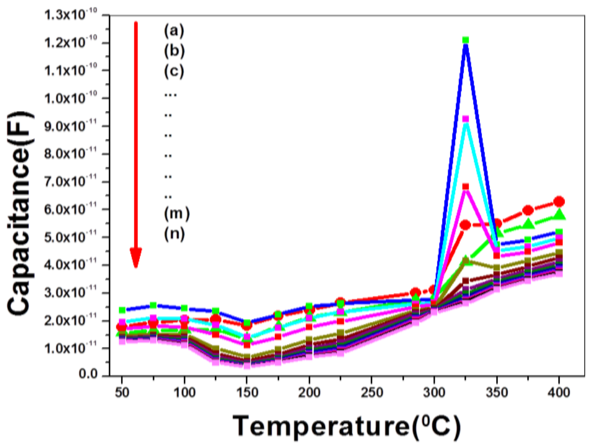

Figure 6: Variation of Capacitance of nano ZnO pellet with temperature and at different frequencies (a) 10 Hz,(b) 100 Hz, (c) 1000 Hz,(d) 2500 Hz,(e) 5000 Hz,(f) 7500 Hz,(g)10000 Hz, (h)20000Hz,(i) 30000Hz,(j) 40000Hz,(k) 50000Hz,(l) 60000Hz,(m)70000Hz,(n) 80000Hz,(o)90000Hz, (p)100000 Hz.

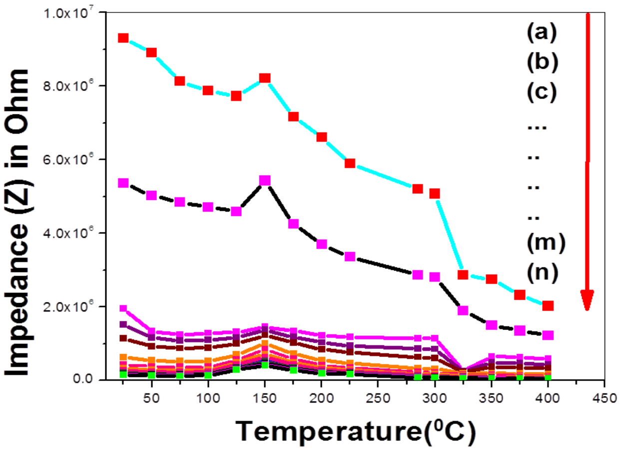

Figure 7: Variation of impedance of nano ZnO pellet with temperature and at different frequencies (a) 10 Hz,(b) 100 Hz, (c) 1000 Hz,(d) 2500 Hz,(e) 5000 Hz,(f) 7500 Hz,(g)10000 Hz, (h)20000Hz,(i) 30000Hz,(j) 40000Hz,(k) 50000Hz,(l) 60000Hz,(m)70000Hz,(n) 80000Hz,(o)90000Hz, (p)100000 Hz.

ACKNOWLEDGMENTS

The Authors are grateful to UGC and DST for their constant financial assistance through SAP and FIST programe for Department of Physics and Technophysics of Vidyasagar University. Thanks to the Department of Physics, Midnapore college (Autonomous).

REFERENCES

1. B. B. Rao, Mater Chem. Phys, 2000; 64: 62.
2. R. W. Birkmire and E. Eser, Annu. Rev. Mater Sci., 1997; 27: 625.
3. T. Aoki, Y. Hatanaka, and D. C. Look, Appl. Phys. Lett., 2000; 76: 3257.
4. A.K.Bhunia, T.Kamilya and S.Saha, Temperature dependent and kinetic study of the adsorption of bovine serum albumin to ZnO nanoparticle surfaces, Chemistry Select, 2016; 1: 2872-2882.
5. A.K.Bhunia, P.K.Samanta, S.Saha and T.Kamilya, ZnO nanoparticle interaction: Corona formation with associated unfolding, Applied Physics Letters, 2013; 103: 1401-1437.
6. K K Korir, G Cicero and A Catellani, Piezoelectric properties of zinc oxide nanowires: an ab initiostudy, Nanotechnology, 24(47): 475401 (5pp).
7. Z.Yang, Q.H.Liu, The structural and optical properties of ZnO nanorods via citric acid-assisted annealing route, Journal of Materials Science, 2008; 43: 6527-6530.
8. A. K. Bhunai, P. K. Jha, D. Rout and S. Saha , Morphological Properties and Raman Spectroscopy of ZnO Nanorods, Journal of Physical Sciences, 2016; 21: 111-118.
9. Haibo Zeng, Guotao Duan, Yue Li, Shikuan Yang, Xiaoxia Xu, and Weiping Cai, Blue Luminescence of ZnO Nanoparticles Based on Non-Equilibrium Processes: Defect Origins and Emission Controls. Adv. Funct. Mater. 2010; 20: 561–572.

10. L. Guo , Y. Liang Ji , and H. Xu ,P. Simon, Z. Wu, Regularly Shaped, Single-Crystalline ZnO Nanorods with Wurtzite Structure, *J. Am. Chem. Soc*., 2002; 124(50): 14864–14865.
11. A. K. Bhunia, P. K. Samanta and T. Kamilya, , S. Saha, Chemical Growth of Spherical Zinc Oxide Nanoparticles and Their Structural, Optical Properties, Journal of Physical Sciences, 2015; 20: 205-212.
12. Zhigang Zang, XiaoshengTang, Enhanced fluorescence imaging performance of hydrophobic colloidal ZnO nanoparticles by a facile method, Journal of Alloys and Compounds, 69: 98-101.
13. AK Singh, Synthesis, characterization, electrical and sensing properties of ZnO nanoparticles,Advanced Powder Technology, 2010; 21: 609–613.
14. AK Singh , Synthesis, characterization, electrical and sensing properties of ZnO anoparticles, Advanced Powder Technology 21 (2010) 609–613.