



OPTICAL PROPERTIES OF ZnO NANORODS SYNTHESIZED USING THE CHEMICAL BATH DEPOSITION

D. V. Rupnawar

Lal Bahadur Shastri College, Satara.

Email : dadasaheb5@yahoo.com

ABSTRACT:

In the present study, zinc oxide nanorods are synthesized using chemical bath deposition method. The nanorods are synthesized at 90°C. The structural properties of zinc oxide nanorods are investigated using the x-ray diffraction spectroscopy and Fourier transform infrared spectroscopy. The morphological properties are studied using the field emission scanning electron microscope. The optical properties are studied using the UV-visible spectrophotometer. In the optical properties absorbance, transmittance, bandgap have studied.

KEY WORDS: *Zinc oxide, Nanorods, Absorbance.*

INTRODUCTION:

ZnO has generated considerable interests in material research owing to its attractive properties, such as direct and wide bandgap of 3.37 eV, large exciton binding energy of 60 meV at room temperature, excellent thermal stability, and specific electrical and optoelectronic properties [1-3]. The ZnO nanomaterials are synthesized using different methods. The electrodeposition [4], thermal evaporation [5], chemical vapor deposition [6], chemical bath deposition (CBD) [7-8]. Among these methods, CBD is a good method to develop different nanomaterials. CBD has the advantages of chemical composition control, simplicity, homogeneity of sol solution, and capability for large-scale production [9]. Recently one dimensional ZnO nanostructures such as nanowire, nanorod, a nanobelt, nanotube, nanofibre have attracted more attention in many applications [10]. The optical behaviour of ZnO investigated by many researchers.

The ZnO nanorods are also developed by many research groups and used for different application. Gu et al. [11] synthesized ZnO nanorods on the zinc microspheres and studied the effects of the oxidising parameters on the diameters and lengths of the ZnO nanorods. Vu et al. [12] hydrothermally synthesized ZnO

nanorods arrays on the stainless steel mesh. Zhang et al. [13] hydrothermally synthesized ZnO nanorods on the Si substrate and investigated the effects of the annealing processes in a vacuum and air on the surface morphologies and the wettability of the ZnO nanorod arrays. As optoelectronic material, ZnO nanorod has attracted full attention [14]. The nanorod grows with time, and the length of nanorods progressively increases, as well as the crystallinity regularly progresses. The transmittance is gradually enriched, and the absorption edge near 375 nm becomes steeper [15]. In the fields of optoelectronic materials and micro-nano technology, the preparation and application of ZnO nanomaterials is still a hot research topic.

In the present investigation, the ZnO nanorods are synthesized using the chemical bath deposition. The chemical bath deposition parameters are identified for developing the nanorods. The structural, morphological and optical properties are studied for synthesized ZnO nanorods. The structural properties are studied using the x-ray diffraction spectroscopy and Fourier transform infrared spectroscopy. The morphological properties are investigated using the field emission scanning electron microscope. The optical properties are examined with UV-visible spectrophotometer.

EXPERIMENTAL

In a typical process, 50 ml of 0.1 M zinc acetate was prepared in double-distilled water. Then the pH of the solution is adjusted by adding aqueous ammonia 3.2 ml dropwise into the solution with continuous stirring. Substrates were cleaned using labelling and then boiled in chromic acid for 15 minutes, and finally, substrates were exposed to methanol vapors to remove any impurities if present on the substrate. The whole system was kept in a water bath which maintained at constant temperature 90°C for 2 hours. After removing the substrates from reaction bath, they were rinsed in double distilled water to remove unreacted particles on the films. These films were dried at room temperature for two hours and annealed afterwards at 400°C for three hour.

RESULTS AND DISCUSSION

X-ray diffraction study

The fig 1 (a) shows the XRD pattern of ZnO nanorods deposited at 2 hours. The film is polycrystalline and exhibits hexagonal crystal structure (JCPDS Card NO -01-079-0205) with lattice parameter $a=b= 3.24 \text{ \AA}$ and $c=5.18 \text{ \AA}$. The peak at 31.91, 34.63 and 36.44° represent orientation (100), (002) and (101), respectively. The crystallite size is calculated using Scherer's formula [16-17].

$$D = \frac{0.9\lambda}{\beta \cos\theta}$$

Where D is crystallite size, λ is the wavelength of X-ray (1.5406 \AA), β is full width at half maximum (FWHM). Crystallite size of ZnO thin film for the highest intensity peak (002) is found to be 47 nm. The typical Fourier Transform Infrared spectra of the polycrystalline films deposited at ZnO nanorods are shown in Fig. 1 (b). The signal at 3775.58 cm^{-1} belongs to -OH group. The 3153.61 cm^{-1} signals are assigned to the stretching vibration of the N-H bond of polycrystalline, i.e. Primary and Secondary, amide structure. The CHO stretching vibration signal at 2879.60 cm^{-1} is assigned to the aldehyde group. The signals at 1891.90 cm^{-1} represent the X=C=Y in-plane vibration Alkenes, ketone, isocyanates, isothiocyanates. Furthermore, the signal around 1820.45 cm^{-1} is attributed to the anhydride group, which indicates that the polycrystalline process. The peak at 672 cm^{-1} belongs to Zn-O vibration [18].

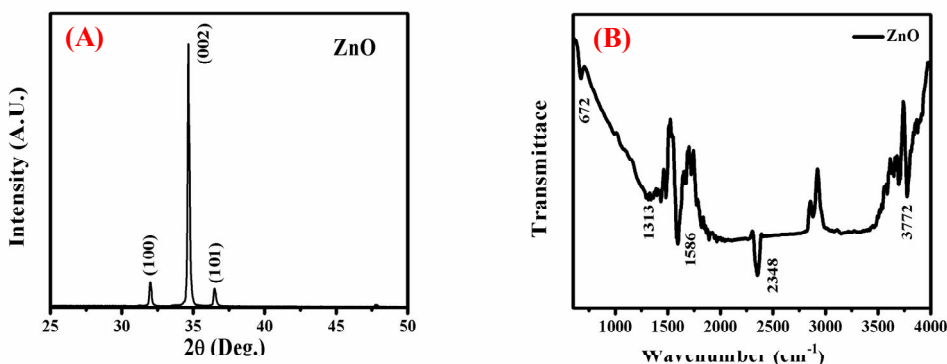


Fig. 1 Structural properties of ZnO nanorods, (A) X-ray diffraction pattern of ZnO thin film, (B) FTIR spectra of ZnO nanorods

SCANNING ELECTRON SPECTROSCOPY

The surface morphology of CBD deposited ZnO thin film is studied by using a Scanning electron microscope. The FESEM images of ZnO films deposited at 2 hours. The well-organized ZnO hexagonal nanorods are observed in FESEM image. The observed nanorods have 350 nm in width. The seed layers are created before the deposition. Therefore, as starting deposition, Zinc ions are deposited on seed layers, and easily ZnO nanorods are formed [19-20].

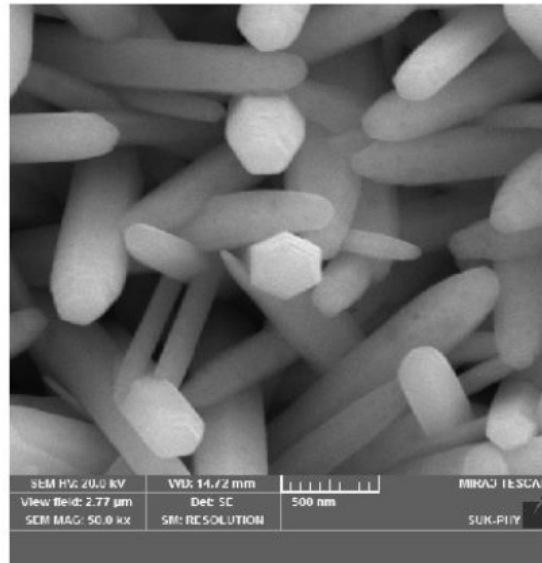


Fig.2 FESEM images of ZnO nanorods

ABSORBANCE SPECTRA

The Optical absorbance spectra of the deposited films were obtained using Shimadzu 1800 UV-VIS spectrophotometer. The UV-visible spectrum shows the absorbance at 374 nm, this shown in fig. 3 (absorbance). Fig. 3 (transmittance) shows the maximum transmittance upto 35% at 300 nm and a minimum at 20% at 1100 nm. The bandgap plot is mentioned in fig.3 (bandgap); it shows the bandgap near to 2.85 eV. The observed band is low from its standard bandgap; this is because of deposition was carried out at 95 degrees. The bandgap is also a function of temperature [21-22].

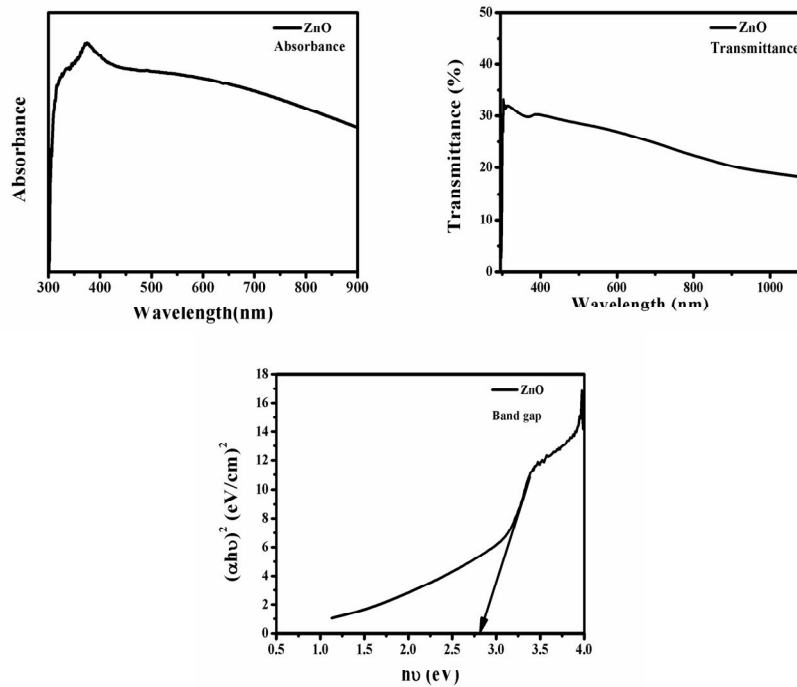


Fig. 3 Optical properties of ZnO nanorods

CONCLUSION

The thin film of zinc oxide was prepared by a chemical bath deposition method. The prepared nanorods were characterized by X-ray diffraction spectroscopy, Infrared spectroscopy, Scanning electron spectroscopy and UV-visible spectroscopy. The XRD result shows the ZnO are polycrystalline with hexagonal structure. The Fourier Transform Infrared spectrum confirms the formation of ZnO. From SEM micrographs, it is clear that ZnO nanorods are developed. The deposited films show the deposition time affects significantly on the morphology of the films. The bandgap energy of the bulk ZnO is observed at 2.85 eV.

REFERENCES

- [1] Yangsi Liu, Wei Gao, Journal of Alloys and Compounds 629 (2015) 84-91
- [2] UOzgur, Y.I. Alivov, C. Liu, A. Teke, M.A., Reshchikov, S. Dogan, V. Avrutin, S.J. Cho, H. Morkoc, J. Appl. Phys. 98 (2005) 1-103.
- [3] L. Vayssieres, Adv. Mater. 15 (2003) 464-466.
- [4] Y.M. Yeh, H. Chen, Thin Solid Films 529 (2013) 103-106
- [5] D.H. Kuo, J.Y. He, Y.S. Huang, J. Electron. Mater. 41 (2012) 451-456
- [6] P. Hu, N. Han, D. Zhang, J.C. Ho, Y. Chen, Sens. Actuators, B 169(2012) 74-80
- [7] P. Hari, J. Seay, K. Farmer, K. Roberts, Adv. Sci. Technol. 77 (2013) 280-284
- [8] R. Shabannia, H.A. Hassan, Appl. Phys. A 114 (2014) 579-584.
- [9] R. Shabannia, Progress in Natural Science: Materials International,
- [10] A. Janotti, C.G. Van de Walle, Rep. Prog. Phys. 72 (2009) 126501
- [11] Z.J. Gu, M.P. Paranthaman, J. Xu, Z.W. Pan, ACS Nano 3 (2009) 273.
- [12] T.T. Vu, G. Marbán, Appl. Catal. B: Environ., 51 (2014) 152-153
- [13] J. Zhang, Y. Liu, Z.Y. Wei, J.Y. Zhang, Appl. Surf. Sci. 265 (2013) 363.
- [14] M. Willander, L.L. Yang, A. Wadeasa, S.U. Ali, M.H. Asif, Q.X. Zhao, O.Nur, J. Mater. Chem. 19 (2009) 1006-1018.
- [15] J. Zhao, X. Wang, J. Liu, Y. Meng, X. Xu, C. Tang, Mater. Chem. Phys. 126(2011) 555-559
- [16] G. M. Lohar, J. V. Thombare, S. K. Shinde, S. H. Han, V. J. Fulari, J Mater Sci: Mater Electron (2014) 25:1597-1604
- [17] G.M. Lohar, S.K. Shinde, M.C. Rath, V.J. Fulari, Materials Science in Semiconductor Processing 26 (2014) 548-554
- [18] D. Tsiourvas, Journal of Materials Science: Materials in Medicine, 22 (2011) 85-96
- [19] Q. Zhao, H.Z. Zhang, Y.W. Zhu, S.Q. Feng, X.C. Sun, J. Xu, D.P Yu, Applied Physics Letters 86(2005) 203115.
- [20] C. Li, G.J. Fang, J. Li, L. Ai, B.Z. Dong, X.Z. Zhao, The Journal of Physics, chemistry C 112 (2008) 990-995.
- [21] G. M. Lohar, S. K. Shinde, V. J. Fulari, Journal of Semiconductors, 35 (2014) 113001
- [22] J. V. Thombare, S. K. Shinde, G. M. Lohar, U. M. Chougale, S. S. Dhasade, H. D. Dhaygude, B. P. Relekar, V. J. Fulari, Journal of Semiconductors 35 (2014) 063001