International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Special Issue 38 (February, 2016), PP. 13-16

FACILE HYDROTHERMAL SYNTHESIS OF $ZNSNO_3$NANOPARTICLES AND ITS CHARACTERIZATIONS

P.Prabakaran, M. Victor Antony Raj, J. Madhavan*
Department of Physics, Loyola College, Chennai, India 600 034.
*Corresponding author. Tel: +919840479638; E-mail: jmadhavang@yahoo.com

Abstract: **The ternary semiconducting oxide Zinc Stannate ($ZnSnO_3$) has recently drawn considerable interest in the research community owing to its potential applications in gas sensors, electronic devices, solar cells, plating additives, etc., The hydrothermal method has been established as an effective route due to its operational simplicity, cost-efficiency and continuous productions potential compared with other methods. The present work reports facile hydrothermal synthesis of $ZnSnO_3$ nanoparticles and it was characterized by XRD, UV, FTIR, SEM and dielectric study. X-ray diffractogram provides the structural property of $ZnSnO_3$ and average crystallite size was calculated as 41.87nm. The FTIR analysis confirms the function group of $ZnSnO_3$. The morphology was analyzed using SEM micrographs and it exhibit cubic structure. Dielectric constant and dielectric loss was observed to be decrease when frequency increases for the synthesized $ZnSnO_3$ nanoparticles.**

Keywords: **Zinc Stannate ($ZnSnO_3$), hydrothermal technique and Dielectric studies.**

I. INTRODUCTION

One-dimensional (1D) nanostructure of semiconducting metal oxides, such as ZnO,SnO_2 and TiO_2have attracted great attention because of the potential applications in fabricating gas sensors, humidity sensors, and nano-electronic circuits. Especially, ZnO and SnO_2 nanowires were paid more attention due to their potential applications in gas sensing and optoelectronics[1-5]. Nowadays, more efforts have been taken to study 1D ZnO-SnO_2 composite nanostructures due to their novel properties in nano devices[6-9]. Recently, $Zn_2SnO_4$and $ZnSnO_3$have been reported as two phases of the nanoparticles system under air pressure at room temperature[10]. Zn_2SnO_4 crystal with high thermal stability has been characterized clearly in chemistry structure. However, single-phase Zn_2SnO_4materials exhibit a very low gas sensitivity [10-14].Consequently, its application is limited in gas sensing, although Zn_2SnO_4nanostructures have just been synthesized.[7-9]. In contrast,$ZnSnO_3$ with a high sensitivity has recently paying more attention.[13-14].Zinc stannate ($ZnSnO_3$) is a multifunctional material which has been fascinated substantial attention due to their wide-ranging application in numerous fields, such as gas sensors, moisture detectors, electronics materials[15-18]. From a crystallographic point of view, $ZnSnO_3$ is a structure of perovskite oxides and Ilmenite structure, forming face-centered-cubic (FCC) closed packing [19].

In recent times, to synthesis$ZnSnO_3$ nanostructures, different approaches were utilized such as thermal evaporation, low temperature ion exchange,[19] co-precipitation[20] and hydrothermal synthesis.[21-23] Nevertheless, it still remains a great challenge to progress a facile, mild and low-cost technique for the synthesis of $ZnSnO_3$ nanostructures. The hydrothermal method has been recognized as an effective route owing to its operational simplicity, continuous production potential and cost-efficiency compared with other approaches.

The current investigation was focused on the facile synthesis of zinc stannate via hydrothermal technique. The characterization such as XRD, UV, FTIR, SEM and dielectric study were carried out to reveal the structural, optical, electrical and morphological properties of $ZnSnO_3$.

II. EXPERIMENTAL PROCEDURE

The hydrothermal method was carried out for the preparation of $ZnSnO_3$ cubic crystallites. All chemicals were of analytical grade. In a typical procedure, the aqueous solution containing zinc acetate ($Zn(CH_3COO)_2 \cdot 2H_2O$) (0.8M), stannic chloride hydrated($SnCl_4 \cdot 5H_2O$) (0.8M) was prepared in double distilled water and stirred continuously for 4 h at room temperature. The suitable amount of NaOH was added drop-wise to the reaction mixture with continuous stirring until the final solution pH value of about 10 was achieved. Then, the reaction mixture was decanted into a Teflon-lined stainless steel autoclave of 100 ml in volume and maintained at140˚C for 15 h and then cooled to room temperature naturally. After hydrothermal process, the precipitate was collected by centrifuging the solution and rinsed several times with double distilled water and ethanol and dry in air 90^0C.The obtained $ZnSnO_3$ was utilized for further characterization.

III. RESULTS AND DISCUSSION

A. X- Ray Diffraction Studies

The powder XRD analysis was carried out using Rich Seifert diffractometer with CuK_α (λ=1.5418Å) radiation. The intensity versus 2θ values is recorded between the ranges 10-80˚. The XRD pattern of as-synthesized product is depicted in fig.1. All of the diffraction peaks can be indexed to the

standard $ZnSnO_3$with the perovskite structure (JCPDS no:11-0274), confirming that the as-synthesized product has a typical face centered cubic (FCC) crystal structure. No diffraction peaks due to impurities or other crystalline byproducts such as ZnO or SnO_2 were detected, indicating that pure $ZnSnO_3$ crystallites could be obtained under present synthesis conditions. The average crystallite size was calculated using Scherrer formula and the calculated crystallites size is 48.4 nm.

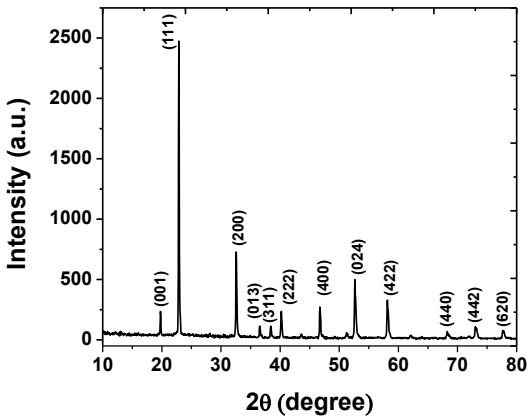

Figure 1: XRD patterns of as synthesized $ZnSnO_3$

B. SEM Analysis

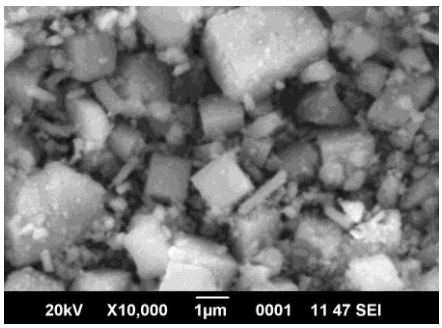

Figure 2: SEM image of $ZnSnO_3$ cubic crystallites.

The morphology of the sample was obtained using SEM analysis. The SEM micrograph of $ZnSnO_3$ nanoparticles prepared via hydrothermal method is shown in Fig 2. This image indicates that the $ZnSnO_3$ products usually exhibit a geometrically cubic-shape.

C. UV Spectral Analysis

The spectroscopic properties of any given sample can be understood by analyzing its UV-Vis spectra. Fig.3 shows the absorption spectra of $ZnSnO_3$nanoparticles synthesized by hydrothermal method. The absorption edge is found to be centered around 380 nm for $ZnSnO_3$ samples, beyond which the sample is completely transparent. A plot of the Tauc's function for direct transitions for the synthesized sample is shown in Fig.3 (b). The optical values of band gap were determined by extrapolating the linear part of the graph to the x-axis. The direct optical band gap was found to be ~5.320 eV for direct transitions.

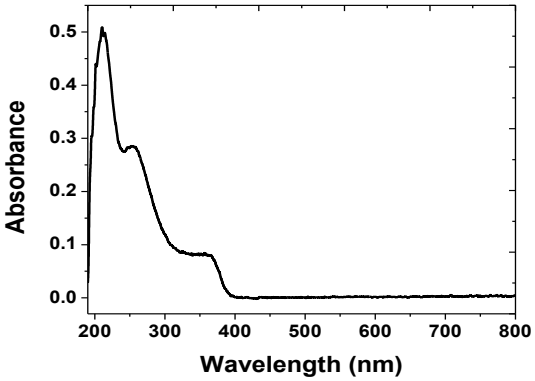

Figure 3(a): Absorbance spectra of $ZnSnO_3$

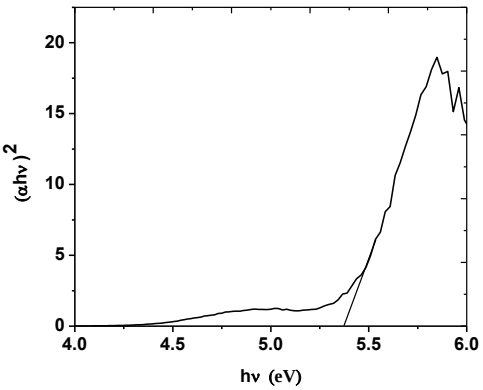

Figure 3(b): Tauc's plot for direct transitions of $ZnSnO_3$

D. Fourier transform infrared spectroscopy

FT-IR studies were performed using Perkin Elmer Spectrum FT-IR Spectrophotometer. FTIR spectrum was recorded for $ZnSnO_3$in the range 400- 4000 cm^{-1} and it was shown in Fig 4.

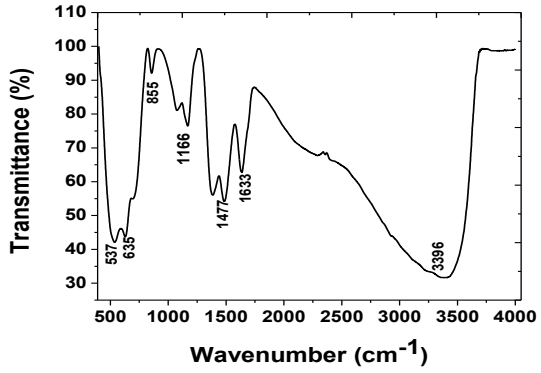

Figure 4: FTIR spectrum of $ZnSnO_3$

A broad absorption peaks occurs at 537 – 635 cm^{-1} for $ZnSnO_3$ was due to symmetric stretching vibration of ZnO and SnO_2 groups respectively and this band could be assigned to the Sn-O-Zn bonding of the $ZnSnO_3$. Sn-O-Zn stretching vibrations group was absorbed at 1166 cm^{-1}. Absorption at 1477 cm^{-1} was assigned to C-H vibration modes and absorption band at 1633 and 3396 cm^{-1} indicates the presence of hydrogen bonds. These observed peaks are attributed to formation of $ZnSnO_3$.

E. Dielectric Studies

$ZnSnO_3$ nanoparticles are subjected to dielectric studies using HIOKI 3532-50 HITESTER LCR meter. The measurements are made at frequencies ranging from 50 Hz to 5 MHz at temperatures 100ºC, 200ºC, 300ºC, 400ºC. The dielectric constant of $ZnSnO_3$ is maximum at lower frequency and decreases with increases in frequency which was evident from fig.5(a). The variation in dielectric constant with respect to the frequency is due to the space charge polarization. At higher frequency the dielectric constant decreases due to periodic reversal of the field at interface. The frequency dependence of the dielectric loss of $ZnSnO_3$ was shown in fig.5(b). The higher value of dielectric loss at lower frequency and it decreases with increases in frequency is due to the free charge motion within the material.

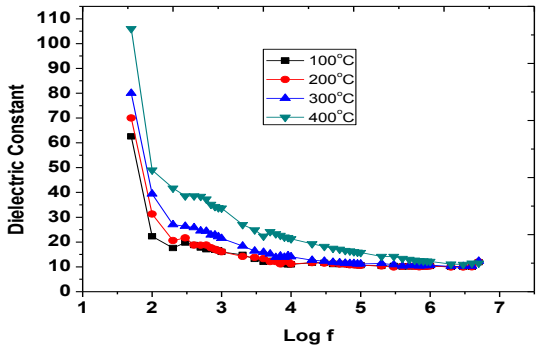

Figure 5(a): Variation of dielectric constant with log f

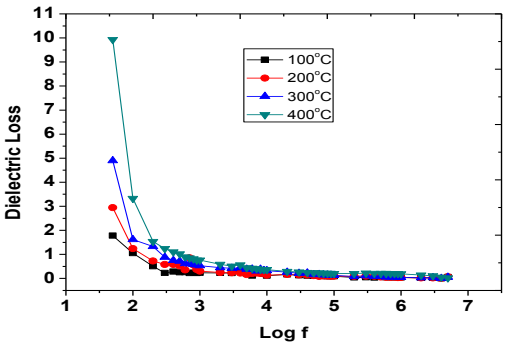

Figure 5(b): Variation of dielectric loss with log f

IV CONCLUSION

The current work was focused on the preparation of $ZnSnO_3$ via hydrothermal technique. Characterization studies XRD,SEM, FTIR, UV spectral analysis and Dielectric were carried out to study the structure, optical property of the material. X-ray diffraction patterns of ZnSnO3 reveal the presence of perovskite structure. The morphology studied from SEM characterization. The functional group of $ZnSnO_3$was confirmed using FTIR analysis. The electrical property and the frequency dependence of the Dielectric constant and dielectric loss for $ZnSnO_3$ were analyzed and studied.

REFERENCES

1. Zheng Wei Pan, ZuRong Dai, and Zhong Lin Wang, Science 291, **2001**, 1947.
2. Y. J. Chen, Q. H. Li, Y. X. Liang, and T. H. Wang, Q. Zhao, and D. P.Yu, Appl. Phys. Lett. 85, **2004**, 5682.
3. Q. H. Li, Q. Wan, Y. J. Chen, and T. H. Wang, H. B. Jia, and D. P. Yu, Appl. Phys. Lett. 85, **2004**, 636.
4. Y. J. Chen, M. S. Cao, T. H. Wang, and Q. Wan, Appl. Phys. Lett. 84, **2004**, 3367.
5. Q. Wan, Q. H. Li, Y. J. Chen, T. H. Wang, X. L. He, J. P. Li, and C. L.Lin, Appl. Phys. Lett. 84, **2004**, 3654.
6. Puxian Gao and Zhong Lin Wang, J. Phys. Chem. B 106, **2002**, 1265.
7. J. X. Wang, S. S. Xie, Y. Gao, X. Q. Yan, D. F. Liu, H. J. Yuan, Z. P. Zhou,L. Song, L. F. Liu, W. Y. Zhou, and G. Wang, J. Cryst. Growth 267, **2004**, 177.
8. J. X. Wang, S. S. Xie, H. J. Yuan, X. Q. Yan, D. F. Liu, Y. Gao, Z. P. Zhou,L. Song, L. F. Liu, X. W. Zhao, X. Y. Dou, W. Y. Zhou, and G.Wang, SolidState Commun. 131, **2004**, 435.
9. JianshengJie, Guanzhong Wang, Xinhai Han, Jieping Fang, Yuan Liao,Bo Xu, Qingtao Wang, J. G. Hou, and Qingxuan Yu, J. Phys. Chem. B 108, **2004**, 8249.
10. D. Kovacheva and K. Petrov, Solid State Ionics 109, **1998**, 327.
11. Won Jae Moon, Ji Haeng Yu, and Gyeong Man Choi, Sens. Actuators B 80, **2001**, 21.
12. I.Stambolova, K. Konstantinov, M. Khristova, and P. Peshev, Phys. Status Solidi A 167, **1998**, 111.
13. Shen Yu-Sheng and Zhang Tian-Shu, Sens. Actuators B 12, **1993**, 54.

14. Xing-Hui Wu, Yu-De Wang, Zi-Hua Tian, Huan-Lin Liu, Zhen-Lai Zhou, and Yan-Feng Li, Solid-State Electron. 46, **2002**, 715.
15. X.H. Wu, Y.D. Wang, Z.H. Tian, H.L. Liu, Z.L. Zhou, Y.F. Li, Solid State Electron. 46, **2002**, 715.
16. Y.L. Cao, D.Z. Jia, J. Zhou, Y. Sun, Chem. 27, **2009**, 4105.
17. T.G. Zhong, B.F. Quan, X.S. Liang, F.M. Liu, B. Wang, B-Solid 151, **2008**, 127.
18. H.X. Wang, J.Q. Xu, Z. Li, C. Li,Sens. Lett. 6, **2008**, 852.
19. X.Y. Xue, Y.J. Chen, Q.H. Li, C. Wang, Y.G. Wang, T.H. Wang, Appl. Phys. Lett. 88, **2006**, 182.
20. D. Kovacheva, K. Petrov, Solid State Ionics 109, **1998**, 327.
21. Y. Zeng, T. Zhang, H.T. Fan, G.Y. Lu, M.H. Kang, Sens. Actuators B 22, **2009**, 450.
22. Y. Zeng, T. Zhang, H.T. Fan, W.Y. Fu, G.Y. Lu, Y.M. Sui, H.B. Yang, J. Phys. Chem.C 113, **2009**, 1900.
23. J.Q. Xu, X.H. Jia, X.D. Lou, J.N. Shen, Solid State Electron. 50, **2006**, 504.