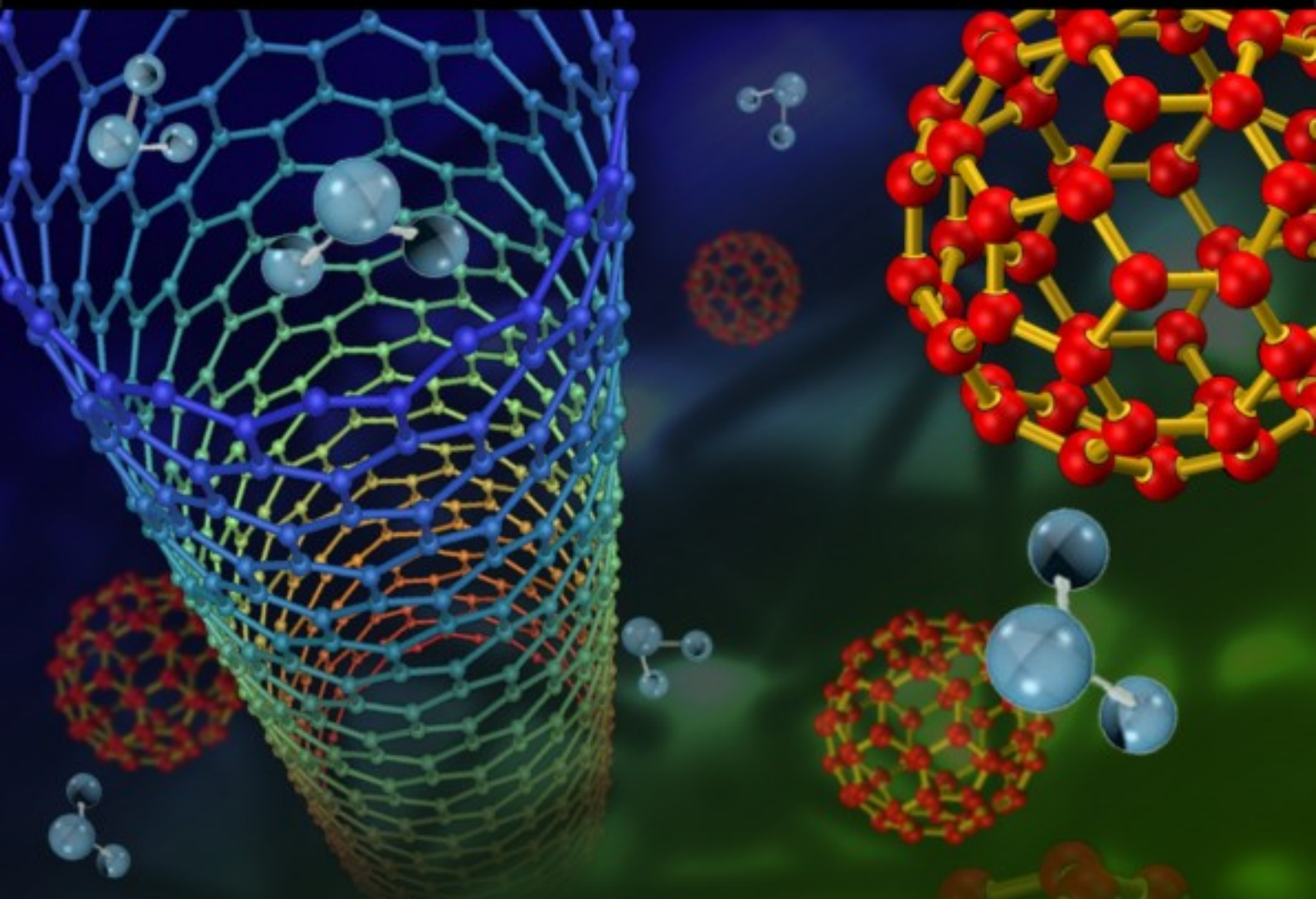


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Room Temperature Ammonium Gas Sensing Behavior of Upright-standing ZnO Nano-sheets

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Abstract: The room temperature operating resistive ammonia gas sensor is designed by using an upright-standing ZnO nano-sheets. Wet chemical route is preferred for growing ZnO upright-standing free nano-sheets of $\sim 2\text{-}5\ \mu\text{m}$ in length and $\sim 100\text{-}150\ \text{nm}$ in width. Structural, surface morphological and room temperature ammonium sensing properties of these nano-plates are elucidated. Well-resolved nano-sheets when kept in ammonium container showing good sensing behavior. Ammonia gas sensor response measured room temperature (300 K) is the function of gas concentration. *Copyright © 2008 IFSA.*

Keywords: ZnO nano-sheets; Surface morphology; Room temperature; Ammonium gas sensor

1. Introduction

Conduct metric gas sensors based on semiconducting metal oxides are actually one of the most investigated groups of gas sensors [1]. They have attracted the considerable attention of due to the low cost and flexibility associated to their production; simplicity of their use; large number of detectable gases/possible application fields [2, 3]. Such a device is normally operated in air, in the presence of humidity and residual gases (e.g. carbon dioxide) [4]. These metal oxide sensors are working at a temperatures between 200 and 400 °C. Hence, it is difficult to maintain such a high temperatures

during their daily use in the daily life. So forth, there is to design sensors having the potentiality of room temperature activation. Due to the transparency in the visible range, high electrical stability, direct band gap (3.37 eV), absence of toxicity, abundance in nature, etc., ZnO is one of the versatile and technologically importance materials [5]. Window layer [6], varistor [7], gas sensor [8-10], etc., are the reported applications. Researchers are now probing on this material as one of the alternative photoanode for dye-sensitized solar cells [11-13]. Nanorods [13-17], nanocastles [16], nanowires [17-22] are quoted forms of ZnO in literature. However, best of our knowledge and reference available with us, direct room temperature (RT) ammonium gas sensor application of wet chemically grown ZnO nano-sheets, we not found till date. In continuation to our ZnO based research [5, 23], here in this short communication, we report room temperature ammonium gas sensor design of ZnO nano-sheets. To support or claim, these nano-sheets of ZnO are explored for the structural, morphological properties by means of X-ray diffraction (XRD) and scanning electron microscopy (SEM) techniques, respectively.

2. Experimental Details

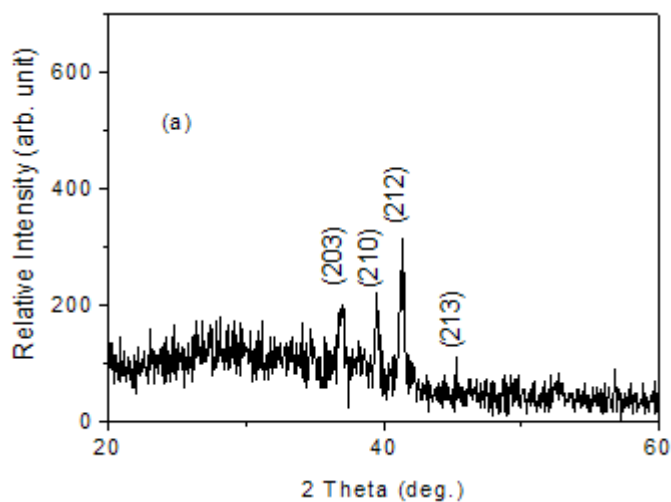
Wet chemical method was used for the fabrication of ZnO nano-sheets, which is based on heating an alkaline bath of zinc salt containing the immersed substrates. The source of zinc was zinc sulfate, 99%, A.C.S. reagent ($ZnSO_4$), and to make it alkaline, ammonium hydroxide was added in excess quantity so as to reach its pH ~ 11 . The glass micro-slides were used as substrates, which were cleaned with acetone, isopropyl alcohol and distilled water for 15 min in ultrasonicator and finally, dried with high pressure oxygen. For the growth of ZnO nano-sheets, these cleaned substrates were kept in above bath for 24 h. After about 10 h, as an indication of heterogeneous reaction with the substrate, a liquid precipitation was appeared. Structural identification of ZnO upright-standing nano-sheets was carried out using X-ray Philips PW 1710 diffractometer using Cu-K α radiation at 40 kV, 100 mA and scanning speed of $0.05^\circ s^{-1}$. For micro-structural analysis, scanned SEM JEOL, Japan and transmission electron microscopy (TEM) assemblies were preferred. The gas sensor testing is performed using ammonia gas fumes obtained by boiling ammonia solution in the spherical gas bowl. The change in vicinal surface current was measured *in-situ* when was adsorbed on the films using Lab Equip current-voltage ($I-V$) measurement set up.

3. Results and Discussion

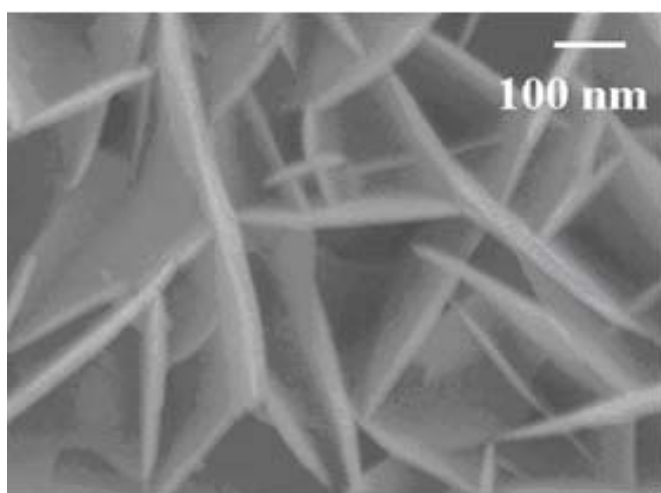
Nucleation formation is the basic and initial step in wet chemical process in which clusters of molecules undergo rapid decomposition to form heterogeneous reaction with the substrate. When $ZnSO_4$ reacts with ammonium hydroxide, white precipitate of $Zn(OH)_2$ was observed. Addition of excess ammonia resulted into re-formation of clear solution. It is accepted that when ionic product exceeds the solubility product, $Zn(OH)_2$ on the substrate starts to deposit and finally, annealing the $Zn(OH)_2$ results into ZnO. Fig. 1(a) shows the XRD pattern of as-deposited ZnO. The XRD pattern has proved the formation ZnO [JCPDS 01-1136]. This spectrum is entirely different than our previously reported ZnO where (002) plane was dominant [5, 24]. This indirectly speculates different type of morphology growth in contrast to previously reported vertical ZnO cones. The spectrum is free from the (002) peak, generally a measurement of electrical resistivity, is completely diminished, indirectly supporting that the as-grown morphology of ZnO would be in favor of gas sensing performance.

Fig. 1 (b, c) shows SEM and TEM images of as-deposited ZnO at two different magnifications. Upright-standing ZnO nano-sheets were noticeable from the SEM image. Crack-free nature of individual sheet was noted. Nano-sheets of ZnO were cross-linked. There were considerable voids in-between the nano-sheets. To knowing exact dimensions, i.e. length, height and width, TEM image was

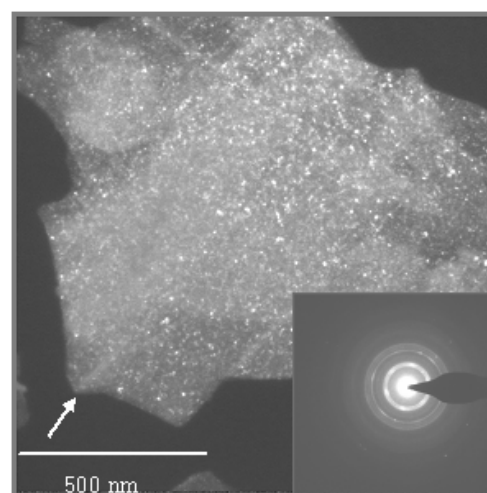
scanned. These nano-sheets were $\sim 2\text{-}5\ \mu\text{m}$ in length and $\sim 100\text{-}150\ \text{nm}$ in width. These nano-plates were $\sim 1156 \pm 5\ \text{nm}$ in height which were similar to that reported by Kakiuchi et al via intermediate $\text{Zn}_4\text{CO}_3(\text{OH})_6\cdot\text{H}_2\text{O}$ [21]. Furthermore, corning edges of every nano-plate were sharp.



(a)



(b)



(c)

Fig. 1. (a) The X-ray diffraction pattern, (b) SEM and (c) TEM images of ZnO.

For ammonia gas sensing experiments, gold metal contacts were made by evaporating gold wire in vacuum chamber without substrate heating. Then, this film was transferred to steel chamber and electrical wires of contact were taken out from it. The ammonia gas was transported from the cylinder into the chamber through small diameter pipe. As seen in Fig. 2 (a), the resistance of the film was decreased with increase in current density as soon as gas was introduced into the chamber at room temperature. The response time was about 10 s and recovery time, resistance with was about 85 s for the upright-standing ZnO nano-sheets ammonia gas sensor, which was considerably smaller than the sensors of metal oxides operating at high temperatures [1-4, 22]. Here, response of the sensor was increased with increase in gas concentration. Fig.2 (b) shows the change in room temperature ammonia sensing behavior of ZnO nano-sheets as a function of gas concentration. It may be due to the electrons

transfer from the adsorbed ammonia molecules at RT in the ZnO nano-sheets and hence the enhanced the response ($R_{\text{gas}}/R_{\text{air}}$).

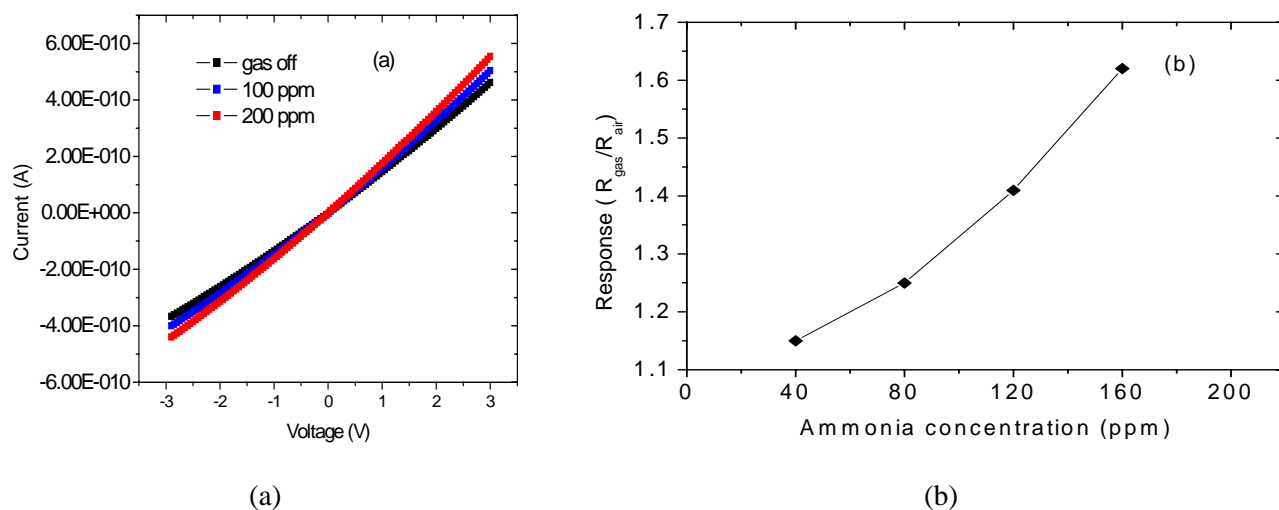


Fig. 2. (a) I-V and (b) response time characteristics of ZnO nano-sheets with different ammonia concentrations.

4. Conclusions

In short, ZnO upright-standing room temperature operating resistive ammonia gas sensor was fabricated. Due to the nanoplate morphology, the XRD pattern of ZnO presented here was free from the commonly observed (002) peak. From the scanning electron microscopy and transmission electron microscopy images, nano-regim dimensions of these platelets were noticed ($\sim 2\text{-}5\ \mu\text{m}$ in length, $\sim 100\text{-}150\ \text{nm}$ in width and $\sim 1150\ \text{nm}$ in height). Furthermore, when ZnO upright-standing nano-sheets were explored in ammonia gas, concentration dependent behavior due to increase in adsorption was noted.

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References

- [1]. D. E. Williams, *Sens. Actuators B*, 57, 1999, p. 1.
- [2]. N. Barsan, M. Schweizer-Berberich, W. Gopel, *J. Anal. Chem.*, 365, 1999, p. 287.
- [3]. G. Korotcenkov, *Sens. Actuators B*, 2005, p. 209.
- [4]. M. Egashira, Y. Shimizu, Y. Takao, S. Sako, *Sens. Actuators B*, 35, 1996, p. 62.
- [5]. Sun-Ki Min, Rajaram S. Mane, Oh-Shim Joo, T. Ganesh, Byung Won Cho, Sung-Hwan Han, *Current Applied Physics*, In Press, 2008.
- [6]. D. J. Goyal, C. Agashe, M. G. Takwale, B. R. Marathe, V. G. Bhide, *J. Mater. Sci.*, 27, 1992, p. 4705.
- [7]. S. Ezhilvalavam, T. R. N. Kutty, *Mater. Chem. Phys.*, 49, 1997, p. 258.
- [8]. M. L. de la Olvera, R. Asomoza, *Sens. Actuators*, 45, 1997, p. 49.
- [9]. X. Jiaqiang, C. Yuping, C. Daoyong, S. Jianian, *Sens. Actuators B*, 113, 2006, p. 526.
- [10]. V. R. Shinde, T. P. Gujar and C. D. Lokhande, *Sens. Actuators B*, 120, 2007, p. 551.
- [11]. M. Law, L. E. Greene, J.C. Hohson, R. Saykally, P. Yang, *Nature*, 4, 2005, p. 455.

- [12].R. S. Mane, W. J. Lee, H. M. Pathan, S. H. Han, *J. Phys. Chem.*, B, 109, 2005, p. 24254.
[13].J. B. Baxter and E. S. Aydil, *Solar Energy Mater. Solar Cells*, 90, 2006, p. 607.
[14].A. B. Kashyout, M. Soliman, M. El Gamal, M. Fathy, *Mater. Chem. Phys.*, 90, 2005, p. 230.
[15].X. L. Zhang, Y. H. Kim, Y. S. Kang, *Curr. Appl. Phys.*, 6, 2006, p. 796.
[16].H. Zhong, J. Wang, M. Pan, S. Wang, Z. Li, W. Xu, X. Chen, W. Lu, *Mater. Chem. Phys.*, 97, 2006, p. 390.
[17].S. He, H. Maeda, M. Uehara, M. Miyazaki, *Mater. Lett.* 61, 2007, p. 626.
[18].M. Wang, C.-H. Ye, Y. Zhang, G. M. Hua, H. X. Wang, M. G. Kong, L. D. Zhang, *J. Cryst. Growth*, 291, 2006, p. 334.
[19].W. Lili, W. Youshi, S. Yuanchang, W. Huiying, *Rare Metals*, 25, 2006, p. 68.
[20].X. Wang, J. Song, Z. L. Wang, *Mater. Phys. Lett.*, 424, 2006, p. 86.
[21].K. Kakiuchi, M. Saito, S. Fujihara, *Thin Solid Films*, 516, 2008, p. 2026.
[22].X. J. Huang, Y.K Choi, *Sens. Actuators B*, 122, 2007, p. 659.
[23].R. S. Mane, W. J. Lee, C. D. Lokhande and S. H. Han, *Curr. Appl. Phys.*, 8, 2008, p. 549.
[24].R. S. Mane, S. J. Roh, S. H. Han, *Chem. Lett.*, 34, 2005, p. 536.

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Guide for Contributors

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Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In addition, some special sponsored and conference issues published annually.

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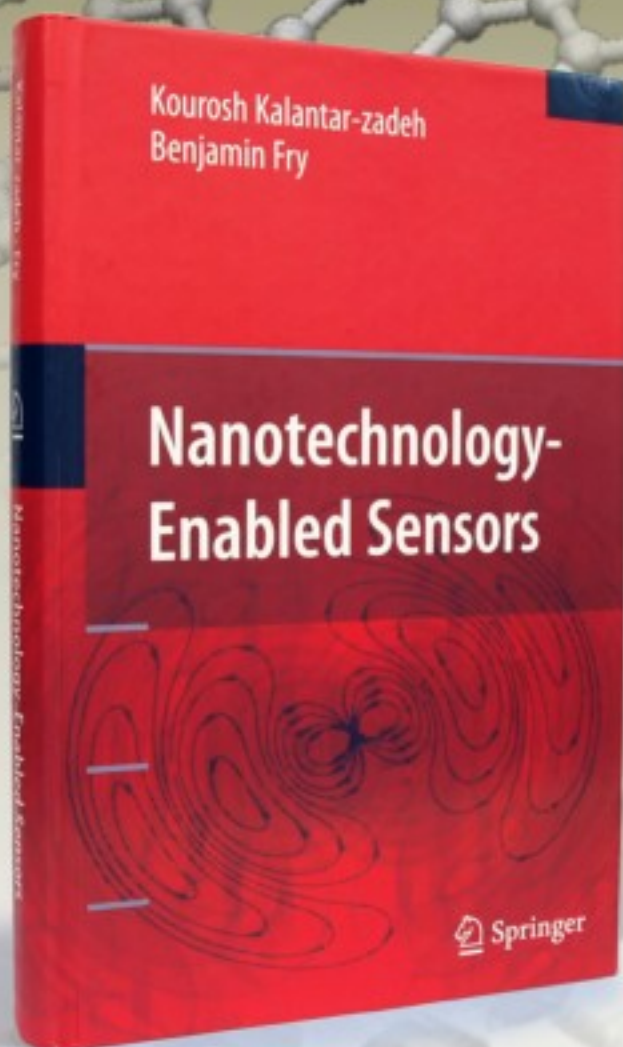
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- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
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