Malaysian Journal of Microscopy Vol.8 (2012) pg. 110-113

THE EFFECT OF THE DIFFERENT TYPES OF CRUCIBLES ON ZnO NANOSTRUCTURES

A.Abd Rahman[1], R.Rusdi [2,3],N.Badar[2,3], K.Elong[2,3], N.Kamarulzaman [2,3]

[1]Centre for Foundation Studies in Science, University of Malaya, 50603 Kuala Lumpur, Malaysia
[2]Centre for Nanomaterial Research, Institute of Science, Level 3 Block C, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[3]Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

ZnO is one of the materials that can be obtained in a variety of morphologies. Synthesis substrates play an important role in affecting the characteristics of nanostructures. This work explores the effect of the types of crucibles used for the annealing process on the morphology of the ZnO. The ZnO nanostructures were synthesized by the sol-gel method. The ZnO precursors obtained were annealed in different types of crucibles using identical conditions, at 300°C for 3 hours. ZnO nanostructures were examined under a Scanning Electron Microscope (SEM) for morphological studies. Results showed that the morphology of ZnO nanorods obtained from the quartz crucible forms uniformly shaped ZnO nanorods of average aspect ratio of 22.9. However, the ZnO nanostructure obtained from the aluminium silicon oxide crucible were made up of an average aspect ratio of 16.8. The different morphologies was attributed to the different surface morphologies of the crucible surfaces as seen under a SEM. The surface of the quartz crucible was much smoother than that of the aluminium silicon oxide crucible. The smoothness of the substrates influenced the crystal growth of the ZnO nanorods whereby the rough and irregular surface of the aluminium silicon oxide crucible truncated the growth of the ZnO rods, thus producing a lower average aspect ratio.

Keywords: ZnO nanorods, sol-gel, quartz crucibles, aluminium silicon oxide

INTRODUCTION

In recent years, ZnO has been extensively studied because of its many distinguished and promising applications in electronics, optics and photonics. For example, in piezoelectric and wireless devices [1], optoelectronics [1-5], sensors [6], solar cells [7] and others. This is largely due to ZnO exhibiting a direct band gap of 3.37 eV at room temperature with large exciton energy of 60meV. These applications are due to the many unique properties of ZnO which depend closely on the microstructures of the material including crystal sizes, aspect ratio as well as surface area and morphology having a crucial role in many of these applications.

Synthesis substrates affect the growth morphology of ZnO nanostructures. This paper reports the effect of two different types of crucibles used in the annealing process; an aluminium silicon oxide crucible and a quartz crucible. The structural and morphological properties of the synthesized ZnO nanopowder were characterized by X-Ray Diffraction (XRD) and Scanning Electron Microscope (SEM)

METHOD AND MATERIALS

Preparation of materials

ZnO nanostructures were synthesized by the sol-gel method. All chemicals used were reagent grade of purity above 99% and used directly without further treatment. Zinc acetate hydrate (Fluka, 99.5% purity) was first stirred in absolute alcohol (HmbG, 99.98% purity) to form a cloudy mixture. Oxalic acid (Fluka, 99.5% purity, 1M solution) was added until the final white gel has a pH of 4. The gel was slow dried and the white precursor material was annealed in two different types of crucibles at 300 °C for 3 hours.

Material characterization

The annealed samples were checked for phase purity using the powder X-Ray diffractometer, PANalytical X'pert Pro MPD. The Bragg-Brentano optical configuration and CuK_{α} radiation were used in the measurement. Scanning electron microscope (SEM), Jeol JSM- 7600 F was used for the morphological and particle size studies and the estimation of the aspect ratio of the nanostructures.

**Corresponding author: Tel. + 6(03)79675800;*
E-mail : azilahar@um.edu.m y,roshidahrusdi@yahoo.com,

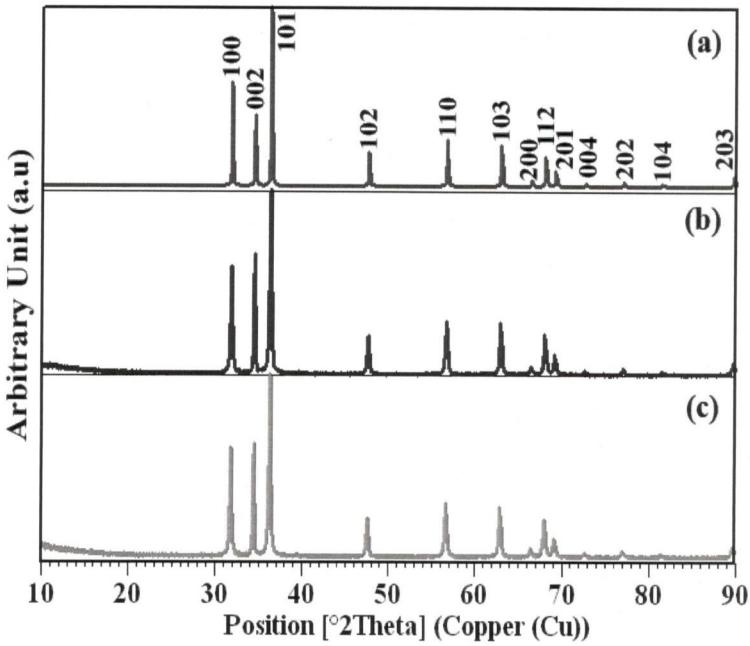

Fig. 1. XRD of (a) reference pattern pattern of ZnO (ICDD reference no: 01-089-7102), (b) nano ZnO annealed in quartz crucible and (c) nano ZnO annealed in aluminium silicon oxide.

RESULTS AND DISCUSSION

Fig.1 shows the XRD patterns at room temperature for the reference pattern of ZnO (ICDD reference no: 01-089-7102) and the samples annealed in a quartz crucible and an aluminium silicon oxide crucible. The XRD patterns show that the samples formed the wurtzite structure with hexagonal crystal symmetry, and are phase pure with no impurity peaks present. The relative intensity of (002) peak is higher in for the ZnO annealed in the quartz crucible than in the aluminium silicon oxide crucible. In both samples the relative intensities of the (002) peaks to the (100) peaks are also higher than those in the reference pattern. This implies that there is a preferred orientation in the [002] direction. This will be duly confirmed by SEM results.

The SEM micrographs for the surface of the two types of crucibles; quartz and aluminium silicon oxide in Figure 2 show the surface of the quartz crucible is smoother than that of the aluminium silicon oxide crucible. The surface of the crucibles act as substrates and the growth of ZnO nanostructures are affected by the micrograins on the surface of the substrate [8-9]. It is found by visual inspection that the quartz crucible has a very smooth surface compared to the aluminium silicon oxide crucible. On further investigation of the surface morphology using field emission SEM (Figure 2(a) and (b)), it can be seen that the surface roughness in the aluminium silicon oxide crucible is higher. This may have influenced the formation of the seed crystals and results in bigger diameter of the nanorods for the sample annealed in the aluminium silicon oxide crucible. The surface of the quartz crucible is very smooth and this may have resulted in smaller seed crystals formed during the heating process giving ZnO nano wires with large aspect ratio.

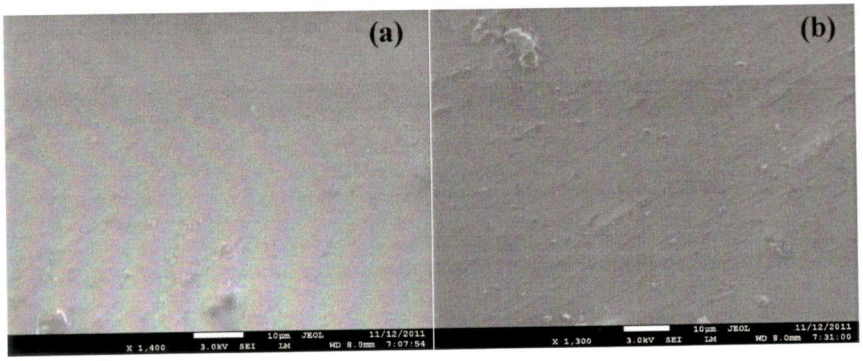

Fig. 2. SEM micrographs of the surface of (a) quartz crucible and (b) aluminium silicon oxide crucible

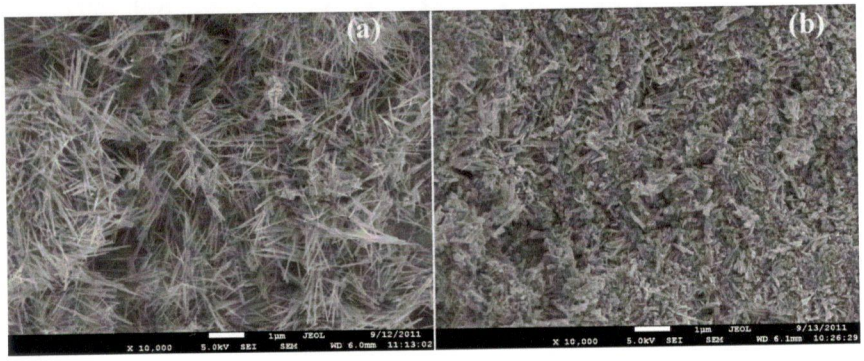

Fig. 3. SEM micrographs of ZnO nanorods annealed at 300 °C for 3h in (a) quartz crucible and (b) aluminium silicon oxide crucible

Fig. 3 shows the micrographs of the ZnO samples; (a) annealed in the quartz crucible and (b) in the aluminium silicon oxide crucible. The ZnO nanorods in (a) consists of uniformly long and thin structures whilst those in (b) a mixture of thick and short structures. The former has an average aspect ratio of 22.9 and the latter was found to have an average aspect ratio of about 16.8. Thus the rough and irregular surface of the aluminium silicon oxide crucible may have truncated the growth of ZnO nanorods into rods of different aspect ratios.

CONCLUSIONS

ZnO annealed in different types of crucibles yield different ZnO nanostructures. This indicate that the surface of the crucibles act as the synthesis substrate which affect the characteristics of the nanostructures. The smoother quartz crucible gave nanowires of quite high aspect ratio compared to the aluminium silicon oxide crucible.

ACKNOWLEDGEMENTS

The authors would like to thank The Institute of Science, Universiti Teknologi MARA and the University of Malaya (grant RG016/09 AFR) for all their technical assistance and financial support in this work.

REFERENCES

[1]. M. Willander, Q.X. Zhao, Q.H. Hu, P. Klason, S.M. Al-Hilli, O. Nur, Y.E. Lozoik, Fundamentals and properties of zins oxide nanostructures: optical and sensingapplications, *Superlattices Microstructures* 43(2008) 352-361.

[2]. T.Sahoo, S.K. Tripathy, Y.T.Yu, H.K. Ahn, D.C. Shin, L.H. Lee, Morphology and crystal quality inverstigation of hydrothermally synthesized ZnO micro rods, *Mater.Res. Bull.*43 (2008) 2060-2068.

[3]. M.Calgar, S. Ilican, Y. Calgar, F. Yakuphonoglu, Electrical conductivity and optical properties of ZnO nanostructured Thin File, *Mater. Chem Phy.* 114 (20090 194-198.

[4]. Y. Tong, J. Cheng, Y. Liu, G.G. Siu, Enhanced photocatalytic performance of ZnOhierarchical nanostructures synthesied via a two- temperature aqueus solution route, *Scr. Mater.* 60 (2009)1093-1096.

[5]. M.A. Mastro, J.A. Freitas Jr., C.R. Eddy Jr.,F. Kub, J. Ahn, H.Y. Kim, J. Kim,

Luminescence characteristics of zinc oxide nanocrystals deposited on glass via solution method. *Physica E.* 41 (2009)487-489.

[6]. R.Y. Hong, J.H. Li, I.I. Chen, D.Q. Liu, H.Z. Li, Y. Zheng, J. Ding, Synthesis, surface modification and photocatalytic property of ZnO nanaoparticles, *Powder Technol.* 189 (2009) 426-432.

[7]. Y.J. Lee, D.S. Ruby, D.W. Peters, B.B. McKenzie and J.W.P. Hsu, ZnO nanostructures as efficient antireflection layers in solar cells. *nano Lett*, 8 (2008) 1501-1505.

[8]. Zhong, Lin, Wang. *J. Phy. Condens. Matter* 16 (2004) R829-859.

[9]. Jinghai Yang, Jiahong Zheng, Hongju Zhai, Xiangmin Yang, Lili Yang, Yang Liu, Tihui Lang, Ming Gao, Review: orientated growth of ZnO nanostructures on different substrates via a hydrothermal method. *J.of Alloys and Compunds*, Vol 489, Issue ! (2010) 51-55.