STRUCTURAL AND OPTICAL PROPERTIES OF PRECURSOR CONCENTRATION ON ZnO NANORODS ARRAYS BY WET CHEMICAL METHOD

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Introduction

ZnO is very promising for applications in optical devices such as light-emitting diodes and laser diodes with high efficiency, covering blue and ultraviolet ranges, due to its wide band gap of 3.37 eV and large exciton binding energy of 60 meV [1,2]. The large exciton binding energy facilitates low-threshold stimulated emission in ZnO via excitonic recombination, which is a more efficient radiative process than an electron-hole plasma process. Efficient lasing action through excitonic recombination at room temperature has been reported in both ZnO thin films and nanostructures [3-5]. In addition, significant efforts for realization of high-sensitivity nanoscale chemical sensors using ZnO nanostructures have been made [6-8].

During the past several years, various methods have been developed for the synthesis of oriented arrays of ZnO nanorods and nanowires, including vapor–liquid–solid (VLS) [9], metal–organic chemical vapor deposition (MOCVD) [10], template-assisted [11], and solution method [12].

In this paper, we describe the wet chemical method of ZnO nanorods arrays under concentration of precursors. And We try to study suitable ZnO nanorods growth condition to apply to a organic-inorganic hybrid solar cell. We demonstrate that the concentration of precursors have influence on the morphology and optical properties, growth density and its distribution of the arrayed ZnO nanorods can be effectively controlled by using suitable conditions.

Experimental

The substrate used in our experiment included indium tin oxide (ITO) glass and ITO PES. In our experiment procesure, a substrate was coated with a droplet of 0.01M zinc acetate dehydrate[$Zn(CH_3COO)_2 \cdot 6H_2O$] aqueous solution, and blown N_2 gas and then annealed at 100℃ for 10min. This coating step is repeated 5 times to get high seed density.

Then the precursor solutions were prepared by mixing zinc nitrate hexahydrate [$Zn(NO_3)_2 \cdot 6H_2O$] with hexamethylentetramine while keeping their volume ratio at 1:1. ZnO nanorods were grown in 250mL of 0.025M~ 0.5M aqueous solution of $Zn(NO_3)_2 \cdot 6H_2O$ and HMT in beaker on hot plate and heated 95℃. After washing several times with de-ionized water and drying at 100℃ on hot plate. To characterize the ZnO nanorods, field emission scanning electron microscope (FE-SEM) were used to investigate the surface morphology of the sample. The optical properties were obtained by UV-Vis spectroscopy.

Results and Discussion

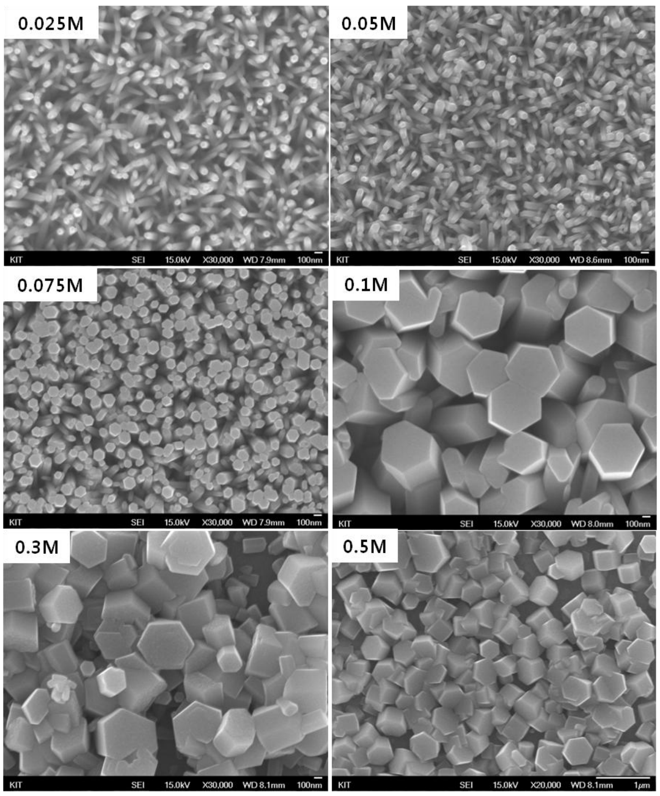

Fig. 1 SEM images of ZnO nanorods grown on ITO glass with different concentration of precursors.

Fig.1 is the FE-SEM photograph which observed the ZnO nanorod surface and section morpology to various concentration of precursors. While concentration of precursors increases, nanorod diameters increased a little. ZnO nanorod having comparatively uniform size was grown by the density of low 0.025M and 0.05M, we were able to observe nanorods of an irregular morpology by the comparatively high density from 0.075M to 0.5M.

For such a reason, Vayssieres [13] reported the formation of ZnO microrods on unmodified substrates and found that the width of ZnO rods can be reduced from 1–2 mm to100–200 nm by lowering the overall concentration of the reactant while keeping the ratio of Zn2+ to amine constant at 1:1 [14]. Since the substrates used in our work were premodified with ZnO nanoparticles and the nanoparticles have a great influence on the diameter of the ZnO rods, it is necessary to investigate the effects of precursor concentration on the size of ZnO nanorods grown on modified substrates.

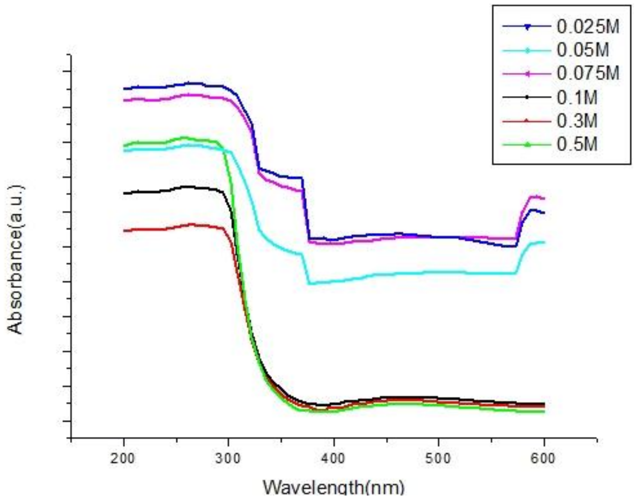

Fig. 2 UV-Vis spectroscopy of the ZnO nanorods grown on ITO glass with different concentration of precursors.

Fig.2 is an UV-Vis spectroscopy graph to examine an optical characteristic of ZnO nanorod grown with different concentration of precursors. Strong peak appears in ultraviolet ray area, and very weak peak appears in visible ray area.

Conclusion

In summary, we studied it for a structural optical characteristic of ZnO nanorod by concentration of precursors. It has been demonstrated that the concentration of precursors have a influence on ordering of ZnO nanorod arrays. The substrate annealing is crucial for the improvement of alighment ordering of ZnO nanorod arrays. The concentration of precursors can influence the nanorod size to some extent.

Reperences

[1] K. Hummer, Phys. Stat. Sol. B 56, 249 (1973).
[2] A. Mang, K. Reimann and St. Ruhenacke, Solid State Commun. 94, 251 (1995).
[3] D. M. Bagnall, Y. F. Chen, Z. Zhu, T. Yao, M. Y. Shen and T. Goto, Appl. Phys. Lett. 73, 1038 (1998).
[4] A. Ohtomo, K. Tamura, M. Kawasaki, T. Makino, Y. Segawa, Z. K. Tang, G. K. L. Wong, Y. Matsumoto and H. Koinuma, Appl. Phys. Lett. 77, 2204 (2000).
[5] M. H. Huang, S. Mao, H. Feick, H. Yan, Y. Wu, H. Kind, E. Weber, R. Russo and P. Yang, Science 292, 1897 (2001).
[6] Q. H. Li, Q. Wan, Y. X. Liang and T. H. Wang, Appl. Phys. Lett. 84, 4556 (2004).
[7] Z. Fan, D. Wang, P. Chang, W. Tseng and J. G. Lu, Appl. Phys. Lett. 85, 5923 (2004).
[8] P. Feng, Q. Wan and T. H. Wang, Appl. Phys. Lett. 87, 213111 (2005).
[9] M.H. Huang, Y.Y. Wu, H. Feick, N. Tran, E. Weber, P.D. Yang, Adv. Mater. 13(2001) 113–116.
[10] K.S. Kim, H.W. Kim, Phys. B: Condens. Matter 328 (2003) 368–371.
[11] Y. Li, G.W.Meng, L.D. Zhang, F. Phillipp, Appl. Phys. Lett. 76 (2000) 2011–2013.
[12] L. Vayssieres, Adv. Mater. 15 (2003) 464–466.
[13] L. Vayssieres, K. Keis, S.-E. Lindquist, A. Hagfeldt, J. Phys.Chem. B 105 (2001) 3350–3352.
[14] L. Vayssieres, Adv. Mater. 15 (2003) 464–466.