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Zinc oxide nanostructures by wet oxidation of zinc thin film for hybrid solar cells

○Jennifer Damasco Ty[1], Christian Mark O. Pelicano[2], Donnabelle Balela[2], and Hisao Yanagi[1]

[1]Graduate School of Materials Science, Nara Institute of Science and Technology, 8916-5 Takayama, Ikoma, Nara 630-0192, Japan

[2]Department of Mining, Metallurgical, and Materials Engineering, University of the Philippines-Diliman, 1101 Quezon City, Philippines

E-mail: d-torres@ms.naist.jp

Zinc oxide (ZnO) is a promising semiconductor material for optoelectronic devices. Due to its wide range of useful properties, numerous devices from light-emitting diodes to gas sensors have been developed. ZnO can be grown by a variety of techniques such as hydrothermal method, chemical vapor deposition, and magnetron sputtering among others. However, these methods, in particular for nanostructured ZnO, involve reaction systems such as toxic reagents, elevated temperature, and costly equipment. The challenge now is to develop a simple and economical technique for the synthesis of ZnO nanostructures.

In this work, we demonstrate the growth of ZnO nanostructures from a metallic Zn thin film at low temperatures using wet oxidation in water. Previous work on wet oxidation showed the effect of water vapor on ZnO formation [1]. Also, Tan et al. reported the influence of growth time on ZnO nanostructures using hot water oxidation of Zn foils [2]. Herein, the Zn thin film precursor was deposited on fluorine-doped tin oxide substrates by vacuum deposition. The substrates are then immersed in 90°C water for 6h and 16h to investigate the effect of growth time on the resulting morphologies of ZnO nanostructures.

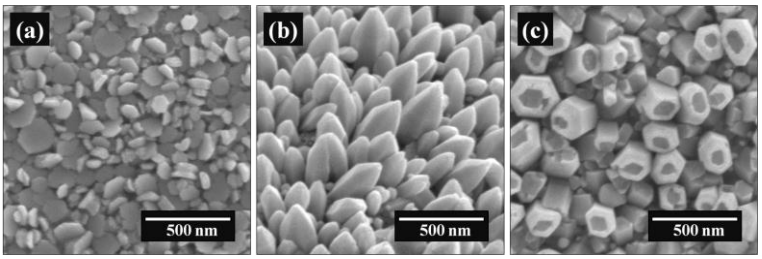

Fig.1 SEM image of (a) vacuum-deposited Zn film and (b) ZnO nanorods and (c) nanotubes after wet oxidation for 16h.

The deposited Zn thin film initially looks metallic and has a reflective surface. After wet oxidation, the thin film becomes transparent. At this point, the Zn thin film is converted to ZnO. Figure 1(a) shows that the metallic Zn thin film is composed of hexagonal-like structures. ZnO nanoparticles having about 150 nm diameters are grown after wet oxidation for 6h. At a longer oxidation time of 16h, the zinc is converted into ZnO nanorods having about 180 nm diameters, as shown in Fig. 1(b). In some parts of the film, nanotube structures were obtained, as seen in Fig. 1(c). This simple method for a variety of nanostructured ZnO in transparent films at a low temperature process could pave the way to future flexible optoelectronic devices such as hybrid solar cells based on substrates with low thermal stability.

References:

[1] R. Chen, C. Zou, X. Yan, A. Alyamani, W. Gao, Thin Solid Films 519 (2011) 1837–1844

[2] Wai Kian Tan et al., Materials Letters, 91 (2013) 111–114