ZnO Nanorods Grown on ZnO Seed Layer Derived by Atomic Layer Deposition Process

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Nanostructures and nanomaterials have attracted extensive attention due to their importance in understanding the fundamental their physical, chemical electrical and optical properties, and their extensive potential applications in microelectronic and optoelectronic devices. Compared to their counterpart bulk materials, nanoscale materials demonstrate remarkably different properties because of their higher surface to-volume ratio and because of their quantum confinement effects as well.

ZnO nanstructures have attracted extensive research attempts for their multifunction properties and versatile applications in spintronics, gas and biological sensors, solar cells, catalysts, electronics, piezoelectric devices and high-efficiency short-wavelength optoelectronic nanodevices owing to their wide band-gap (3.37 eV) with large excitonic binding energy (≈60 meV), high mechanical and thermal stabilities, and good electrical conductivity while being piezoelectric and optically transparent [1,2].

Growth of various one–dimensional (1D) ZnO nanostructures, such as nanorods, nanowires and nanobelts has been reported using various growth methods. However, it is still a significant challenge to obtain controllable growth of ordered nanorods for specific device applications, such as in solar cells, nano-lasers, optical storage, nanoscale heterojunctions, sensors and detectors etc. Various methods have been utilized to grow ZnO nanorods on different substrates.

Among all the available numerous methods, hydrothermal growth of ZnO nanorods is the most energy-efficient and economical, environmentally friendly and does not require a complex vacuum system. In this work, we report on hydrothermal growth of well-aligned ZnO nanorods perpendicularly oriented on substrates. ZnO seed layers were prepared on indium tin oxide (ITO) glass by atomic layer deposition (ALD). In the ALD process, the Dimethyl zinc and water were used as precursors. The growth temperature of ZnO seed layer was 250^{o}C. The N2 was used as a carrying gas with a follow speed of 20 sccm. The ZnO layers were annealed at 350^{o}C for 30 minutes after ALD process. The ZnO nanorods were achieved as nanostructures from a fine grain ZnO seed layer by means of heating an aqueous solution of zinc nitrate hexahydrate and hexamethylenetetramine in a water bath at low temperature in the range of 65-90^{o}C as shown in Figure 1 and 2.

The physical and structural properties of samples are also discussed. The crystal structure of ZnO was analyzed by X-ray diffraction (XRD). ZnO nanorods morphology was inspected using a field emission scanning electron microscopy (FE-SEM) and ZnO seed layer was investigated by atomic force microscopy (AFM). The morphology and microstructure of the ZnO nanorods was characterized by high resolution transmission electron microscopy (HR-TEM).

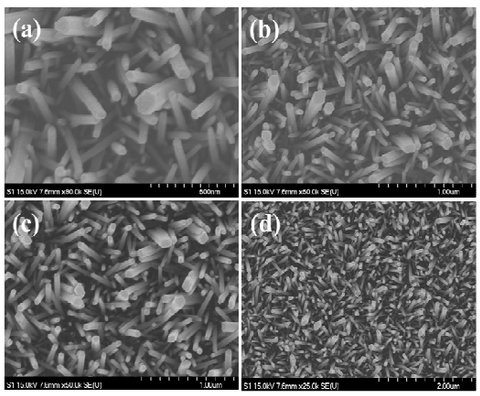

Figure 1: FE-SEM images of morphology aligned ZnO nanorods grown on ITO glass.

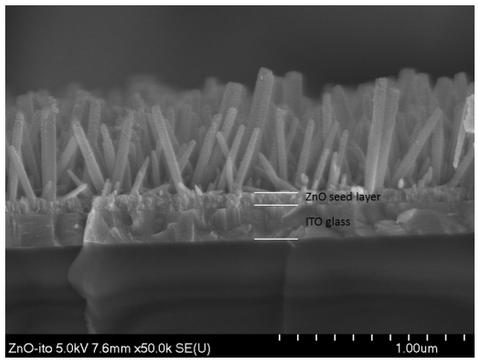

Figure 2: FE-SEM images of cross-section of ZnO nanorods grown on ITO glass.

References:

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2. O, Akhavan, M. Mehrabian, K. Mirabbaszadeh, R. Azimirad, J. Phys. D: Appl. Phys. 42, 225305 (2009)