SUPPORTING INFORMATION

A General Low-Temperature Route for Large-Scale Fabrication of Highly Oriented ZnO Nanorod/Nanotube Arrays

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Experimental

Materials. A sintered ceramic target of ZnO (Aldrich, 99.99%) was employed as source materials for preparing ZnO films. Formamide (99.5%, Aldrich) was used without further purification. Zinc foils (99.9%, Aldrich) with a thickness of 0.127 mm were ultrasonically washed in absolute ethanol before use.

Preparation of ZnO film-coated substrates. ZnO films were deposited on glass substrate by radio frequency magnetron sputtering at a base pressure of $1 \times 10^{-4}$ Pa using a ZnO target. The partial pressure of argon in the sputtering gas mixture of argon and oxygen was remained at ~ 0.1 Pa during the film deposition. The ZnO films were deposited at room temperature and the thickness of the films was controlled at ~ 150 nm. Under such a growth condition, the growth rate of the ZnO film was ~ 3.3 nm/min.

Growth of hexagonal ZnO nanorods and nanotubes. One ZnO film-coated substrate and two $7 \times 7$ mm zinc foils were immersed in 3 mL of 5% formamide aqueous solution (v/v) in a 10 mL sample vial. The reaction was kept at a constant temperature of 65 °C in a laboratory oven for 24 h. Afterwards, the substrates were taken out and washed with ethanol, and then allowed drying in air at room temperature for further characterization. The grown ZnO nanorods were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and high-resolution TEM (HR-TEM). The photoluminescence (PL) measurement was performed at room temperature using He-Cd laser line of 325 nm as an excitation source.
Figure 1s. Structural characterizations of ZnO nanorod arrays. (A) XRD pattern of the as-grown ZnO nanorod array and (B) TEM image of the ZnO nanorod. The bright-field TEM image of the ZnO nanorod shows a uniform rod-like shape with the typical diameter and length of ~ 100 nm and 1 µm, respectively.
Figure 2s. SEM images for the temporal growth of ZnO nanorods on ZnO film-coated substrates after (A) 6, (B) 12, (C) 18, and (D) 24 h of reaction, respectively. After 6 hours of reaction, ZnO nanoparticles with a mean diameter of ~100 nm were grown on the ZnO-film coated substrate. After 12 hours of reaction, nanorods with small diameters grown from these seeds were observed. After 18 hours, short and faceted hexagonal nanorods were grown homogeneously on the substrate. And with extended reaction to 24 hours, the whole substrate was covered by well-oriented nanorods with high density and uniform diameters.
Figure 3s. Crystal habit of wurtzite ZnO hexagonal rod and tube.