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Growth of Single-Crystalline ZnO Nano-/Microstructures: Vertically Aligned Nanowires on ZnO/Si Substrate and Microtubes on Al_2O_3 Substrate

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The control of the shape and the orientation of zinc oxide (ZnO) nano-/microcrystallites with various morphologies such as wire, rod, belt and tube have attracted much attention because of their great potential for fundamental studies of the effects of morphology, dimensionality, and size on their physical and chemical properties [1-4]. ZnO, which has a direct band gap of 3.37 eV and large exciton binding energy of 60 meV, can realize practical applications in the area of nanoscale laser diodes, sensors, varistors and so on. Here, we demonstrate that vertically grown ZnO nanowires and high-quality ZnO microtubes can be fabricated on ZnO/Si substrate and Al_2O_3 substrate using a simple vapor phase deposition method, respectively.

Fig. 1 shows SEM and TEM images of the vertically grown ZnO nanowires, revealing that the synthesized ZnO nanowires are well-aligned on ZnO/Si substrate. The ZnO nanowires have diameters of several tens nanometers and lengths of several micrometers. From SEM and TEM results, we found that the quality of the ZnO nanowires are affected by the quality, preferred orientation and grain size of the ZnO film on Si substrate. In addition, we discuss the optical properties and field emission properties of the vertically aligned ZnO nanowires on ZnO/Si substrate.

Typical SEM images of the synthesized ZnO microtubes are shown in Fig. 2. The SEM images reveal that the ZnO crystals with tubular shape are synthesized in a large scale. The ZnO tubular structures have outer diameters in the range of 0.3-2 μm, wall thickness in the range of 100-500 nm. The magnified SEM images show that the ZnO microtubes have a clear hollow cavity and a faceted hexagonal shape (inset of Fig. 2). From more SEM observations, we found that there were many incomplete ZnO microtubes, which showed the special morphology assembled with several nanowires. The side-viewed SEM images of the various morphologies of tips of the incomplete microtubes are shown in Fig. 3a-c, and the top-viewed SEM image is also shown in Fig. 3d. We suggest that the ZnO microtubes are formed by the coalescence of neighboring nanowires grown on a large individual ZnO grain on the Al_2O_3 substrate.

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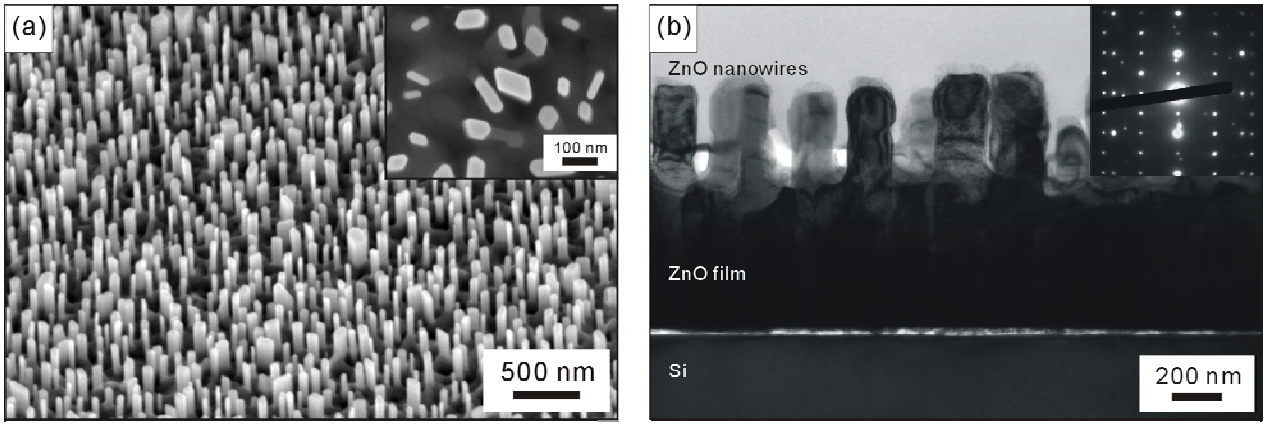

FIG. 1. (a) SEM and (b) TEM images of the vertically aligned ZnO nanowires on ZnO/Si substrate.

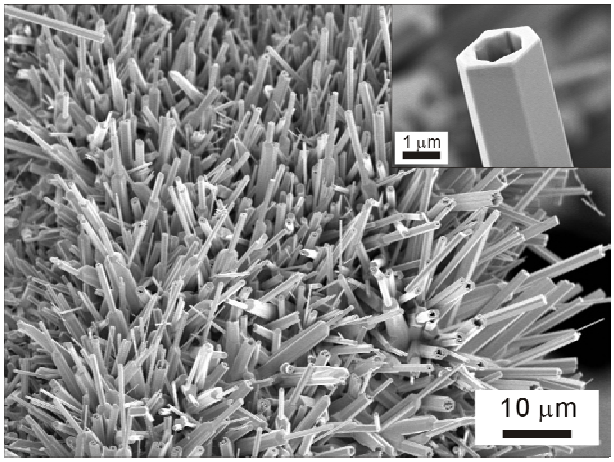

FIG. 2. Typical SEM image of the synthesized ZnO microtubes.

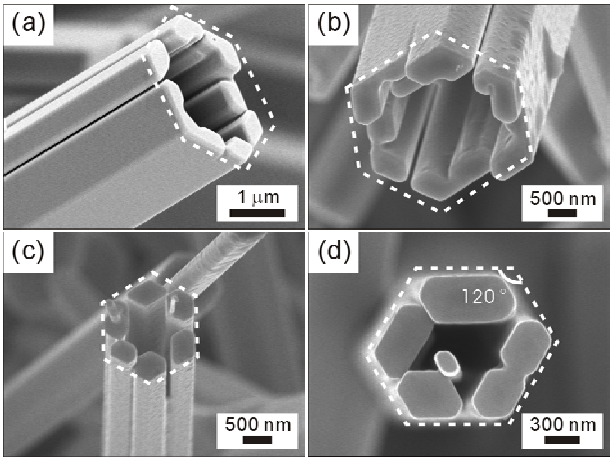

FIG. 3. SEM images of the ZnO microtubes with the morphology assembled with several nanowires.

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