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Gold Catalyzed Growth of Three-dimensional Hierarchical ZnO Nanobelts

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The wide band-gap (3.37 eV), semiconducting ZnO has many important technological applications in photonics, optoelectronics, photovoltaics, energy storage, sensing and catalysis [1]. Although various types of ZnO nanostructures have been synthesized [2], it is still a challenge to reliably synthesize large amount of ZnO nanostructures with high-surface area and controlled surface properties. In order to utilize the unique properties of ZnO nanostructures for practical applications, especially for applications in catalysis, our group has been developing synthesis protocols that can generate large quantities of ZnO nanostructures with defined surface properties for applications in energy, sensing and drug delivery. Here, we report a new synthesis route to grow high-density and high-surface area 3D hierarchical ZnO nanobelts.

The 3D hierarchical ZnO nanobelts were synthesized in a high temperature tube furnace. The experimental setup was similar to the synthesis of ZnO nanobelts as reported in literature [3]. We used the pre-synthesized ZnO tetrapods, coated with Au nanoparticles, as the seed to grow ZnO nanobelts. Fig. 1 is a low magnification SEM image of the ZnO tetrapods dispersed onto the alumina substrate. The whole assemble was put into the tube furnace to collect ZnO nanostructures. We expected to grow ZnO nanobelts on the surfaces of the ZnO tetrapods.

Figure 2a shows a low magnification SEM image of the synthesized material. It can be clearly seen that all the tetrapod seed crystals were covered with various sizes of ZnO nanobelts after the synthesis process. Figure 2b shows an individual tetrapod decorated with ZnO nanobelts on all of its four legs. The sizes of the ZnO nanobelts vary significantly, ranging from 0.5 to 5 micrometers in width and 2 to 20 micrometers in length; the average thickness of the ZnO nanobelts is about 25 nm. The growth direction of most of the ZnO nanobelts is perpendicular to the surfaces of the ZnO tetrapod as shown clearly in Fig. 2c. High resolution backscattered electron images and TEM images revealed that small Au nanoparticles were located at the tips of all the ZnO nanobelts, suggesting that the Au nanoparticles acted as a catalyst to facilitate the secondary growth of the 3D hierarchical ZnO nanobelts on the surfaces of the original ZnO tetrapod crystals. Figure 3 shows schematic diagrams illustrating the Au catalyzed growth processes of the ZnO nanobelts on the original ZnO tetrapods. Detailed growth processes and the morphology dependence on the experimental parameters will be discussed [4].

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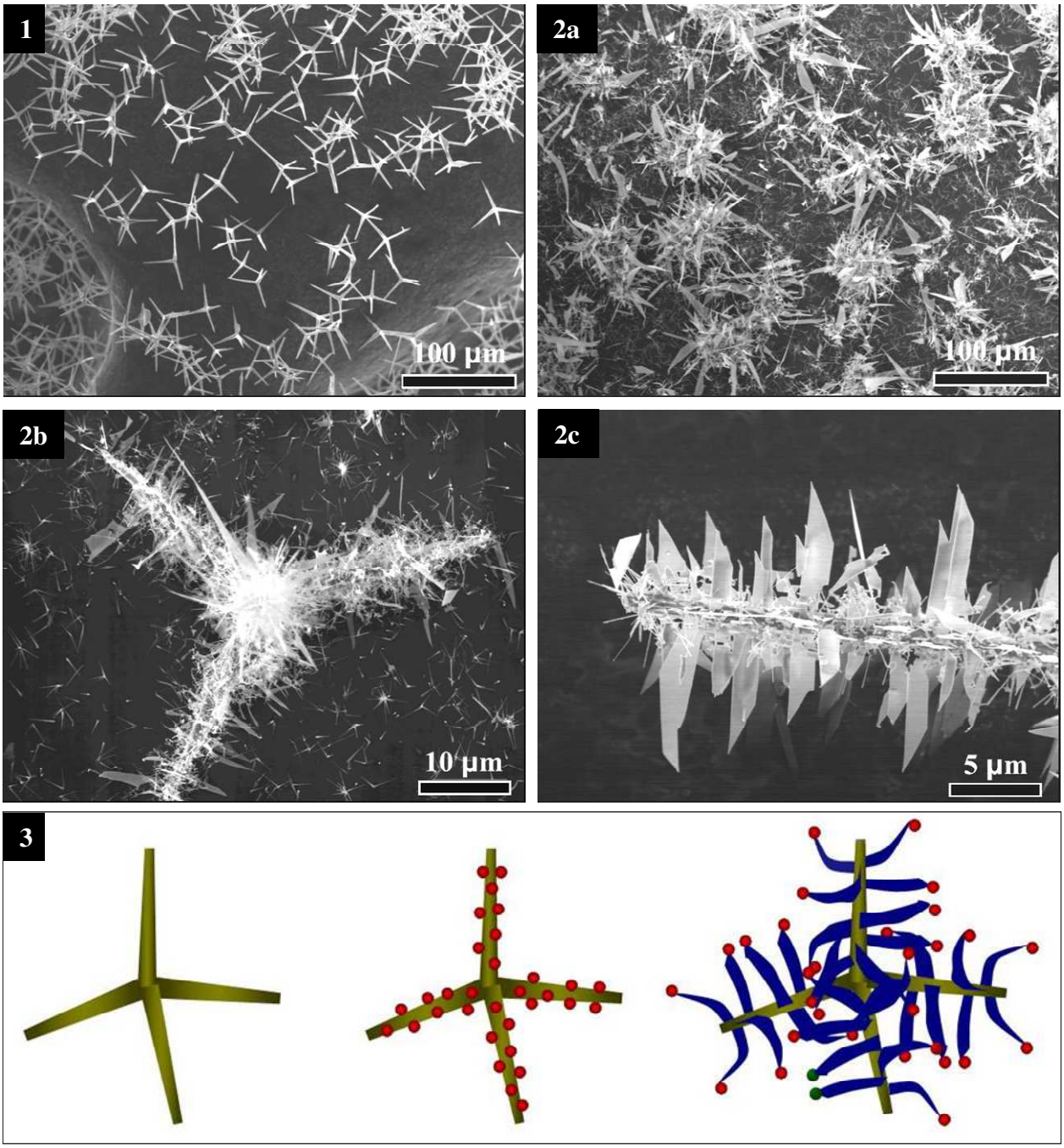

Fig.1. Low magnification SEM image shows the ZnO tetrapods coated with Au nanoparticles.

Fig.2. Low magnification SEM image (a) shows the growth of 3D hierarchical ZnO nanobelts grown on the surfaces of ZnO tetrapods, (b) an individual ZnO tetrapod decorated with ZnO nanobelts of various sizes and (c) an individual leg of a tetrapod showing that the growth direction of the ZnO nanobelts is perpendicular to the surface of the ZnO tetrapod.

Fig.3. Schematic diagrams illustrate the original tetrapod (left panel), tetrapod coated with Au (middle panel) and the Au catalyzed growth of 3D hierarchical ZnO nanobelts (right panel).

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