doi:10.1017/S1431927611009500
Microsc. Microanal. 17 (Suppl 2), 2011

Synthesis and Characterization of ZnO/α-Fe_2O_3 Nano-Architectures

William C. Lowes* and Jingyue (Jimmy) Liu**

* Center for Nanoscience and Department of Physics and Astronomy, University of Missouri-St. Louis, St. Louis, MO 63121
*** Center for Nanoscience, Department of Physics & Astronomy, Department of Chemistry & Biochemistry, University of Missouri-St. Louis, MO 63121 (liuj@umsl.edu)

One dimensional nanocomposite materials and complex nano-architectures possess unique physical and chemical properties and may find potential applications in nanoscale electronic devices, photovoltaics, sensing, and nanocatalysts. Alpha-Fe_2O_3 (hematite) nanowires are of interest because of their potential applications in magnetic recording and as catalyst for the dehydrogenation of ethylbenzene to styrene [1]. Moreover, α-Fe_2O_3 composite materials have attracted interest as gas sensors [2]. In this paper, we report the recent successful synthesis of complex ZnO/α-Fe_2O_3 nano-architectures.

The α-Fe_2O_3 nanowires and nanobelts were synthesized by direct thermal oxidation of Fe substrates in a tube furnace [3]. The as-synthesized α-Fe_2O_3 nanowires and nanobelts were then loaded into a tube furnace as the substrate materials. The ZnO source material, located at the center of the tube furnace, was then heated to 1000°C with a flowing gas (mixture of argon and oxygen) which carried the Zn/ZnO molecules to lower temperature regions where they deposited onto the α-Fe_2O_3 nanowires/nanobelts. The substrates occupied a furnace region where the temperature ranged from about 610°C to about 330°C. A field emission SEM equipped with an energy dispersive X-ray spectrometer and a Robinson backscattered electron detector was used to characterize the morphology, composition and size distribution of both the uncoated α-Fe_2O_3 nanowires/nanobelts and the complex ZnO-Fe_2O_3 nano-architectures.

The as synthesized α-Fe_2O_3 nanowires were aligned and grew perpendicular to the substrate with an average length and width of 10.0 μm and 0.3 μm, respectively. After deposition of ZnO, the α-Fe_2O_3 nanowires maintained their original growth directions and were coated with thin nanowires growing almost perpendicular to the α-Fe_2O_3 nanowires (Fig. 1); the as synthesized materials were collected in the temperature region from about 330°C to about 430°C. The average diameter and length of the nanowires is approximately 30 nm and 1.0 μm, respectively; some of the nanowires grew as long as a few micrometers. Figure 2 shows SEM images of the as-synthesized nanostructures collected in the temperature region from about 450°C to about 550°C. In this temperature region, ZnO nanobelt-like structures were observed and they completely coated onto, and grew almost perpendicular to, the α-Fe_2O_3 nanobelts/nanowires. Energy dispersive X-ray spectroscopy (EDS) technique was used to determine the composition of the nanostructures grown on the α-Fe_2O_3 nanobelts/nanowires. Figure 3a shows a SEM image of a α-Fe_2O_3 nanowire coated with small ZnO nanosheets. Fig. 3b displays an EDS spectrum obtained from the small ZnO nanosheet (indicated by the white arrow in Fig. 3a), confirming that the as-synthesized ZnO nanowires/nanosheets contain a significant amount of Fe. Therefore, we have successfully synthesized Fe-doped ZnO nanowires and nanosheets. The detailed growth mechanisms and the compositional analyses of the as-synthesized ZnO/α-Fe2O3 hetero-phase nano-architectures will be discussed [4].

References

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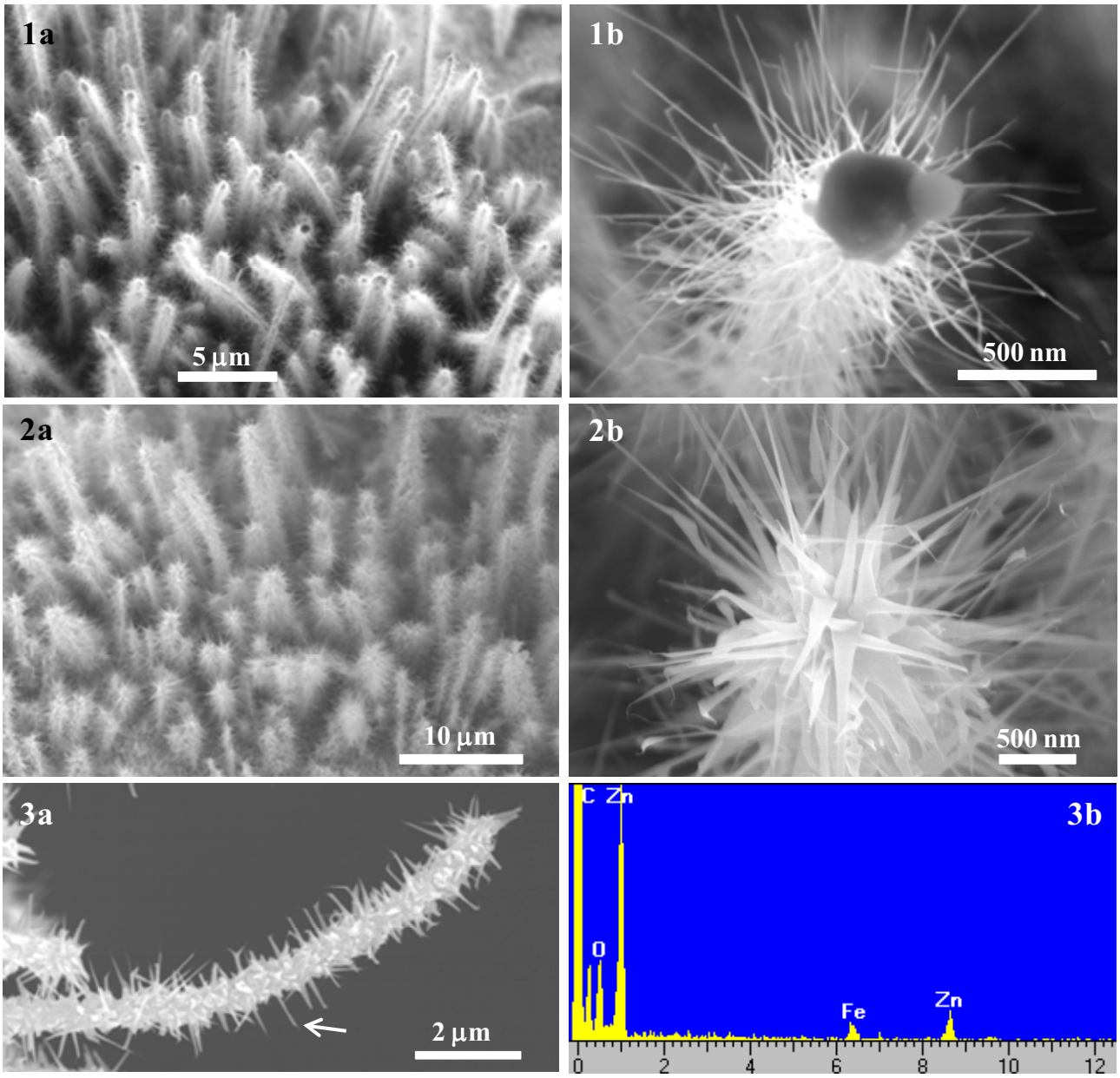

FIG. 1. Low (a) and high (b) magnification SEM images of ZnO nanowires growing almost perpendicular to the original big α-Fe_2O_3 nanowires in the lower temperature region.
FIG. 2. Low (a) and high (b) magnification SEM images of ZnO nanosheets growing almost perpendicular to the original big α-Fe_2O_3 nanowires in the higher temperature region.
FIG. 3 SEM image (a) and the EDS data taken from the small ZnO nanowire (indicated by the white arrow in 3a) showing presence of Fe in the ZnO nanowires.

https://doi.org/10.1017/S1431927611009500 Published online by Cambridge University Press