Synthesis of ZnO Nanowires and Nanobelts by Thermal Evaporation

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ABSTRACT

ZnO nanowires and nanobelts were synthesized by thermal evaporation process using a metallic Zn as a precursors at temperature 1050°C in one atmosphere of air or in one atmosphere of air saturated with water vapor. The diameter of ZnO nanowires vary from 50 nm to 100 nm. The width of the ZnO nanobelts varies from 500 nm to 1500 nm. The scanning electron microscopy and wavelength dispersive X-rays fluorescence instrument are used to characterize the ZnO nanowires and nanobelts.

Key words: ZnO, Nanowires, Nanobelts

INTRODUCTION

Nanostructured materials such as nanowires or nanotubes are very interesting materials due to their unique optical, electrical, superconducting, thermoelectric properties and potential applications in nanodevices (Wang et al., 2002 and Xu et al.,2004). These nanomaterials can be fabricated by many different methods and different growth mechanisms. They can be classified into two different methods: non-catalyst-based and catalyst-based (Li et al.,2004). At the present, ribbon-like nanostructures, nanocake, and nanonet, have been fabricated and their formation mechanisms are different from those of nanowires or nanotubes (Tjong and Chen, 2004). Quasi-one-dimensional systems represent one of the most important frontiers in the advanced materials research (Peng et al., 2003). Because of their restricted size, these structures exhibit novel physical and chemical properties and have opened up a new area of basic research as well as many possible applications in electronic and optoelectronic devices in nanotechnology (Kong et al.,2004). Oxide nanomaterials have great potential for electrical, optical and catalytic application. Considerable efforts have been made to fabricate Oxide nanomaterials such as nanowires and nanotubes (Khan et al., 2006). Zinc oxide has a direct energy gap of 3.37 eV, a large exciton binding energy of 60 meV, and it has the potential to be used in many device applications.

MATERIALS AND METHODS

In this paper, we report the fabrication of ZnO nanowires and nanobelts from metallic Zn through a simple thermal vapor-phase deposition. Metallic Zn (99.99% , Alfa Aesar) were placed in a small ceramic boat and put into the quartz tube which is placed in a horizontal furnace. The position of the ceramic boat is kept in the middle of the tube furnace and heated to temperatures between 650°C and 1050°C in Air. The samples are heated at a specific temperature for one hour and then the power of the furnace is turned off and the sample is cooled inside the furnace. After the furnace had cooled down to room temperature, the ZnO samples were removed from the ceramic boat and characterized by a scanning electron microscope, SEM (JEOL 6400) and a wavelength dispersive X-rays fluorescence instrument, WDXRF (Phillips MagiX).

RESULTS AND DISCUSSION

In Figure 1, two scanning electron microscope images of the synthesized ZnO materials show that blade-shape nanobelts have lengths in the range of several micrometers. We notice that the nucleation of these nanobelts seem to start from the metallic Zn bulk. The base of these nanobelts are larger than the tip of the nanobelts.

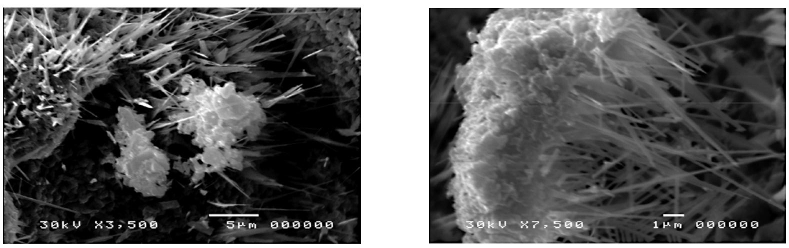

Figure 1. Scanning electron microscope images of Zn nanobelts.

In Figure 2, we show higher magnification images of the same samples. In Figure 2, one blade-shape nanobelt with a one micron width is shown among other smaller nanowires, some of them as small as 100 nm. We also observe in Figure 2 that one nanobelt has a width of about 3 μm. mixed with other much smaller nanowires.

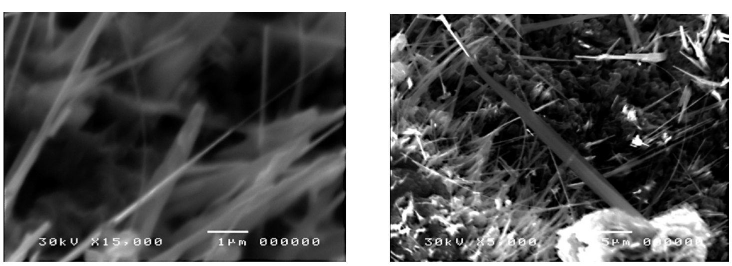

Figure 2. Show the width of nanobelts of products.

When water vapor is added to the flow of air that passed through the sample during our synthesis of ZnO nanomaterials, we notice a minimum change in the morphology of the ZnO nanowires and nanobelts synthesized. This maybe due to the fact that oxidation processes are similar whether it is wet (with H_2O) or dry (without H_2O). Figure 3 reveal the morphology of the nanostructures of synthesized ZnO.

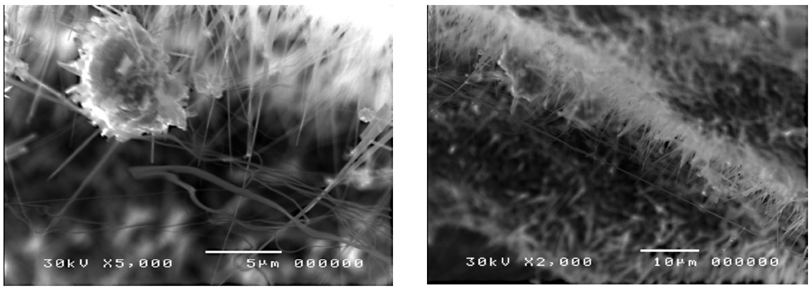

Figure 3. Scanning electron microscope images of Zn nanowires.

In Figure 3, the ZnO nanowires and nanobelts can be easy seen. We observe that the lengths of nanowires in Figure 3 are in the range of several to several tens of micrometers. Similar ZnO nanowires in this range have been reported by electrodeposition process (Wang et al., 2005). This image also show the diameter of ZnO nanowires is well below 1 micrometer. We can see some nanobelts in this figure.

In Figure 4, we show the spectrum of the wavelength dispersive X-ray fluorescence (WDXRF) measurement. Since the energy of the oxygen Kα X-ray is below the detection limit of our instrument, we only show the X-ray fluorescence from Zn only. The WDXRF analysis demonstrates that the nanostructures of our products consists of Zn only. Comparison of our SEM image of the nanowires and nanobelts in the literature, we conclude that ZnO nanowires and nanobelts can be synthesized.

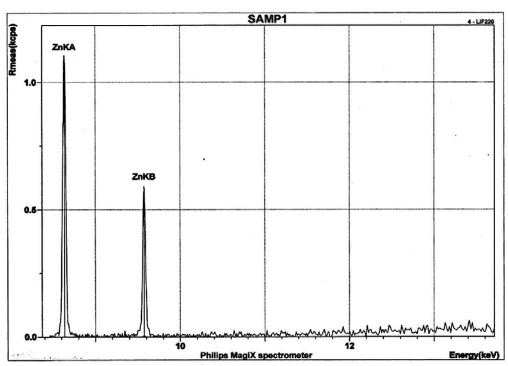

Figure 4. Wavelength dispersive X-ray fluorescent (WDXRF) pattern of metallic Zn nanowires. No other peak is shown except for the Zn.

CONCLUSION

In summary, thermal evaporation can be used to synthesize ZnO nanobelts and anowires from metallic Zn. The structures of these nanomaterials have been haracterized by SEM. These nanostructures may be used in future applications in anotechnology.

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