DOI: 10.1017/S1431927603442463
Microsc Microanal 9(Suppl 2), 2003

Semiconducting Nanobelts of ZnO and ZnS

Zhong L. Wang *, Puxian Gao, Christopher Ma, Daniel Moore, Jing Li, William Hughes, Yolande Berta

School of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332-0245;
* E-mail: zhong.wang@mse.gatech.edu

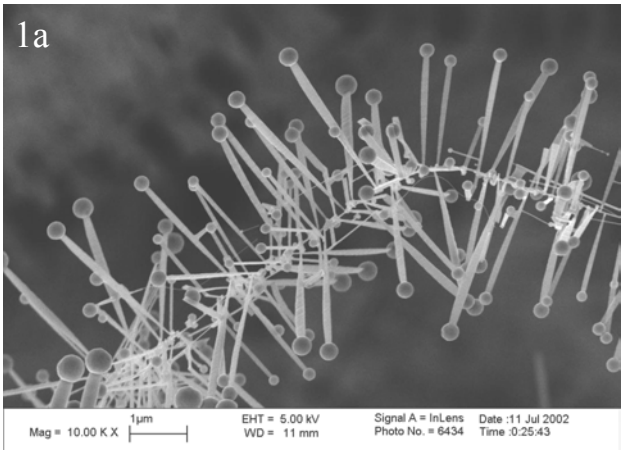
Semiconducting oxides and sophides have attracted considerable attention in scientific research and technological applications. In this paper, by thermal evaporating a mixture of ZnO and SnO_2, self-assembled nanowire-nanoribbon junction arrays of ZnO have been synthesized (Fig. 1) [1]. The growth is dominated by the vapor-liquid-solid (VLS) mechanism and Sn particles reduced from SnO_2 serve as the catalyst for the growth. The axial nanowires (the "rattans") are the result of fast growth along [0001], and the surrounding "tadpole-like" nanoribbons are the growth along 〈10-10〉. An isotropic growth along six 〈10-10〉 results in the ordered radial distribution of the nanoribbons around the axial nanowire. The junction arrays of ZnO structures reported here are likely to have ultra-high surface sensitivity due to the unique structure, and they are a candidate for building sensors with ultra-high sensitivity.

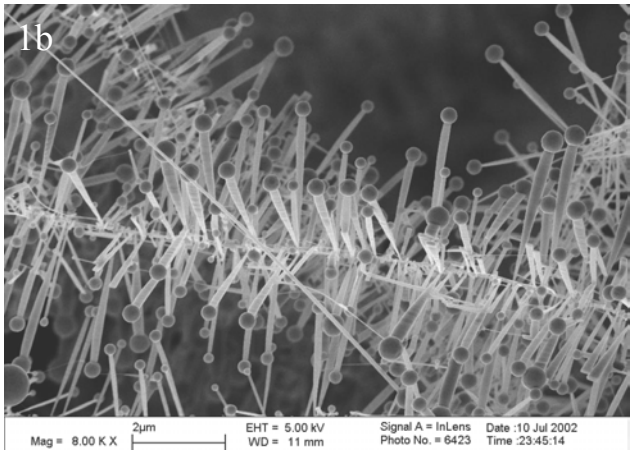
Zinc Sulfide has two types of crystal structures: hexagonal wurtzite ZnS and cubic zinc blend ZnS. Typically, the stable structure at room temperature is zinc blend. We report here the success of synthesizing stable wurtzite structured nanobelts, nanocombs and nanowindmills of ZnS, using thermal evaporation of ZnS powders at elevated temperature (Fig. 2). The nanobelts have a uniform cross-section along their length, with a typical width of 2-30 μm, and extend to over 100 μm in length. The nanobelt grows along [0001], with side surfaces (01-10) and the top surfaces (2-1-10).

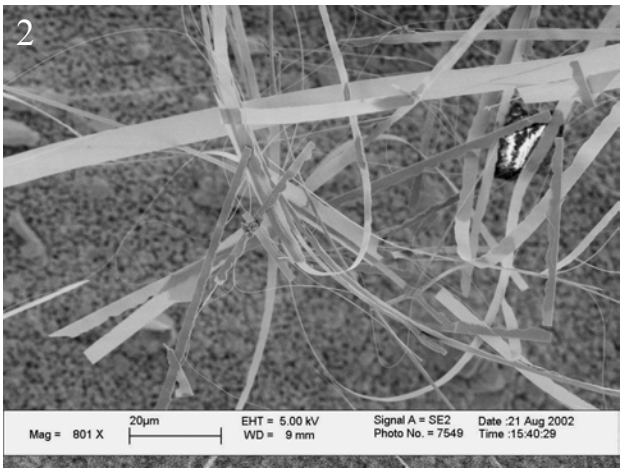
Wurtzite structured ZnS is unstable and it may transform to zinc blend structure. Shown in Figures 3a and b are two images recorded from the same area before and after the sample was illuminated for about 10 min under 200 kV electrons, showing an increase in density of planar defects. Electron diffraction pattern recorded from the area shows the co-existence of the hexagonal wurtzite structure and the cubic zinc blend structure (Figure 3c). The orientation relationship between the two phases are: [2-1-10] || [01-1], and (0001) || (111). The two phases co-exist by sharing the same (0001) or (111) plane. It is also known that the cubic phase ZnS typically has the {111} twins. The existence of the twins is indicated by the electron diffraction pattern, and the diffraction spots and the corresponding indexes from the hexagonal phase, the cubic phase and its twin are illustrated in Figure 3d. Detailed high-resolution TEM proved the proposed structural transformation model.

The belt-like morphology appears to be a unique and common structural characteristic for the family of semiconducting oxides with cations of different valence states and materials of distinct crystallographic structures [2,3]. The nanobelts are an ideal system for fully understanding dimensionally confined transport phenomena in functional oxides and building nano-size sensors and field effect transistors using individual nanobelts [4,5].

[1] P. X. Gao and Z. L. Wang *J. Phys. Chem*. B, 106, 12653 (2002) + cover.
[2] Z. W. Pan, Z. R. Dai and Z. L. Wang, *Science*, 291, 1947 (2001).
[3] Z. R. Dai, J. L. Gole, J. D. Stout, Z. L. Wang, *J. Phys. Chem. B* 106, 1274 (2002).
[4] M.S. Arnold, P. Avouris, Z.W. Pan, and Z.L. Wang, *J. Phys. Chem*. B 107, 659 (2002).
[5] E. Comini, G. Faglia, G. Sberveglieri, Z.W. Pan, and Z. L. Wang, *Appl. Phys. Lett.* 81, 1869 (2002).
[6] Research supported by NSF and NASA.







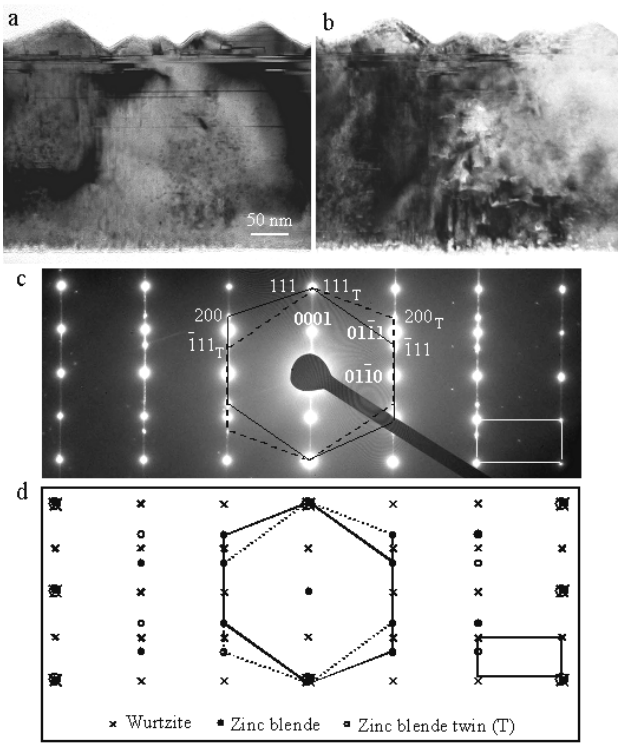


FIG. 1. SEM images of the as-synthesized ZnO nanostructures, showing strings of "tadpole-like" nanostructures.

FIG. 2. SEM image of ZnS nanobelts.

FIG. 3. (a, b) TEM images of a saw-like ZnS nanostructure prior and post illuminated by the electron beam for ~ 10 min, showing the formation of planar defects. (c) Electron diffraction pattern recorded from the area, which can be indexed as the co-existence of the hexagonal and cubic phases with the presence of twins in the cubic phase. (d) A schematic showing the systematic reflections in corresponding to the experimental pattern shown in (c).

https://doi.org/10.1017/S1431927603442463 Published online by Cambridge University Press

https://doi.org/10.1017/S1431927603442463 Published online by Cambridge University Press