산화망간 나노휘스커의 제조와 특성평가

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Preparation and Characterization of Manganese Oxide Nanowhiskers

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1. Introduction

Manganese oxide is used for catalyst in organic chemistry, electrode for lithium ion batteries, and magnetic materials. It is also used to produce soft magnetic materials or intercalation compounds like lithium manganese oxide for electrodes of lithium batteries. When manganese oxide is in a form of powder, wire, or whisker in nano scale, it would show higher activity and efficiency. Since the property of nanomaterial is a function of its size and morphology, control of size and morphology are critical for the application of manganese oxide.

In this study, we prepared nano-size whiskers of manganese oxide of hybrid nanostructure by the soft chemistry template synthesis method using block copolymer as structure-directing agent, and characterized them by electron microscopy and spectroscopy.

2. Experimental Procedures

Manganese chloride was dissolved in ethanol with an addition of directing agent polymers. Prepared solution was deposited on the silicon wafer and dried at room temperature followed by the calcinations at 400C in air.

The structure and chemistry of whiskers were analyzed by using x-ray powder diffractometry, transmission electron microscopy, electron energy loss spectroscopy, and energy dispersive x-ray spectrometry.

3. Results and Discussion

It was noted that nano-size whiskers grew from the surface of nano-size particles of hausmannite, Mn_3O_4.This material has a unique structure of inter-woven nanowires grown from faceted nanoparticles (Fig. 1), and we anticipate that it may provide another kind of manganese oxide with different characteristics. It was found by XRD that the major phase was hausmannite. However, it was found by TEM, EDS, and EELS that nanowhiskers had various phases, with oxygen content in a range of 0.7-1.6, implying that diverse nanowhiskers were grown from hausmannite nanoparticles. HREM revealed that nanowhiskers had lattice defects which was identified as nano-size domains of short-range ordered point-type defects, interplanar distance modulation defects, or planar-type defects (Fig. 2). Diffraction pattern from nanowhiskers without defects showed regular spots with some streaks, while that with defects showed multiple spots and streaks along the line perpendicular to the wire length direction (Fig. 3). Most nanowhiskers were found having defects as proven by multiple-spot patterns.

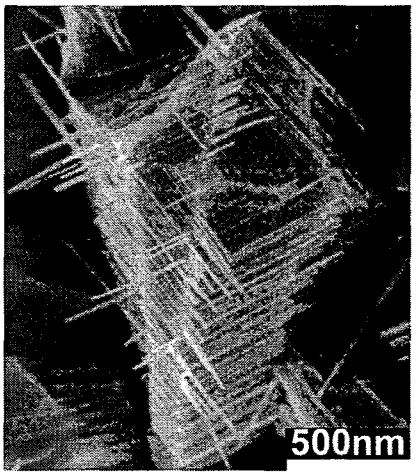
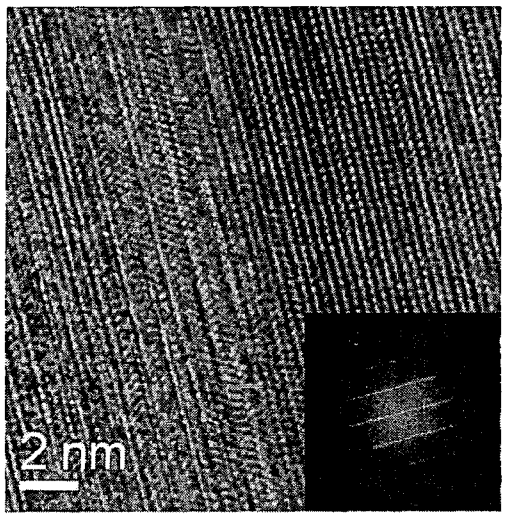
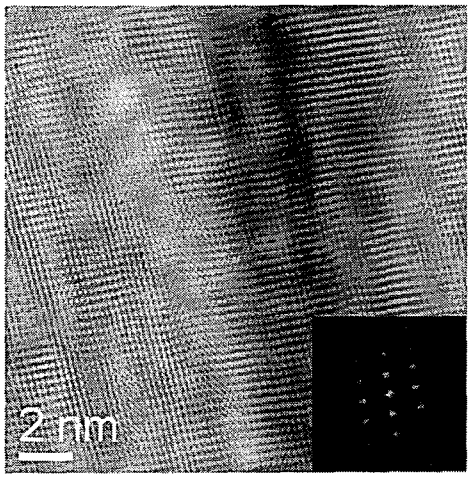


Fig. 1 Manganese nanowires grown from nano particles in 3-D direction

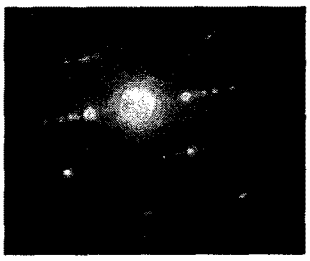


(a)

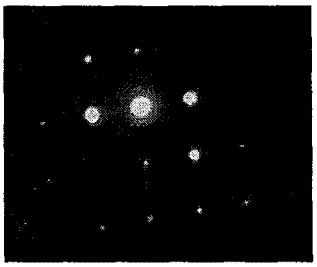


(b)

Fig.2 (a) Image of high resolution electron microscopy of nanowhisker and (b) the same image filtered by FFT showing defect structure. FFT images were shown in the insets.



(a)



(b)

Fig.3 Diffraction spots of nanowires from regions a) with and b) without defects.