Facile Preparation of $CuO@SnO_2$ Nanobelts as a High-Capacity and Long-Life Anode for Lithium-Ion Batteries

Xiaoshu Zhu, Huimin Shi, Jinwei Yin, Huimin Zhu, Yiming Zhou, Yawen Tang, Ping Wu* and Tianhong Lu

Jiangsu Key Laboratory of New Power Batteries, Jiangsu Collaborative Innovation Center of Biomedical Functional Materials, School of Chemistry and Materials Science, Nanjing Normal University, Nanjing 210023, PR China.

E-mail: zjuwuping@njnu.edu.cn

Experimental Section

Synthesis of the $CuO@SnO_2$ Nanobelts. All the chemicals were analytical grade without further purification. The CuO nanobelt templates were prepared through a simple wet chemical process using $CuCl_2 \cdot H_2O$ and NaOH as reactants described elsewhere. $CuO@SnO_2$ nanobelts were obtained *via* a facile hydrothermal method by using CuO nanobelts as templates. Typically, 0.1 g CuO nanobelts were dispersed in 40 mL mixed solution of ethanol and water (3:2 v/v), and then 0.1 g $Na_2SnO_3 \cdot 4H_2O$ and 0.9 g urea was added to the solution. After sonication for 30 min, the solution was transferred into a 50 ml Teflon-lined stainless steel autoclave flowed by heating at 170 ^oC for 1 h. Finally, the resulting solid product was washed with distilled water and ethanol, and then dried at 80 ^oC in air, yielding the $CuO@SnO_2$ nanobelts. For comparison, bare SnO_2 nanocrystals were synthesized through the same approach but

without CuO templates.

Characterization. The morphology, structure, and composition of the CuO@SnO_2 nanobelts were characterized by transmission electron microscopy (TEM, JEOL H-7650, 80 kV), scanning electron microscopy (SEM, JEOL JSM-7600F), and high-resolution transmission electron microscopy (HRTEM, JEOL JEM-2010F, 200 kV) equipped with an energy-dispersive X-ray spectrometer (EDS, Thermo Fisher Scientific, NORAN System 7). X-ray powder diffraction (XRD) measurements were performed with Rigaku D/max-rC diffractometer using Cu-Kα radiation (λ=0.15406 nm) and operating at 45 kV and 100 mA.

Electrochemical Measurements of the CuO@SnO_2 Nanobelts. Electrochemical measurements were carried out by 2025 coin-type half-cells (20 mm in diameter and 2.5 mm in thickness) using a lithium foil as the counter electrode. The cells were assembled in an IL-2GB glove box (Innovative Technology) filled with ultra-pure argon. For the preparation of working electrodes, a mixture of CuO@SnO_2 nanobelts, Super P carbon black, and polyvinylidene fluoride (PVDF) in N-methyl-2-pyrrolidene (NMP) at a weight ratio of 80:10:10 was sufficiently stirred, and then the slurry was coated on the surface of copper foam substrates at room temperature and dried at 120 ^{o}C under vacuum for 12 h. The electrolyte solution was 1 M $LiPF_6$ in ethylene carbonate (EC) and dimethyl carbonate (DMC) (1:1 v/v). Finally, the cells were aged for 12 h before measurements. A galvanostatic cycling test of the assembled cells was examined on a Land CT2001A system in the potential range of 0.01-3 V at a current density of 100 mA g^{-1}. The voltages mentioned herein were referred to Li^+/Li redox

couple.

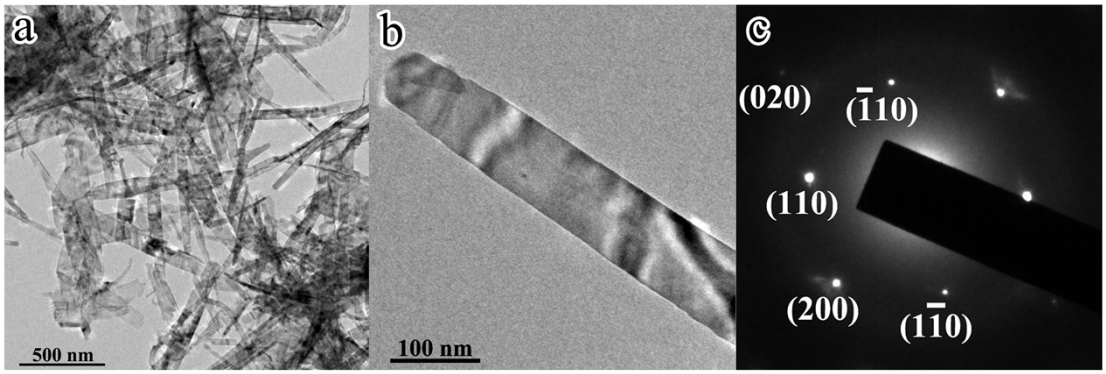

Figure S1 TEM images and SAED pattern of bare CuO nanobelts.

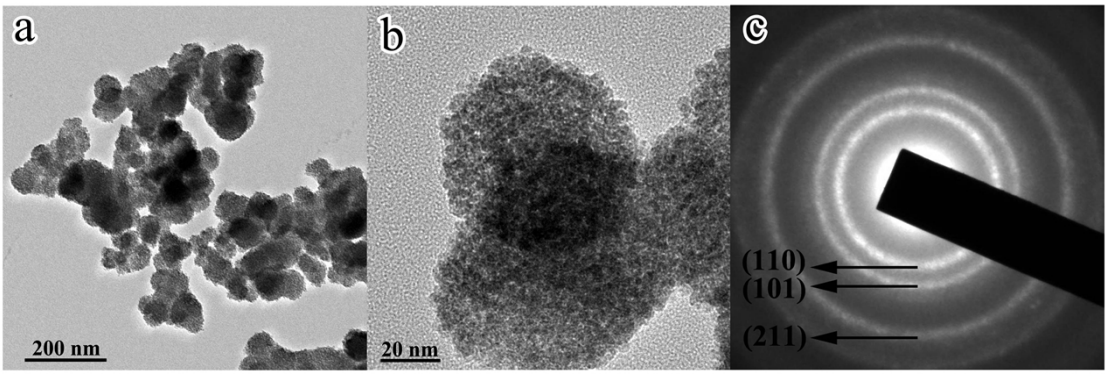

Figure S2 TEM images and SAED pattern of bare SnO_2 nanocrystals.

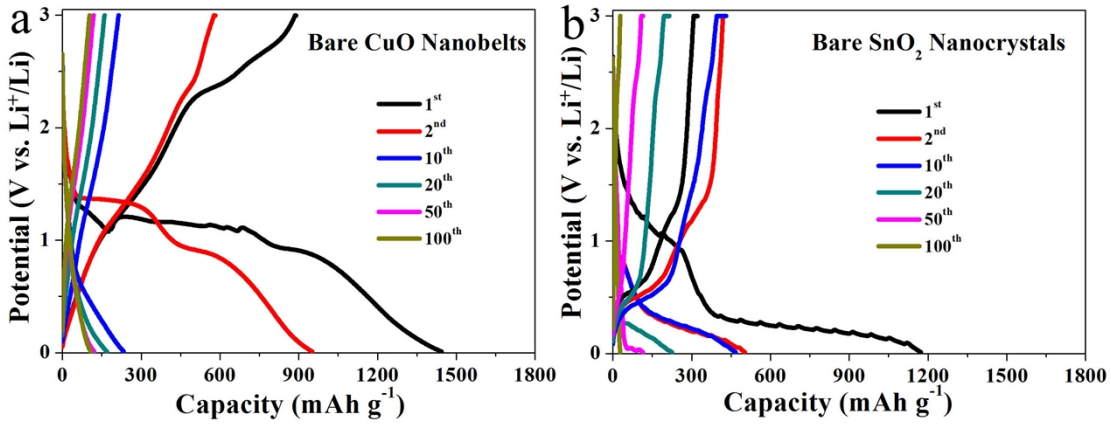

Figure S3 The 1st, 2nd, 10th, 20th, 50th, and 100th discharge and charge curves for bare CuO nanobelts (a) and bare SnO_2 nanocrystals.

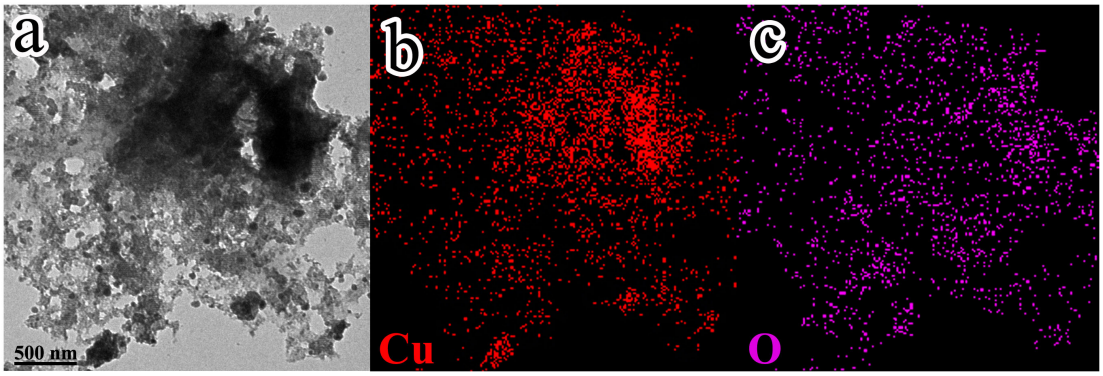

Figure S4 TEM-EDS elemental mappings of bare CuO nanobelts in a de-lithiated state (3.0 V *vs.* Li^+/Li) after 100 cycles: (a) TEM image, (b,c) EDS elemental mappings of Cu (red) and O (purple).

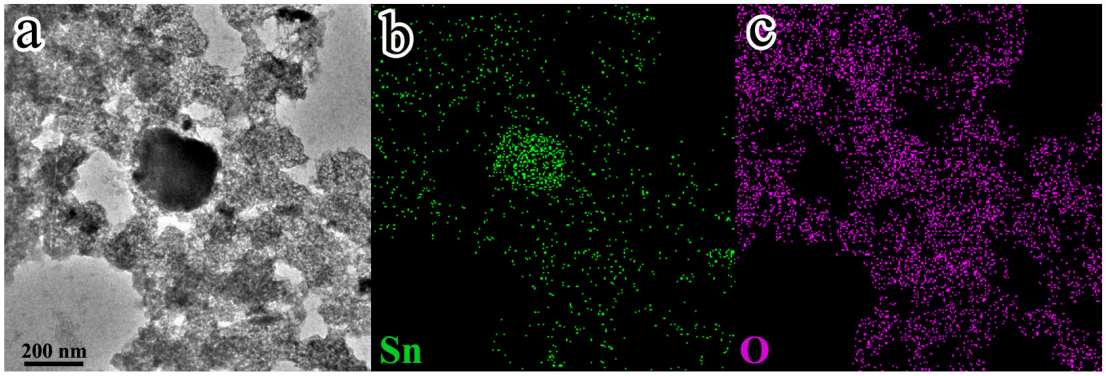

Figure S5 TEM-EDS elemental mappings of bare SnO_2 nanocrystals in a de-lithiated state (3.0 V *vs.* Li^+/Li) after 100 cycles: (a) TEM image, (b,c) EDS elemental mappings of Sn (green) and O (purple).