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Layer-Stacked Tin Disulfide Nanorods in Silica Nanoreactors with Improved Lithium Storage Capabilities

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Experimental details

Synthesis of Sn-SiO_2 Nanorods. Sn nanorods were prepared by a simple reaction using $SnCl_4$ as a precursor and poly(diallyldimethylammonium chloride) (PDDA) as soft templates at room temperature according to our previous paper.[21,25] Sn-SiO_2 nanorods were prepared by a modified Stöber method.[24] Briefly, the pristine Sn nanorods were fully dispersed in 120 mL ethanol. Then, 20 mL water, 20 mL 28 % ammonia and a certain amount of tetraethyl orthosilicate (TEOS) were added sequentially into the ethanol solution under stirring. The reaction mixture was stirred for 1 h at room temperature. Finally, the resulting solid products were centrifugalized,

washed with distilled water and ethanol, and dried at 80 ^{o}C under vacuum.

Synthesis of SnS_2-SiO_2 and SnS-SiO_2 Nanorods. The as-synthesized Sn-SiO_2 nanorods (0.5 g) were kept in an evacuable quartz tube furnace under H_2S/Ar (10 % H_2S) atmosphere. The sulfidation process for SnS_2-SiO_2 nanorods was performed in an open system with pressure = 20 Torr, temperature = 400 ^{o}C, and time = 6 h, whereas the sulfidation process for SnS-SiO_2 nanorods was performed in a closed system with the other conditions unchanged.

Characterization. The obtained samples were characterized by X-ray powder diffraction (XRD) using a Rigaku D/max-ga x-ray diffractometer with graphite monochromatized Cu Kα radiation (γ = 1.54178 Å). The morphology and structure of the samples were examined by transmission electron microscopy (TEM, JEM-200 CX, 160 kV), high-resolution transmission electron microscopy (HRTEM, JEOL JEM-2010) and field emission scanning electron microscopy (FESEM, Hitachi S-4800) with energy-dispersive X-ray spectrometer (EDX, Horiba 7593-H). X-ray photoelectron spectroscopy (XPS) analysis was performed on an AXIS-Ultra instrument from Kratos Analytical, using monochromatic Al Kα radiation (225 W, 15 mA, 15kV) and low-energy electron flooding for charge compensation.

Electrochemical Measurements of SnS_2-SiO_2 Nanorods. Electrochemical measurements were performed by 2025 type coin cells which were assembled in a glove box (Mbraun, labstar, Germany) under an argon atmosphere. The anodes were made as follows: 80 wt % SnS_2-SiO_2 nanorods, 10 wt % acetylene black, and 10 wt % polyvinylidene fluoride (PVDF) in N-methyl-2-pyrrolidene (NMP) were mixed, then

the slurry was coated on the surface of Cu foil substrates (12 mm in diameter) at room temperature and dried under vacuum at 120 ^{o}C for 12 h. The counter and reference electrodes were lithium metal foils (15 mm in diameter), and the electrolyte solution was 1M solution of $LiPF_6$ in ethylene carbonate (EC) and dimethyl carbonate (DMC) (1:1 by volume). Finally, the cells were aged for 12 h before measurements. A galvanostatic cycling test of the assembled cells was carried out on a Land CT2001A system in the potential range of 0.01-1.15 V. Cyclic voltammetry were recorded on a MSTAT4 (Arbin Instruments) system in the potential range of 0.0-2.5 V at a scan rate of 0.1 mV s^{-1}.

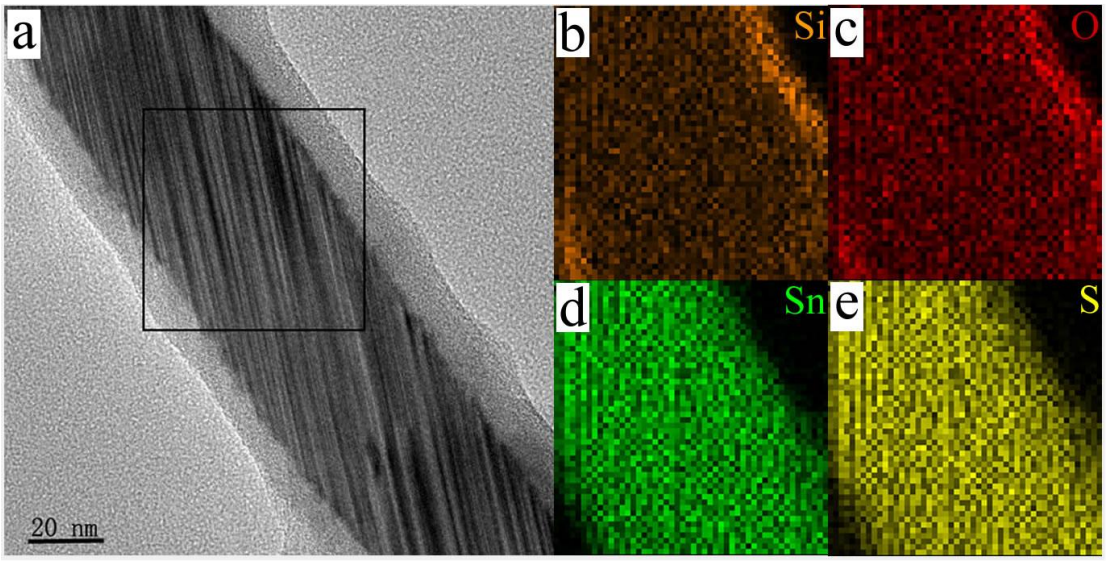

Fig. S1 EDX elemental mapping of a single SnS_2-SiO_2 nanorod.

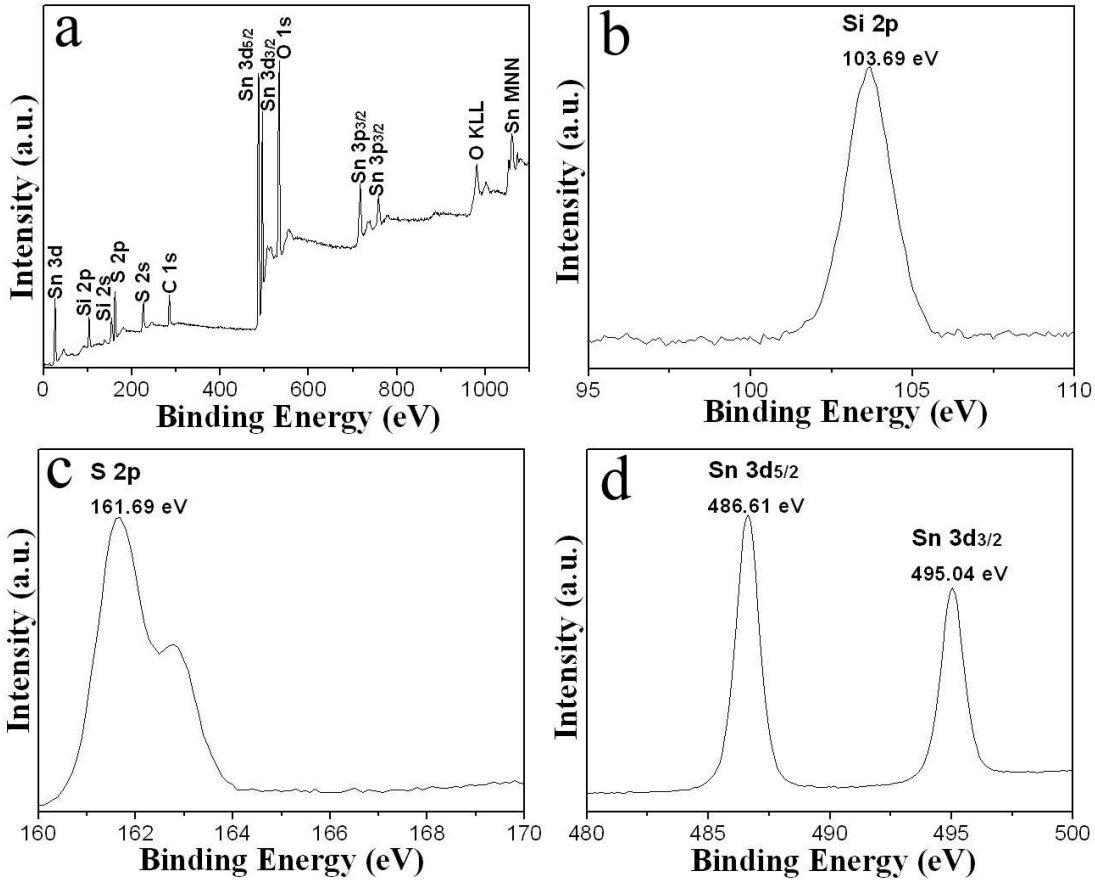

Fig. S2 XPS spectra of the SnS_2-SiO_2 nanorods.

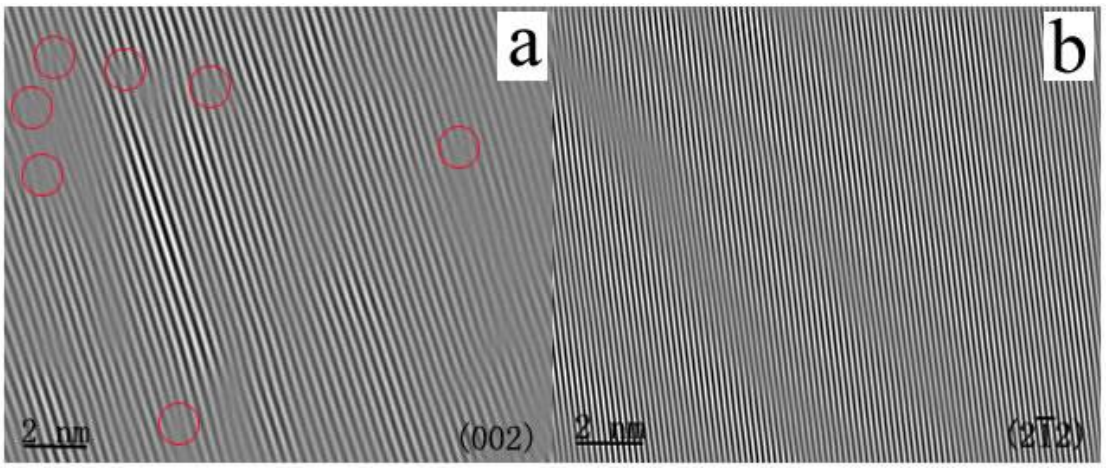

Fig. S3 Inverse FFT-filtered images of the regions in figure 3e (a) and figure 3f (b) related to (002) and (2-12) reflections, respectively.

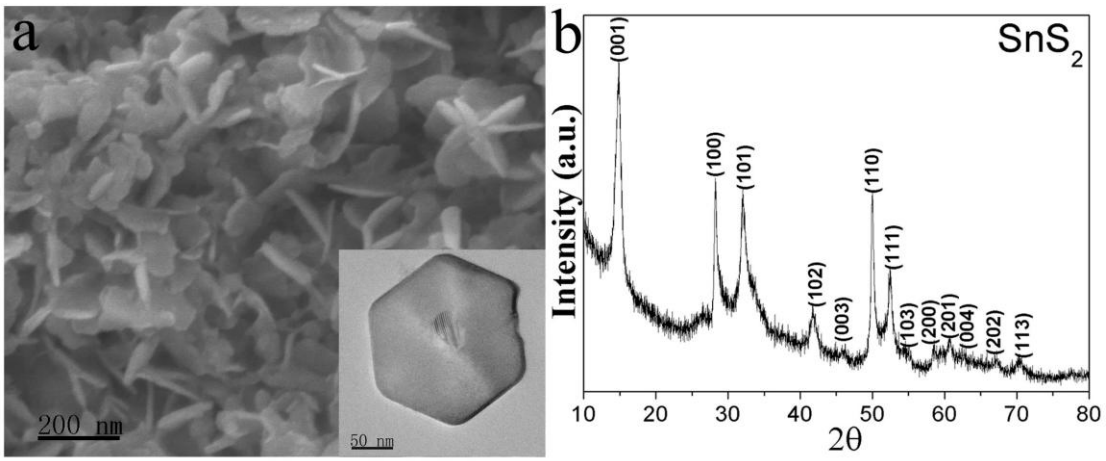

Fig. S4 Morphological and structural characterizations of the product using pristine Sn nanorods as precursors without silica nanoreactors: (a) FESEM and TEM (inset) images; (b) XRD pattern.

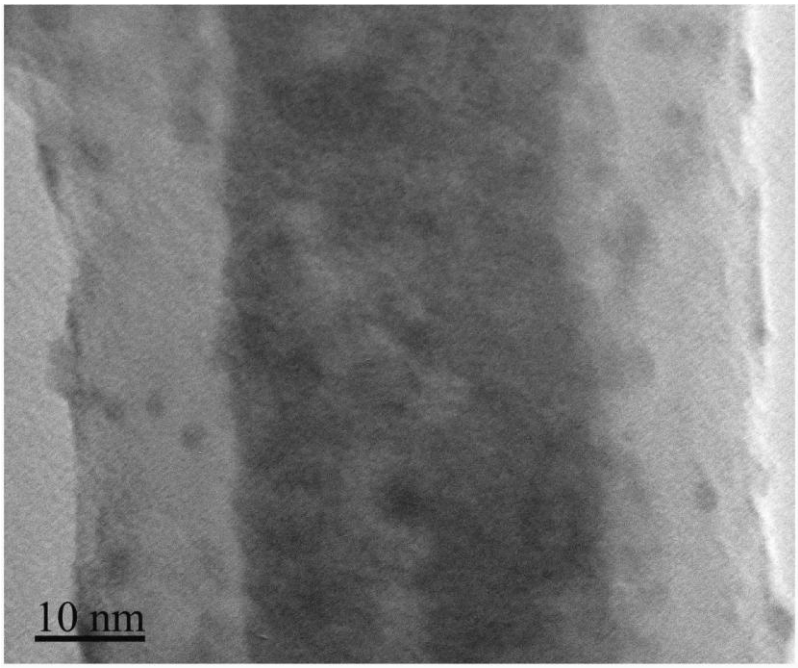

Fig. S5 TEM image of the SnS_2-SiO_2 nanorod anode in a fully delithiated state after cycling.