

Supporting information

Carbon/SnO₂/Carbon Core/Shell/Shell Hybrid Nanofibers: Tailored Nanostructure for Anode of Lithium Ion Batteries with High Reversibility and Rate Capacity

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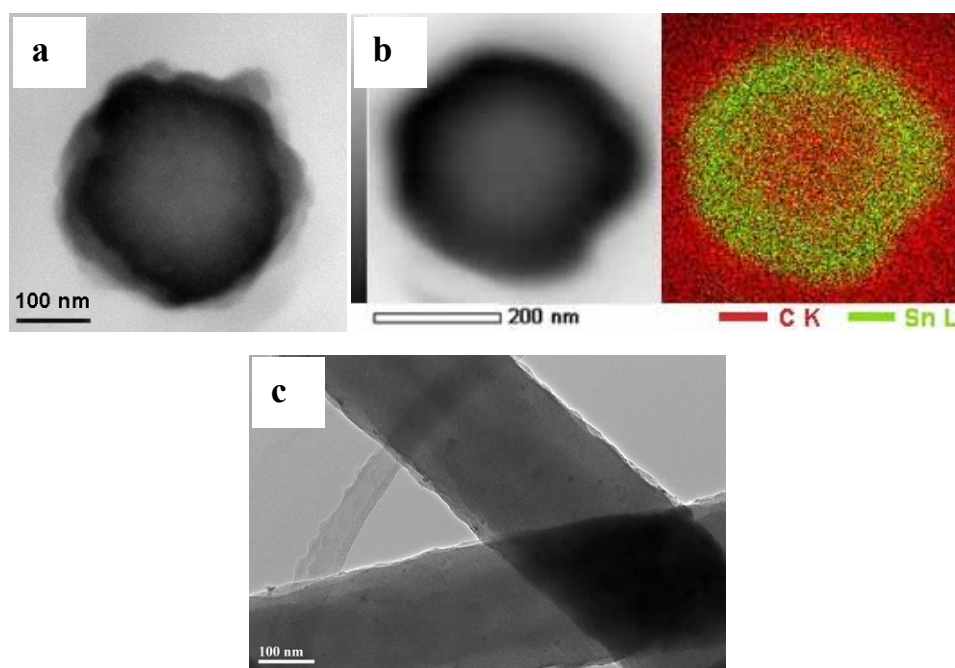


Fig. S1. (a) Cross section TEM image of the carbon/SnO₂ (HF50) hybrid nanofibers, showing the core/shell morphology with carbon-rich core of approximately 200 nm in diameter and SnO₂-rich shell of about 50 nm in thickness. (b) Scanning TEM-energy dispersive X-ray spectroscopy (STEM-EDX) element mapping image of HF50, confirming the formation of carbon/SnO₂ core/shell morphology after carbonization. (c) TEM side view of HF50, showing the compact SnO₂ shell with relatively smooth surface.

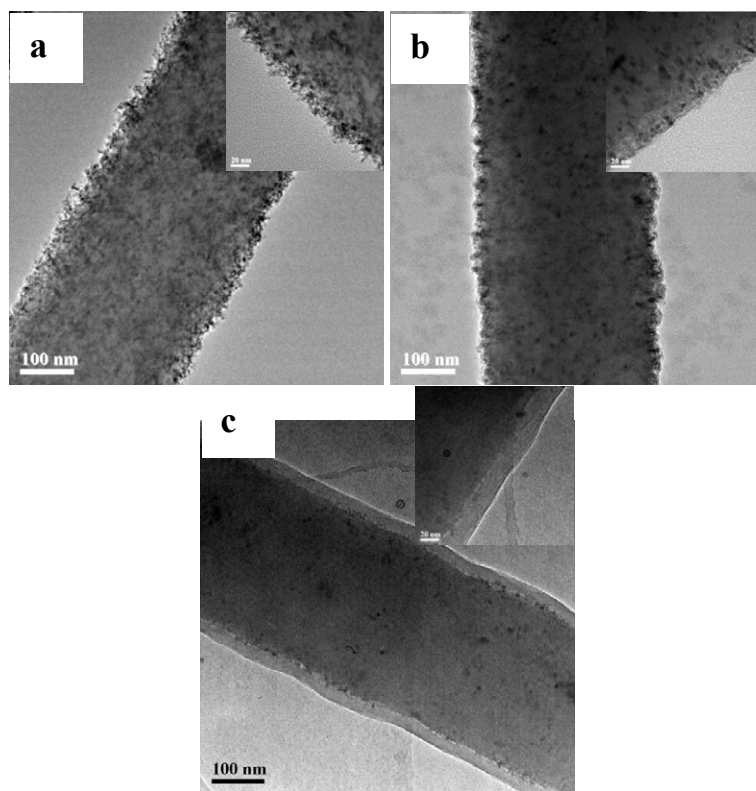


Fig. S2. TEM side views of carbon/SnO₂/carbon core/shell/shell hybrid nanofibers with carbon skin in various thicknesses through adjusting the glucose concentration from (a) 1 mg/ml, (b) 2.5 mg/ml, (c) 10 mg/ml. Insets show the corresponding high magnification images. The thickness of carbon skin increases with increase of glucose content. The roughness of surface of SnO₂ shell and appearance of carbon-embedded distinguishable SnO₂ nanoparticles with size of less than 10 nm can be clearly observed, which is due to the high-pressure and high-temperature hydrothermal treatment for long time. The surface of deposited carbon skin is smooth.

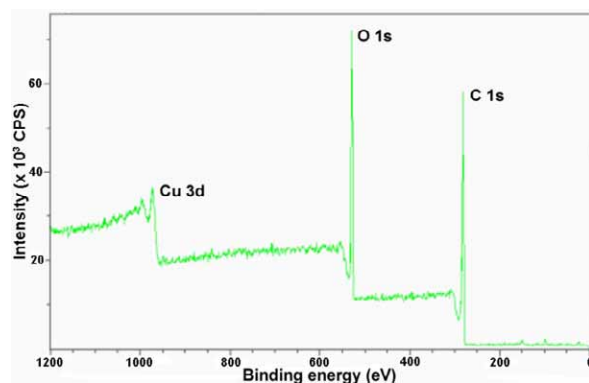


Fig. S3. XPS result of BP-HF50/C15 collected from hydrothermal mother solution of HF50/C15. No obvious signal can be assigned to Sn (at binding energy of 493.2 eV for Sn 3d^{3/2}) in XPS spectrum, indicating that SnO₂ is not dissolved into solution during hydrothermal treatment.

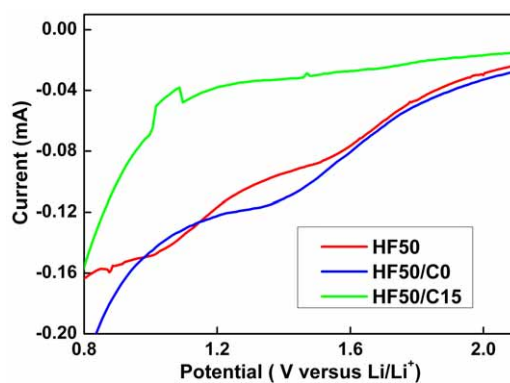


Fig. S4. Enlarged cyclic voltammograms of HF50, HF50/C0 and HF50/C15 at the 1st cycle between the voltage window and scanning rate of 2.1~0.8 V and 0.01 mV/s, respectively. The broad reduction peak at 0.8~1.7 V can be clearly observed.

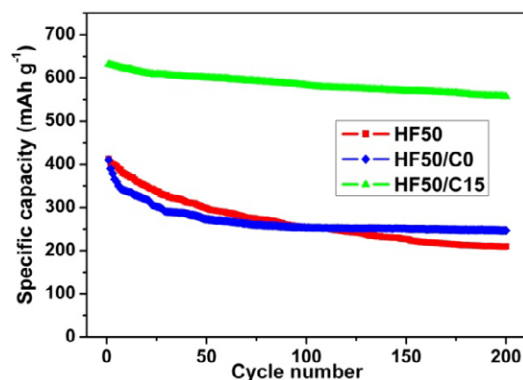


Fig. S5. Cycle capacity of HF50, HF50/C0 and HF50/C15 at charging rate of 1C. The cycling test condition is as follows: discharging at 1C rate to 0.005V, then standby for 5 min, and finally discharging at 0.1C rate to 0.005V followed by charging at 1C rate to 3V.

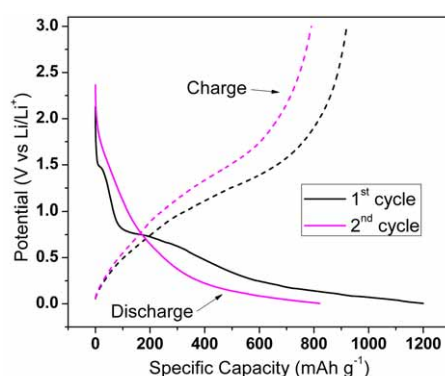


Fig. S6. Discharge/charge profile (1st and 2nd cycle) of pure carbon nanofibers with hydrothermally coated carbon skin of 15-nm thickness. Hydrothermal treatment and post calcination was carried out to the pure carbon nanofibers under the same conditions as that for HF50/C15. The capacity test at current rate of 0.1C was carried out under following conditions: discharging at 1C rate to 0.005V, then standby for 5 min, and finally discharging at 0.2C rate to 0.005V followed by charging at 0.1C rate to 3V. Higher capacity than that of graphite is observed for this reference sample.

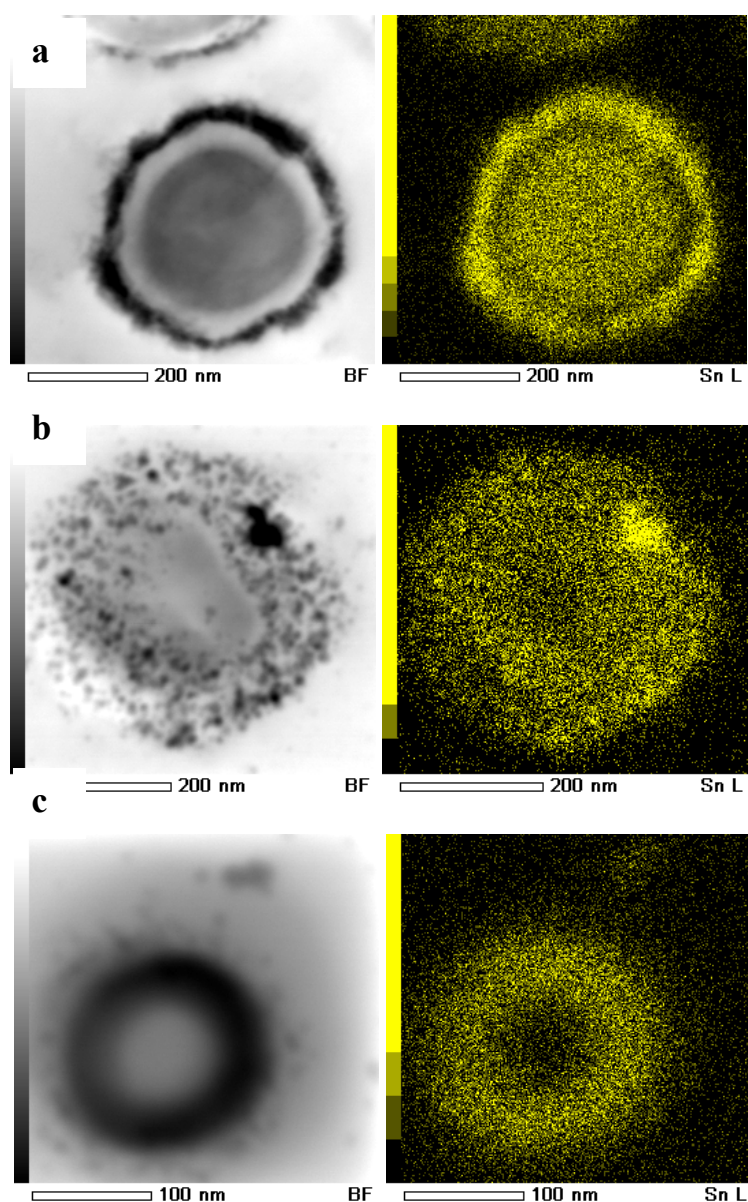


Fig. S7. STEM-EDX element mapping of (a) HF50, (b) HF50/C0 and (c) HF50/C15 after 50 charging cycles at current rate of 0.1C, showing the morphology change after discharge/charge. It is clearly showed that detachment occurred for HF50 after cycling, resulting in a wide gap between carbon core and SnO₂ shell, which is due to the outward expansion of SnO₂. This expansion is also observed in HF50/C0, in which the SnO₂ shell

became very loose, and individual SnO₂ nanoparticles turned to be larger due to the aggregation during discharge/charge. In contrast, the core/shell/shell morphology of HF50/C15 is well preserved after cycling, indicating the excellent stability of the designed structure.