Supplementary Information

Free-standing Ag/C Coaxial Hybrid Electrode as Anodes for Li-Ion Batteries

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Experimental section

Synthesis of Ag/C coaxial nanocomposites: The hydrothermal synthesis of 3D interconnected silver-Polyvinyl alcohol (PVA) composites was reported elsewhere [1]. Typically, 0.136 g PVA was dissolved into 18 mL deionized water at room temperature to form a clear solution, to which then 0.077 g $AgNO_3$ and 0.012 g NaCl were added. The solution was transferred into a 40 mL Teflon-lined stainless steel autoclave after stirring for 5 min. The sealed autoclave was maintained at 160 ^oC for 72 hrs and then cooled to room temperature. The yellow sponge-like product was collected, washed with deionized water to get rid of the remnants. After freeze-drying, the product was calcinated in N_2/C_3H_6 (98/2 v/v) atmosphere at 1000 ^oC for 2h to turn PVA into carbon and the Ag/C coaxial hybrid nanocomposites were obtained.

Characterization: The Ag/C coaxial hybrid nanocomposite was examined by X-ray diffraction (XRD, Brucker D8 Discover and field-emission scanning electron microscopy (FESEM, JSM-6700F). High-resolution transmission electronic microscopy (HRTEM) was performed using a JEOL JEM 2011 transmission electron microscope. Energy-dispersive X-ray spectroscopy (EDX) analysis was applied using an EDX system (Oxford Inca) with a condenser aperture of 25 nm.

Electrochemical performance evaluation: The electrochemical properties of the Ag/C coaxial hybrid electrode as anode in lithium ion batteries were investigated in Swagelok cells. The Ag/C coaxial hybrid nanocomposites were cut into pellets (Φ = 8mm) and used as working electrode directly (the mass of each electrode is ~ 1 mg), lithium metal was used as counter electrode, separated by a glass fiber as separator and a solution consisting of 1.0 M $LiPF_6$

in ethylene carbonate (EC) and dimethyl carbonate (DMC) as electrolyte (a volume ratio of 1:2, Novolyte Technologies). The cells were assembled in an Ar-filled glove box, with moisture and O_2 content being less than 1 ppm. The galvanostatic measurements were performed by an Arbin battery test system in the potential range of 0.005-3 V vs. Li^+/Li. The cyclic voltammetry was conducted by Autolab instrument with a scan rate of 0.2 mV s^{-1}. The cycled electrode for SEM examination was charged back to 3 V and kept at 3 V till current was lower than C/20 (1C = 372 mA g^{-1}).

The electrochemical performance of HNO_3 etched Ag/C free-standing electrode and commercial Ag nanoparticles were investigated for the purpose of comparison. The Ag/C electrode was etched with concentrated HNO_3 to remove the silver in composites. The commercial Ag nanoparticles were mixed with super P and Polyvinylidene fluoride (PVDF) with a weight ratio of 8:1:1 in N-methyl-2-pyrrolidone (NMP) solvent, coated onto a copper foil and cut into pellets (Φ = 8 mm) after dried in vacuum at 80 ^oC overnight. The batteries were assembled in the same way as mentioned above.

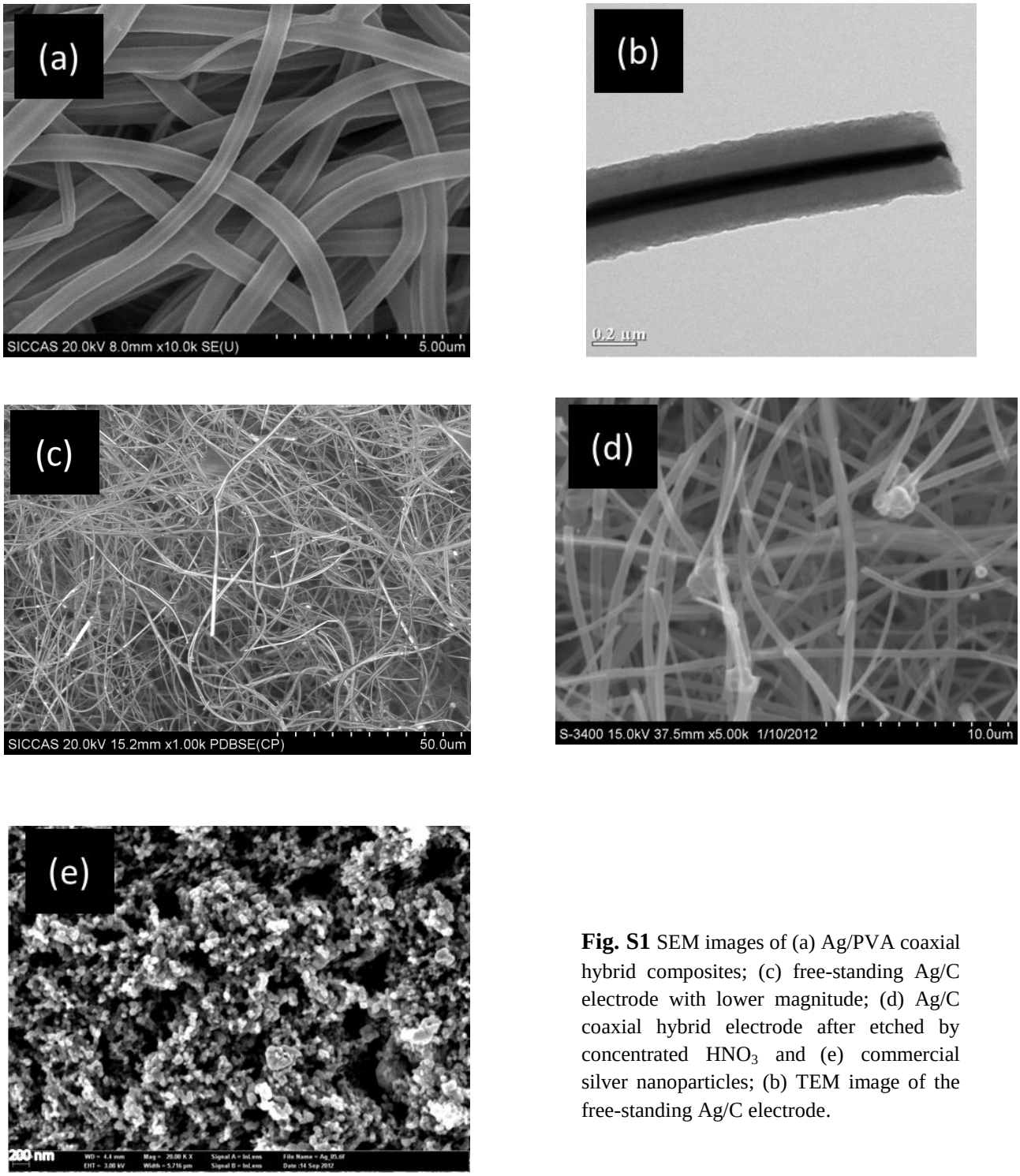

Fig. S1 SEM images of (a) Ag/PVA coaxial hybrid composites; (c) free-standing Ag/C electrode with lower magnitude; (d) Ag/C coaxial hybrid electrode after etched by concentrated HNO_3 and (e) commercial silver nanoparticles; (b) TEM image of the free-standing Ag/C electrode.

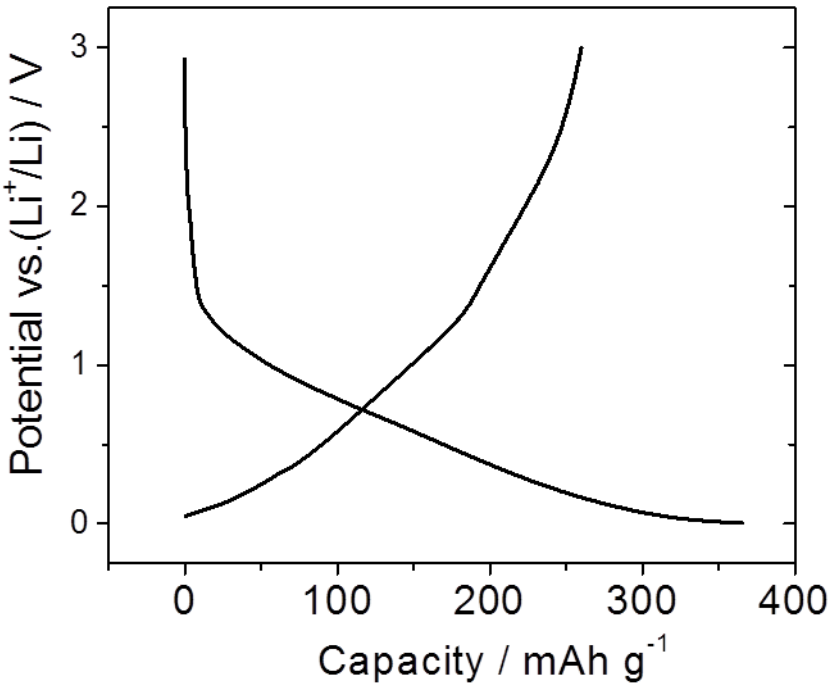

Fig. S2 First discharge-charge profile of free-standing Ag/C electrode at 0.2 C.

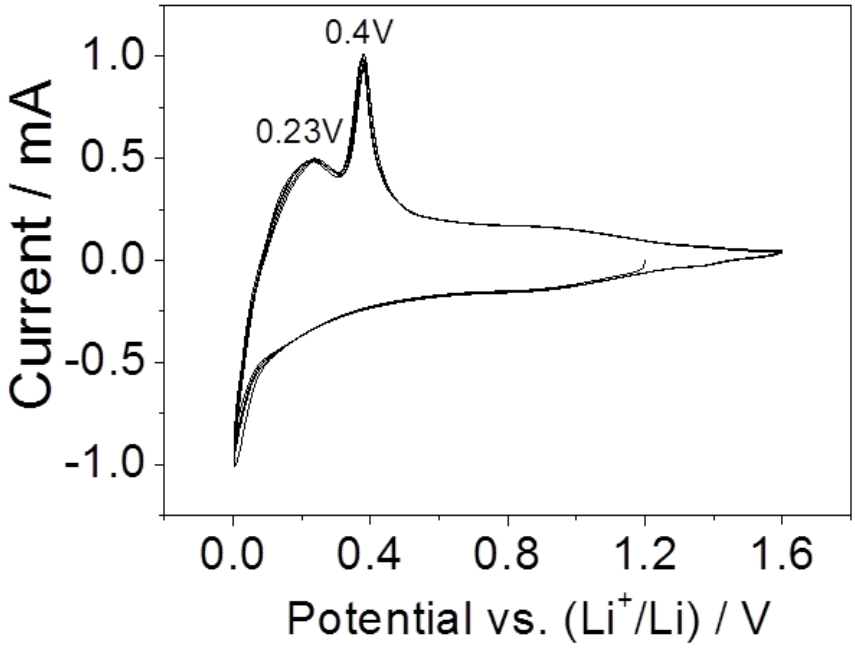

Fig. S3 Cyclic voltammograms of free-standing Ag/C coaxial hybrid electrode after 10 cycles with a scan rate of 0.2 mV s^{-1}.

Reference

1. L.-B. Luo, S.-H. Yu, H.-S. Qian and T. Zhou, *J. Am. Chem. Soc.*, 2005, **127**, 2822-2823.