Supporting Online Materials For

Crystalline-Amorphous Core-Shell Silicon Nanowires for High Capacity and High Current Battery Electrodes

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Materials and Methods

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Materials and Methods

Silicon crystalline-amorphous (c-a) core-shell nanowires (NWs) were grown inside a chemical-vapor-deposition (CVD) furnace. Stainless steel (SS) 304 foil (100 μm thickness) substrates were put inside a tube furnace which uses a 1-inch quartz tube. The furnace was pumped to vacuum, purged with pure argon then heated to desired temperatures. A compressed gas of 2% silane balanced in argon was flowed to produce silicon NWs on SS substrates. Flow rates between 50 sccm and 200 sccm were used for the delivery of SiH_4/Ar gas. The furnace was kept at a constant pressure of 100 Torr and silicon c-a core-shell NWs was observed at temperatures between 460 ^{0}C and 510 ^{0}C. It was found that larger flows and higher temperatures promote the yield of Si NWs. The average diameter of the NWs was larger when higher temperatures were used. The mass of the Si NWs on a given substrate (~200 μg/cm^2) was accurately determined by

measuring the mass of the substrate using a microbalance (Sartarious SE2, 0.1 μg resolution) before and after growth.

Half-cells were fabricated out of the Si NW/SS electrode, Li metal foil, and Celgard 2250 separator soaked in electrolyte. The electrolyte was 1.0 M $LiPF_6$ in 1:1 w/w ethylene carbonate: diethyl carbonate (Ferro Corporation). No binders or conducting carbon were used. The cells were assembled inside an Ar-filled glovebox and sealed in aluminized polyethylene laminate bags. Electrochemical potential spectroscopy (EPS) was done with a potential step of 5 mV and C/20 threshold current (~ 40 mA/g) using a Biologic MacPile II. Galvanostatic measurements were made using a Biologic VMP3 multichannel system. The Si NW electrodes were cycled between 2 V and different lower voltage cutoffs. Si NWs grown at 500 ^{0}C and 510 ^{0}c were used for cell fabrications because better electrochemical performance was found for NWs grown at higher temperatures.

The NWs were characterized by an FEI Sirion scanning electron microscope (SEM) and a Philips CM20 transmission electron microscope (TEM), which incorporates an energy dispersive X-ray spectrometer (EDX). For TEM and EDX measurements, the NWs were deposited via a dry transfer stamping technique onto lacey carbon film on copper grids. Delithiated NW electrodes after cycling were took out of the cell bags inside a glovebox, washed with acetonitrile (ACN) to remove the residual electrolyte and lithium salts and dried at room temperature before further SEM and TEM characterizations.

Figure Captions

Figure S1. SEM images of Si c-a core-shell NWs on SS substrates grown at 485 ^{0}C and for different growth time. (**A**) 10 minutes (**B**) 20 minutes (**C**) 40 minutes

Figure S2. (**A**) TEM image of a single NW grown at 485 ^{0}C for 40 minutes. (**B**) EDS spectrum taken on the corresponding circled area in Figure S2A.

Figure S3. Potential versus capacity profile of different cycles for the electrode sample that was cycled at 0.2C rate and 150 mV cutoff.

Figure S4. Potential versus capacity profile of four samples cycled at different rates using a 150 mV cutoff. The 0.1C and 0.2C profiles were from the 5th cycle measurements and the 0.8C and 1.6C profiles were from the 60th cycle.

Figure S1

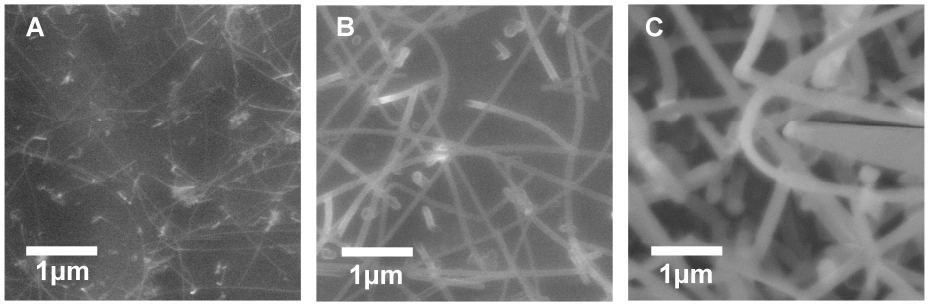

Figure S2

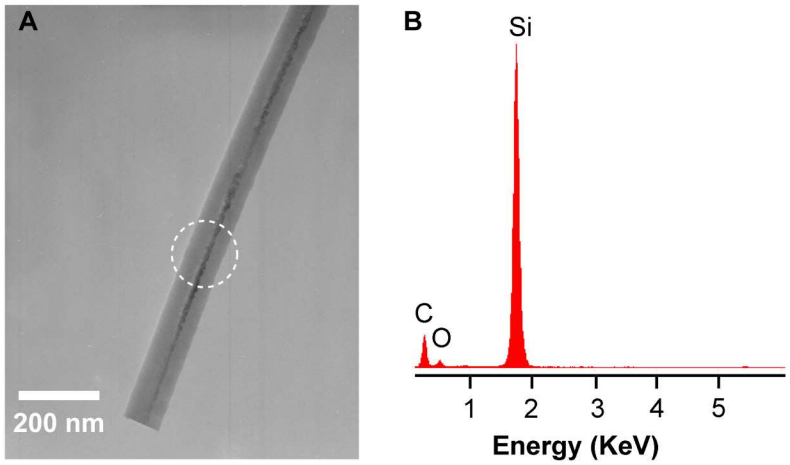

Figure S3

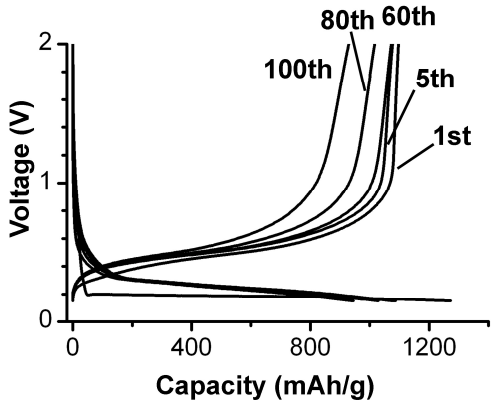

Figure S4