Electronic Supplementary Material (ESI) for Journal of Materials Chemistry

Electronic Supplementary Information

Silicon Nanowires with a Carbon Nanofiber Branch

as Lithium-Ion Anode Material

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Experimental

Fig. S1 SEM and TEM images of Si nanowire

Fig. S2 Raman spectrum of Si nanowire

Fig. S3 Electrochemical performances of Si-CNF structures

Fig. S4 Voltage profiles of CNFs

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Synthesis of Si nanowires with a carbon nanofiber branch and characterization

Si nanowires were grown on SUS 304 stainless steel (Nilaco) substrates via vapor-liquid-solid (VLS) reactions. Negatively charged, 30 nm diameter, colloidal Au catalysts were decorated on the substrate and functionalized with positively charged poly-L-lysine. The Au colloid decorated substrate was placed in the center of a quartz reactor of a CVD tube furnace. H_2 and SiH_4 (10 vol % diluted in H_2) were co-flowed in at 10–30 sccm and 30–100 sccm, respectively. The temperature and reactor pressure were kept at 520 ºC and 40 Torr (5.3 kPa), respectively. Next, two sets of samples were made by using a thermal evaporator to deposit one set of 0.3 nm and another set of 3 nm films on the Si nanowires. CNF growth on the Ni coated Si nanowire substrates was carried out at 760 Torr and 600 ºC for 7 s. High purity H_2 and acetylene were flowed in at 100–150 sccm and 5–10 sccm, respectively. The morphology of the samples was investigated using a Hitachi S-4300SE and S-5500 field emission scanning electron microscope (SEM) and a Jeol JEM 2100F field emission transmission electron microscope (TEM).

Evaluation of electrochemical performance

Coin-type half cells (2016R type) were fabricated to investigate the electrochemical performance of the two kinds of Si-CNF composite electrodes. Pure Li metal and 1.3 M $LiPF_6$ with ethylene carbonate/diethylene carbonate (EC/DEC, 3:7 vol.%) were used as a counter electrode and an electrolyte, respectively. The galvanostatic cycling performances of the coin-type half cells were evaluated at a C/5 rate in the voltage range between 0.01 V and 2 V using a Toyo Systems TOSCAT 3000 battery cycle tester.

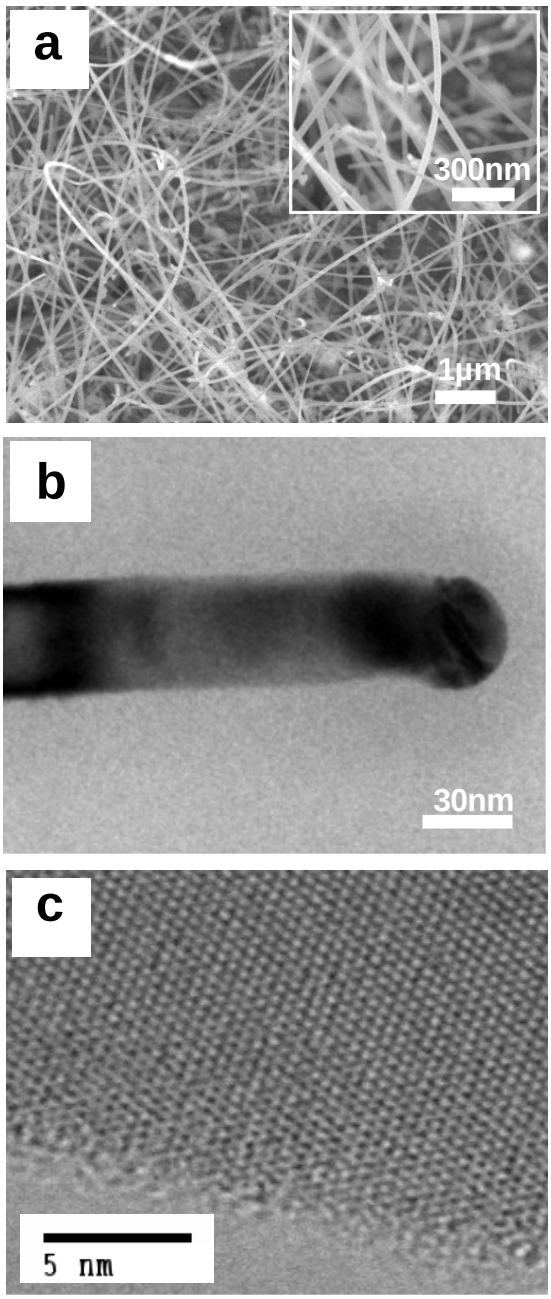

Fig. S1 (a) SEM image of as synthesized SiNWs (inset: high magnification image) (b) TEM image of a single SiNW. (c) HR-TEM image of the surface of a SiNW.

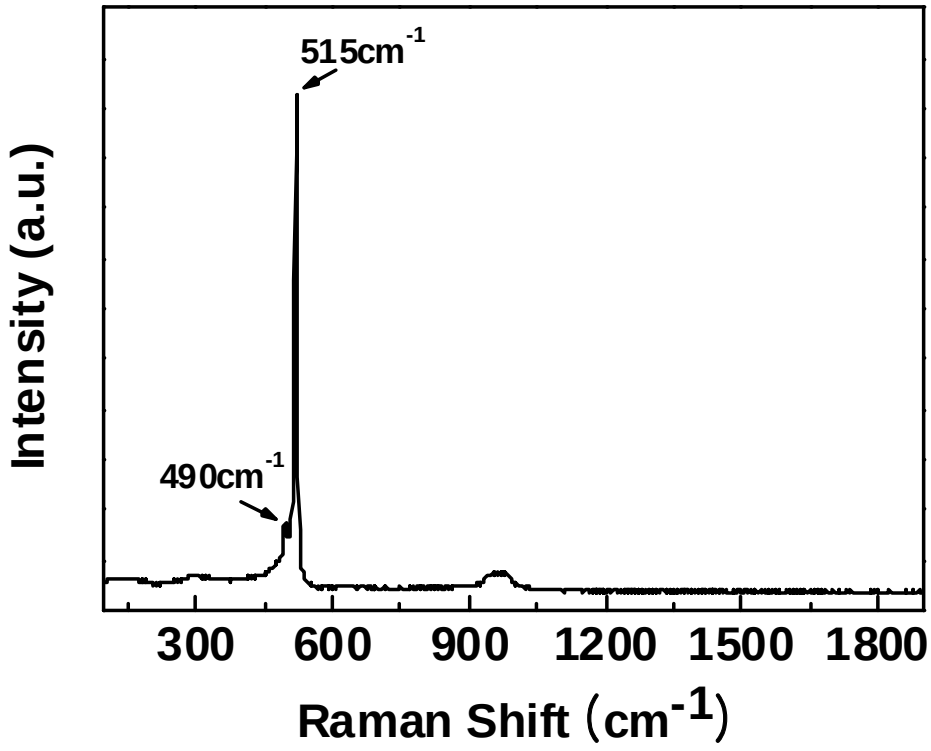

Fig. S2. Raman spectrum of SiNWs on an SUS substrate.

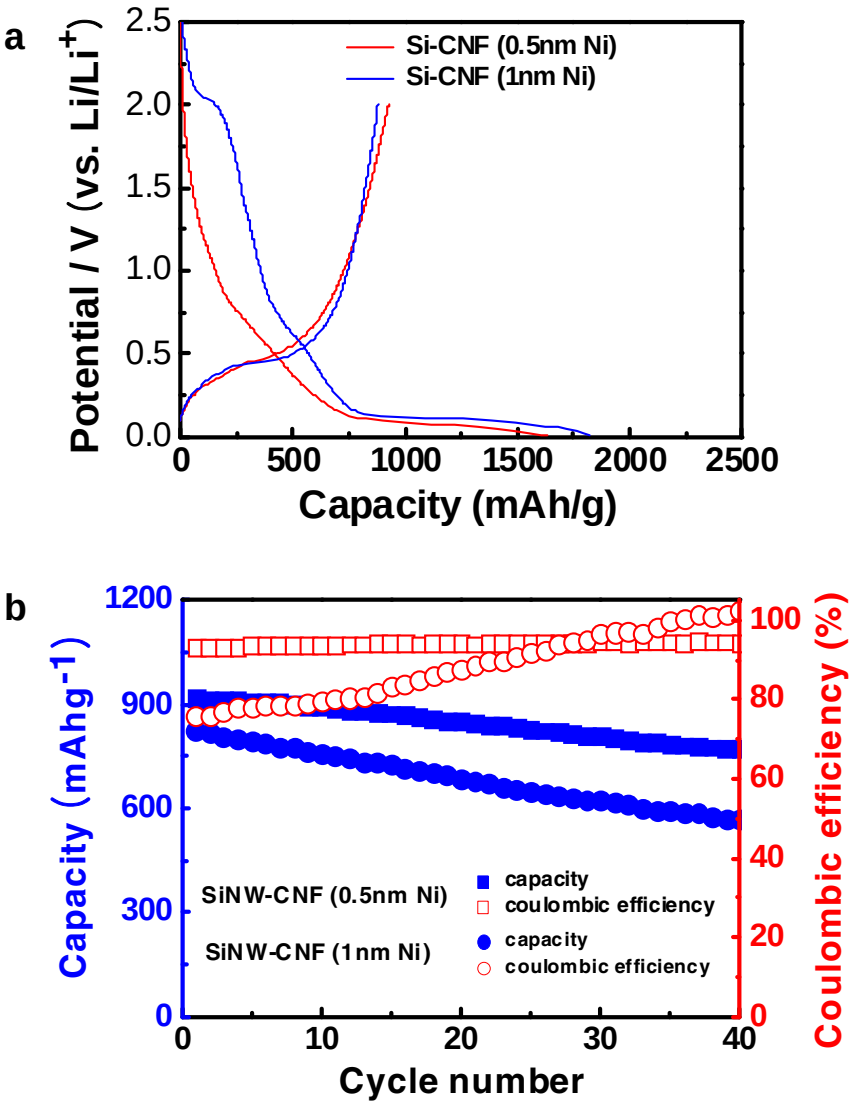

Fig. S3. (a) Voltage profiles of two types of SiNWs-CNFs composites for the first cycle at a rate of 0.2 C. (b) Cycle performances at a rate of 0.02 C. SiNWs-CNF structures grown using a Ni catalyst of 0.5 nm and 1 nm thickness are denoted as SiNWs-CNF (0.5nm Ni) and SiNW-CNF (1nm Ni), respectively.

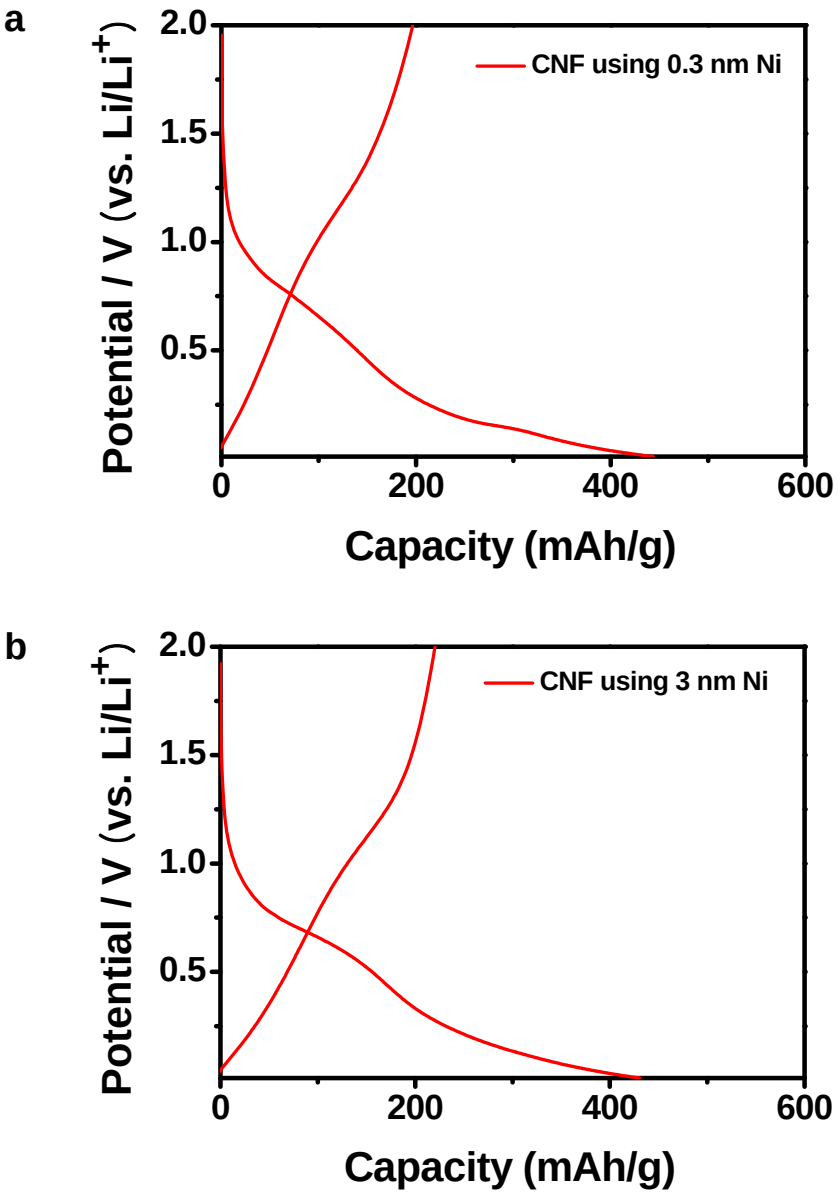

Fig. S4. (a) Voltage profiles of CNFs synthesized using a Ni catalyst with 0.3 nm thickness at the first cycle. (b) Voltage profiles of CNFs synthesized using a Ni catalyst with 3 nm thickness at the first cycle.