

Silicon-Coated Carbon Nanofiber Mat for Anode of Lithium Ion Battery

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Abstract

Si-coated carbon nanofiber (Si/CNF) mat was fabricated by electrochemical method for the anode of lithium ion battery (LIB). The free-standing CNF mat was first fabricated by electrospinning of polyamic acid followed by stabilization and carbonization, and then the as-prepared CNF mat was used for Si electrodeposition through cyclic voltametry (CV), as shown in Figure 1.¹ Spaghetti or granule-like Si was obtained by varying the deposition conditions, see Figure 2 a and b. This Si/CNF mat was directly used as an anode material, which involves neither binders nor additional metal substrate. The best performance was achieved in spaghetti-like Si due to its highly porous nature which can accommodate the volume expansion and large surface area which benefits efficient charge transfer of ions at the electrode/electrolyte interface. The optimized Si/CNF mat anode after annealing at 1000 °C delivered initially a capacity of 1545 mAh/g and 1388 mAh/g after 50 cycles at 0.1 C rate with an average fading rate of 0.34 % per cycle, improving the capacity of pure CNF mat (280 mAh/g at the 50th cycle), as shown in Figure 3. Our X-ray photoemission spectroscopy and electrochemical analysis revealed that the formation of Si-C bond through high temperature annealing can enhance the adhesion between silicon and carbon at the interface which benefited the cyclic performance of the anode material ultimately.

References

[1] N. T. Xuyen, E. J. Ra, H. Z. Geng, K. K. Kim, K. H. An, Y. H. Lee, J. Phys. Chem. B, **111** (2007), 11350.

Figures

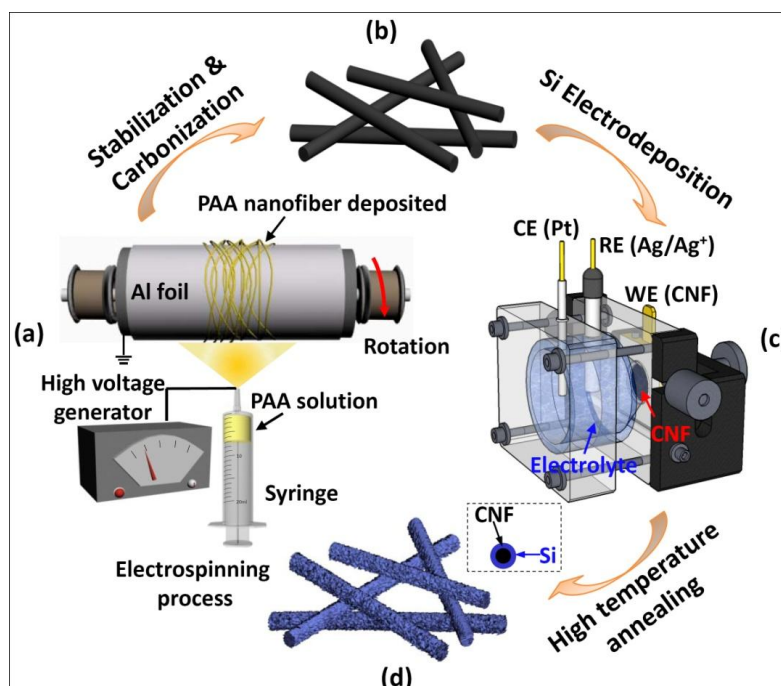


Figure 1. Schematic of a silicon-coated CNF mat fabrication processes; (a) schematic of electrospinning apparatus, (b) the fabricated nanofiber network, (c) apparatus of electrodeposition of Si, and (d) the deposited Si/CNF mat. The inset shows cross section of coaxial type Si/CNF.

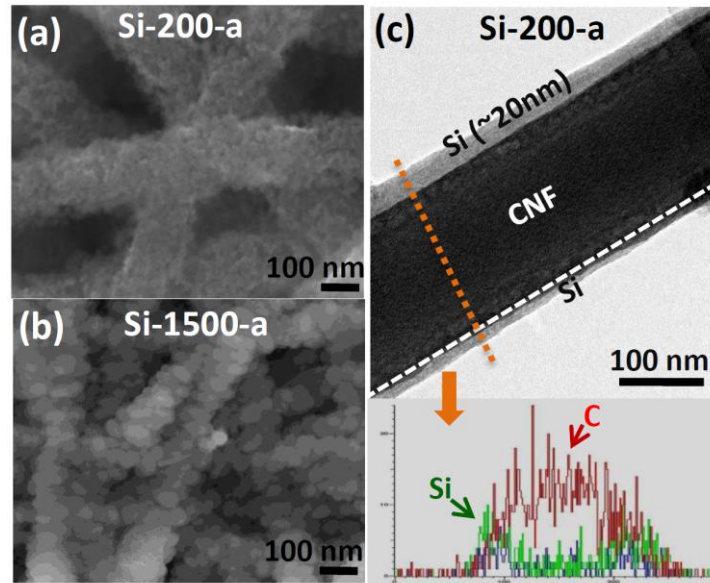


Figure 2 SEM images of Si/CNF mat with (a) 200 and (b) 1500 cycles of Si deposition (after 1000 °C annealing). (c) TEM image of Si-200-a. The EDS line profile along the dashed line is shown in the bottom panel.

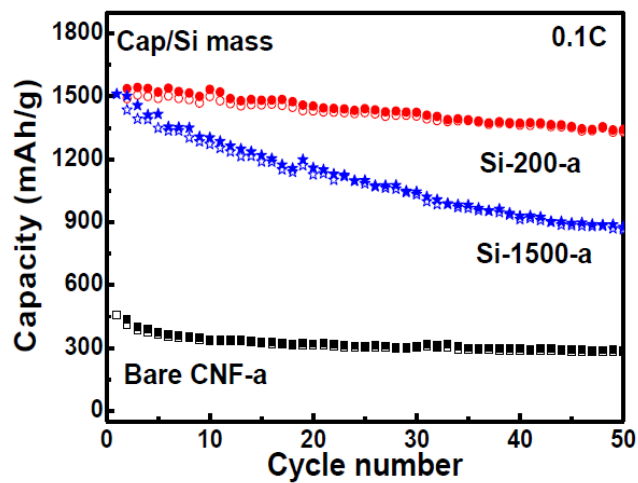


Figure 3 Charge (filled symbols)/discharge (open symbols) capacity in terms of different numbers of silicon deposition cycles (200, 1500 cycles) after high temperature annealing (1000 °C). Capacity was calculated based on silicon mass only.