Carbon-Coated Silicon Nanoparticles in a Few-Layer Graphene-based Conductive Network: a High-Capacity Anode for Lithium-Ion Batteries

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The design of high-capacity anodes based on silicon is appealing for the realization of high-energy density Li-ion batteries. In fact, silicon has a high theoretical capacity (3600 mAh/g^{-1}) that is far beyond the theoretical specific capacity of graphite (372 mAh g^{-1}) [1-2], but still suffers of an enormous volume expansion (up to about 400%) upon Li alloying/de-alloying during charge/discharge cycles, and low Si conductivity [2]. In this work, carbon-coated polycrystalline silicon nanoparticles are embedded in a few-layer graphene (FLG)-based conductive network to realize an anode nanocomposite material with high capacity in half-cell configurations. By assessing the correlations of anode morphological and electrical characteristics and the electrochemical performances of the half-cells, the FLG-based conductive network is optimized in terms of anode capacity and half-cell cyclic stability. By rationally controlling formation and charge/discharge protocols, our optimized anodes display capacity above ~1000 mAh g^{-1} with a Coulombic efficiency (CE) > 97% over more than 200 cycles at a current density of 1 A g^{-1}. The FLG-based conductive network enhances the conductivity of silicon nanoparticles and contrast the electrode failure associated to mechanical expansion/contraction upon cycling. In addition, the method of production of the silicon-FLG nanocomposite is scalable and cost-effective [4] and does not rely on energy-consuming annealing processes after the production of carbon-coated silicon nanoparticles. Overall, our strategy represents an effective route to design advanced Si-based anodes for their advent in commercial high-capacity gen3 and gen4 lithium-ion batteries, as well as future gen5 batteries [5].

References

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Figures

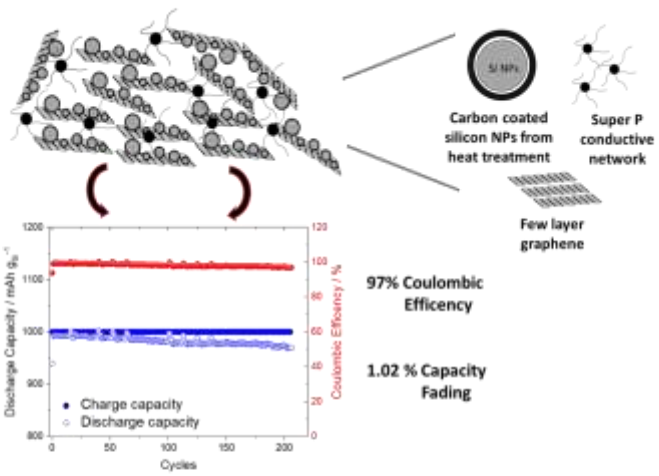

Figure 1: Structures and features of carbon-coated silicon nanoparticles embedded in FLG-based conductive network as high-capacity anode for lithium-ion batteries.

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