Highly Porous Silicon Embedded in a Ceramic Matrix: A Stable High-Capacity Electrode for Li-Ion Batteries

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We demonstrate a cost-effective synthesis route that provides Si-based anode materials with capacities between 2000 and 3000 $mAh\cdot g_{Si}^{-1}$, Coulombic efficiencies above 99.5%, and almost 100% capacity retention over more than 100 cycles. The Si-based composite is prepared from highly porous silicon (obtained by reduction of silica) by encapsulation in an organic carbon and polymer-derived silicon oxycarbide (C/SiOC) matrix. Molecular dynamics (MD) simulations show that the highly porous silicon morphology delivers free volume for the accommodation of strain leading to no macroscopic changes during initial Li-Si alloying. In addition, a carbon layer provides an electrical contact whereas the SiOC matrix significantly diminishes the interface between the electrolyte and the electrode material and thus suppresses the formation of a solid electrolyte interphase (SEI) on Si. Electrochemical tests of the micrometer-sized, glass-fibres derived silicon demonstrate the up-scaling potential of the presented approach.