Binding SnO2 nanoparticles with MoS2 nanosheets towards highly reversible and cycle-stable lithium/sodium storage

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Abstract

SnO2, with its high theoretical capacity, abundant resources, and environmental friendliness, is widely regarded as a potential anode material for lithium-ion batteries (LIBs). Nevertheless, the coarsening of the Sn nanoparticles impedes the reconversion back to SnO2, resulting in low coulombic efficiency and rapid capacity decay. In this study, we fabricated a heterostructure by combining SnO2 nanoparticles with MoS2 nanosheets via plasma-assisted milling. The heterostructure consists of in-situ exfoliated MoS2 nanosheets predominantly in 1T phase, which tightly encase the SnO2 nanoparticles through strong bonding. This configuration effectively mitigates the volume change and particle aggregation upon cycling. Moreover, the strong affinity of Mo, which is the lithiation product of MoS2, toward Sn plays a pivotal role in inhibiting the coarsening of Sn nanograins, thus enhancing the reversibility of Sn to SnO2 upon cycling. Consequently, the SnO2/MoS2 heterostructure exhibits superb performance as an anode material for LIBs, demonstrating high capacity, rapid rate capability, and extended lifespan. Specifically, discharged/charged at a rate of 0.2 A g-1 for 300 cycles, it achieves a remarkable reversible capacity of 1173.4 mAh g-1. Even cycled at high rates of 1.0 and 5.0 A g-1 for 800 cycles, it still retains high reversible capacities of 1005.3 and 768.8 mAh g-1, respectively. Moreover, the heterostructure exhibits outstanding electrochemical performance in both full LIBs and sodium-ion batteries.

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