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Experimental Study on Sodiation of Amorphous Silicon for Use as Sodium-Ion Battery Anode

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Abstract

Amorphous Si (*a*-Si) powders have been synthesized using various synthetic methods, and their electrochemical sodiation behaviours have been studied in detail. These methods include (1) a chemical delithiation method where Si is first lithiated and then delithiated either in an aqueous or organic solution, (2) a mechanical method where crystalline Si is subjected to high-energy ball milling, and (3) a mechanical fusion method where a Si-Sn composite with a Si-Sn atomic ratio of 0.94:0.06 is synthesized through high-energy ball milling. Commercial silicon monoxide (SiO) has also been examined for comparison. It is shown that facile oxidation of *a*-Si encountered in the methods (1) and (2) has led to low sodiation capacity and huge first-cycle irreversible capacity, similar to those of SiO. By contrast, the mechanically fused Si-Sn composite, which contains a Sn shell that prevents the oxidation of the partially amorphized Si core, exhibits a maximum sodiation capacity of 161 mAh g⁻¹ based on active material. This is translated to an estimated sodiation capacity of no more than 230 mAh g⁻¹ for the *a*-Si component in the composite. The presence of the Sn shell considerably reduces the first-cycle irreversible capacity and charge-transfer resistance, resulting in improved rate

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