Scalable synthesis of $Si(FeSi_2)/C$ nanocomposite anode material by high-energy mechanical milling for lithium-ion rechargeable batteries

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Abstract:

Silicon has attracted a great deal of attention as the most promising anode for the advanced lithium-ion rechargeable batteries (LIBs) due to the high theoretical capacity of 3579 mAh g^{-1} [1]. However, the Si electrode undergoes considerable volume expansion of about ~300% during lithiation/delithiation, which is leading to rapid and severe capacity loss [2]. In this work, we present a scalable synthesis for preparing the cost-effective $Si(FeSi_2)/C$ nanocomposite anode material composed of less-active $FeSi_2$ (prepared by induction melting) via a two-stage high-energy mechanical milling (HEMM). The formation of the carbon layer and the less-active $FeSi_2$ nanocrystalline phase can act as a buffer layer to mitigate the volume expansion changes during the lithiation/delithiation. The Crystallinity of the milled nanocomposite powders was investigated by the X-ray diffraction technique. Field-emission scanning electron microscopy (FE-SEM) and high-resolution transmission electron microscopy (HR-TEM) were utilized to study the structure and microstructure of the nanocomposite powders. The effect of milling time on changes in crystalline size, and distribution of the nanocomposite powders, mechanical properties (nanoindentation), and their electrochemical properties were investigated. And the Electrochemical Impedance Spectroscopy (EIS) was used to characterize the anode electrodes on cycling. The results revealed that the nanocomposite delivered a higher charge capacity, prolonged cycle performance along with high coulombic efficiency, due to the enhancement of the electrical conductivity by the carbon layer and the $FeSi_2$ buffer phase. Consequently, in this work, we report a scalable and cost-effective method for preparing $Si(FeSi_2)/C$ anode provides the promising application potentials in the lithium-ion rechargeable batteries.

References:

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