Coiled Spring-Like Hard Carbon as an Anode Material for Lithium-ion Batteries

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Carbon micro-coils (CMCs) with a coiled spring-like morphology and hard carbon structure were prepared using metal Ni powder as a catalyst by chemical vapor deposition method at 750 °C in a mixed gas atmosphere ($\text{N}_2:\text{H}_2:\text{C}_2\text{H}_2=1:3:1$). The obtained CMCs have a screw diameter of approximately 10 μm and a modest surface area of 61.2 $\text{m}^2 \text{g}^{-1}$ with a total pore volume of 0.076 $\text{cm}^3 \text{g}^{-1}$. When used as an anode material in lithium-ion batteries, CMCs electrodes exhibit excellent electrochemical performances. In particular, a comparable good cycling stability with no obvious capacity loss, preserving almost over 99.0% of capacity retention ratio can be achieved at 100 mA g^{-1} after 200 cycles. A lithium storage mechanism for the CMCs has been proposed based on the quantity of the mesopores, which can be applied to explain the irreversible capacity of the CMCs during the first cycle. Electrochemical impedance spectroscopy results show that the CMC electrode has small values for both the electrolytic resistance and combined resistances including the contact resistance and passivation film resistance. This study illustrates the great promise of CMCs and other hard carbon materials with unique morphologies for application in energy storage and conversion systems such as lithium-ion batteries, sodium-ion batteries and supercapacitors.

Keywords: Lithium-ion battery, Carbon micro-coils, Lithium storage mechanism, Electrochemical impedance spectra, Anode

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