Encapsulating Sulfur into Magnéli Phase Ti₄O₇ Nanotube Array for Lithium Sulfur Battery Cathode

by

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Abstract

Magnéli phase Ti₄O₇ nanotube array (NTA) was synthesized in situ on a titanium nitride mesh substrate, functioning as a free-standing electrode in a lithium-sulfur (Li-S) battery. The successful synthesis of which was verified by XRD spectra and SEM images. When forming a composite material with sulfur and assembled into electrochemical cells, Magnéli phase Ti₄O₇ provided sulfur with a high electronic conductivity and strong chemisorption of lithium polysulfide, which tremendously improved the specific capacity of sulfur and enhanced the capacity retention upon cycling. This chemisorption, as evidenced by XPS data, was a redox interaction in nature, and should assist the uniform deposition of charged/discharged solid products. The designed structure of nanotube array increased significantly the electrochemical surface area available for the sulfur redox reactions and the deposition of solid products. When coating the sulfur-Ti₄O₇-NTA composite with carbon, outstanding cycling stability was obtained with an ultra-low capacity decay rate of 0.0322% per cycle for more than 1800 cycles at 0.5C. High values of specific capacity and excellent rate capability were obtained, with a performance of 1604mAh/g at 0.05C, 1220mAh/g at 0.1C, 1060mAh/g at 0.2C, 830mAh/g at 0.5C, 750mAh/g at 1C, 660mAh/g at 2C, 500mAh/g at 4C, and 270mAh/g at 6C. Improvements in cell performance were investigated through the examination of galvanostatic charge/discharge curve, cyclic voltammetry, and electrochemical impedance spectroscopy. Sulfur was introduced into the depth of the nanotubes by a two-step method of electrodeposition followed by melt-infusion. The obtained loading producing some of the best cell performance was in the range of 1.3~2.8mgS/cm², while cells with higher loadings in the range of 3.6~4.9mgS/cm², also delivered satisfactory performance under moderate current rates.

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ALL ARE WELCOME