Mesoporous CoSnO$_3$ Nanocubes with Multilevel Structure as High-performance Anodes for Lithium-ion Batteries

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Abstract: Nowadays lithium-ion batteries are the predominant power source for portable electronics and show incomparable electrochemical properties, such as their advantages of high energy density, long lifespan, no memory effect and environmental friendly.[1-4] Here, we report the syntheses and characterization of mesoporous CoSnO$_3$ nanocubes with multilevel interiors as anode for lithium-ion batteries.

CoSnO$_3$ nanocubes were successfully prepared by a specially designed multi-step synthesis procedure involving precipitation, unusual “pumpkin-carving” protocol with 6 M NaOH, and calcination. The unique structure of the mesoporous nanocubes benefit from the passivation layer of Co(III) species around the liquid-solid interface. Bi-layer and tri-layer CoSnO$_3$ were also synthesized by a similar method with NaOH in various concentrations.

The obtained samples were characterized by X-ray diffraction (XRD), transmission electron microscope (TEM) and scanning electron microscopy (SEM). The XRD analyses indicate the formation of amorphous CoSnO$_3$. The magnified SEM images (Fig. 1 a-d) reveal the detailed morphologies and structures, showing that the monolayer nanocubes possess a size of 200-300 nm, and the tri-layer CoSnO$_3$ with dense to sparse structure have a size of 300-400 nm, while the sparse to dense structure possess a size of 400-500 nm. TEM images (Fig. 1 e and f) indicate that the dense to sparse structure has a layer thickness of 40-45 nm, while the sparse to dense structure is 30-35 nm.

The electrochemical properties of the CoSnO$_3$/Li cells were tested. The results indicate that the CoSnO$_3$ samples have high discharge and charge capacities. Multiple layer structure possesses more superior properties than that of monolayer. The tri-layer CoSnO$_3$ with sparse to dense structure possesses remarkable the highest initial discharge and charge capacities of around 1449 mAh g$^{-1}$, the highest rate capability and the largest capacity retention among them (Fig. 2).

Figure 1. SEM images of mesoporous nanocubes etched by 2 and 6 M NaOH (a and b); SEM images of tri-layer CoSnO$_3$ nanocubes with sparse to dense structure and dense to sparse structure (c and d); and TEM images of tri-layer CoSnO$_3$ nanocubes with sparse to dense structure and dense to sparse structure (e and f).

Figure 2. Comparative cycling performance of tri-layer CoSnO$_3$ nanocubes with sparse to dense structure and dense to sparse structure at a current density of 200 and 600 mA g$^{-1}$ (a, b).

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References: