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SWCNT-supported Amorphous Gallium Sulfide as a New High-performance Anode for Lithium-ion Batteries

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Introduction

As one of the most promising energy storage technologies, lithium-ion batteries (LIBs) are being developed to power the next generation of electrical vehicles (EVs). For this goal, new battery materials are urgently needed to address challenges in cost, safety, energy and power, and service life. Among potential candidates, metal sulfides represent an important class with the potential to provide high capacity [1] and high lithium conductivity [2].

Besides some well-known metal sulfides such as FeS_2, CoS_2, and Cu_2S, commercial Ga_2S_3 has recently been demonstrated as a promising LIB anode material [3]. Atomic layer deposition (ALD) is an attractive technology for fabricating nanostructured LIB materials [4]. Consequently, we have developed ALD amorphous gallium sulfides (GaS_x) and deposited this material on single walled carbon nanotubes (SWCNTs). Electrochemical testing revealed that these SWCNT-GaS_x composites showed high performance as LIB anodes.

Experimental

GaS_x was ALD performed on commercial SWCNTs (see figure 1(a)) using $Ga_2(NMe_2)_6$ and H_2S precursors. ALD allows the deposition of GaS_x on SWCNTs with excellent uniformity and conformality, and the resultant SWCNT-GaS_x nanocomposites (see figure 1(b)) showed well-controllable GaS_x loadings. Using the SWCNT-GaSx composites as anodes, we investigated their electrochemical performance in LIBs. Also, we explored the underlying reaction mechanisms during charge-discharge cycling using synchrotron X-ray measurements at the Advanced Photon Source at Argonne National Laboratory (IL, USA), including in situ X-ray diffraction (XRD) and in situ X-ray adsorption spectrometry (XAS).

Results

The as-synthesized SWCNT-GaS_x showed superior electrochemical behavior compared to commercial Ga_2S_3 powders. As exemplified in figure 2, the cycling stability and capacity of SWCNT-GaS_x are excellent, while the capacity of commercial Ga_2S_3 decreased with cycling numbers.

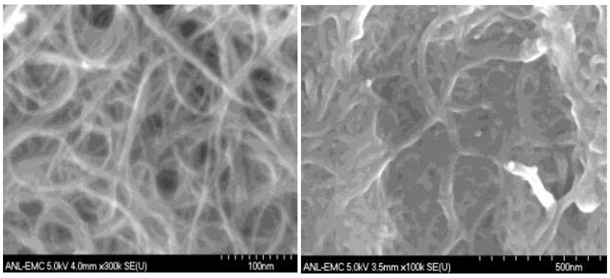

Figure 1. (a) Pristine and (b) GaS_x coated SWCNTs.

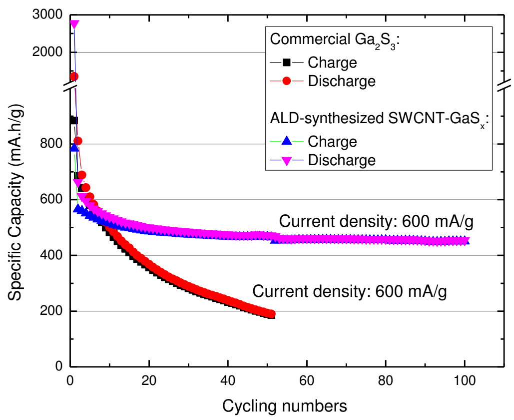

Figure 2. Capacity vs. cycling numbers at a current density of 600 mA/g.

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