Carbon-coated sulfur nanowire array for lithium-sulfur battery

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ABSTRACT

In order to fulfill the growing demands of advanced energy storage devices with higher energy densities is critical for powering our future society. Li-ion batteries have one of the highest specific energies among rechargeable batteries. Despite the numerous advantages, the overall energy density of lithium ion batteries is limited by the low capacity of current cathode materials compared to those of the anode. Therefore, high capacity cathode materials have been given a considerable attention in rechargeable batteries to achieve higher specific energy.

Elemental sulfur (S) is a promising cathode material for a number of desirable properties. Sulfur cathodes have a theoretical specific capacity of 1675 mAh g^{-1} with very high specific energy density of 2500 Wh kg^{-1}. Moreover, using sulfur as the cathode material for batteries has many other advantages such as low cost, abundant, environmental benignity and widespread availability

Despite the considerable promises, a number of significant challenges need to be solved for the commercialization; intrinsic poor electrical conductivity of sulfur (5 × 10^{-30} Scm^{-1} at 25 ^{o}C), dissolution of polysulfides (Li_2S_x, $4 \leq x \leq 8$) in electrolyte and large volumetric expansion of sulfur.

In the present investigation, we developed a sulfur electrode focusing on electrode design. In the electrode design perspective, sulfur was completely covered by minimal amount of carbon, and the carbon coated sulfur nanowire was highly aligned. The electrode design address all of the aforementioned issues at once and result in excellent electrical performance: a specific capacity reaching the theoretical value, substantial capacity retention over 1000 cycles, and rate capability with <1 min discharge time were achieved. Furthermore, these battery performances were achieved under the highest sulfur content to date: ~81 wt% in the active material.

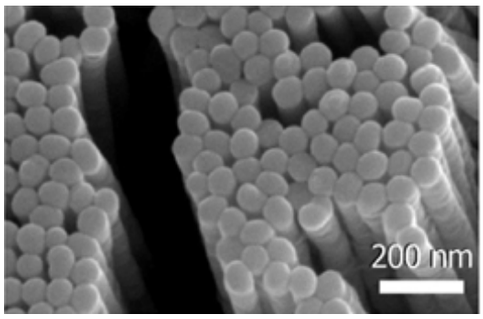

Fig. 1. SEM images of carbon-coated sulfur nanowire array.

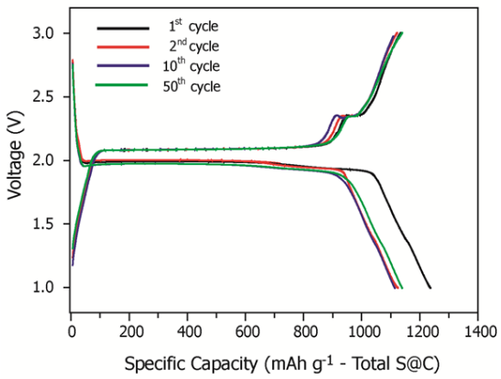

Fig. 2. Cyclability performance of the electrode.

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