Cathode and Anode Design for High Capacity Lithium-Sulfur Batteries with Enhanced Cycle Life

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One of the most promising future generation candidates for safe, low-cost and long-lasting high energy density rechargeable energy storage systems is the lithium-sulfur (Li-S) battery utilizing sulfur as active material. Sulfur offers the highest theoretical capacity of all known solid-state cathode materials (1672 Ah kg-1) and is, furthermore, widely abundant in nature, inexpensive as well as environmentally friendly.

However, despite more than two decades of intensive scientific research focusing on all cell components the commercialization of a viable lithium-sulfur battery has not been realized so far due to several challenges coupled with the electrochemical conversion of sulfur. One of the major drawbacks is the repeated dissolution and deposition of highly insulating sulfur compounds during cycling, which is furthermore accompanied by an extensive expansion and shrinking of the active material as well as a parasitic self-discharge mechanism referred to as polysulfide shuttle. A further challenge is the development of stable anode materials, as metallic Lithium is known to form dendrites upon cycling, leading to degradation and also safety issues. To overcome these shortcomings the design of appropriate cathode and anode materials, as well as their adaption to each other is highly demanded.

Here, we present a cell design offering high reversible capacity over more than 1.300 cycles. The significantly enhanced stability is attributed to the cell components consisting of new carbon/silicon-composite-anodes and porous carbon based cathodes. Furthermore, the nanocomposite-cathodes enable very high sulfur utilization resulting in specific capacities as high as 1.400 Ah kg-1 sulfur. The influence of structural material properties on cell performance will be discussed.

Our work demonstrates, that the limited cycle life of lithium-sulfur cells can be overcome by optimized cathode materials, alternative anodes and adjusted cell design. Together with innovative process technologies these results are expected to be an important step towards significantly enhanced energy storage devices based on the lithium-sulfur chemistry.

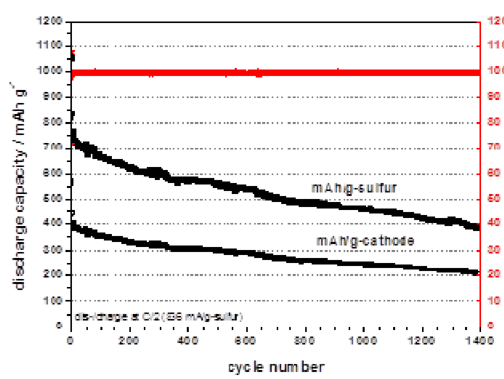

Fig. 1: Full cell test with carbon /silicon anode and sulfur cathode. Reversible capacity obtained over 1300+ cycles.