
Fabrication and Performance Evaluation of Lithium-Sulfur Pouch Cells

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Lithium-sulfur battery (LSB) are being explored as a promising candidate to overcome the energy density limitations of traditional lithium-ion batteries (LIB). Conventional LSBs use elemental sulfur (S₈) as the cathode material due to its high theoretical specific capacity of 1672 mAh g⁻¹, world-wide abundance, and low-cost alternative to nickel and cobalt-containing LIBs.[1] Metallic lithium serves as the anode, offering a theoretical specific capacity of 3860 mAh g⁻¹. The theoretical energy density of LSB is 2600 Wh kg⁻¹, which is three to five times higher than that of LIBs.[2] However, several critical challenges hinder the commercial competitiveness of the LSB, including the low conductivity of S, volume expansion, the lithium polysulfide (LiPS) shuttling effect, and sluggish reaction kinetics. To address these limitations, various advancements in electrolytes, separators, carbon materials, and electrode designs have been proposed.[3]

Despite significant research efforts demonstrating promising cell performance, most studies remain limited to small-scale coin cells, without considering for scalable designs. A considerable gap still exists between lab-scale scientific findings and practical advancements at the product level.

This work promotes the practical development of next-generation high-energy battery systems by bridging the gap between lab-scale cell assembly and prototype cell development. The proposed electrode design adopts a novel architecture, representing a disruptive approach compared to commercial LIBs. The electrodes consist of vertically aligned carbon nanotube (VACNT) carpet synthesized directly on a macroscopic metallic foil acting as a current collector. The dense VACNT carpet is decorated with S active material (S@VACNTs). Additionally, the unique architecture exploits the high electrical conductivity and large surface area of VACNTs to facilitate rapid charge transport, enabling repeated fast charging and improved power performance in high-specific-energy batteries.[4] Pouch cells have been successfully fabricated, demonstrating significantly enhanced performances with both liquid and quasi-solid electrolytes. Research on upscaled prototypes is imperative to identify and overcome key bottlenecks on the path toward commercialization of this technology.

References

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