Design, Processing, and Integration of Pouch-Format Cell for High-Energy Lithium-Sulfur Batteries

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2020 Vehicle Technologies Annual Merit Review

Project ID: bat450

Overview

Timeline*

- Start date: May 2019
- End date: April 2021
- Percent complete: ~40%

Budget*

- Total project funding:
  - DOE: $0.8 M
  - Cost share: 0.21 M (21%)

Barriers

- Need high loading (>5mg-S/cm^2) and low porosity (<50%) of sulfur cathode while still achieving high capacity to reach target energy density
- Need to solve polysulfide shuttle issue and improve cycle life

Collaborations

- Pacific Northwest National Laboratory

  Dr. Jun Liu and Dr. Jie Xiao serve as technical advisors

* Phase II only

Relevance

Impact

- Provide a handful of solutions to address the current issues of all major components of the Li-S battery in pouch-cell level.
- The innovative techniques and strategies can be further expanded and modified for other energy storage systems
- Small businesses or institutes could benefit from this complete solution, thus reducing the effort required for their own development work on the system.

Objectives

- Sulfur cathode optimization
- Electrolyte optimization
- Pouch-format cell design, fabrication, and test protocol

Milestones

Time	Task Title	Milestone Type	Description	Status
Jan. 2020	Sulfur cathode optimization	Milestone	Demonstration of electrochemical performance of high loading and low porosity sulfur cathodes fabricated by new optimized and scale-up process.	Complete
Oct. 2020	Electrolyte optimization	Go/No-go	Demonstration of electrochemical performance of the selected cathode with the optimized electrolyte.	On-going
April 2021	Final cell design and test	Milestone	Demonstration of the final pouch cell design and the optimized test protocols	On-schedule

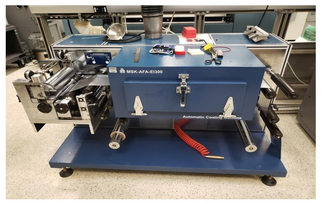
Approach

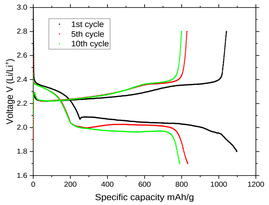
- Sulfur cathode optimization
  - Screening of binder and additive for better adhesion
  - Surface treatment for better interface contact
  - Roll-to-roll scale up of slurry coating process
  - Cathode porosity control by optimization of calendar process
- Electrolyte optimization
  - Develop new dual-phase electrolytes
- Pouch-format cell design, fabrication, and test protocol
  - Implement of polysulfide trapping interlayer
  - Cell design with an internal developed software tool

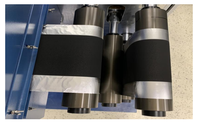
Technical Accomplishments and Progress

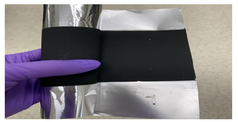
❑Continuous fabrication process

Roll-to-roll coater for kg-scale coating









Corona discharge for Al Surface treatment: Improved adhesion

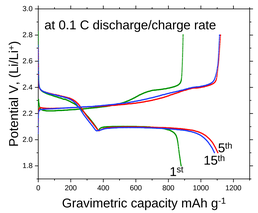
Double sided Flexible & Rollable Cracking free: 5 mg-S/cm^2

❑ Implement of polysulfide trapping layer to improve cyclability of sulfur cathode

- The PP separator was coated with mixture of nano oxide/C layer with thickness of 10-16 μm
- In-house developed continuous coating process that can be easily scaled-up for pouch cell fabrication

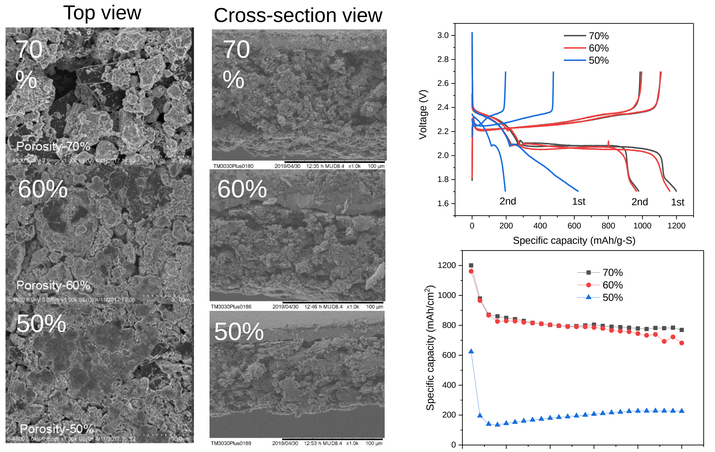
Surface coated PP separator

Coating layer to prevent polysulfide shuttling and improve sulfur utilization



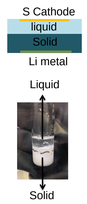
Voltage vs specific capacity curves for Li-S coin cell made of coated separator (~4 mg-S/cm^2)

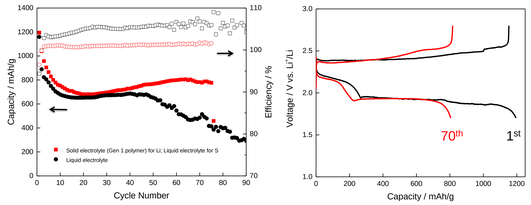
❑ Impacts of porosity on morphology and performance



- S/C ratio in composite: 80:20; Total S in electrode: 70 wt%; Loading: ~4.3 mg-S/cm^2
- Coin cell test DOL/DME electrolyte; 100um Li; E/S ratio=8:1 (μL/mgS) ; 2 Cycles at C/20 then C/10

❑ Dual-phase electrolytes: solid for anode protection and liquid for S cathode





- The cycling stability of the cell using this two phase electrolyte is much better than that of the cell liquid electrolyte, especially after the 45th cycle.
- The coulombic efficiency of the cell with dual-phase electrolyte is close to 100%.

Summary

❑**Sulfur cathode**

- Successful kg-scale up of C/S composite
- Roll-to-roll double sided continuous coating of S electrode
- Flexible and cracking-free high loading S electrode with >5mg-S/cm^2 and ~70 wt-S%.
- Oxide/C coated separator enhances capacity and mitigates polysulfide shuttle
- Separator coating process that can be easily scaled-up for pouch cell fabrication

❑ **Electrolyte optimization & lithium protection**

- Proof-of-concept of new dual-phase electrolyte shows improvement on Li/S cycle ability

Remaining challenges

- Demonstrated 1 Ah pouch cell with > 400 Wh/kg energy density by end of phase I (Mar. 2019), need further increase sulfur loading and reduce porosity of sulfur electrode to reach the target energy density of 500 Wh/kg.
- Cycle life is still quite limited, need improve lithium cycling efficiency/morphology to reach the cycle life target.

Future/On-going work

- Continue to optimize the roll-to-toll fabrication process to further increase sulfur loading
- Addition of additive to improve sulfur cathode utilization with low porosity of <50%
- Continue to optimize both the solid and liquid electrolytes to further enhance the cycle performance

* Any proposed future work is subject to change based on funding levels