

Progress and Status of Battery500 Consortium

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Project ID bat317

Overview

Timeline

- Project start date: 10/01/2021
- Project end date: 9/30/2026
- Percent complete: 70 percent

Budget

- Total project funding: DOE share \$75M
- Funding received in FY 2024: \$15M
- Funding for FY 2025: \$15M

Barriers

- Barriers addressed
 - Increasing the energy density of advanced lithium (Li) batteries beyond what can be achieved in today's Li-ion batteries is a grand scientific and technological challenge.

Partners

- Project lead: PNNL
- Team: Binghamton Univ., BNL, INL, GM, Penn State Univ., Stanford Univ./SLAC, Texas A&M, UC San Diego, Univ. of Maryland, Univ. of Pittsburgh, Univ. of Texas at Austin, Univ. of Washington
- Seedling team: Brown Univ., Iowa State, Penn. State, Univ. of Houston, Univ. of Maryland, Univ of Wisconsin at Milwaukee, Virginia Commonwealth Univ., Virginia Tech.
- Industry Advisory Board



Relevancy:

Project Objectives

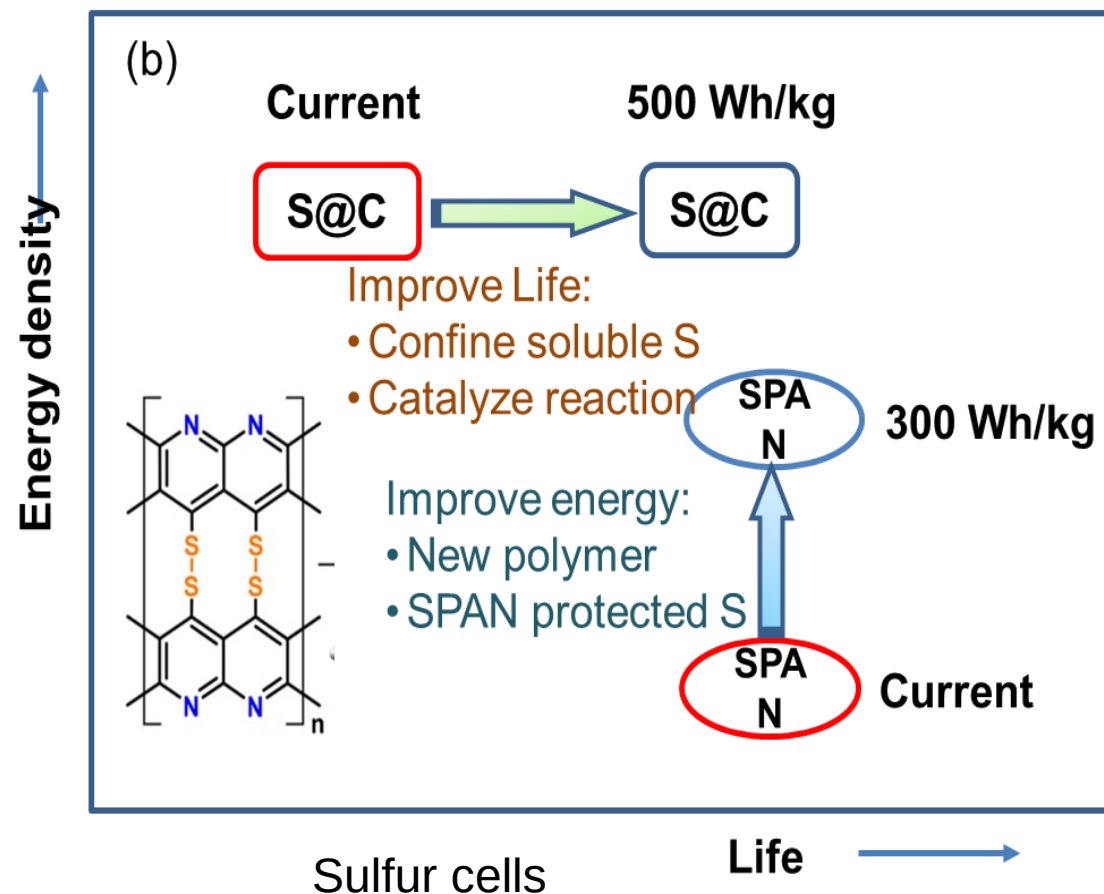
- Develop next generation high-energy, low-cost batteries for electric vehicles
- Design, fabricate and validate high energy pouch cells up to 500 Wh kg⁻¹
- Scale up pouch cell capacity up to 5-10 Ah
- Demonstrate long cycle life of up to 1,000 deep charge-discharge cycles
- Achieve total control of battery chemistries for robust, scalable and commercially viable technologies

Battery500 Cell Level Milestones

Milestones and Go/No-Go Decisions	Date	Status
Demonstrate > 200 cycles for Li-S and Li-SPAN pouch cells up to 325 Wh/kg (GM/UCSD/INL).	9/31/2025	ON Track
Demonstrate fabrication and >50 cycles of 500 Wh/kg NMC pouch cells	9/31/2025	On Track

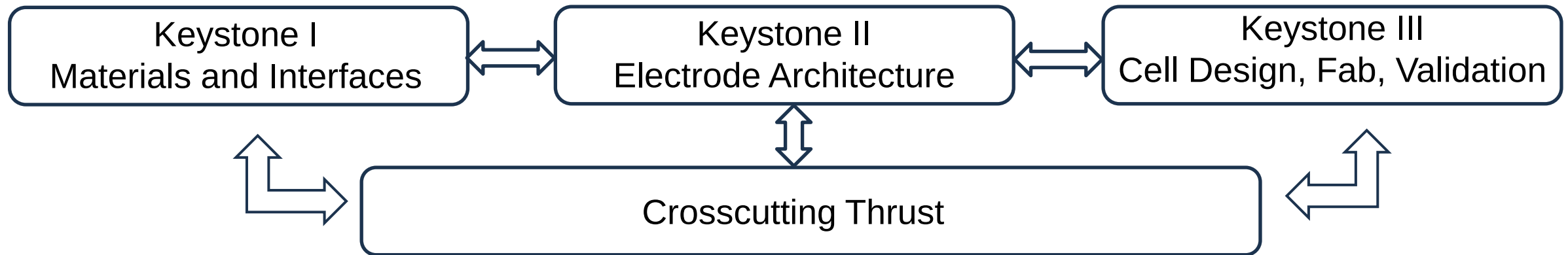
Approaches

- **Fundamental breakthroughs in controlling the electrochemical reactions in high energy electrode materials and cells for next generation high-energy, low-cost batteries;**
- **Integrating development and discoveries from materials to cell level, and rapidly incorporating and validating latest results in realistic cells;**
- **Leveraging materials developed under other DOE programs, and state-of-the-art DOE facilities to understand and prevent degradation.**
- **Developing and deploying multi-disciplinary approaches and enhancing collaborations between national laboratories, universities and industry.**



Technical Approaches: Integration from Materials to Pouch Cells

- Increase stability of high-capacity cathodes
- Develop new S cathode materials
- New electrolytes for Li and Li-S systems
- Stabilize SEIs and CEI on electrodes
- Fabrication of high-loading cathodes
- Scale up S and SPAN cathodes
- Stabilize Li anode
- Scale up high-capacity cathodes
- Design high energy Li and S cells
- Fabricate Li and S pouch cells
- Scale up Li and S cells
- Develop testing protocols and methods
- Control full cell reactions



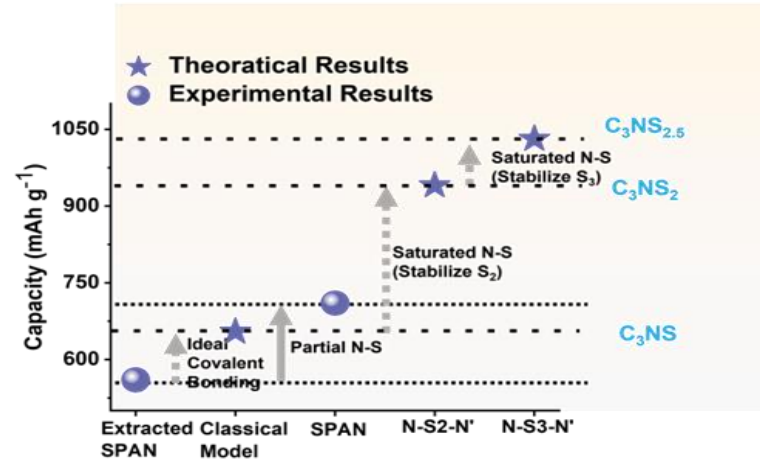
- Understand and control cathode degradation
- Understand and control SEI structures and reactions
- Illustrate molecular structures of S and SPAN cathodes
- Illustrate S and SPAN reaction pathways

Deliverables:

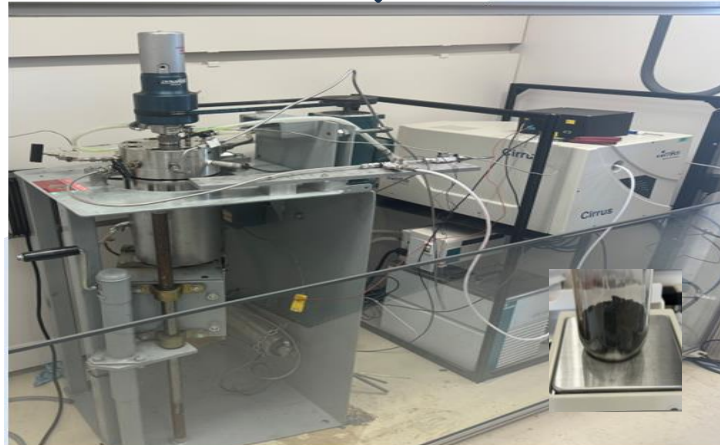
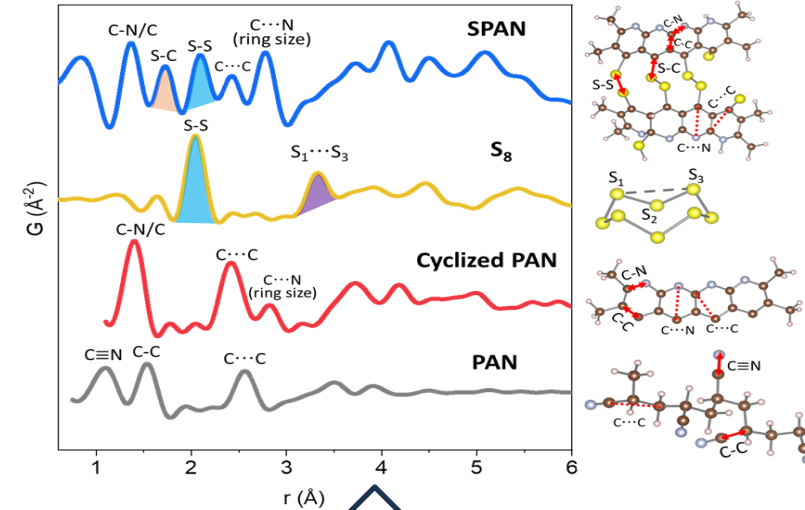
- Develop high energy Li metal pouch cells
- Develop high energy Li-S pouch cells
- Develop and validate low-cost Li-SPAN pouch cells

Technical accomplishments: Development of new SPAN cathodes materials and cells

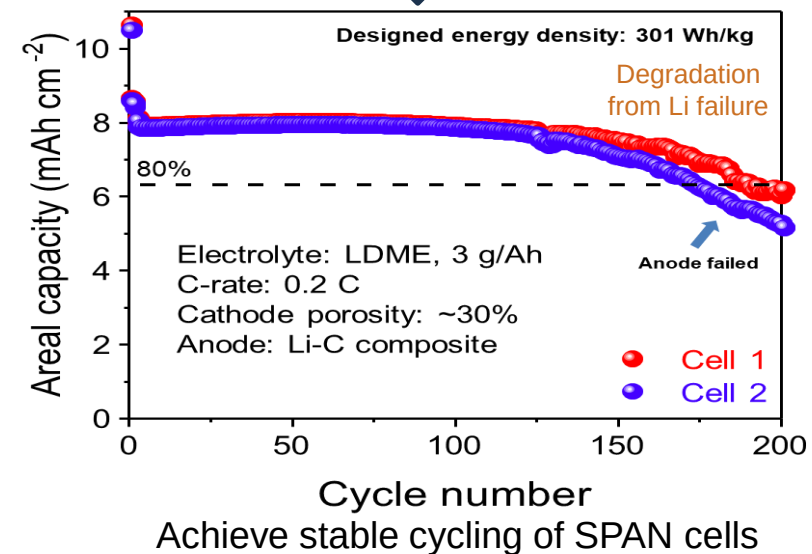
Design and synthesis of high-capacity SPAN cathode



Understanding the molecular chemistry of SPAN



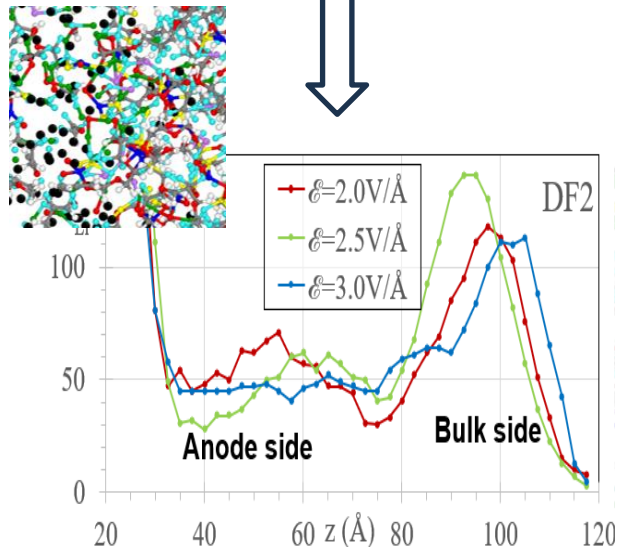
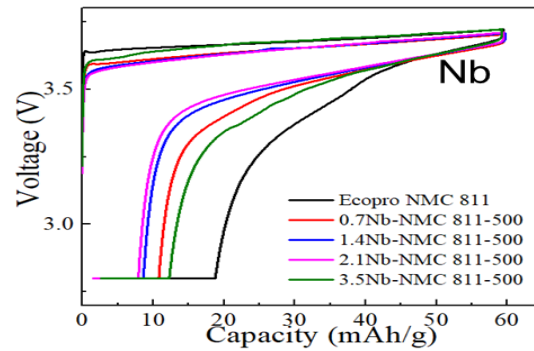
Scaling up SPAN cathodes



Technical accomplishments: Development of materials and pouch cells for Li-NMC system

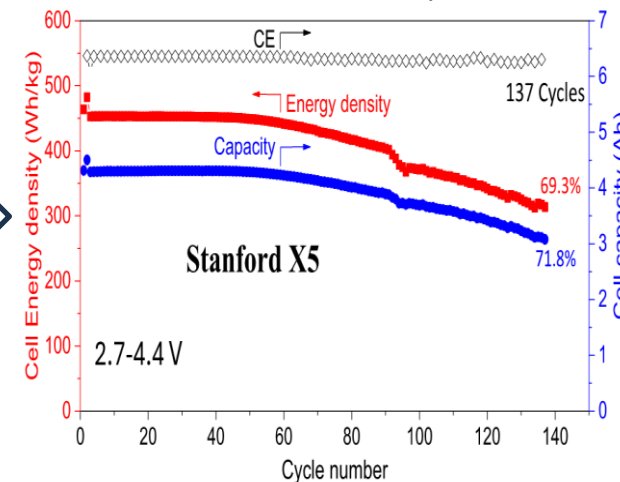
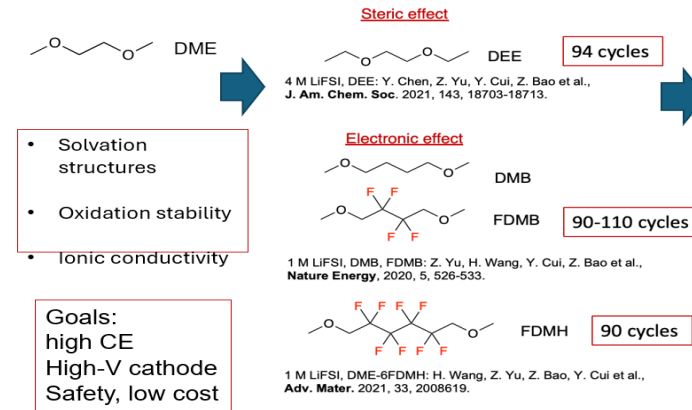
Stabilizing NMC cathode materials

Nb treatment to reduce first cycle loss of NMC

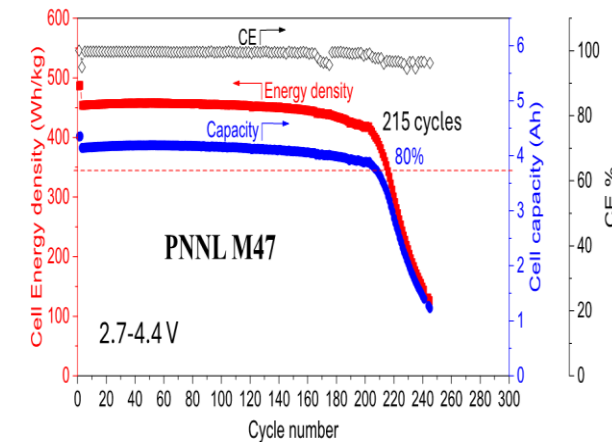


Understanding and controlling SEI structures

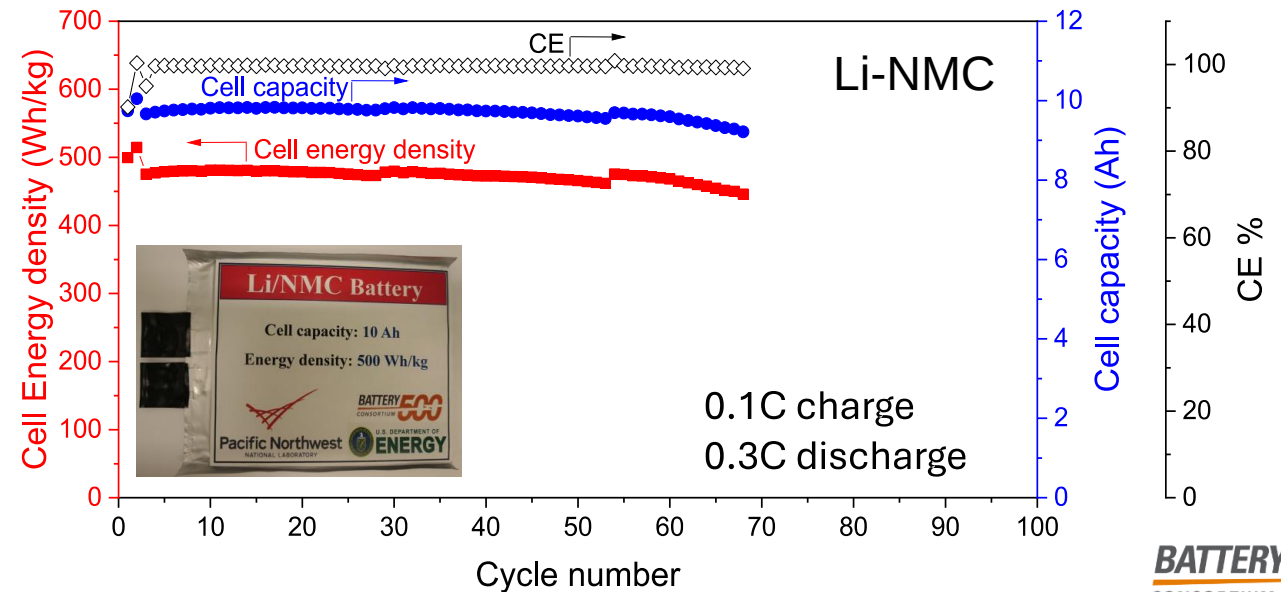
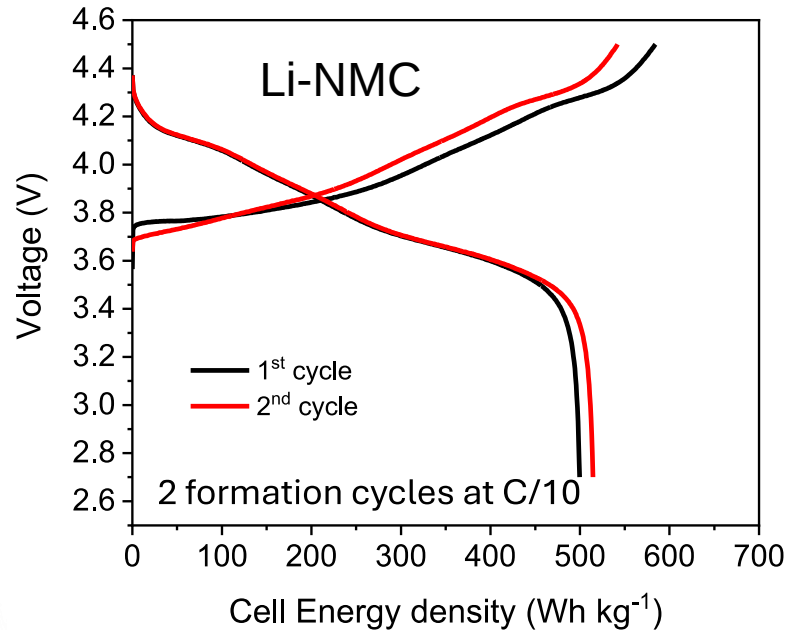
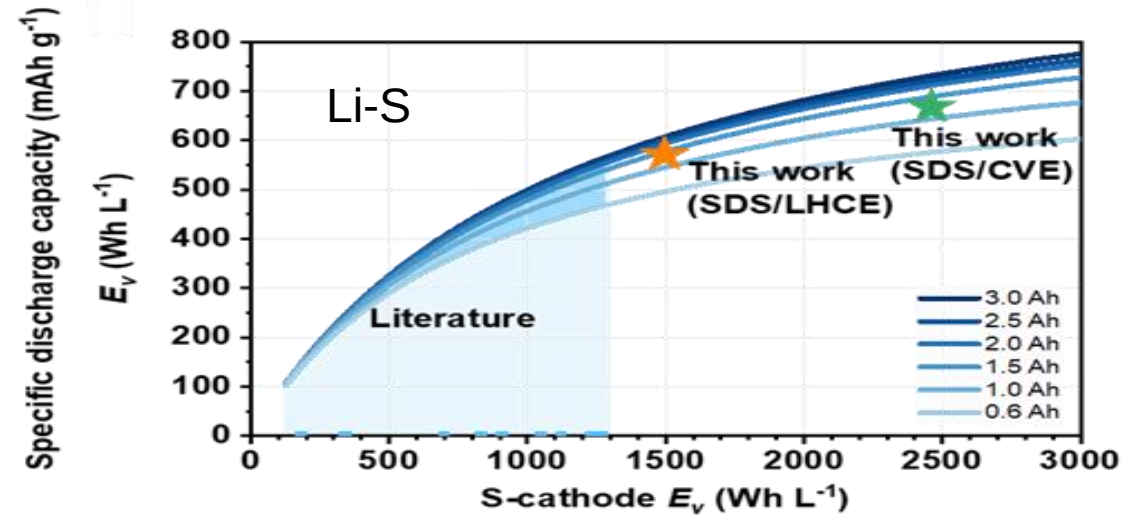
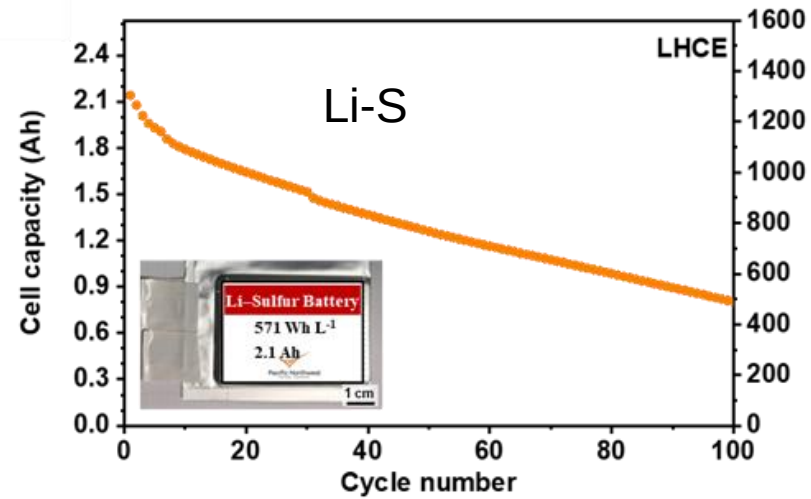
Rational design of stable electrolytes for Li



Comparing of 450 Wh/kg pouch cell behavior



Technical accomplishments: Development of materials and pouch cells for high energy systems



Battery500 Consortium Seedling Projects on Solid Electrolytes: Scalable, Deployable

- Eric Wachsman, Optimizing Cathode Architecture for Solid-State Li Metal-Sulfur Batteries
- Chunsheng Wang, Thin Composite Solid Electrolyte for Li Metal Batteries
- Yan Yao, Scalable Noble-metal-free Interlayer Design for Sheet-type Dendrite-free Solid-state Lithium Metal Batteries,
- Deyang Qu, Battery500 Solid-State Battery Seedling Projects
- Brian Sheldon, Blocking Li Metal Dendrites In Solid Electrolytes With Ion-Exchange Induced Residual Stresses
- Donghai Wang, Developing Materials to Enable High-Energy-Density Cathode and Stable Li Anode for Solid-State Li-S Batteries
- Louis Madsen, Molecular Ionic Composite Solid Electrolytes for Long-Cycling and High Voltage Li-Metal Batteries
- Puru Jena, Stable Sulfide-based Anode-Free and Anode-Limited All-Solid-State Lithium Battery
- Steve Martin, Development of Thin, Robust, Lithium-Impenetrable, High-Conductivity, Electrochemically Stable, Scalable, and Low-Cost Glassy Solid Electrolytes for Solid State Lithium Batteries that Meet Battery500 Consortium Targets



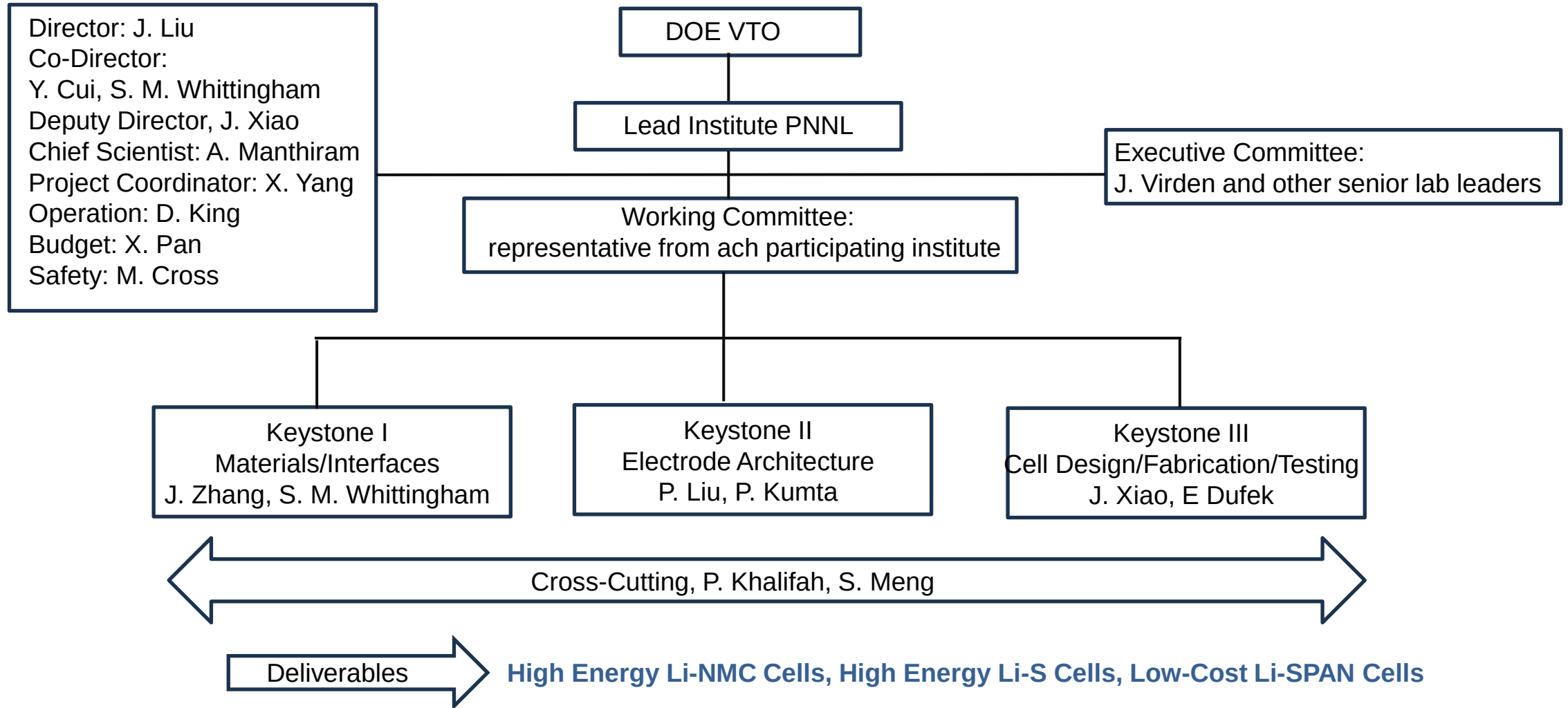
Summary

- Battery500 Consortium has identified key materials and components for next generation high energy batteries using Li metal anodes.
- Battery500 Consortium has developed the design principles, cell level parameters and requirements for practical high energy pouch cells.
- Battery500 Consortium has developed standard testing protocols for rapidly validating the performances and properties of new materials and concepts to integrating with practical cells.
- Battery500 Consortium has developed new stable electrolytes for Li metal anodes enabling stable cycling of high energy pouch cells.
- Battery500 have developed and utilized state-of-the-art characterization tools to characterize, understand and control the materials and cell level properties for high energy cells.
- Battery500 Consortium has developed, fabricated and validated high energy pouch cells up to 500 Wh/kg with good cycle life.
- The Battery500 design tool has been licensed by industry and universities.
- The Battery500 materials and cell performances have been validated by industry.

Future Work

- Address Li metal anode challenges at full cell levels and achieve more than 99.9% Coulombic efficiency (CE) for Li deposition
- Achieve total control of battery chemistries for robust, scalable and commercially viable technologies
- Scale up pouch cell capacity up to 5-10 Ah
- Demonstrate long cycle life of up to 1,000 deep charge-discharge cycles
- Fabricate alternate low-cost and resource-secured Li||S cells of $\sim 300 \text{ Wh kg}^{-1}$ with up to 1,000 cycles
- Perform cost analysis and develop strategies to significantly less than \$100 (kWh)⁻¹
- Independently validate cell performances by industry.

Collaboration: multi-disciplinary team to take advantage of the best capabilities in materials sciences, materials chemistry, electrochemistry, synthesis, battery engineering, characterization and testing.



Core Team: Z. Bao (SLAC/Sanford), P. Balbuena (Texas A&M), X. Cao, (PNNL), W. Chueh (SLAC/Stanford), F. Dai (GM), Y. Cui (SLAC/Stanford), E. Dufek (INL), P. Kumta (U Pittsburgh), P. Khalifah (BNL), E. Hu (BNL), P. Le (PNNL), J. Liu (PNNL/UW), P. Liu (UCSD), A. Manthiram (UT Austin), S. Meng (UCSD), C. Wang (Maryland), J. Nanda (SLAC), D. Wang (SMU), M. S. Whittingham (Binghamton), J. Xiao (PNNL), W. Xu (PNNL), J. Yang (UW), J. Weker (SLAC), X. Yang (BNL), J. Zhang (PNNL)

Response to last year's reviewer comments

N/A This presentation was not reviewed.
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