Overview and Progress of the Exploratory Technology Research Activity: Batteries for Advanced Transportation Technologies (BATT)

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Project ID: ES108
Overview

Perform cutting-edge research on new materials, and address fundamental chemical and mechanical instabilities.

Timeline

- Start – October 2008
- Finish – September 2014
- 33% Complete

Budget

- $15.1 million in FY 2010
- $22.3 million in FY 2011

Challenges

- Research and develop next generation anode and cathode materials
- Understand failure mechanisms to enable higher energy, longer lasting, less expensive batteries
- Comprehensive modeling of cell and material behavior

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Participants

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Material Synthesis, Diagnostics, and Modeling Across Length Scales

Length Scales

10 nm-10 µm

100µm-300µm

Structural Diagnostics

Electrochemical Diagnostics

Electrode Diagnostics

Electrochemical Analysis

Material Synthesis/Modifications

New/Improved Material

Lab Cell Fabrication/Evaluation

Improved Chemistry

Structural Modeling

Electrode Modeling

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The BATT Portfolio in 2011

High-Voltage Cathode
• Ni/Mn Spinel

Novel electrodes, electrolytes, and separators

Beyond Li-ion
• Li-metal anode
• Li-S
• Li-air

High Capacity Anode
• Silicon

Novel electrode processing

Beyond Lithium
• Sodium?
• Magnesium?

Specific System And Material Research

Novel additives

New Materials/Processing Research

Beyond Li-ion Chemistry Research

3-5 years

5-7 years

7-10 years
2010 Anode Highlights

- Cui’s group at Stanford demonstrated that size & morphology control can improve performance: hollow Si nanotubes show greatly enhanced cycling.

- Dillon’s group at NREL applied “atomic layer deposition” coatings to MoO$_3$ nanoparticle-based anodes. ALD-coated particles do not cycle nearly as well as ALD-coated electrodes.

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2010 Cathode Highlights

- Cabana’s group at LBNL compared the cycling ability of high-voltage LiNi_{1/2}Mn_{3/2}O_{4} with different sizes and morphologies. Nanostructures (blue and red) may not improve performance.

- Manthiram’s group at University of Texas produced an Fe-doped, high-voltage material that cycles well at 4.8 V and 137 mAh/g.

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2010 Diagnostics Highlights

- Zaghib’s group at Hydro-Quebec developed an *in situ* SEM tool to directly observe the expansion/contraction of silicon oxide anodes. Cracks formed during expansion remain after contraction.

- Grey’s group at Stony Brook Univ. developed an *in situ* NMR technique to differentiate between bulk and dendritic Li, monitor the growth of \( \mu \text{m-sized} \) dendritic/mossy Li, and determine what Li participates in the electrochemistry.

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All Projects are Competitively Selected

- Request for Proposals Schedule:
  - 2008 – New electrolytes
  - 2009 – New anodes
  - 2010 – New cathodes

  - Nov. 2011 – Advanced Diagnostics, Modeling and Assembly of Battery Materials and Electrodes
  - Nov. 2012 – Novel Electrolytes and Additives
  - Nov. 2013 – Novel Anode Materials and Structures
  - Nov. 2014 – Novel Cathode Materials and Structures

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## New Electrolyte Projects

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<td>ANL</td>
<td>Advanced Electrolytes and Electrolyte Additives</td>
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<td>C.A. Angell</td>
<td>Arizona State</td>
<td>Sulfones with Additives as Electrolytes</td>
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<td>W. Henderson</td>
<td>North Carolina State</td>
<td>Inexpensive, Nonfluorinated (or Partially-Fluorinated) Anions for Lithium Salts and Ionic Liquids</td>
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<td>B. Lucht</td>
<td>U. of Rhode Island</td>
<td>Development of Electrolytes for Lithium-ion Batteries</td>
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<td>D. Scherson and J. Protasiewicz</td>
<td>Case Western Reserve</td>
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## New Anode Projects

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<td>K. Chan</td>
<td>Southwest Research Institute</td>
<td>Synthesis and Characterization of Si Clathrates for Anode Applications in Li-ion Batteries</td>
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<td>Y. Cui</td>
<td>Stanford</td>
<td>Wiring Up Silicon Nanoparticles for High-Performance Lithium-ion Battery Anodes</td>
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<td>A. Dillon</td>
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<td>P. Kumta</td>
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<td>M. Thackeray</td>
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<tr>
<td>D. Wang</td>
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<td>Synthesis and Characterization of Polymer-Coated Layered SiOₓ-Graphene Nanocomposite Anodes</td>
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New Cathode Projects

- 102 white papers received
- Initial review completed
- Full proposals requested
- Selections expected summer 2011
2011 Plans

- New focus groups to understand critical issues with high-voltage spinel cathodes and Si anodes
  - LiMn$_{1.5}$Ni$_{0.5}$O$_4$ system: side reactions and transport properties. Will continue to understand and improve this system and the electrolytes to be used with it.
  - Si anode: define a baseline for new binder studies, investigate shape and morphology impacts on cycling, and new surface coatings and additives to stabilize the anode.
- Complete evaluation of new cathode project proposals and award new contracts
- Solicit new proposals for advanced diagnostics, modeling and assembly of battery materials and electrodes

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