U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Overview and Progress of the Batteries for Advanced Transportation Technologies (BATT) Activity

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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

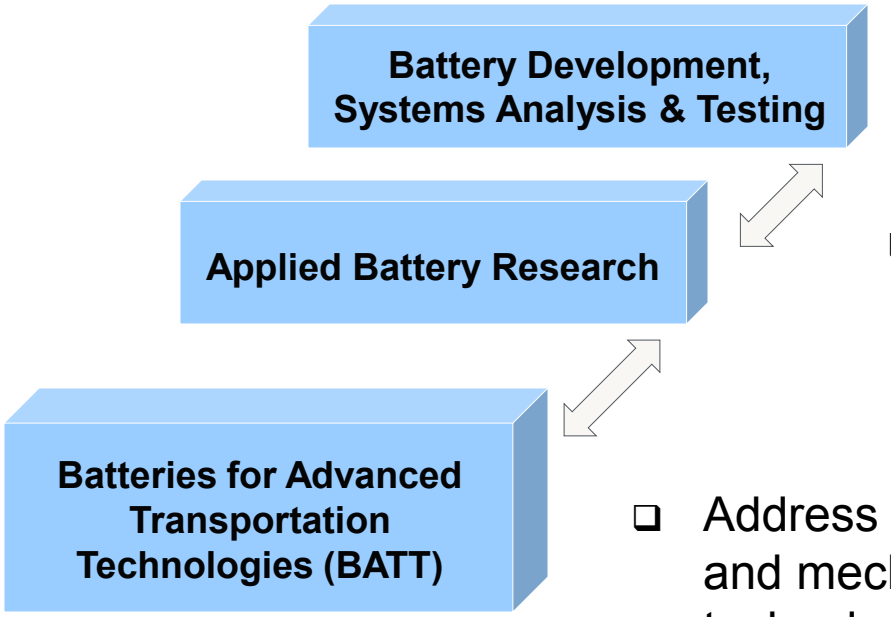
Budget

- FY 2011: $24.5M (BATT: $20.9M)
- FY 2012: $24.7M (BATT: $21.1M)

Challenges

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

Energy Storage R&D: Vehicle Technologies Program (VTP)



- Develop full prototype battery systems with industry (USABC, other industry).
- Assist developers of lithium-ion technologies (PHEV applications) overcome key barriers to large-scale usage.
- Address the fundamental science of chemical and mechanical instabilities in current battery technologies, and develop new materials for next generation batteries.

Research efforts closely coordinated with the Office of Basic Energy Sciences, ARPA-E, and the Office of Electricity

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Participants

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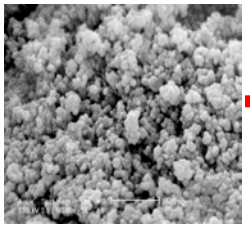
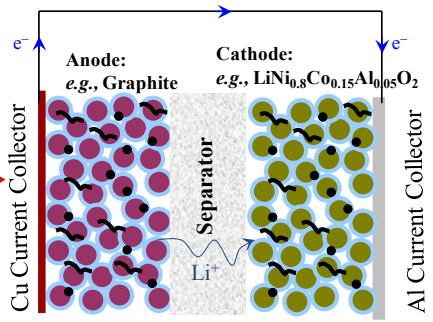
Material Synthesis, Diagnostics, and Modeling (Across Length Scales)

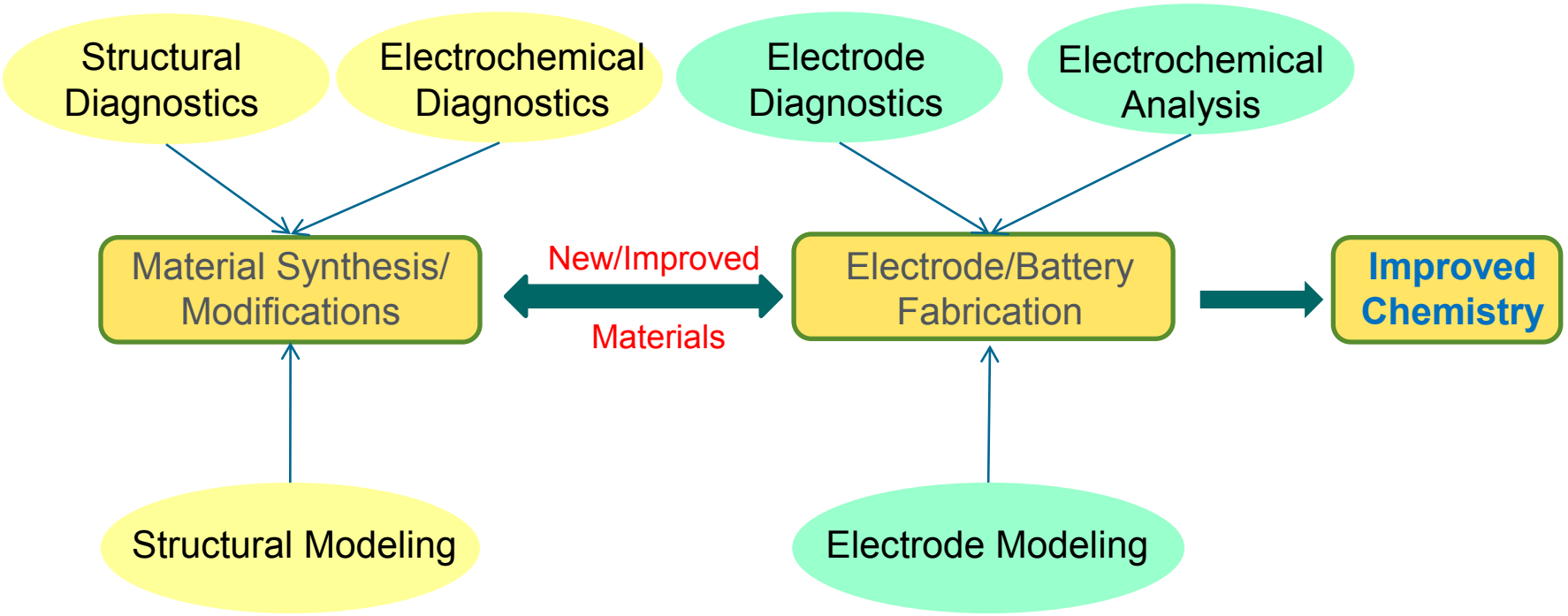


10nm –10μm

Length Scales



100μm – 300μm



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FY 2012 BATT Portfolio

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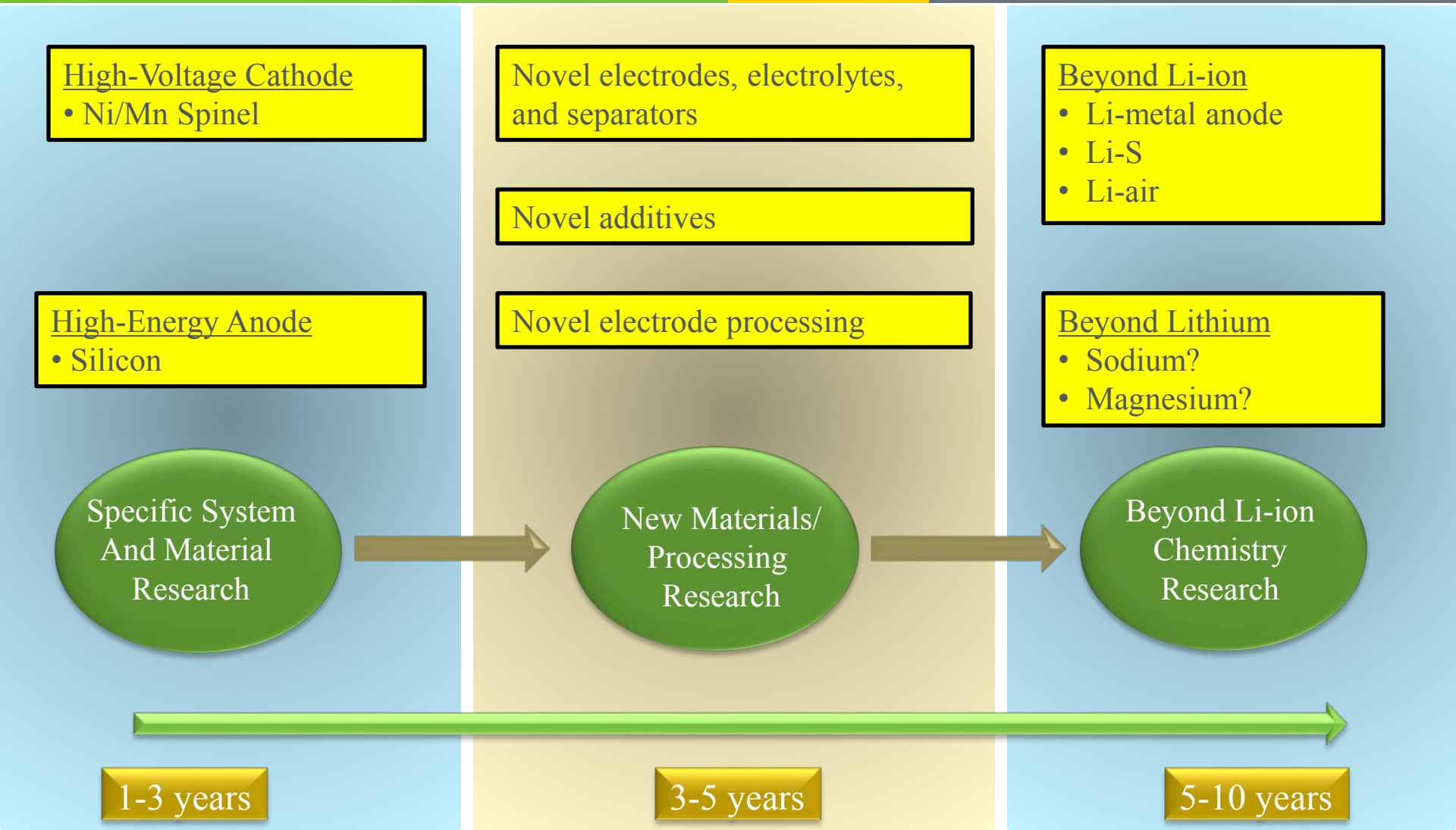

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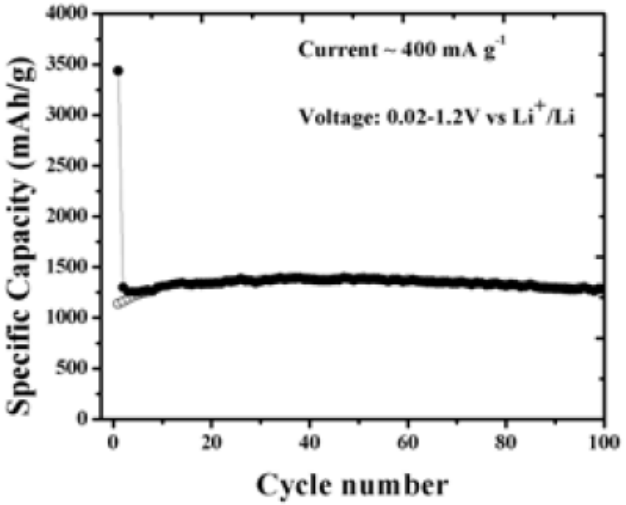
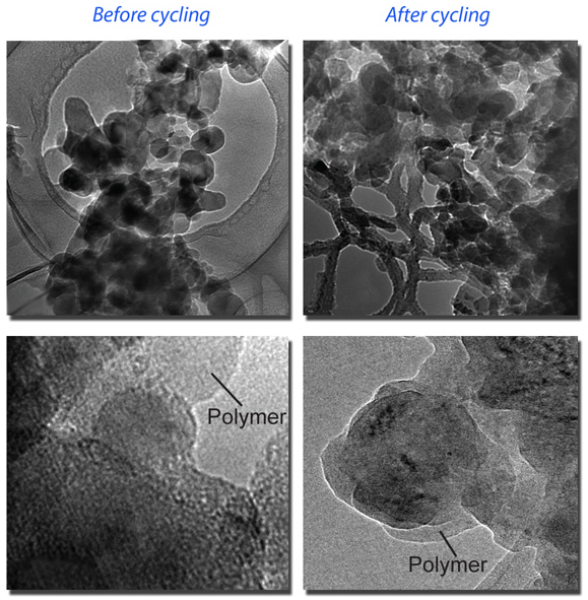
FY 2011 Highlights: Anodes

- **University of Pittsburgh** (Kumta's Group) developed an amorphous-Si electrode that cycles well at 1,300 mAh/g. Depositing thin amorphous-Si films directly on the current collector eliminates the use of binders and conducting agents, thereby simplifying the process and making it amenable to large-scale manufacturing.



- **LBNL** (Liu's Group) developed a new kind of composite silicon anode that can absorb 8x more lithium than current Li-ion batteries and maintains a high capacity of 2,100 mAh/g in Si after 650 cycles. This anode contains an electronically conductive polymer that can accommodate volume changes in the Si nanoparticles during cycling.



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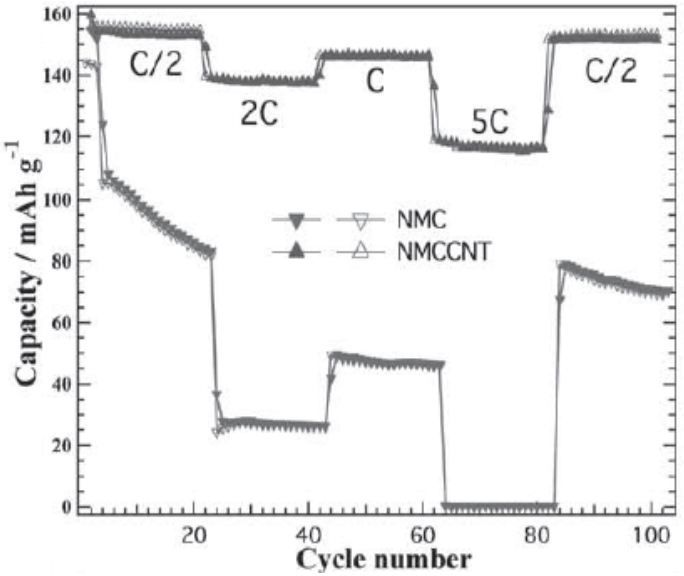
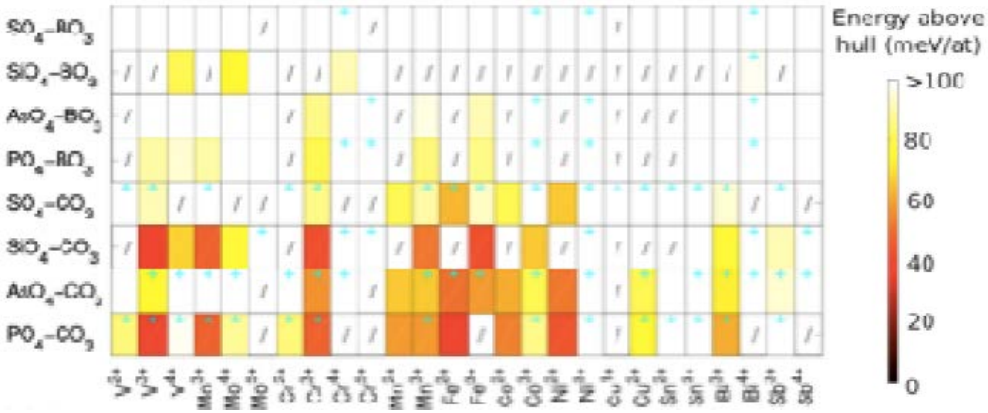
FY 2011 Highlights: Cathodes

- **NREL** (Dillon's Group) and Binghamton U. (Whittingham's Group) incorporated single-wall carbon nanotubes into NMC cathodes to enhance their conductivity and rate capability. These composite cathodes exhibit stable high-rate capacities, ~130 mAh/g at 5C and nearly 120 mAh/g at 10C for over 500 cycles, which are significantly higher than those achieved with conventional NMC cathodes.



- **MIT** (Ceder's Group) used high-throughput, computational search to identify new cathode materials based on the sidorenkite crystal structure. Two-electron activity and high specific energies (>800 Wh/kg) may be achievable with this class of materials.



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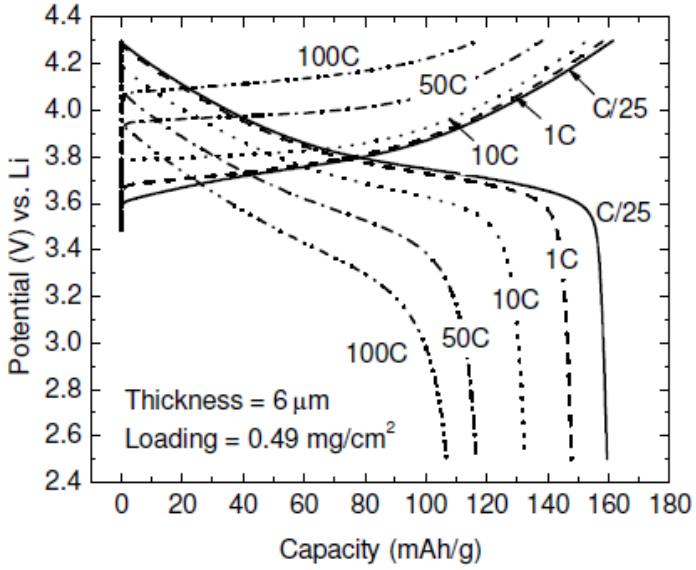
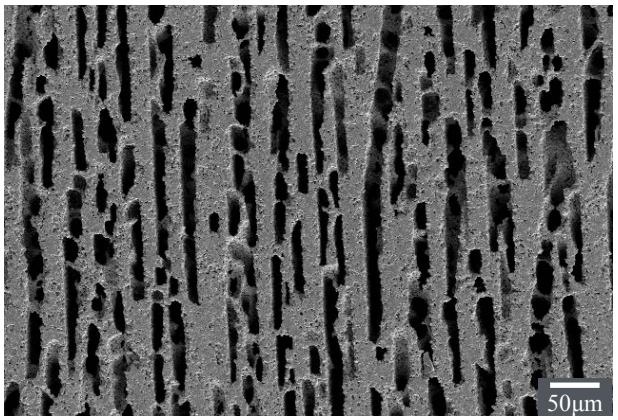
FY 2011 Highlights: Cell Analysis

- **LBNL** (Srinivasan's Group) demonstrated that thin NCM electrodes (~6 μm) can retain more than 50% capacity when discharging at rates up to 100C, with even higher rate capability seen for charge cycles.



- **MIT** (Chiang's Group) produced high-density, binder-free, sintered $LiCoO_2$ cathodes with directionally aligned pores. Electrochemical tests indicate high utilization (ca. 140 mAh/g) at C/10, as expected.



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All Projects Competitively Selected

- Request for Proposals schedule:
  - 2010 – New anodes
  - 2011 – New cathodes
  - 2012 – Advanced Diagnostics, Modeling and Assembly of Battery Materials and Electrodes
  - Jan. 2013 – Novel Electrolytes and Additives
  - Jan. 2014 – Novel Anode Materials and Structures
  - Jan. 2015 – Novel Cathode Materials and Structures

Cathodes

Investigator	Institution	Project
J. Cabana	LBNL	New Mixed Anion Cathode Materials: Exploration of Li-M-O-F Systems
M. Doeff	LBNL	Design of High Performance, High Energy Cathode Materials
J. Graetz	BNL	In-situ Solvothermal Synthesis of Novel High Capacity Cathodes
J. Kiggans, D. Shin, F. Montgomery, N. Dudney	ORNL	Lithium-bearing Mixed Polyanion (LBMP) Glasses as Cathode Materials
A. Manthiram	U. of Texas at Austin	High-capacity, High-voltage Cathode Materials for Lithium-ion Batteries
M. Thackeray	ANL	High-Capacity Composite Cathode Materials: New Synthesis Routes and Structures
J. Zhang	PNNL	High-Energy Cathode for Lithium-ion Batteries

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Advanced Diagnostics, Modeling, and Assembly of Battery Materials and Electrodes

- 170 white papers received
- Requested full proposals to be received (May 2012)
- Selections expected (Summer 2012)

FY 2011 Collaborations and Coordinations

- Focus groups formed to understand critical issues with high-voltage spinel cathodes and Si anodes
- **$LiMn_{1.5}Ni_{0.5}O_4$ cathode:** side reactions and transport properties. Will continue to understand its fundamental limitations with the aim to improve its performance.
- **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.

FY 2012-2013 Plans

- Complete evaluation of new “Advanced Diagnostics, Modeling, and Assembly of Battery Materials and Electrodes” project proposals and award new contracts
- Solicit new proposals for Novel Electrolytes and Additives