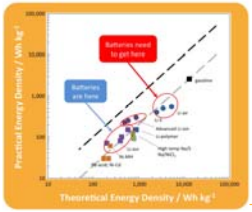
EXPLORE AND COLLABORATE
AMERICAN INDUSTRY AND AMERICA'S NATIONAL LABS
MATERIALS FOR ENERGY APPLICATIONS

Materials for Electrical Energy Storage

Moving Storage Technology Forward Through Advances in Materials Science & Engineering



The performance of current electrical energy storage (EES) technologies falls well short of requirements for using electrical energy efficiently in transportation, commercial, and residential applications. For example, EES devices with substantially higher energy and power densities and faster recharge times are needed if all-electric /plug-in hybrid vehicles are to be deployed broadly. Progressing to the higher energy and power densities required for future batteries will push materials to the edge of stability; yet these devices must be safe and reliable through thousands of rapid charge-discharge cycles.

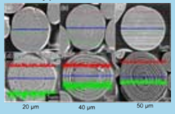
Materials Challenges

Cathode Challenges

- Increase energy density
- Improve the cycling efficiency
- Lower the cost of component materials

Strategy:

- Nano-engineer particle morphologies and electrode structures to optimize power and conductivity
- Combine advances in computational materials science with discovery synthesis to identify new electro-active structural types



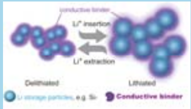
Concentric ring cross-sections for both precursor and lithiated compounds (Argonne National Laboratory)

Anode Challenges

- Increase energy density and capacity
- Identify synthetic strategies that produce lower dimensional morphologies or new composites with emerging materials

Strategy:

- Combine advances in computational materials science, discovery synthesis, and advanced characterization techniques to discover new anode structures



Conductive polymer binder for silicon anode (Lawrence Berkeley National Laboratory)

Electrolyte Challenges

- Increase stability at high voltage
- Develop ability to form stable protective layer with the anode
- Increase safety characteristics

Strategy:

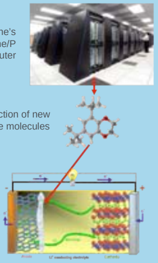
- Identify and explore new solvents and salt combinations
- Evaluate the required additives in many commercial systems to improve safety

Metal-based ionic liquids for flow batteries (Sandia National Laboratories)

Materials Research

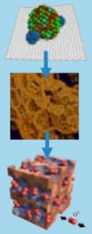
Computation

Argonne National Laboratory is using high-performance computing to predict new electrolyte additives for protective interfaces in Li-ion batteries.



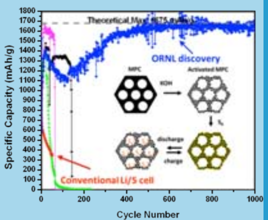
Characterization

Pacific Northwest National Laboratory is working with industry to develop commercially-viable electrode materials, including nano-engineering graphene electrodes to enhance storage capacity.



Nano-Engineering

Oak Ridge National Laboratory's novel sulfur-carbon composites and electrolyte additives could increase the cycle-life of lithium-sulfur batteries to over 1,000 cycles.



Industrial Engagement

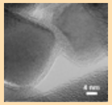
Materials Example

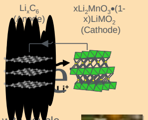
High-Energy Lithium Batteries:

From Fundamental Research to Cars on the Road

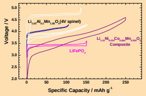
Basic Science	Applied R&D	Manufacturing/ Commercialization
Discovered new composite structures for stable, high-capacity cathodes	***Created*** high energy Li-ion cells…	***Licensed*** to materials and cell manufacturers and automobile companies

Tailored electrode-electrolyte interface using nanotechnology





…with double cathode capacity, enhanced stability

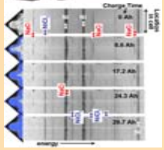


GM VOLT
BASF
ENVIA SYSTEMS
TODA KOGYO CORP.
LG Chem

Characterization Example

Cross-sectional X-ray diffraction patterns of General Electric's (GE's) sodium metal halide battery taken at various times during charging of the Na/MCl2 = NaCl/M Battery. Each strip on the right represents a position along the vertical line on the left; the dark lines within each strip indicate which phases are present at that location and thus, reveal changes in battery chemistry.

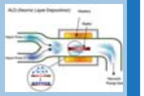
Image taken at the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory



Process Engineering

Atomic Layer Deposition for Batteries

The National Renewable Energy Laboratory (NREL) is using ALD to apply thin < 1nm coatings of amorphous aluminum oxide to a variety of Li-ion battery electrodes. The sequential chemical reactions allow for controlled deposition on an entire porous electrode. The coating mitigates side reactions at the solid electrolyte interface, delay anode expansion and stabilize the cathodes at higher voltage. NREL is demonstrating an atmospheric ALD process that may be easily integrated into the current Li-battery electrode manufacturing lines.



Scale-Up R&D

Scale-up research at Argonne National Laboratory bridges the gap between small-scale laboratory research and high-volume battery manufacturing.

PROCESS MODELING

Proven industrial software is used to create simulations and unit operations models to generate cost estimates and provide a better understanding of process economics.

PROCESS SCALE-UP

Researchers can conduct 1-10 kg process scale-up work.

MATERIALS CHARACTERIZATION

Provides a rapid turnaround for process development and quality assurance testing.

CELL FABRICATION

Novel battery chemistries in standard cell formats are rapidly assessed.

PERFORMANCE TESTING

Batteries of all sizes are tested for life cycle, calendar life, and other factors.

INDUSTRY

Industry is provided with tested, scalable processes, bulk materials with full quality assurance analysis, performance testing results, and finished cells for their own validation testing.

Post-Testing

Argonne National Laboratory researchers are now able to dissect, harvest and analyze battery materials from used and previously tested battery cells in order to identify for developers and manufacturers the exact mechanisms that limit the life of their battery cells. In the past, the cause of performance degradation could only be inferred. This information is fed back to materials scientists who use it to improve the performance of storage technologies.

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