Sustainable TRANSPORTATION

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

Overview and Progress of the Advanced Battery Materials Research (BMR) Program

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ES 108

Advanced Battery Materials Research (BMR) Program

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- Previously known as:
  - Batteries for Advanced Transportation Technologies (BATT)
  - Exploratory Technology Research (ETR).
- 10 Topic areas, 52 research projects
  - Electrode modeling, diagnostics, cell analysis, silicon anodes, cathodes, liquid electrolytes, metallic lithium & solid electrolytes, sulfur electrodes, lithium air and sodium ion batteries.
- Participants include universities, national laboratories, and industry.
- Funding mechanisms:
  - Annual Operating Plan (AOP) process for the national laboratories.
  - Federal opportunity announcements (FOAs) for awards to universities and industries.

Task Leads

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- Silicon Anode Research – Ji-Guang Zhang
- Advanced Cathode Research – Jagjit Nanda
- Cell Analysis – Vincent Battaglia
- Diagnostics – Guoying Chen
- Liquid Electrolytes – Zhengcheng Zhang
- Metallic Lithium and Solid Electrolytes – Nancy Dudney
- Lithium Air – Ji-Guang Zhang
- Lithium Sulfur Batteries – Prashant Kumta
- Modeling Advanced Electrode Materials – Venkat Srinivasan
- Sodium Ion Batteries – Xiao-Qing Yang

Cost Reduction – Advanced Battery Technologies

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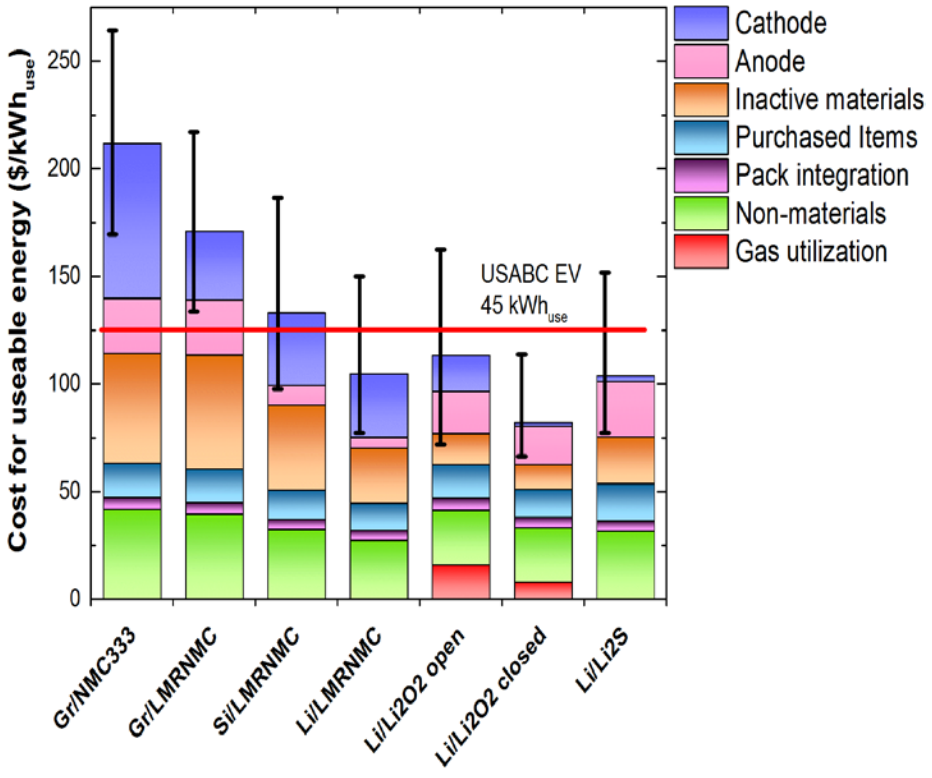
- Extensive cost modeling has been conducted on advanced battery chemistries using the ANL BatPaC model.
- Significant cost reductions are possible using more advanced lithium-ion materials systems.
  - **Lithium-ion:** Silicon anode coupled with a high capacity cathode presents moderate risk pathway to battery systems for less than 125/kWh$_{use}$
  - **Lithium metal:** a higher risk pathway to generation of systems below $100/kWh$_{use}$

Projected Cost for a 100 kWh Battery Pack



These are the **best case projections** assuming:

- **Elimination of chemistry problems**
- **No performance limitations**
- **Assumptions of favorable system engineering are valid**
- **Realization of high-volume manufacturing**

Courtesy: JCESR Energy Storage Hub

Li Metal Anode

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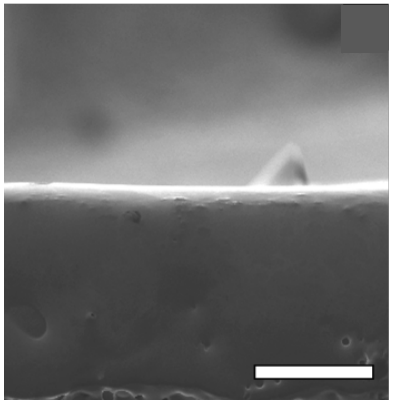
Opportunity

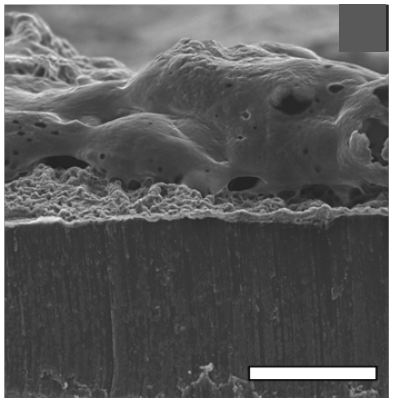
- Dramatic increases in specific and volumetric energies possible.

Objectives

- Key technical hurdle is to prevent the gradual loss of lithium and impede dendrite formation while providing adequate power.
- This will be addressed through:
  - Improved understanding of the chemical and physical processes that consume lithium at the electrode-electrolyte interface.
  - Electrolyte additives to prevent dendritic Li growth.
  - Engineered barrier materials, solid or liquid electrolytes, to stabilize the anode-electrolyte interface.



Before cycling (with SEI layer)



10 cycles

Evolution of an SEI Layer on Cycling of a Metallic Lithium Electrode (scale bars represent 100 microns)

Source: ORNL

Li Metal Anode (cont'd)

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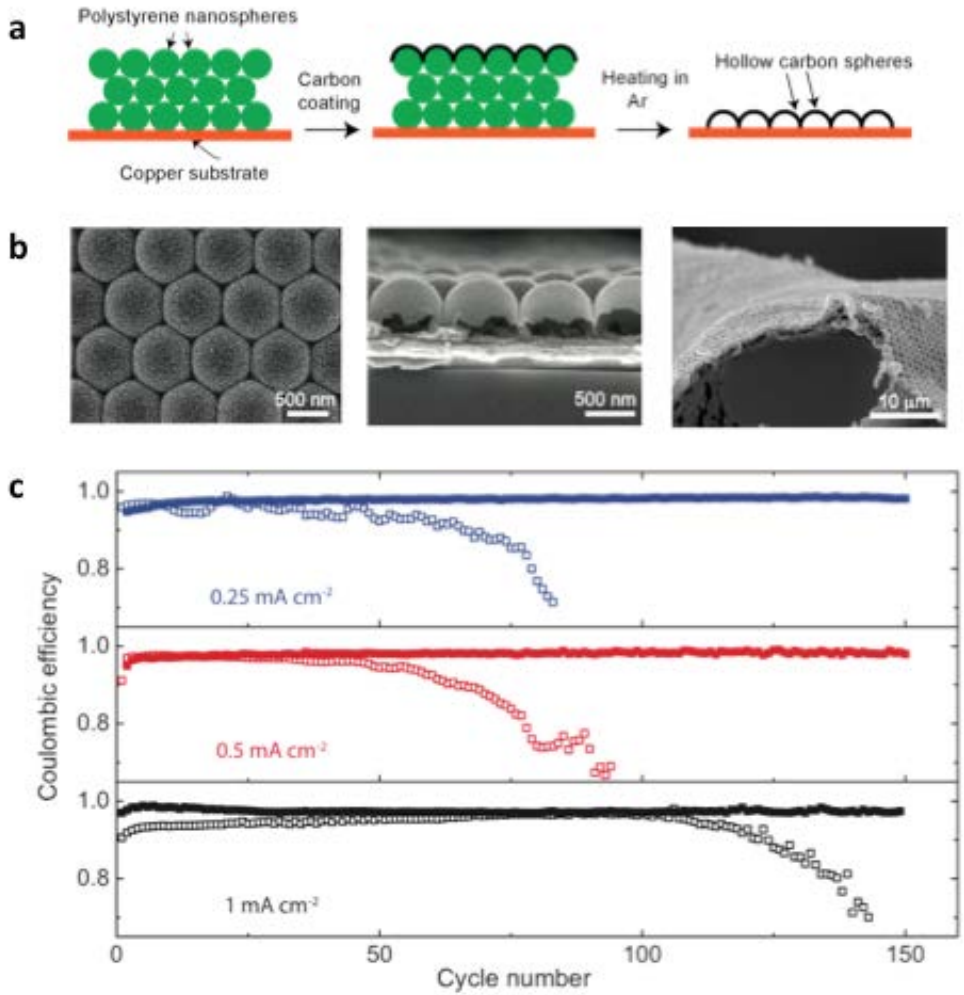

Source: Stanford University, SLAC

Approach

- Study the use of Cesium salts and organic additives to typical carbonate solvents to impede dendrite formation (PNNL).
- Apply interfacial layers between lithium metal and electrolyte to stabilize the lithium surface upon cycling (Stanford University).

Stable lithium metal cycling enabled by interconnected carbon hollow spheres. (a) Fabrication process (b) SEM images. (c) Cycling performance of lithium metal with (solid) and without (open) hollow carbon coating at different current densities

Solid Electrolytes

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Barriers

- Not all are stable against lithium.
- Have relatively poor ionic conductivity.
- Exhibit inherently very large interfacial impedance (Potential Showstopper).
- Brittle and difficult to fabricate.

Approach

- Perform mechanical studies through state-of-the-art nano-indentation techniques to probe the surface properties of the solid electrolyte and the changes occurring to lithium (ORNL, UTK, UM).
- Develop composite electrolytes (polymer and ceramic electrolytes) – investigate lithium ion transport at the interface to study the effective ionic conductivity achievable for the composite membrane (ORNL).
- Identify the relation of defect types that could impact the current density limit in Garnet-based electrolytes (UM).
- Computationally and experimentally study the interfacial structure-impedance relationship in Garnet-based electrolytes to design new materials (U. Maryland).

Summary

- Advanced Battery Materials Research (BMR) Program underwent a recent name change
  - Previously known as BATT, ETR
  - Name better reflects the materials focus of the program
  - 10 Topic areas
  - 52 Research projects
  - The new website is: http://bmr.lbl.gov
- Funding Opportunity Announcement for BMR Program
  - Notice of Interest will be announced later this year

BlueCar – Electric Vehicles with Lithium Metal Battery

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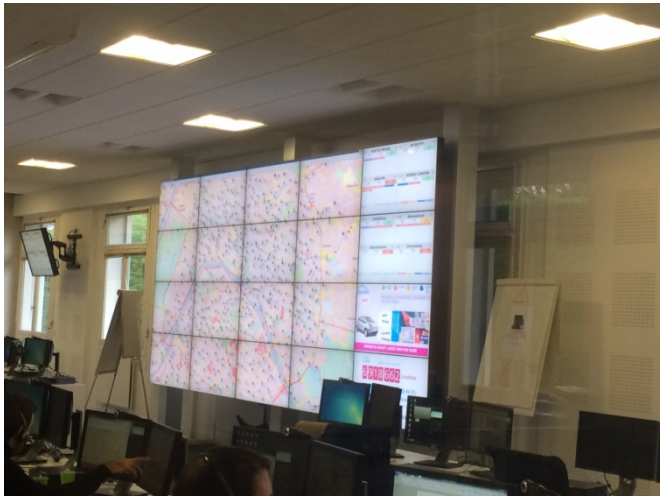
- Started in 2011, currently there are over 2,000 BlueCar vehicles available for rental from Autolib'– one-way car sharing in Paris.
- Technology is based on $Li^0/PEO/LiFePO_4$ operating at 60°/80°C.
- Batteries (30 kWh) are currently manufactured in:
  - Boucherville, Montreal.
  - Brittany, France.
- Demonstrated 3,000 cycles when discharged to 50% DOD.
- Energy density: 100 Wh/kg.



autolib'