CHANGING WHAT'S POSSIBLE

Integration and Optimization of Novel Ion Conducting Solids (IONICS)

The Integration and Optimization of Novel Ion Conducting Solids (IONICS) program will create high performance separators and electrodes built with solid ion conductors, while also focusing on new processing methods and device integration to accelerate these high performance components to commercial deployment. IONICS projects will work to improve energy storage and conversion technologies in transportation batteries, grid-level storage, and fuel cells. The IONICS program contains four categories: 1) Li ion conductors that enable the cycling of Li metal without shorting, 2) Selective and low-cost separators for batteries with liquid reactants (e.g., flow batteries), 3) Alkaline conductors with high chemical stability and conductivity, and 4) Other approaches that could achieve the IONICS Program Objectives.

PROJECT DESCRIPTIONS

CATEGORY 1:

24M – Cambridge, MA

Large Area Lithium Electrode Sub-Assemblies (LESAs) Protected by Self-Forming Microstructured Polymer-Inorganic Single-Ion Conducting Composites – $3,500,000

24M and team will use nano-composite organic-inorganic protective layers to enable reversible lithium metal electrodes and low-cost, high-energy batteries based on those electrodes. The team's core innovation takes advantage of the interfaces between the polymer and inorganic components to provide the necessary dendrite-blocking ability of ceramic-based conductors while still being highly conductive and manufacturable using traditional roll-to-roll processes.

Ionic Materials – Woburn, MA

Novel Polymer Electrolyte for Solid State Lithium Metal Battery Technology – $3,000,000

Ionic Materials has invented a new solid electrolyte made of a polymer material. The project team will optimize this material and the interface between the polymer and lithium metal to enable hundreds of charging cycles with no dendrite formation. In addition, Ionic Materials seeks to develop composite polymer cathodes based on conventional lithium-ion active materials. The team will use computer modeling, materials characterization, and electrochemical analysis to optimize the development of their cell to maximize desirable traits like cycle life and energy density while minimizing cost and ensuring manufacturability.

Iowa State University – Ames, IA

Development and Testing of New, High–Li+ Ion Conductivity Glassy Solid Electrolytes for Lithium Metal Batteries – $2,250,000

Iowa State University will develop a new process to create glassy solid electrolytes (GSEs) that allow for long lifecycle batteries, an important goal for the energy storage community. Through a scalable glass processing process, the project team seeks to make GSEs that are low cost while having the needed qualities of high conductivity, mechanical robustness, and thermal and chemical stability.

Oak Ridge National Laboratory – Oak Ridge, TN

Metastable and Glassy Ionic Conductors (MAGIC) – $3,000,000

The Oak Ridge National Laboratory team seeks to find glassy lithium-ion conductors that are stable and can be fully integrated into battery cells at a low cost. Glassy electrolytes were chosen for their ability to withstand many charging cycles while preventing the formation of lithium dendrites at higher currents. Glass also provides a flexible platform for experimenting with a variety of different lithium-rich materials. Advanced glass processing will allow for a range of different structures and materials while remaining cost effective to produce.

Pennsylvania State University – University Park, PA

Cold-Sintering Composite Structures for Solid Lithium Ion Conductors – $1,000,000

Pennsylvania State University will develop solid ceramic and composite electrolytes using its recently developed “cold sintering” process. Cold sintering enables the creation of solid ion conductors at a relatively low temperature of around 100 degrees Celsius, greatly enhancing the types of materials that can be produced by the process, including composite electrolytes and those made of a combination of ceramics and polymers. The cold sintering process also offers greater ability to lower the electrolyte resistance and prevent the growth of battery-killing dendrites, two significant obstacles to the development of solid electrolytes.

PolyPlus Battery Company – Berkeley, CA

Flexible Solid Electrolyte Protected Li Metal Electrodes – $5,250,000

PolyPlus is partnering with glassmaker SCHOTT North America to develop thin electrodes made of lithium metal foil protected by a flexible Li-ion conductive glass sheet. This approach produces a separator that is highly conductive while preventing the formation of dendrites, and is based on highly scalable commercial techniques for glass sheet manufacturing. If successful, commercial availability of this Li-metal/glass electrode will allow for highly energy-dense rechargeable batteries of over 1000 watt-hours per liter and 400 watt-hours per kilogram.

Sila Nanotechnologies – Alameda, CA

Melt-Infiltration Solid Electrolyte Technology for Solid State Lithium Batteries – $1,000,000

Sila Nanotechnologies will develop a new method of producing solid-state lithium batteries that overcomes the drawbacks of existing approaches, namely their volumetric inefficiency and manufacturing costs. The Sila team has proposed a method that would allow a melted electrolyte to fill a porous stack of cathode and separator materials, increasing energy density and reducing cost. Importantly, Sila’s approach improves the thermal stability of the battery and is compatible with existing available cathode materials.

University of Colorado Boulder – Boulder, CO

Flash Sintering System for Manufacturing Ion-Conducting Solids – $1,000,000

The University of Colorado Boulder will develop their invention of flash sintering for manufacturing solid-state electrolytes, replacing the currently used liquid electrolytes, with the promise of lithium ion batteries that are safer and have longer life and higher energy density. The low temperatures and short processing times, the highlights of flash sintering, are well suited for manufacturing of lithium containing oxide ceramics. If successful, the process could lead to one-step fabrication of several battery components. In this way, flash sintering can integrate materials selection, design and manufacturing of next generation lithium ion batteries.

CATEGORY 2:

Colorado School of Mines – Golden, CO

Hybrid Polyoxometalate Membranes for High Proton Conduction with Redox Ion Exclusion – $1,564,386

The Colorado School of Mines team will develop a membrane for use in a redox flow battery with a goal of cost-effective commercialization. Their “hybrid polymer” membrane uses large heteropoly acid molecules, linked to a commercially produced synthetic elastomer, to offer a highly selective, robust solution for the production of flow batteries at a price point that allows their affordable integration into the power grid. If successful, such a battery would enable the widespread deployment of intermittent renewable resources on the U.S. grid, transforming domestic energy production.

United Technologies Research Center – East Hartford, CT

Synergistic Membranes and Reactants for a Transformative Flow-Battery System – $2,712,559

The United Technologies Research Center's project seeks to further reduce the capital cost of redox flow batteries by making their active materials and membranes more affordable. The project team will develop these components simultaneously, from which they expect to achieve synergies that will greatly inform the team's progress. Proposed membranes will be polymer-based and much less costly than currently used ion-exchange membranes, with significantly higher selectivity. New reactants will be made of inexpensive large organic molecules that make it easier for the membrane to be selective to the ion it transports.

University of Colorado Boulder – Boulder, CO

Anion Channel Membranes – $3,000,000

The University of Colorado Boulder will develop a chloride (Cl^-) conducting membrane that will greatly reduce the cost of an all-iron flow battery. This technology will assist in reaching a storage system cost of less than $100/kWh with a round trip efficiency of over 80%. This highly selective membrane excels at preventing the passage of non-chloride ions and is based on a nanoporous liquid-crystalline polymer that can be readily produced at low cost while remaining highly efficient and having a competitive cycle life.

Washington University in St. Louis – St. Louis, MO

Reinforced AEM Separators Based on Triblock Copolymers for Electrode-Decoupled RFBs – $2,000,000

The Washington University in St. Louis team will use readily available and inexpensive commercial polymers to create a membrane for use in redox flow batteries. The team will investigate possibilities with four types of membrane construction with the goal of achieving the high thermal, chemical, and mechanical stability necessary for use in applications like flow batteries that contain materials like acids. A highly charged nanopowder will be used to improve the conductivity of the membrane while simultaneously increasing its selectivity.

CATEGORY 3:

3M Company – St. Paul, MN

Low Cost, Durable, Commercially Viable Polymeric Anion Exchange Membranes – $2,300,000

The 3M Company will develop and evaluate polymer membranes based on hydrocarbon chains to determine the viability of low cost, easily manufactured, durable membranes for use in products like fuel cells. The team will use positively charged cation side chains attached to the polymer backbone to facilitate passage of hydroxide through the electrolyte, resulting in enhanced ionic conductivity. The use of hydrocarbons instead of fluorine in the polymer backbone is expected to improve chemical stability in an alkaline environment and will reduce cost.

Rensselaer Polytechnic Institute – Troy, NY

Channel Engineering of Hydroxide Ion Exchange Polymers and Reinforced Membranes – $2,245,327

The Rensselaer Polytechnic Institute team will develop a highly conductive, chemically stable, and mechanically durable membrane using a hydrocarbon-based polymer backbone. The membrane's water-repelling backbone will allow hydroxide ions to pass through extremely small channels while preventing swelling and structural damage. By using a polymer chain requiring fewer fluorine-based components, the team expects to reduce cost. Side chains attached to the backbone will facilitate the passage of hydroxide through the electrolyte.

University of Delaware – Newark, DE

Highly Conductive, Stable and Robust Hydroxide Exchange Membranes Based on Poly (Aryl Piperidinium) – $1,800,000

The University of Delaware project team will create a series of polymer-based alkaline exchange membranes (AEMs). This membrane provides excellent chemical stability while maintaining high conductivity and mechanical robustness. The team aims to create a process to easily synthesize the polymer at scale, creating large area membranes for testing that are thinner than human hair. Production costs will be minimized by using a lower cost polymer and recycling the catalyst used in its manufacture.

CATEGORY 4:

University of California, San Diego – La Jolla, CA

Self-forming Solid-State Batteries – $1,000,000

The University of California, San Diego will develop a self-forming, high temperature solid-state lithium battery. The team seeks to reduce cost by designing a manufacturing process for forming the solid electrolyte and cathode from a single affordable material, eliminating processes and materials that drive up cost. Performance limitations will be addressed by elevating the battery's operating temperature to enhance charge rate and keep the lithium stable, using a self-healing electrolyte that prevents damage from dendrites, and using a non-flammable polymer to add structural strength. The battery is expected to have a long life of over 500 cycles, high rate, and low cost.