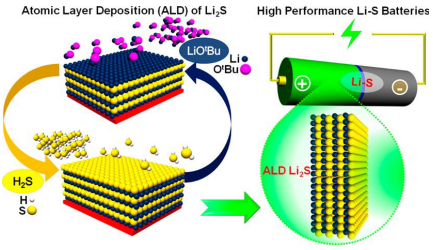
AVAILABLE FOR LICENSING

NEW MATERIALS FOR SOLID STATE LI-ION BATTERIES

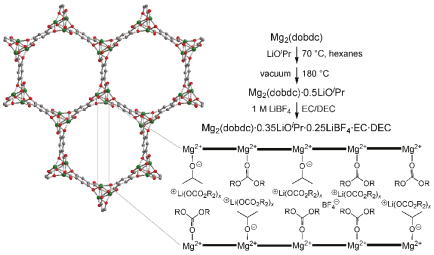
This patent bundle combines novel, high-performance materials and processes that will help industry reach the next level in lithiumion- battery (LIB) technology. From clean anodic Li films for longer life in rechargeable Li ion batteries, solid Li electrolytes for increased safety, to block copolymer based cathodes that can transport both electronic charge and ions, this bundle provides Li ion producers strategic pathways to increase battery power, energy density, lifetime, and safety with novel alternatives that exhibit excellent electrochemical performance.

KEY TECHNICAL ADVANCES:

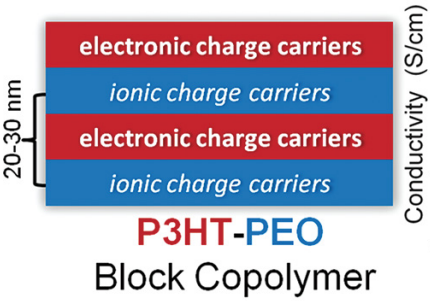
- Atomic Layer Deposition (**ALD**) method to deposit metal sulfide films for use in an anode, cathode, or solid-state electrolyte of a lithium-ion battery or a lithium-sulfur battery. Single-walled carbon nanotubes (**SWCNTs**) coated by ALD GaS_x, $Li_xGa_yS_z$ (tunable compositions), Al_2S_3 and Li_xAl_yS, can be deposited into thin, precise electrolyte layers that are exceptionally uniform over large areas, even on substrates with complex geometries.
- Solid lithium electrolyte was developed by adding lithium salts to metal-organic frameworks (MOFs), inhibiting dendrite growth. In addition, the honeycomb-like structures facilitate lightweight, higher capacity lithium anodes. The rigid structure of the solidstate MOF serves both as an electrolyte and separator.
- A block copolymer material serves both as a binding agent that holds active cathode particles in place and as a two-lane conductor that simultaneously carries lithium ions and electronic charge. This technology offers the potential for an intelligent lithium battery designed to charge rapidly, protect against overcharging, and turn itself off to prevent damage.
- An electrolytic refining process prepares clean anodic lithium films for safe, stable lithium ion batteries with high energy densities and good cycle life. The block copolymer electrolytes lack faceted impurities on which damaging structures grow and cause battery failure by short circuit, therefore enhancing safety over conventional lithium anodes.



Meng, Elam, et al. Vapor-Phase Atomic-Controllable Growth of Amorphous Li2S for High-Performance Lithium-Sulfur Batteries. ACS Nano 2014, 8, 10963.



Meng, Elam, et al. Gallium Sulfide–Single-Walled Carbon Nanotube Composites: High-Performance Anodes for Lithium-Ion Batteries Adv. Funct. Mater. 2014, 24, 5435.



Patel, Javier, Balsara. Electrochemically Oxidized Electronic and Ionic Conducting Nanostructured Block Copolymers for Lithium Battery Electrodes. ACS Nano 2013, 7, 6056.

CONTACT
Shanshan Li
Technology Commercialization Associate
Phone: 510-486-5366
E-mail: shanshanli@lbl.gov

U.S. DEPARTMENT OF ENERGY
Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.

December 2017

MOTIVATION, CHALLENGE, AND OPPORTUNITY Lithium-ion batteries (LIBs) could fulfill the energy storage requirements for increased renewable power and electric vehicles (EVs). LIBs have dominated the consumer electronics market since their introduction in 1991. However, to meet the demanding requirements for EVs, the specific energy of LIBs must increase by 2 to 5 times from the current value of 150 Wh/kg. This IP bundle compiles valuable strategies to increase power, energy density, lifetime, and safety in LIBs, which have been developed both at Laurence Berkeley National Lab (LBNL) and Argonne National Lab (Argonne). In addition, industry leaders will have the opportunity to leverage the expertise from both National Labs, through one standard and convenient agreement.

Addressing the growing need for safe, small, lightweight batteries with high energy density and longer run time

TECHNOLOGIES IN THIS BUNDLE

TECHNOLOGY	NUMBER
Clean Anodic Lithium Films for Longer Life, Rechargeable Lithium Ion Batteries	US2017-0110714A1, LBNL 2015-139
Modified Metal Organic Framework (MOF) as a Solid Lithium Electrolyte for Safer Lithium-Ion Batteries	US2014-0045074, US2016-0211545, LBNL 3097
Block Copolymer Cathode Binder to Simultaneously Transport Electronic Charge and Ions	US8552144, LBNL 3025
Materials for Solid State Electrolytes and Protective Electrode Coatings for Lithium Batteries	US2015-0364747A1, ANL IN-13-057