LITHIUM SULFUR BATTERIES

This IP bundle combines novel, high-performance materials that will propel future battery technology. Driven by the low cost of sulfur as a raw material and the high specific energy density of 2500 Wh/kg (nearly 5X that of Li-ion technology), this IP bundle includes the work and expertise of Argonne and Lawrence Berkeley National Laboratories National Labs.

TECHNICAL ADVANCES Graphene nano-cages combined with source material may incorporate sulfur into their structure- helps to mitigate shuttling effect of polysulfides.

New cathode material for Li-S batteries improving Coulombic efficiency and cyclability. A method to produce the cathode material on copper foil via a slurry is provided.

The composite material: stabilizes the electrochemical performance of the cathode materials; and is able to accommodate the volume expansion observed during the lithiation/de-lithiation process while maintaining the mechanic integrity of the particles.

Lithium-sulfur battery with non-polar fluorinated ether electrolyte solvent exhibit high active material utilization, long cycle life, and diminished or no self-discharge.

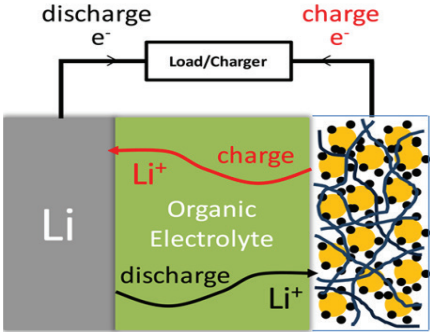
The lithium-sulfur electrolyte suppresses shuttle phenomenon, protects lithium metal, provides extremely high capacity, outstanding cycling stability, excellent rate capabilities, and near 100% Columbic efficiency in lithium-sulfur batteries.

In addition, it prevents cathode active material loss and inhibits polysulfide shuttling mechanisms, thus minimizing the capacity fade and low efficiency problems in conventional lithium-sulfur batteries.

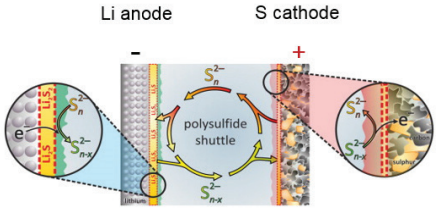
IMPACT The combination of advanced materials in all components of the battery can answer these challenges and achieve targets for wider adoption of Li-S technology.

REFERENCES Frost & Sullivan. "*Post Lithium-ion Batteries – Future Tech TOE.*" Accessed February 24, 2017. http://www.frost .com.

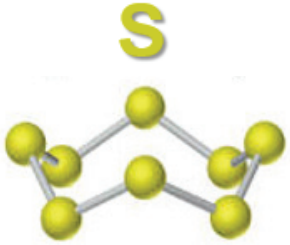
Shmuel De-Leon Energy Ltd. "*Lithium Sulfur & Li-Metal Rechargeable Batteries, Technology, Applications & Market Review 2016*" Accessed February 24, 2017. www.sdle.co.il.lbid



Lithium Sulfur Battery



Dissolution-diffusion-deposition process in Li-S batteries



Sulfur is abundant and inexpensive as a raw material, with a theoretical energy density of over 2500 Wh/kg.

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MOTIVATION, CHALLENGE, AND OPPORTUNITY Lithium Sulfur (Li-S) batteries are considered one of the near-term market-ready technologies beyond the Li-ion technology. The work from Argonne, Oak Ridge and Berkeley National Laboratories is currently addressing increasing voltage, cycle life, and charge efficiency. Industry leaders will have the opportunity to leverage the expertise from these two Labs through one standard and convenient agreement.

INTELLECTUAL PROPERTY INCLUDED IN THIS BUNDLE

TECHNOLOGY	NUMBER
Porous graphene nancages for battery applications	US20140272610
Ultra-stable cathodes for lithium sulfur batteries	US20160308209
Sulfur cathode hosted in porous organic polymeric matrices	US20140255794
Lithium-sulfur batteries	US20170033406
Lithium-sulfur electrolytes and batteries	US20140023936
Non-aqueous electrolytes for electrochemical cells	US20120082890
Core-shell structured nanoparticles for lithium-sulfur cells	US20150311508
Durable carbon-coated Li_2s core-shell materials for high performance lithium/sulfur cells	US20160248084