ADVANCED FUNCTIONAL MATERIALS

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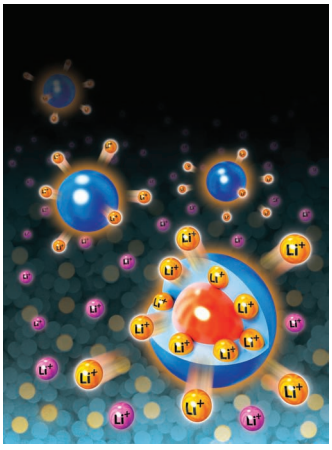
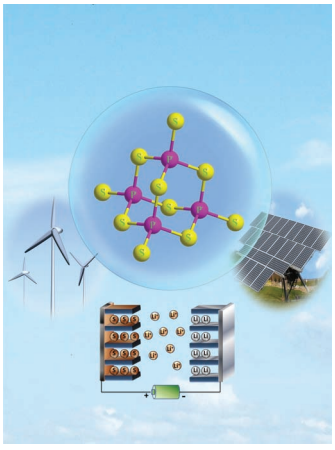


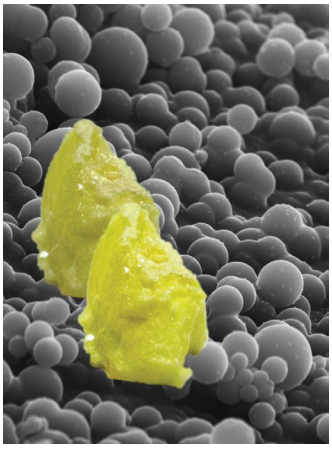
Composite Polymer Electrolytes

As lithium ion sources of a single ion conductor, core–shell structured $SiO_2(Li^+)$ nanoparticles with uniform spherical shape are synthesized and used as functional fillers in composite polymer electrolytes. As reported on page 1019 by Woo Young Yoon, Dong-Won Kim, and co-workers, the composite polymer electrolytes prepared with $SiO_2(Li^+)$ particles exhibit high ionic conductivity and good mechanical strength and are used to prepare thin films for high performance lithium powder polymer batteries.

Cathode Materials

Phosphorous pentasulfide (P_2S_5) is discovered to be a novel electrolyte additive for high-energy lithium-sulfur (Li-S) batteries. P_2S_5 passivates the surface of metallic lithium anodes, promotes the dissolution of Li_2S, blocks the polysulfide shuttle, and thus enables long battery cycle-life. On page 1064, Chengdu Liang and co-workers demonstrate that with a theoretical energy density of 2600 Wh/kg, which is about 3–5 times higher than that of the lithium-ion batteries, Li-S batteries are promising for the next generation of high-energy batteries for large scale energy storage.





Lithium–Sulfur Batteries

On page 1076, Yang-Kook Sun, Jusef Hassoun, Bruno Scrosati, and co-workers report and characterize a hard carbon spherules-sulfur electrode that is prepared by impregnation of crystalline sulfur into the carbon spheres through melting and thermal treatment. This material demonstrates very high capacity and rate capability, and is therefore proposed as a new generation cathode to drive electric vehicles over a long range.

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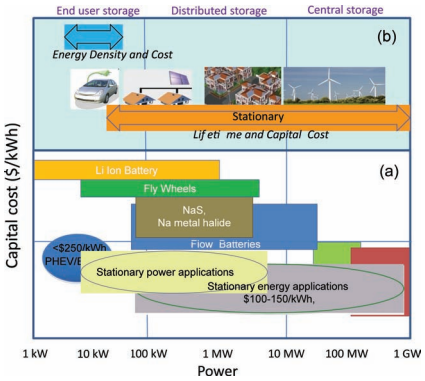
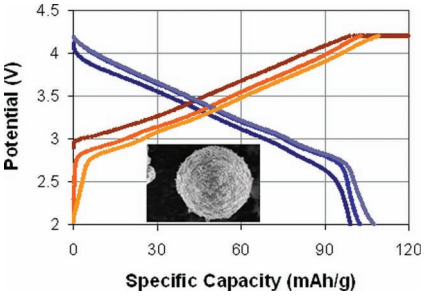
Energy Storage



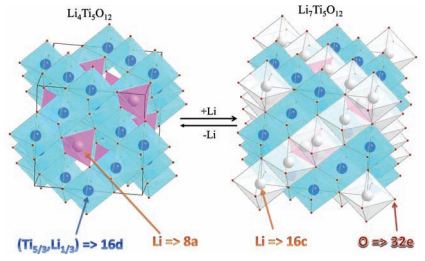
The different applications of energy storage, different technologies, and the cost requirements from the kilowatt to gigawatt scale are compared. Li-ion batteries have attracted attention for transportation storage, while many other technologies are considered for stationary applications.

Sodium-Ion Batteries



The research and development of ambient temperature Na-ion batteries is progressing quickly and is now poised to penetrate the energy storage landscape. The combination of new electrode materials, electrochemical couples, and engineering advances coupled with a potential for low-cost and long-life make them attractive candidates for grid storage.

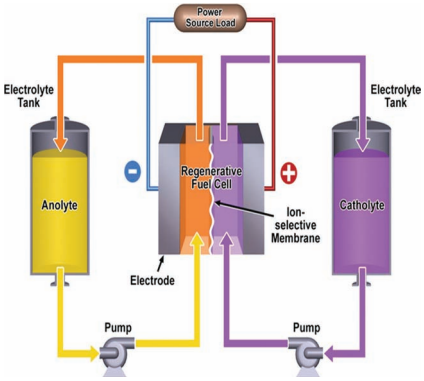
Lithium-Ion Batteries



Nanostructured titanium-based oxide materials have been long pursued as anode materials for safe, extremely long life, and high power lithium-ion batteries. The outstanding safety and electrochemical performance of titanium-based anodes originates from their relatively high working potential, much higher than the potential needed for graphitic anodes, to form solid electrolyte interphase. Compared to graphite, lithiated titanium-based anodes release a substantially smaller amount of heat under abuse conditions.

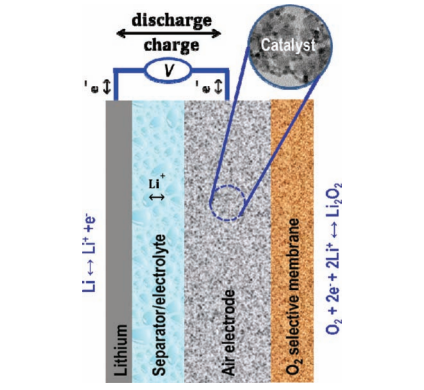
FEATURE ARTICLES

With its unique configuration and mechanism, the redox flow battery technique is considered to be one of the most promising technologies for large-scale stationary energy storage. Recent progress in the research and development of redox flow battery cell-level components is highlighted, including electrolytes, electrodes, and membranes for both aqueous and non-aqueous systems.



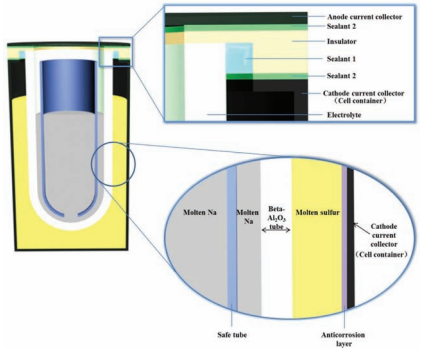
Energy Storage

Rechargeable lithium-air batteries could potentially provide an energy storage capacity of three to five times that of current Li-ion batteries. However, significant material challenges exist for each of its components, among which are electrolytes, cathodes/catalysts, anodes, and oxygen-selective membranes for oxygen supply.



Batteries

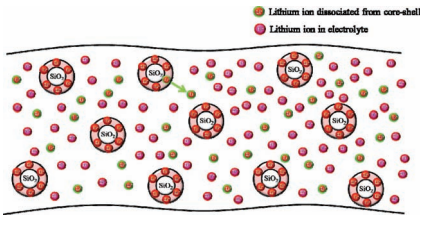
The key materials and the main interfaces in sodium-sulfer (NAS) batteries, which are among the most important factors determining the performances and cost of the battery, are reviewed. Some of the latest research results for NAS battery materials and interfaces are presented. The outlook for future research directions is also discussed.



Sodium-Sulfur Batteries

FULL PAPER

Composite gel polymer electrolytes exhibiting high ionic conductivity and good mechanical stability are prepared and characterized. Core-shell structured $SiO_2(Li^+)$ nanoparticles of uniform spherical shape are used as functional fillers in the composite gel polymer electrolytes. Lithium powder polymer batteries composed of a lithium powder anode and a LiV_3O_8 cathode deliver a high discharge capacity and exhibit good capacity retention.



Lithium Batteries

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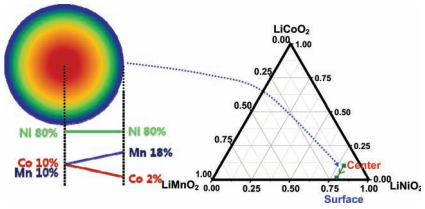
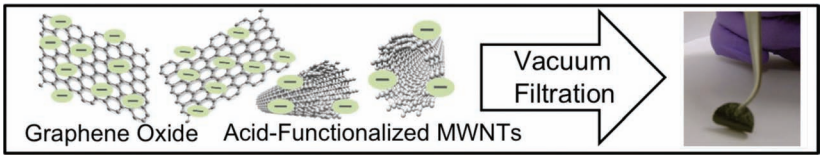
Batteries



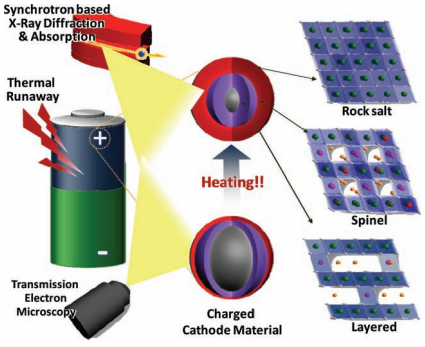
Tomograms of concentration gradient particles reveal that $Li[Ni_{0.8}Co_{0.1}Mn_{0.1}]O_2$ shows a high concentration of Ni (80%) throughout the spherical particle and the Co content at the center (10%) is gradually reduced to the outer surface (2%). Mn replaces the reduced Co content, forming a solid solution in the particle.

Electrodes

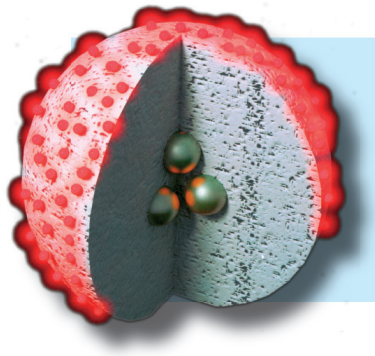
Free-standing electrodes of hierarchically structured oxygen-functionalized multiwalled carbon nanotubes and graphene oxide are shown to deliver high volumetric energies up to 450 Wh L^{-1} at 5 kW L^{-1} in lithium cells, which are attributable to high mass densities (>1 g cm^{-3}) and controllable utilization of surface oxygen species for Li^+ Faradaic reactions.



Cathode Materials



The structural origin of the thermal instability of cathode materials, which is a critical safety issue for lithium-ion batteries, is studied systematically using a combination of various in situ synchrotron X-ray techniques and transmission electron microscopy. The in-depth understanding of the thermal decomposition behavior of overcharged cathode materials provides valuable guidance for developing new cathode materials with improved safety characteristics.



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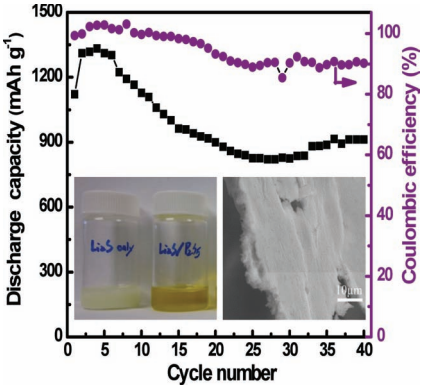
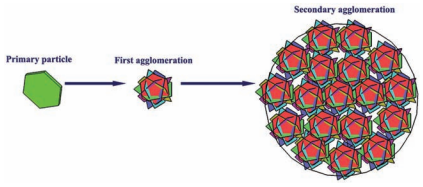
FULL PAPERS

Phosphorous pentasulfide reacts with lithium metal to form a protective coating that conducts lithium ions and improves the coulombic efficiency of Li-S batteries. The surface coating blocks the polysulfide shuttle, which is a key challenge to the longevity of Li-S batteries. By forming a complex with Li_2S_x, P_2S_5 facilitates the redox reactions in Li-S batteries and leads to great retention of capacity.



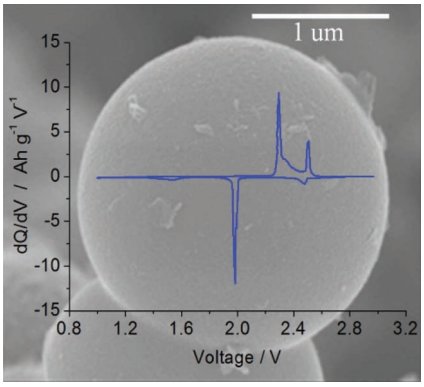
Cathode Materials

Nanoarchitectured hydroxide precursors with two levels of particle agglomerations are synthesized with a continuously stirred tank reactor. Li- and Mn-rich cathodes with a layer-layer-spinel composite structure inherit the morphology of these precursors and exhibit excellent electrochemical performance.



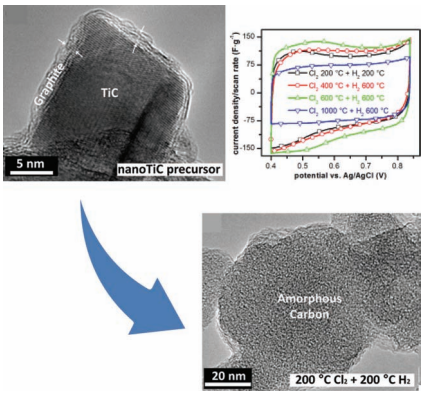
Composite Materials

A porous hard carbon spherules-sulfur (HCS-S) composite cathode shows remarkable electrochemical behavior in a lithium cell using a solution of lithium triflate ($LiCF_3SO_3$) in tetraethylene glycol dimethyl ether (TEGDME) as the electrolyte. The new composite, characterized by high capacity, long cycle life, and remarkable sulfur content, is proposed as a new cathode material for high energy-lithium batteries.



Lithium–Sulfur Batteries

Microporous carbon nanoparticles synthesized at 200–1200 °C by extraction of titanium from nanometer-sized titanium carbide (nanoTiC-CDC) show excellent electrochemical performance as supercapacitor electrode materials due to their easily accessible pores and a large specific surface area. Low temperature synthesis produces highly disordered carbons and leads to the presence of CN sp^1 bonds.



Supercapacitors