Using Reactive Gases to Generate Artificial Inorganic Interphases on Lithium

Technology #20830

Applications

This invention generates surface films on alkali metals, including lithium, to protect from self-plating and corrosion induced by organic electrolytes in rechargeable batteries. The film permits the ionic conductivity needed for cycling and allows lithium to be used as a battery anode in rechargeable batteries. This invention offers the potential to increase the energy densities of current rechargeable batteries by preserving the function of metal electrodes, like lithium, and can be applicable to energy-intensive processes like the grid-scale storage of renewable energy and electric vehicle energy storage.

Problem Addressed

Rechargeable lithium-ion batteries, based on a graphite anode, play a central role in energy storage technologies for portable power and consumer electronics; however, their energy densities need to be significantly increased to be viable for energy-intensive processes like grid-scale storage of renewable energy. Current lithium electrode technology is limited by several problems which reduce battery lifespan and storage capacity including: self-plating of lithium onto itself to form dendrites, aggressive volume expansion and contraction during cycling, and corrosion by organic electrolytes. Solutions to these problems are critical to achieving the higher energy-density chemistries possible with lithium-oxygen and lithium-sulfur batteries. This invention develops a methodology to overcome these limitations by coating the metal, such as lithium electrodes, in a film that still permits ionic conductivity.

Technology

This invention generates an ion conducting film on lithium electrodes by reacting the metal with one of the following: nitrous oxide, nitrogen trifluoride, or sulfur hexafluoride. Reaction of nitrous oxide with lithium surfaces at temperatures below melting (<180.5 °C) for 24 hours results in the incorporation of oxygen into the surface film, which can be as thick as 1μm. Upon ambient air exposure, these nitrous-oxide-coated lithium electrodes do not visibly react or discolor in contrast to untreated lithium surfaces that rapidly discolor and blacken due to the formation of lithium oxide. They also exhibit stable cycling over 150 hours, with lowered overpotentials at current densities of 1 mA/cm2 and capacities of 1 mAh/cm2. Reaction of nitrogen trifluoride and sulfur hexafluoride with lithium electrodes at 175 °C and 150 °C respectively result in the incorporation of fluorine into the surface film. Lithium-fluorine-coated films exhibit up to 5-fold improvement (~50 hrs) in cell lifetime before dendrite formation and growth led to short circuiting.

Advantages

- *Ex situ* growth of purely ionic layers onto lithium surfaces using a simple low temperature thermochemical approach

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- Avoids co-inclusion of reduced electrolyte (solvent and salt) products into the solid electrolyte interphase (SEI) of a lithium electrode
- Coated electrode exhibits up to 5-fold improvement (~50 hrs) in cell lifetime
- Fixed composition of SEI with materials that are already thermodynamically stable against lithium
- Use of industry-friendly gases to chemically manipulate the lithium SEI

Categories For This Invention:

Energy
Energy Storage
Batteries
Lithium Batteries

Intellectual Property:

Artificial solid electrolyte interphase layers
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Publications:

Electrochemical Conversion of Nitrogen Trifluoride as a Gas-to-Solid Cathode in Li Batteries
The Journal of Physical Chemistry Letters
July 27, 2018, p 4700-4706

External Links:

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