

High Energy Density Low Tortuosity Battery Electrodes and Methods of Manufacture

Technology #14844

Applications

The use of porous electrodes in batteries improves energy and power density in various types of batteries, including primary and rechargeable lithium-ion batteries.

Problem Addressed

The pore space in rechargeable batteries has a high tortuosity (effective path length over projected path), which causes energy density of the battery to be limited at a given power level. Current design and fabrication methods of rechargeable lithium-ion batteries involve manufacturing thin laminates of powder-based electrodes, which are highly compressed, and subsequently infused with inorganic liquid electrolytes. Although powder-based electrodes are the lowest-cost forms of metal oxide or carbon-based electrode-active materials, such electrodes have a substantial amount of electrochemically-inactive material. This invention uses a high volume fraction of electrode-active material, in which the existing porosity, which is filled with electrolyte, has a low tortuosity in the primary direction of ion transport during charge and discharge of the battery. The use of low tortuosity electrodes while also maintaining high active materials volume fraction compensates for the decrease in energy density of the battery created with highly porous electrodes.

Technology

This invention describes a design and manufacturing process of aligned-porosity, high energy density and low tortuosity electrodes. Such electrodes are manufactured by a directional freeze-casting process that involves a ceramic suspension of solid particles in a liquid, producing unidirectional crystals. The invention also provides means to manipulate the porosity and microstructure of the ceramic structures by changing the processing parameters such as initial slurry concentration. Additionally, additives can be mixed in the ceramic slurry to modify the crystalline structure of ice. After subsequent freeze drying, these changes are replicated in the ceramic structure and lead to improved performance of the final product.

Advantages

- Increases energy density
- Low tortuosity
- Maintains high active materials volume fraction

Categories For This Invention:

Energy

Energy Storage

Batteries

Other (Batteries)

Intellectual Property:

Controlled porosity in electrodes

Issued US Patent

Controlled porosity in electrodes

Issued US Patent

9,065,093

Inventors:

Yet-Ming Chiang

Can Erdonmez

John Halloran

Qiang Fu

Antoni Tomsia

Chang Bae

Publications:

Design of Battery Electrodes with Dual-Scale Porosity to Minimize Tortuosity and Maximize Performance

Advanced Materials

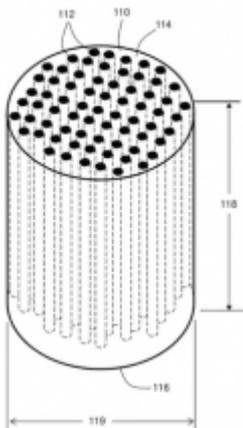
25 (9), 2013 pp.1254 - 1258

External Links:

New Electrode Designs for Ultrahigh Energy Density

https://www1.eere.energy.gov/vehiclesandfuels/pdfs/merit_review_2011/electrochemical_storage/es071_chiang_2011_o.pdf

Image Gallery:



255 Main Street, room NE 18-501

Cambridge, MA 02142-1601

Phone: 617-253-6966 Fax: 617-258-6790

<http://tlo.mit.edu>

Contact the Technology Manager: tlo-inquiries@mit.edu