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Framework substituted clathrates for lithium-ion battery anodes (Alternate title: Alloys of clathrate allotropes for rechargeable batteries)

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The lithium battery industry is undergoing rapid expansion, now representing the largest segment of the portable battery industry and dominating the computer, cell phone, and camera power source industry. Beyond consumer electronics, LIBs are also growing in popularity for military, electric vehicle, and aerospace applications. Lithium-ion batteries are a family of rechargeable battery types in which lithium ions move from a negative electrode to the positive electrode during discharge, and back when charging. Compared to graphite anodes, much higher capacities are expected in silicon materials. Si is an attractive anode material for Li-ion batteries because of a high specific energy density. However, despite extensive research, Li-ion batteries with Si anodes suffer from low cyclability due to the large dimensional changes and pulverization of the Si anode after a few tens of charging and discharging cycles.

Researchers at Arizona State University have developed a technology that overcomes these challenges. The present invention relates to alloy cage structures of silicon, germanium and/or tin for use as an anode (negative electrode) and/or cathode (positive electrode) in rechargeable batteries. The theoretical charge storage capacity for silicon is about 4000 mAh/g, more than an order of magnitude higher than for graphite, the existing Li-ion battery anode. However, the structural changes that occur during this process results in the 300% change in volume between the unlithiated and lithiated phases. The use of nanostructuring has been applied in order to allow the silicon to undergo this volume change without fracturing or pulverizing. Such compositions may therefore provide electrode materials with improvement in capacity, energy density and stability over battery materials currently employed.

Related publications:

Enhanced lithium ion conductivity in lithium lanthanum titanate solid electrolyte nanowires prepared by electrospinning

Composite Polymer Electrolytes with $Li_7La_3Zr_2O_{12}$ Garnet-Type Nanowires as Ceramic Fillers: Mechanism of Conductivity Enhancement and Role of Doping and Morphology

Needleless Electrospinning for High Throughput Production of $Li_7La_3Zr_2O_{12}$ Solid Electrolyte Nanofibers

Potential Applications:

- Lithium Ion Batteries

- Hybrid Electric Vehicles
- Electric Vehicles
- Portable Electric Devices
- Renewable Energy Storage

Benefits and Advantages:

- Improved battery capacity
- Higher energy density