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Lithium Iron Phosphate Composites for Lithium Batteries (ANL-IN-11-024)

Inexpensive, electrochemically active phosphate compounds with high functionality for high power and high energy lithium batteries.

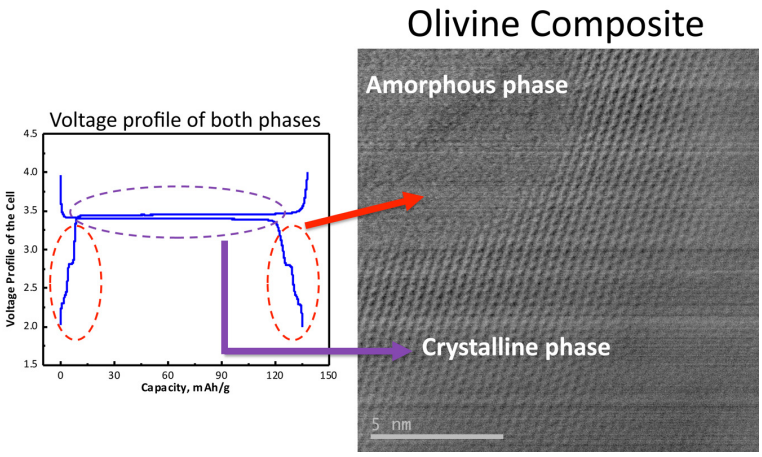
The Invention

A family of lithium iron composite materials with unique electrochemical features that enable the high energy and power performance of olivine cathodes without the use of carbon coatings. The materials have excellent rate capability when used as the active material in a Li-ion battery. Also described is the synthesis and characterization of composite materials that include $LiFePO_4$ for use in, but not limited to, electrode materials for lithium-ion batteries.

The compounds have multiple integrated phases of the general formula $(1\text{-}x)LiFePO_4 \cdot Li_xTi_x(PO_4)_\delta$ where both the $LiFePO_4$ and the $Li_xTi_x(PO_4)_\delta$ are electrochemically active components. The phrase "multiple integrated phases" refers to more than one crystallographic phase being present within the material. The integrated phases are not simply a solid solution where the titanium would substitute for the iron within the olivine $LiFePO_4$ structure, or a mixture of $LiFePO_4$ and a lithium titanium phosphate species. Instead, a "multiple integrated phase" refers to the co-existence of a predominantly olivine phase $LiFePO_4$ material, and the segregation at the nanometer or micrometer scale of other titanium-containing phases. The process yields inexpensive, electrochemically active phosphate compounds with high functionality for use in high-power and high energy lithium batteries.

Benefits

- The process by which the compounds are prepared is simple and straightforward, uses inexpensive precursors, and does not involve high energy consuming steps;
- Materials show increased energy density and cycle lifetime;
- No carbon coating is needed, which saves a processing step and reduces costs by 50 percent; and
- The materials can be added at low cost without changing current scalable cathode manufacturing processes.



A bright field STEM image obtained in a high-resolution mode with a spatial resolution of 1Å. The image indicates the presence of crystalline-amorphous regions in one of the $LiFePO_4$ composite grains. These $LiFePO_4$-inorganic composites have better cycling behavior and rate capability compared to the pristine material, all in the absence of carbon coating.

Applications and Industries

Electrodes used in batteries for

- Electric and plug-in hybrid electric vehicles;
- Portable electronic devices;
- Medical devices; and
- Space, aeronautical, and defense-related devices.

Developmental Stage

Reduced to practice

Availability

Available for licensing

Patent Information

U.S. Patent Pending 13/237,203

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