Mapping Battery Activity at the Level of a Billionth of a Meter

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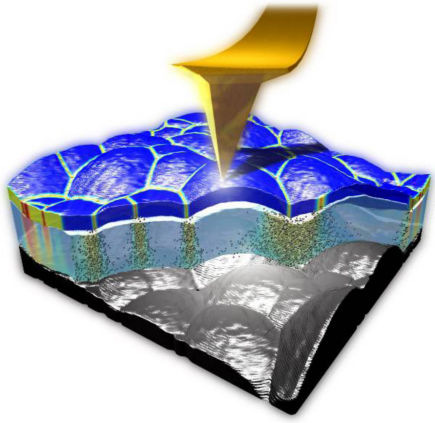
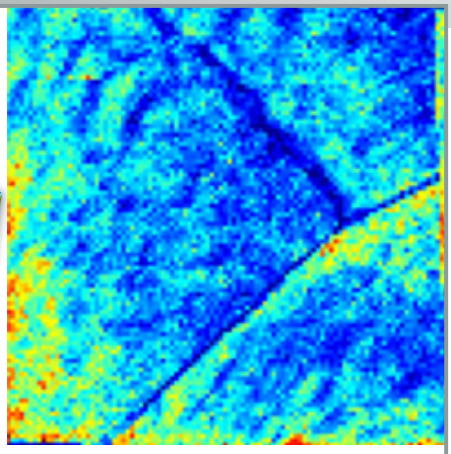


Schematic representation of electrochemical strain microscopy (ESM) of battery device.



Experimental image of lithium-ion activity in a silicon anode of all-solid thin film batteries ($LiCoO_2$/LiPON/a-Si).

Technology Summary

An ORNL method and apparatus offer a new approach to revealing battery behavior at the nanoscale. With this invention, researchers successfully mapped lithium diffusivity and electrochemical activity, showing how the battery works at the level of a billionth of a meter.

Future energy technologies will rely heavily on lithium-based batteries for electrochemical energy storage. To develop and to optimize battery performance, researchers need to understand how lithium, electron transport, and electrochemical kinetics work locally, at the micron level. They must also determine functional mechanisms at the nanometer scale, where individual structural defects exist but techniques for such examination are lacking.

The invention features a module, configured to generate a signal, that is applied to the surface of an ionic conductor to monitor activity. A probe is placed in contact with the surface to detect any displacement of the ions though the local electromechanical strains. A detector then measures the response at points on the surface where the ions are displaced. The method has been demonstrated for a variety of Li-ion conductors (Li_xCoO_2 cathodes, Si anodes, Li-ion conductive ceramics), several oxygen conductors ($La_xSr_{1-x}CoO_3$, YSZ, SDC) and is universally applicable to all ionic conductors.

Advantages

- Addresses a lack of techniques capable of probing lithium-ion and other ion currents on the nanometer scale
- Provides a proven tool for understanding, developing, and optimizing battery materials
- Deciphers individual mechanisms responsible for battery functionality at the nanoscale

Potential Applications

- Electrochemical energy storage (EES) batteries
- Lithium ion batteries
- Electrochemical energy conversion systems
- Solid oxide fuel cells and polymer fuel cells
- Li-air batteries
- Solid state ionics
- Memristive and electroresistive materials

Patent

Nina Balke, Nancy Dudney, Stephen Jesse, and Sergei V. Kalinin. *Real Space Mapping of Ionic Diffusion and Electrochemical Activity in Energy Storage Materials*, provisional U.S. Patent application filed on November 24, 2010.

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