Argonne Coin Cell NMR/MRI Imager

Unique device lets researchers study battery components in real time, under real test conditions

Lithium-ion batteries have grown to a $4 to $5 billion market over the past 15 years. In addition to the electronics and communications uses familiar to most consumers, lithium systems offer the best future opportunities for high-power, high-energy batteries for transportation (electric vehicles, and in the nearer term, hybrid-electric vehicles, which represent a major growth opportunity), medical devices, aerospace, defense, and power tools.

But there are serious materials challenges to be overcome in realizing the potential of lithium-ion batteries, including finding safer, less costly, and more stable anode and cathode materials.

Seeing Events as They Unfold

Most investigations of the causes of battery degradation are performed after the battery has cycled for some number of times, or been held at some temperature; the battery components are studied “post-mortem.”

Now, however, it is possible for the first time to study what happens to battery components as events occur. Thanks to a unique design twist (see diagram on reverse side of this fact sheet) the Argonne Coin Cell NMR/MRI Imager offers the heretofore impossible capability to conduct NMR/MRI analysis in-situ, on real components, in real time, and under real test conditions. Using add-on features, a film sample can be studied under user-set adjustable temperature and pressure simultaneously from two additional perspectives—electrochemistry and video imaging. This is akin to seeing an event from multiple, dynamic perspectives as it unfolds rather than piecing the event together afterward from information gathered by several different sources.

The Argonne Coin Cell NMR/MRI Imager is a modular system with a standalone base unit for electrochemical analysis and that a variety of add-on kits (video, temperature, pressure, additional reference electrode, and flow). Each of the add-on features can be used with the base unit alone or in combination with other features.

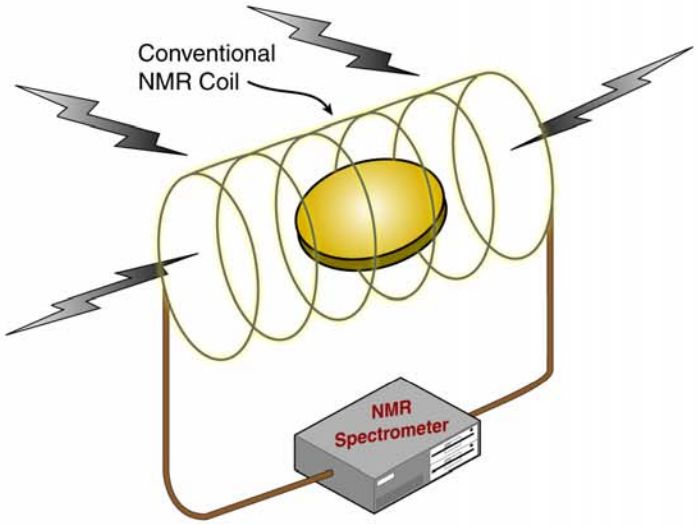
The base unit is superior to comparable commercial devices, and is simpler and less expensive. That alone is a significant technological advantage because more cells can be purchased for parallel experiments. A video imaging add-on has the advantage of being simpler in design than comparable capabilities in competing products. But because of a unique design twist that uses metal disks as the detector element of an NMR device, the Argonne Coin Cell NMR/MRI Imager offers the heretofore impossible capability to conduct NMR/MRI analysis on actual, as-manufactured battery components (thin films and membranes) in real time and under real test conditions, including user-specified pressure and temperature.

These capabilities can greatly impact the advancement of coatings and adhesives, but the most significant impact of Argonne's Coin Cell NMR/MRI Imager will be realized in the development of the batteries and fuel cells that are essential to meeting our energy needs for the future.

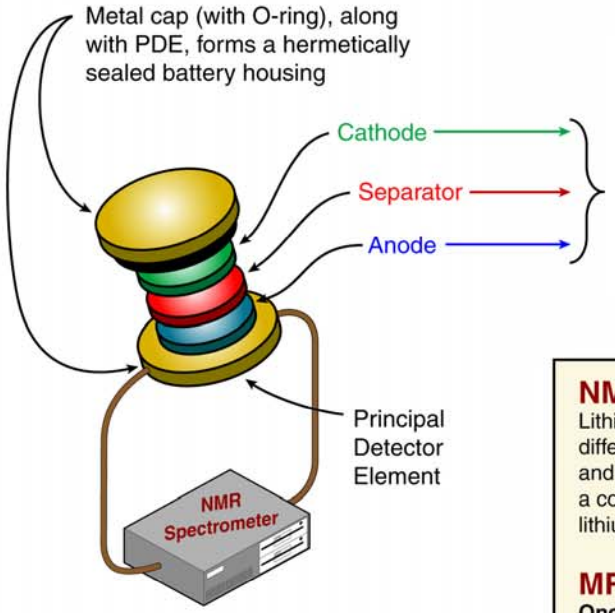
The patented Argonne Coin Cell NMR/MRI Imager is available for licensing.

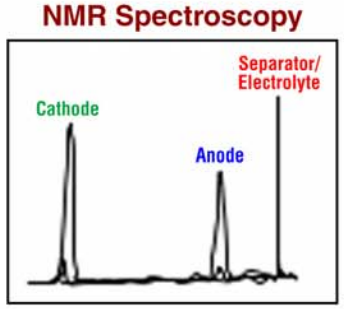
For more information, contact Rex E. Gerald II (630-252-4214, gerald@cmt.anl.gov).

Argonne Coin Cell NMR/MRI Imager: Turning a Problem into a Solution



A solenoid coil is the principal detector element (PDE) of a conventional NMR probe; a flat circular disc is the PDE of the Coin Cell NMR/MRI Imager, and forms part of a hermetically sealed housing for the battery components.





NMR Spectroscopy

Lithium is present in battery materials in different species (metallic, intercalated and ionic). NMR spectrometry produces a composite of spectra showing all of the lithium species present in a battery cell.

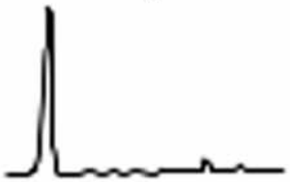
MR Imaging

One-dimensional magnetic resonance imaging separates the composite spectrum into a series of spectra, each one associated with a component of the cell (anode, separator, cathode).

MR Imaging Detail

Cathode

The position of this peak (far left) indicates the presence of lithium metal, as would be expected.



Separator

The position of this peak (far right) indicates lithium ions in the electrolyte solution, as would be expected.

The position of this peak indicates lithium metal on the anode where it doesn't belong (a dendrite).

Anode

The position of this peak indicates lithium ions intercalated into the carbon anode, as would be expected.