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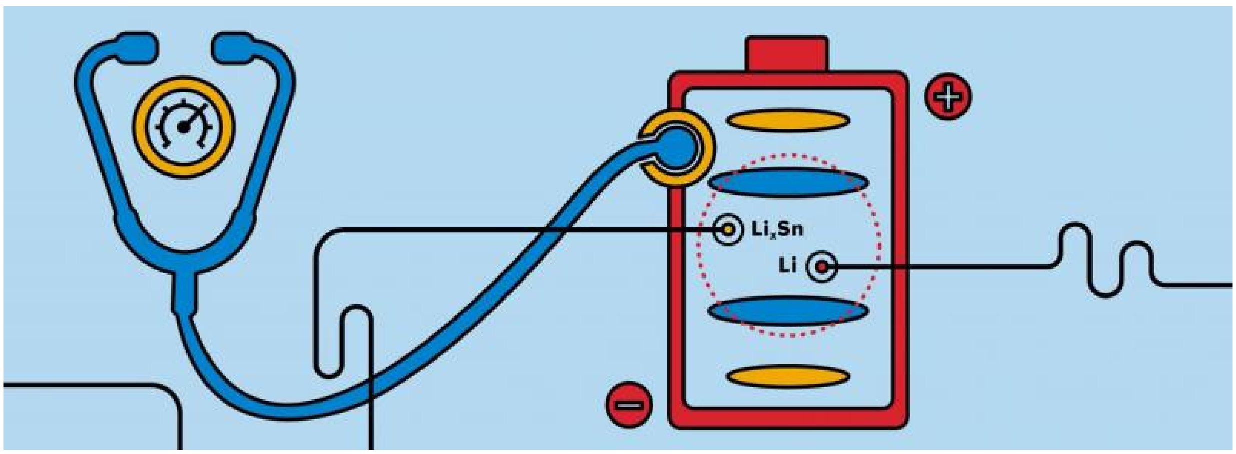
Researchers continue to pave way for improved battery performance testing

March 31 2016



Reference electrodes provide insights into a battery cell's health. The image above depicts two reference electrodes within a battery cell. This configuration that allows researchers to evaluate a battery's anode and cathode separately at all stages of cycling and aging. Credit: Sana Sandler/Argonne National Laboratory

Scientists at the U.S. Department of Energy's Argonne National Laboratory have demonstrated that the design and placement of a tiny measurement device called a reference electrode enhances the quantity and quality of information that can be extracted from lithium-ion battery cells during cycling.

Reference electrodes (REs) are used to measure the voltages of individual electrodes that make up the battery cell. "Such information is critical, especially when developing batteries for larger-scale applications, such as electric vehicles, that have far greater energy density and longevity requirements than typical batteries in cell phones and laptop computers," said Argonne battery researcher Daniel Abraham, co-author of a newly published study in the *Journal of The Electrochemical Society*. "This kind of detailed information provides insight into a battery cell's health; it's the type of information that researchers need to evaluate battery materials at all stages of their development."

Argonne battery researchers have been at the forefront of using REs to evaluate the performance of lithium-ion cells, Abraham said. Their studies have provided crucial insights into cell aging phenomena, including the effects of test temperatures and cycling voltages. Mitigating the root causes of aging can increase cell longevity and improve the commercial viability for applications that require long-term battery durability.

Until recently, Argonne battery researchers would use only one RE, based on a lithium-tin (Li-Sn) alloy, to collect information. However, Abraham's team found that by sandwiching a Li-Sn RE between the positive and negative electrodes, while simultaneously positioning a pure Li metal RE next to the stack, they could obtain insights into electrode state-of-charge shifts, active material use, active material loss and impedance changes.

In testing the new RE configuration, researchers used a cell containing a lithiated oxide cathode (NCM-523), an Argonne-developed silicon-graphite anode (Si-Gr) and various electrolytes, including ones with fluoroethylene carbonate (FEC) or vinylene carbonate (VC) additives. Both NCM-523 and Si-Gr are materials of interest for high-energy-density lithium-ion batteries being developed to extend the driving range of vehicles.

"Silicon-containing electrodes could double the energy stored in lithium-ion cells," said Abraham. But because Si-containing cells degrade more quickly, the Argonne team wanted to know the impact of the FEC and VC addition to the cell electrolyte. "Our new RE configuration confirms the beneficial impact of these additives, not only in reducing capacity loss but also in mitigating the impedance rise displayed by cells without these additives," he added.

More information: Matilda Klett et al. Electrode Behavior RE-Visited: Monitoring Potential Windows, Capacity Loss, and Impedance Changes in Li (Ni Co Mn) O /Silicon-Graphite Full Cells , *Journal of The Electrochemical Society* (2016). DOI: 10.1149/2.0271606jes

Provided by Argonne National Laboratory