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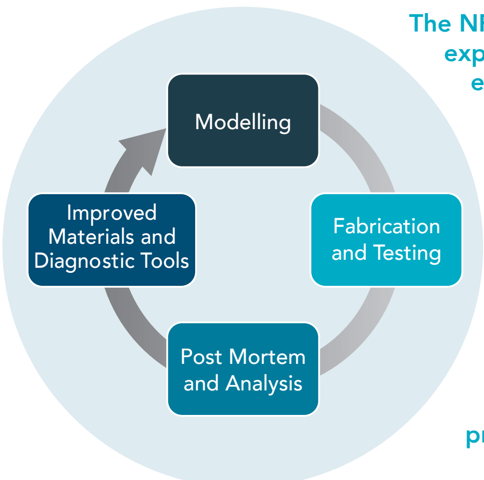
DEGRADATION MECHANISMS

Nickel-rich NMC lithium-ion batteries



The NRC's multi-disciplinary team has expertise in the characterization of energy materials, examination of material interfaces, assessment of materials compatibility, and evaluation of the durability of cell components through in-situ and ex-situ instruments and electrochemical analysis. A fundamental understanding of these issues is used to improve battery materials, electrode structures, cell fabrication processes, and diagnostic tools.

IMPROVING PERFORMANCE

As lithium-ion batteries become increasingly critical to the smooth functioning of our everyday lives, so does the desire to increase their performance, reduce their cost and ensure their safe operation. It has been well documented that by increasing the nickel content of the cathode in a nickel-manganese-cobalt- (NMC) based lithium-ion battery, one can materially improve the capacity, thus lowering the per-unit cost while still maintaining relative safety compared to some other commercially available alternatives.

For this reason, $Ni_{0.8}Mn_{0.1}Co_{0.1}O_2$ (NMC811) is a Ni-rich NMC composition that is currently attracting considerable attention. However, the delivered capacity of NMC811 is very limited when charged under high-voltage conditions (over ~4.2V) due to poor structural stability of he cathode material. In previous studies, the NMC811 cathode has been shown to undergo irreversible structural evolution until its highly conductive layered structure transitions to a lattice structure, and strain within particles eventually leads to particle cracking after prolonged cycling, causing deterioration of capacity and increase in electrode impedance, both of which limit the long term performance of cells based on this chemistry.

Substantial studies have been done to understand the degradation mechanisms outlined above. Various in-situ and ex-situ characterization technologies have been utilized to understand the root cause of the failures, and establish accurate models both for material development and for the eventual inclusion into algorithms used by battery management systems. Electrochemical Impedance Spectroscopy is one such electrochemical characterization method used to measure and de-convolute cell resistances. This method has been extensively used in studying battery aging mechanisms, including conductivity loss, and loss of active materials.

OUR APPROACH

In this project, we propose new insight into the phase transition, the strain within particles, particle cracking and impedance change processes that occur during charge and discharge of the NMC811 cathode over prolonged cycling at high voltages. Our method includes the use of time-dependent electrochemical impedance spectroscopy (TD-EIS) combined with differential capacity measurement and post-physical characterization to interpret data and compare the resistance change of every cycled cell upon high voltage and prolonged cycling. These efforts will provide data for the fundamental understanding of high voltage and prolonged cycling influence on the structure-impedance relationship and will help to optimize the use of NMC811 in lithium-ion batteries.

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Paper: Cat. No. NR16-302/2020 • ISBN 978-0-660-33773-9
PDF: Cat. No. NR16-302/2020E-PDF • ISBN 978-0-660-33771-5
012020

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