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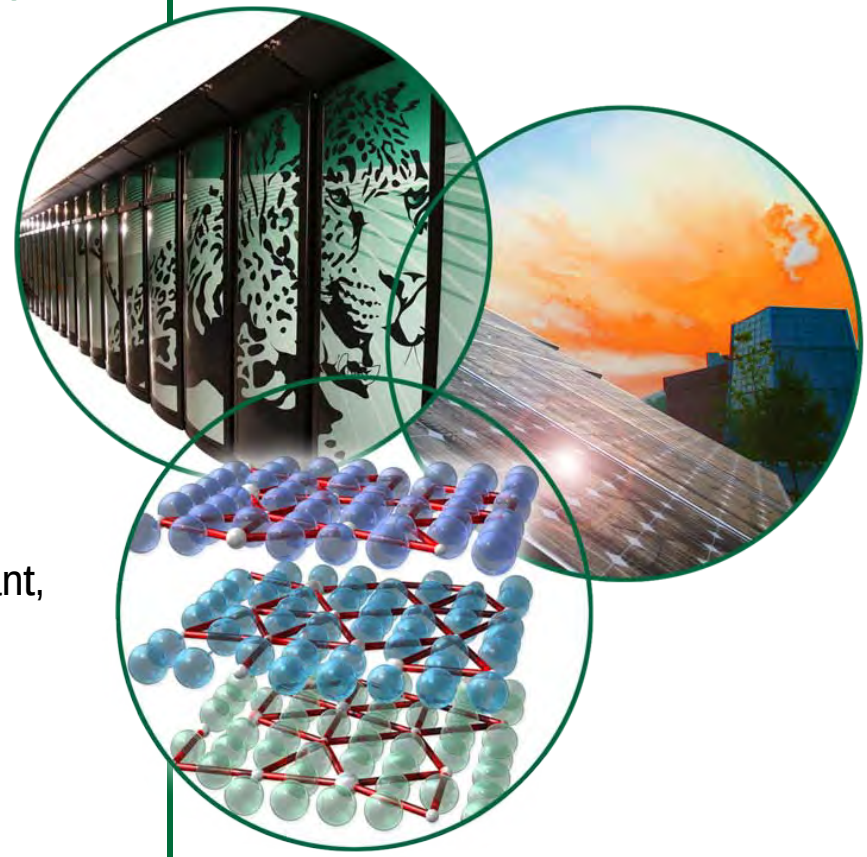
Project ID #ES039

In-situ characterization and diagnostics of mechanical degradation in electrodes



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Oak Ridge National Laboratory

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UTK: Kevin Rhodes
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ANL: Daniel Abraham
General Motors: Steve Harris, Yan Wu
Dow Kokam: Maneesh Bahadur, Erin O'Driscoll

March 10, 2011

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Overview

Timeline

- Start: August 2009
- End: September 2012
- 60% complete

Budget

- Funding FY10
  - $300K
- Funding FY11
  - $300K

Barriers

- Poor cycle life

Goals

- Cycle life: 5000 cycles
- Calendar life: 15 years

Partners

- Argonne National Laboratory
- General Motors
- Dow Kokam

Objectives

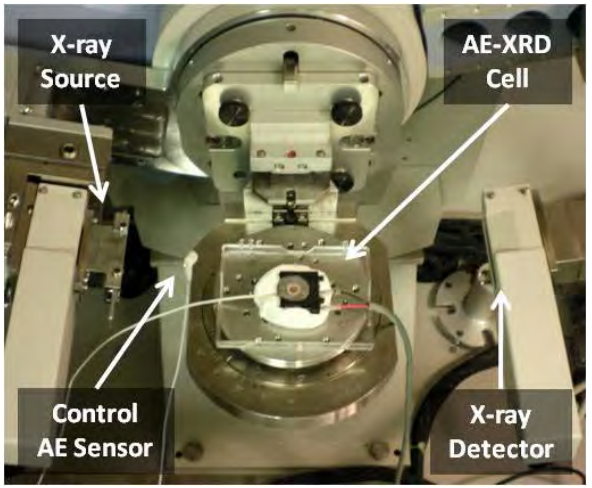
- Development of in-situ tool to characterize mechanical degradation (crack initiation, crack growth, particle fracturing, particle loosening) during cycling.
- In-situ characterization of phase transformations, stress and strain, and texture in electrochemically cycling materials
- Understanding of accumulation of defects and resulting mechanical degradation. Opportunity to develop a real life time prediction for different materials.
- True quantification of mechanical degradation

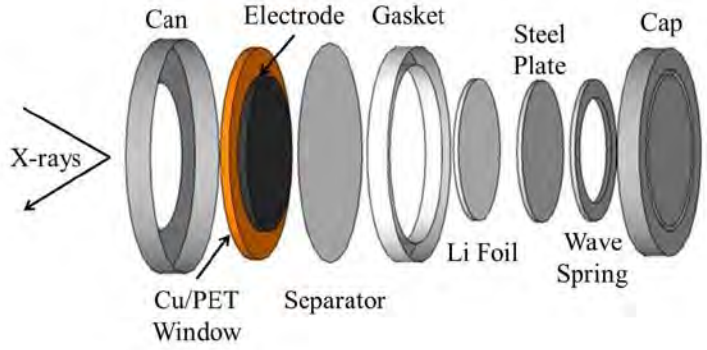
Milestones FY2010/11

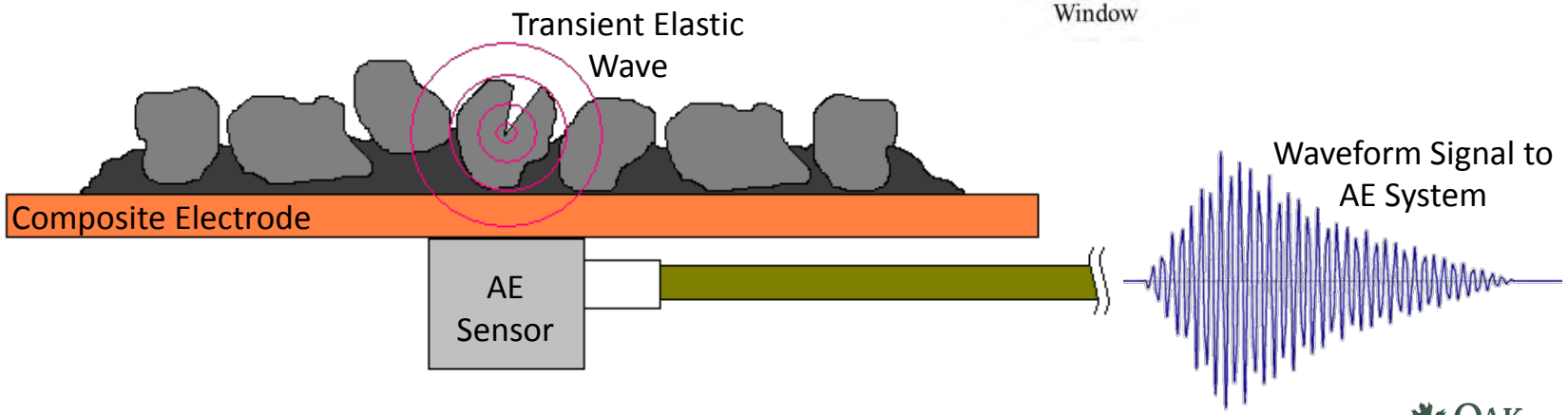
Month/Year	Milestone or Go/No-Go Decision
Oct 09 	Acoustic emission detection and classification of events in coin cell samples based on signal signature.
Apr 10 	In-situ studies combining acoustic emission spectroscopy and X-ray diffraction
Sept 10 	Establishing combination with other methods such as neutron diffraction, x-ray diffraction
Sept 11 	Understanding of physical evidence to acoustic emissions and degradation mechanisms in electrodes and link to phase transformation and cracking events – 80% complete
Sept 12 	Development of life time prediction tools and ‘fatigue’ like models for materials behavior

Approach

- Utilizing acoustic emissions stemming from mechanical events to probe degradation
- Cells are cycled while acoustic emissions are recorded and analyzed
- In-situ cell with x-ray transparent window is used for phase, stress, strain, texture analysis in cells
- Neutron scattering has been performed on small and commercial 40Ah cells

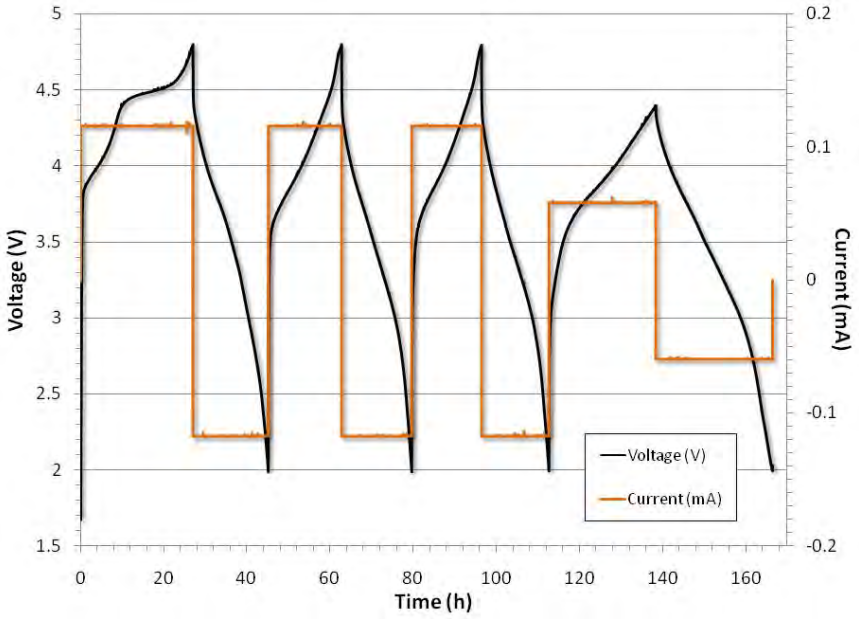


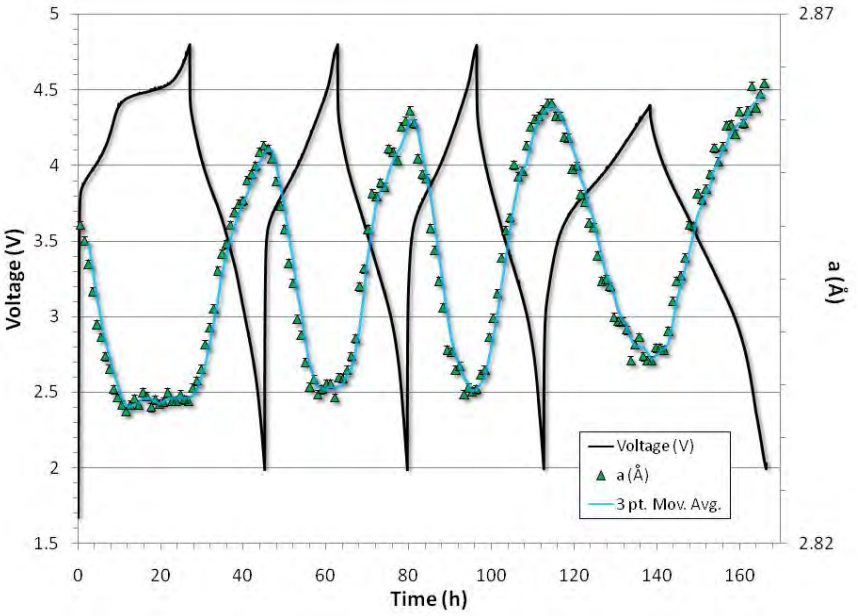


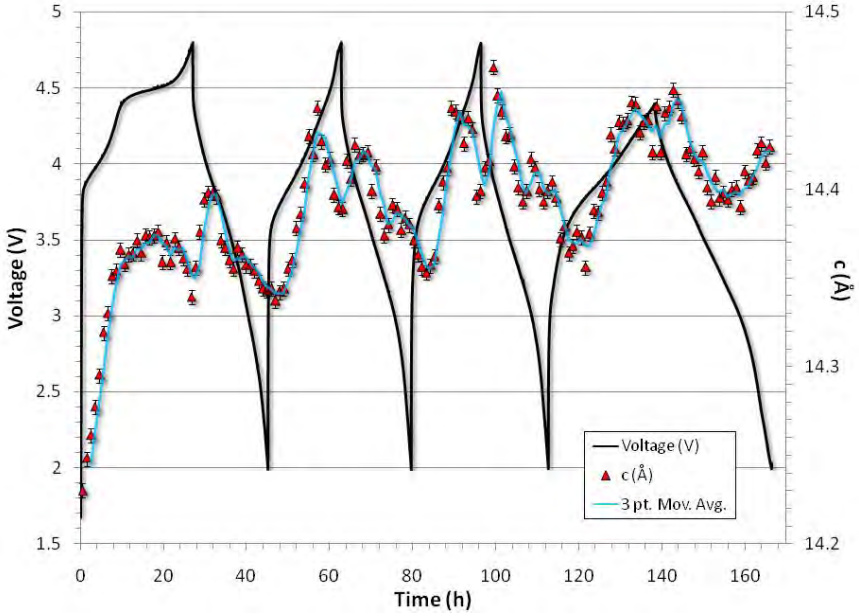


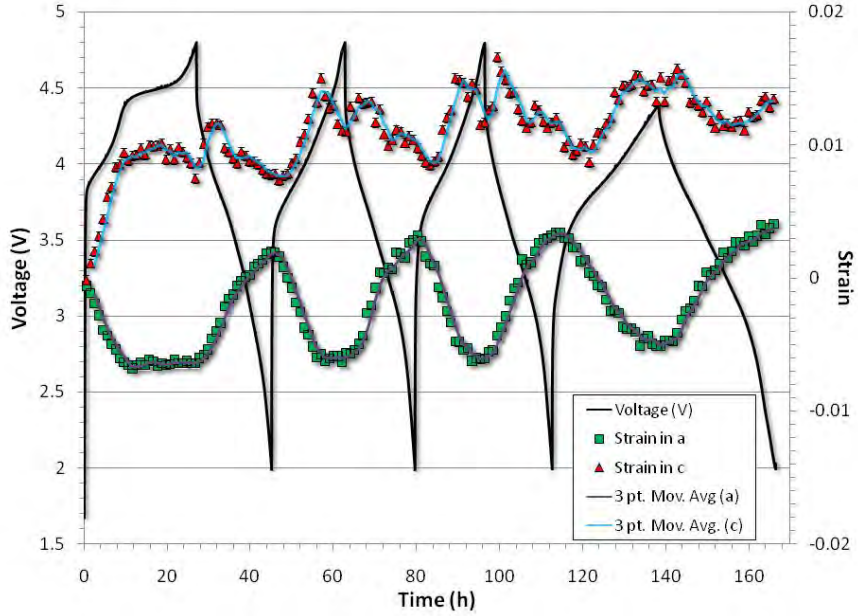
Rhodes, Daniel, et al. JRevSciInstrum.

Result of In Situ AE-XRD for NMC Electrode



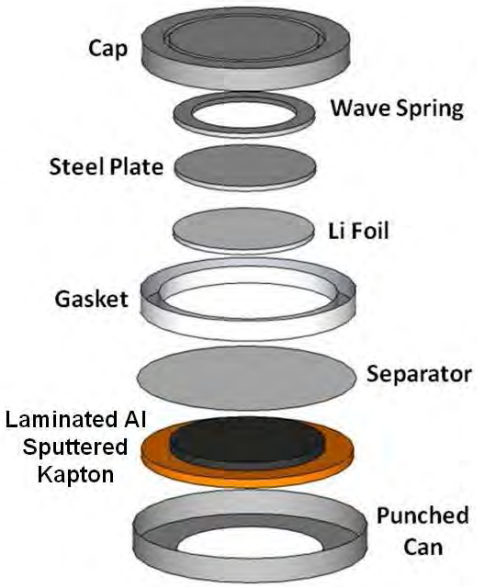


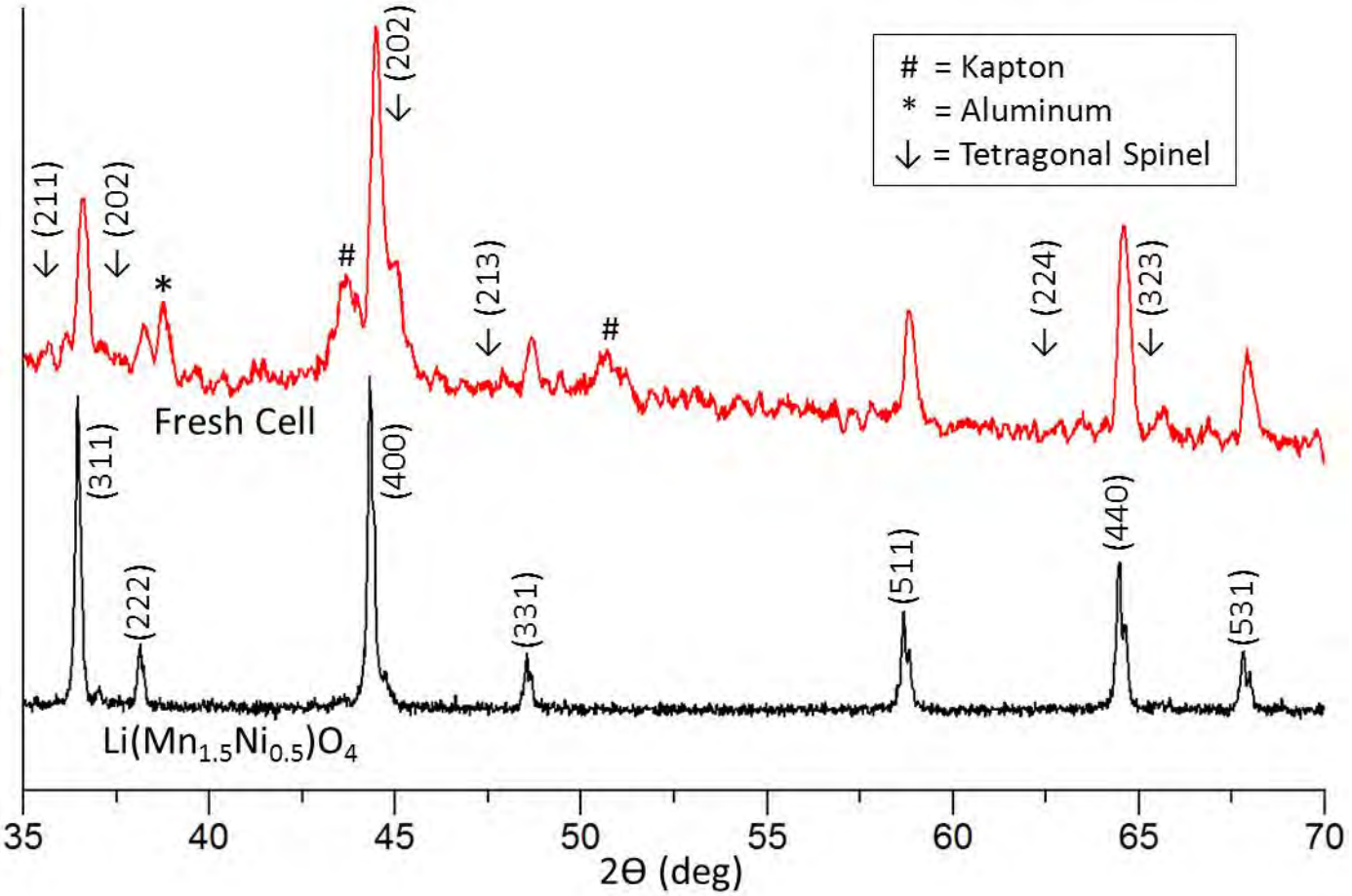




Rhodes, Wu, Daniel, et al., JECS, (in review)

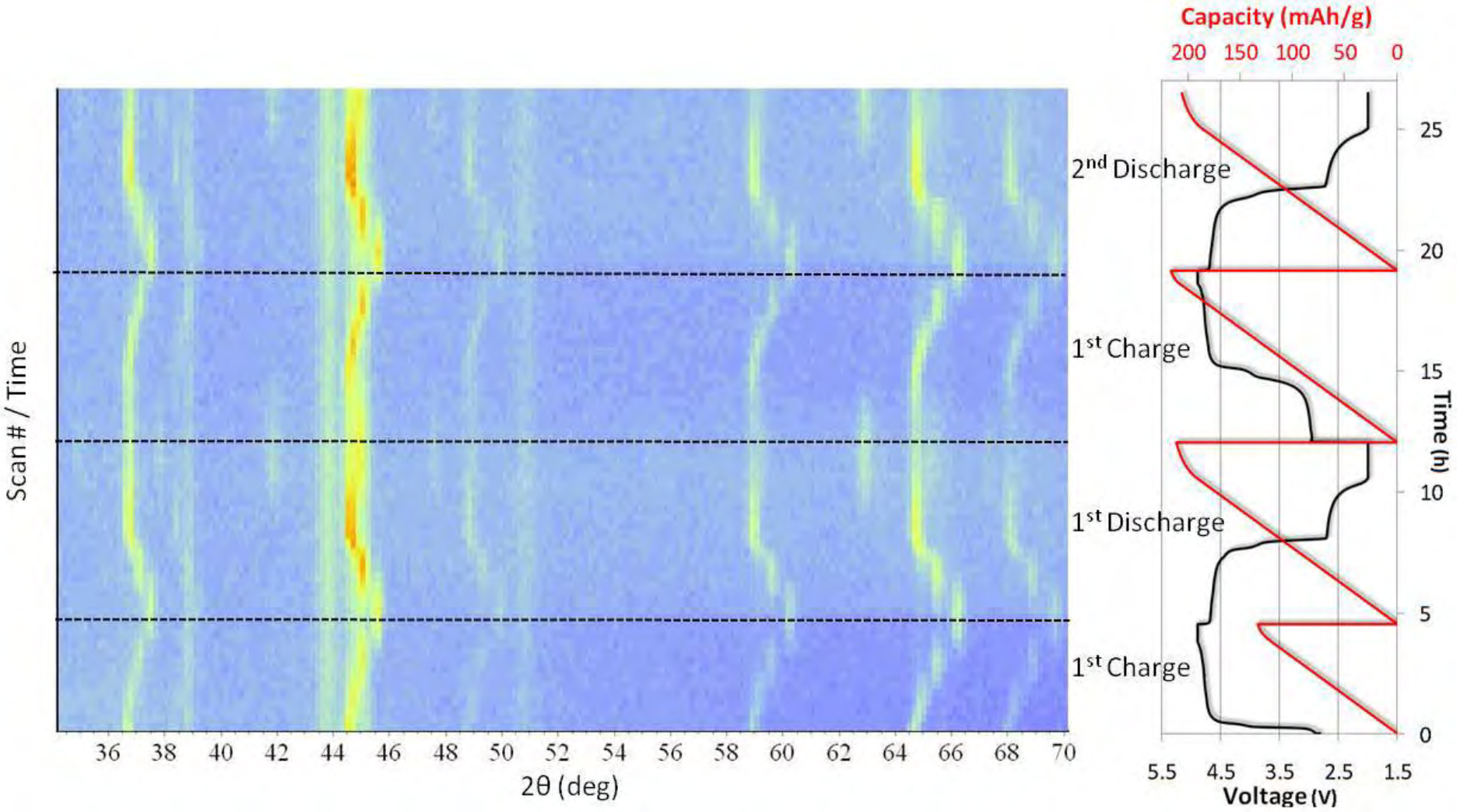
Result of In Situ AE-XRD for MNO Electrode





Rhodes, Daniel, et al., JECS, (in review)

Result of In Situ AE-XRD for MNO Electrode



Rhodes, Daniel, et al., JECS, (in review)

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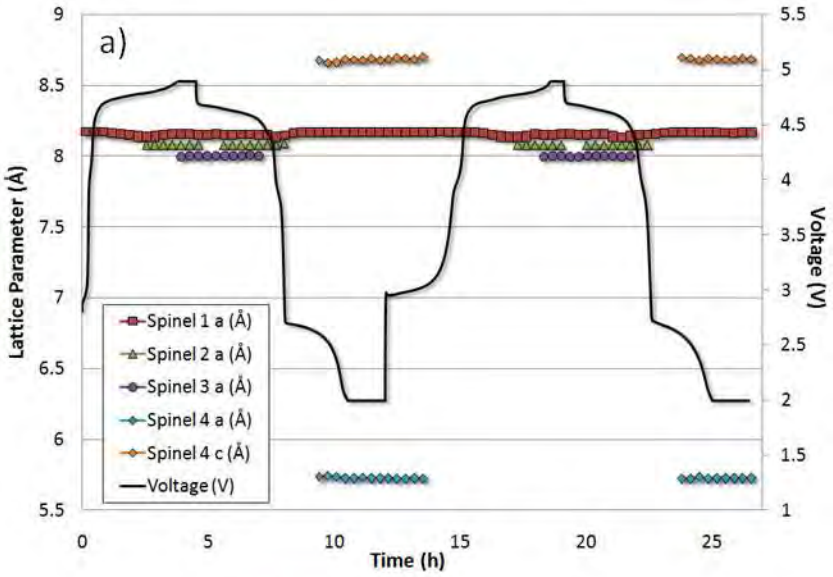
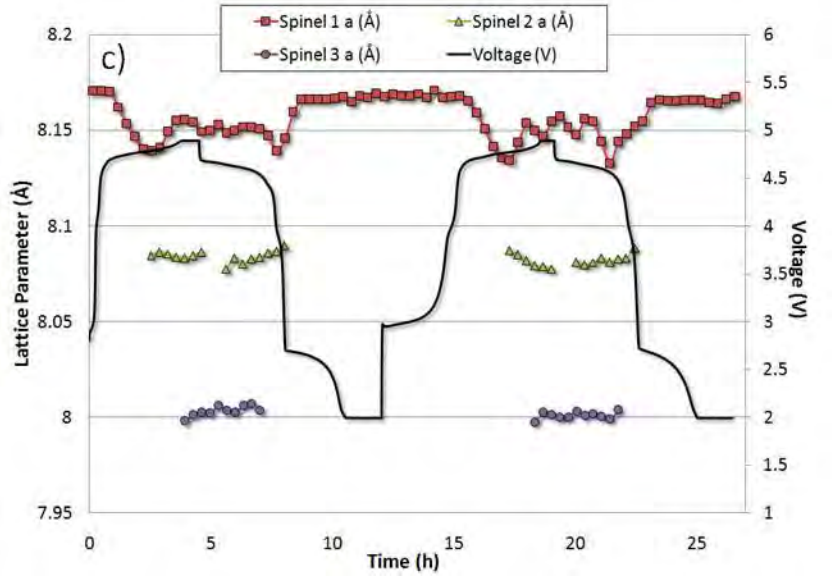
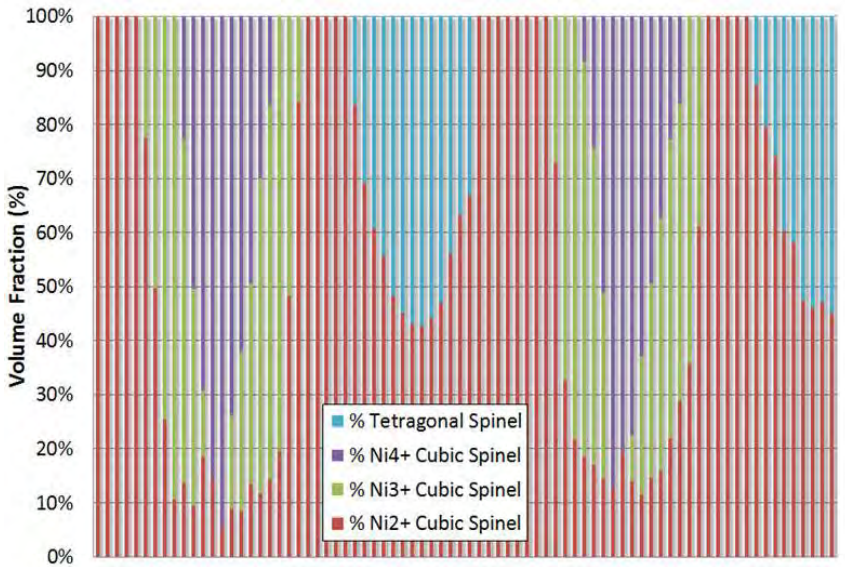
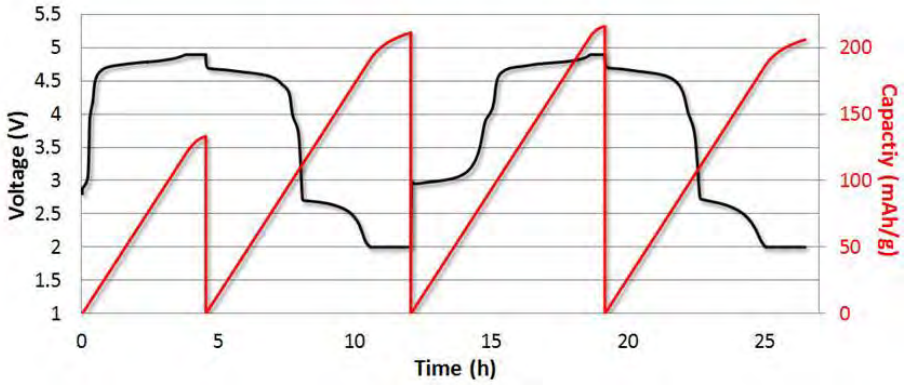


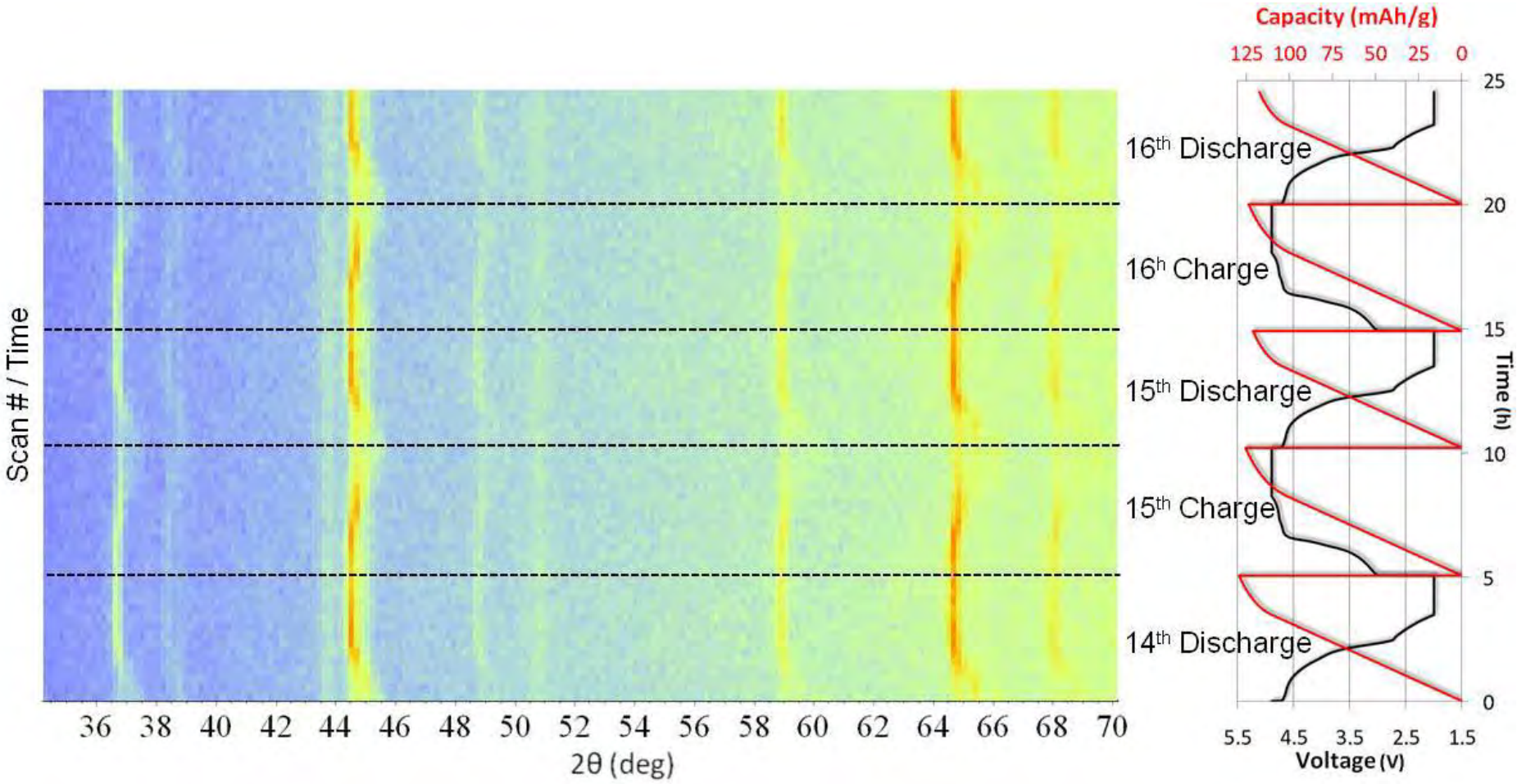






Rhodes, Daniel, et al., JECS, (in review)

Result of In Situ AE-XRD for MNO Electrode



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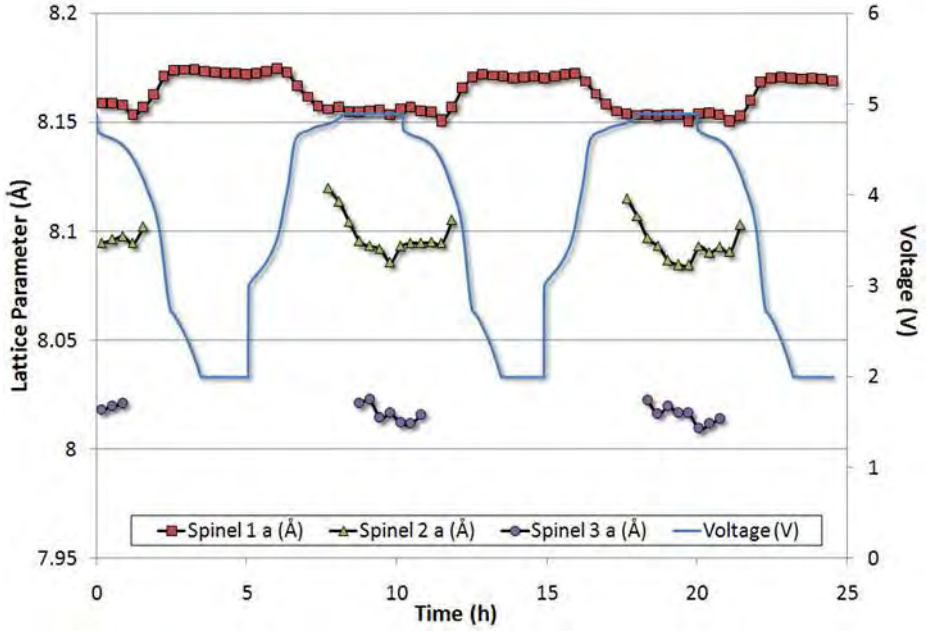
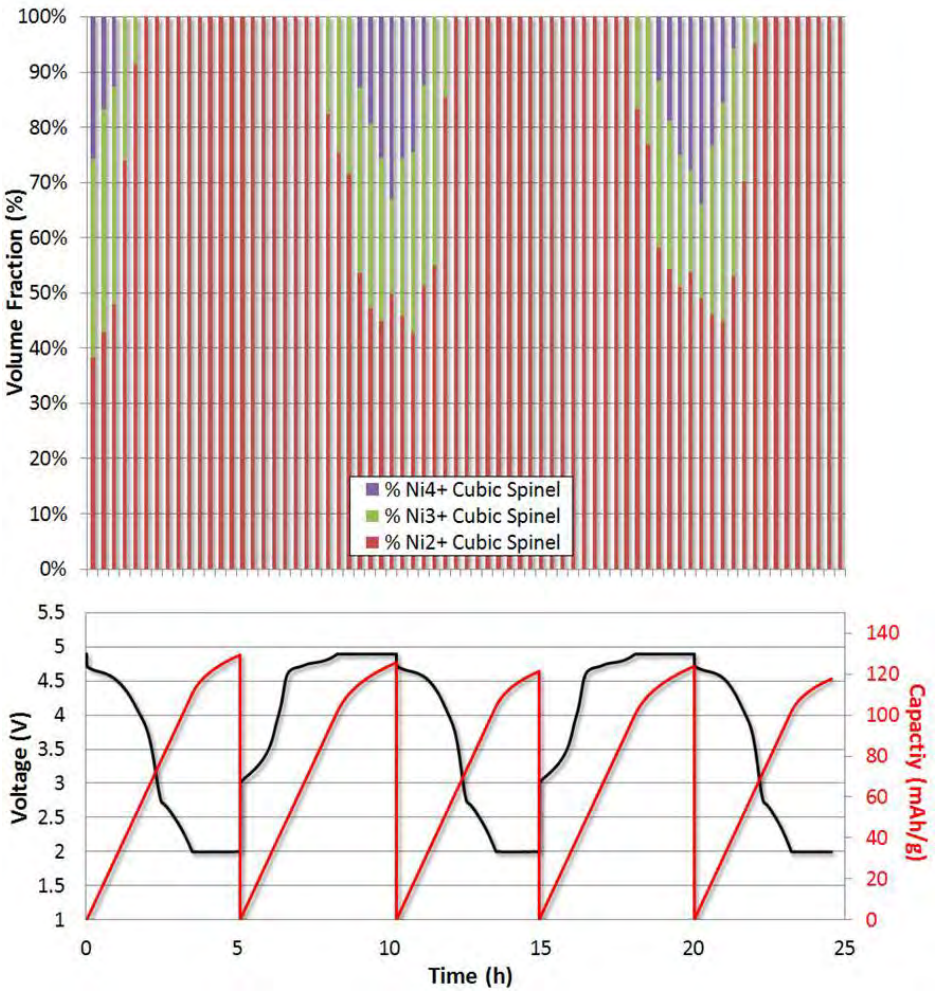
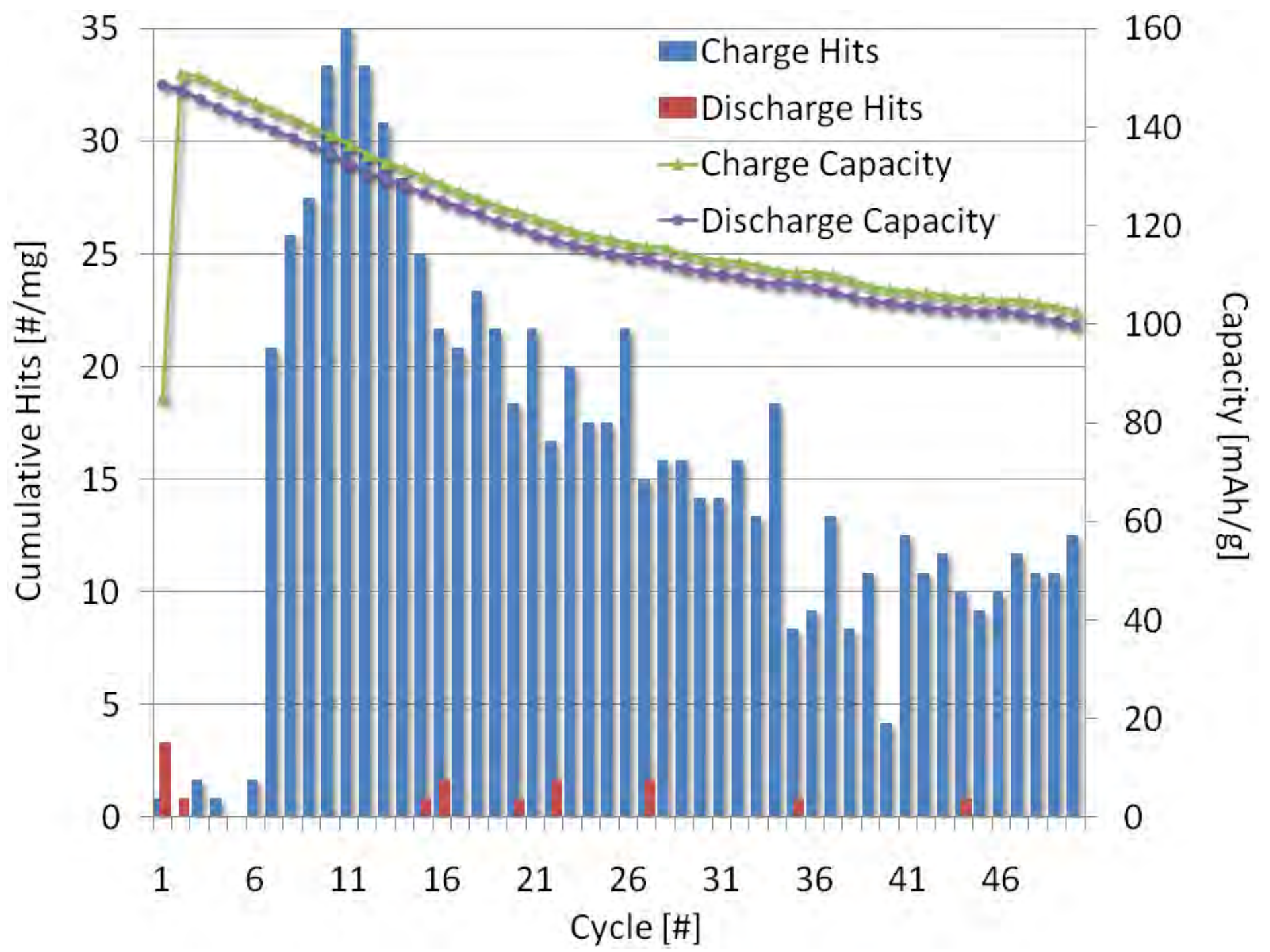
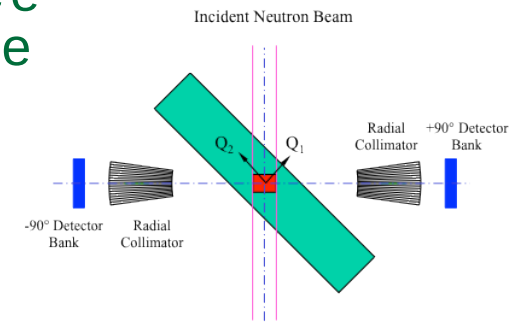


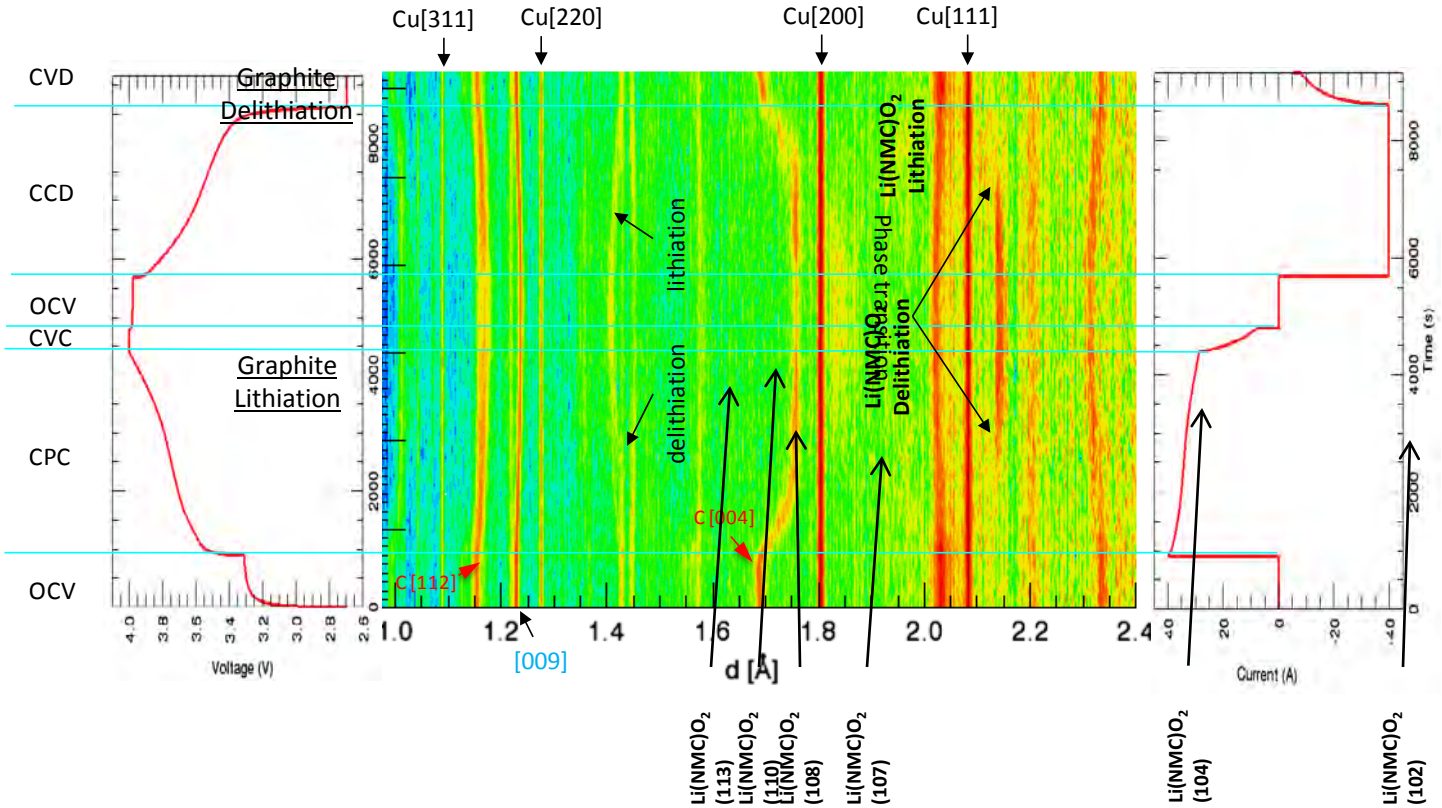


Rhodes, Daniel, et al., JECS, (in review)


Charge Hits
Discharge Hits
Charge Capacity
Discharge Capacity
Cumulative Hits [#/mg]
Capacity [mAh/g]
Cycle [#]
0
5
10
15
20
25
30
35
0
20
40
60
80
100
120
140
160
1
6
11
16
21
26
31
36
41
46

Spallation Neutron Source Vulcan use for large scale cells





CVD-constant voltage discharge, CCD-constant current discharge, OCV open circuit voltage
CVC-constant voltage charge, CPC-constant power charge

Feng, Rhodes, Daniel, Wood, et al., JECS, (in review)

Collaborations

Partners

- Argonne National Laboratory: Daniel Abraham
- General Motors: Yan Wu, Steve Harris
- Dow Kokam: Maneesh Bahadur, Erin O'Driscoll
- High Temperature Materials Laboratory: Andrew Payzant, Melanie Kirkham, Robbie Meisner
- Shared Research Equipment and Collaborative User Center: Chad Perish
- University of Tennessee: Claus Daniel, Kevin Rhodes

Summary

- Development of in-situ combination characterization
- Integration of acoustic emission with x-ray diffraction
- Understanding of phase transformation, stress and strain analysis
- Widened included material beyond last year's carbon and silicon materials to NMC and MNO cathode materials
- Investigation of overcharge capacity boost phenomenon in NMC electrodes
- Investigation of phase transformation behavior in MNO high voltage electrodes

Proposed Future Work

- Further study of high voltage cathodes
- Intensify inclusion of ABR NCM material in concert with other diagnostic partners in ABR program
- Diagnostics coordination through Daniel Abraham
- Minimization of capacity fading through mechanical degradation
- Life time understanding, predication, and “fatigue” theory development