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Reliability and Safety Studies at Sandia

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NYBEST and JCESR Energy Storage and Technical Conference, Buffalo, NY

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Approach

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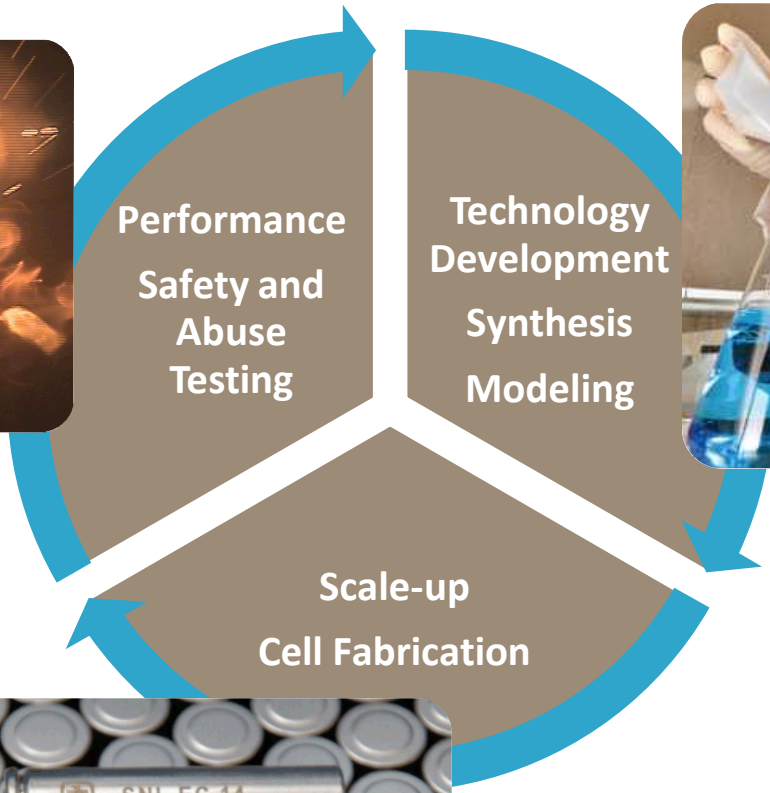

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SNL Energy Storage System Analysis Laboratory

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Providing reliable, independent, third party testing and verification of advanced energy technologies for cell to MW systems

Testing Capabilities Include:

- Expertise to design test plans to fit technologies and their potential applications
- OE supported testing
- CRADA opportunities
- WFO arrangements

Cell, Battery and Module Testing

- 14 channels from 36 V, 25 A to 72 V, 1000 A for battery to module-scale tests
- Over 125 channels; 0 V to 10 V, 3 A to 100+ A for cell tests

72 V 1000 A Bitrode (2 Channels)

Energy Storage Test Pad (ESTP)

System Testing

- Up to 1 MW, 480 VAC, 3 phase
- 1 MW/1 MVAR load bank

Battery Safety and Abuse Testing

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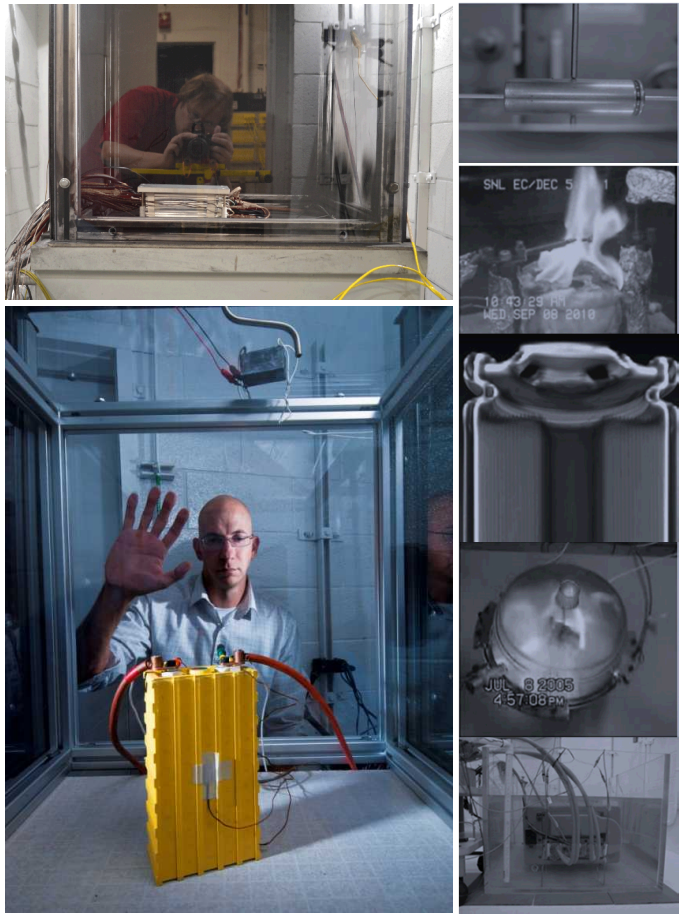
Cell and Module Testing
Battery Abuse Testing Laboratory (BATLab)



Battery Pack/System Testing
Thermal Test Complex (TTC)

Battery Calorimetry

Overview of the DOE OE Safety Meeting

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- Share knowledge on safety validation, commissioning, and operations from the perspectives of a diverse cross section of the energy storage community
- Identify the current gaps in understanding, managing, standardizing and regulating safety in energy storage systems
- Use the outcomes and future input as the basis of a DOE OE Strategy to foster energy storage safety

DOE OE Energy Storage Safety Meeting: Preliminary Outcomes

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- Current deployments of energy storage systems are increasingly further ahead of current codes, standards and regulations (CSR) resulting in challenges to secure needed approvals
  - Increases installations costs
  - Delays commercial projects
  - Becomes a reason to seek other technology solutions
- Root causes for a CSR gap
  1. Universally accepted safety validation techniques
  2. Codes, standards and regulations need updating
  3. Incident preparedness not fully developed for the new storage technologies
- A roadmap to validate the safety of energy storage systems has been developed and is currently under review at DOE

Technology development - Atomistic modeling and advanced characterization for battery reliability studies

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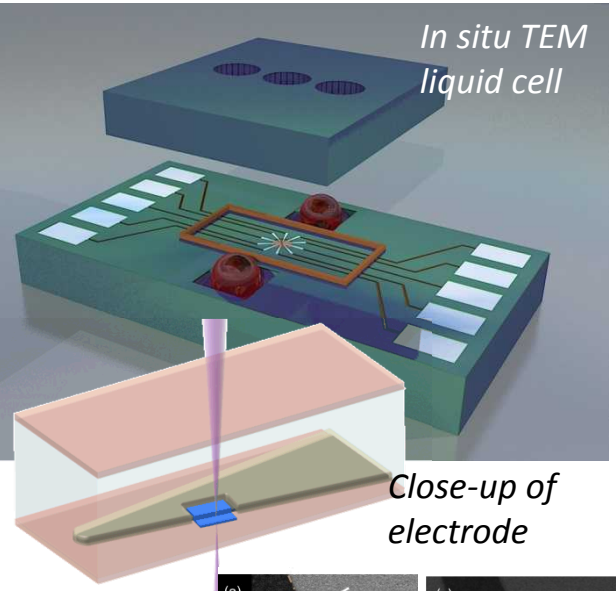
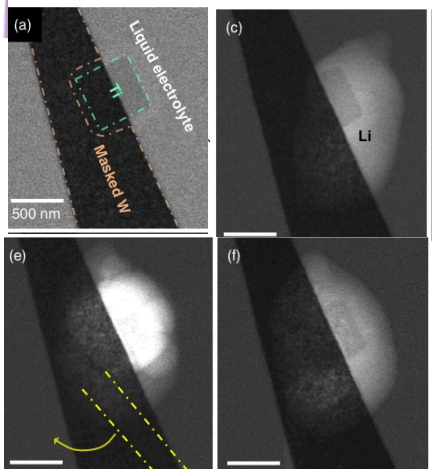
Li-ion cell electrochemistry inside a TEM

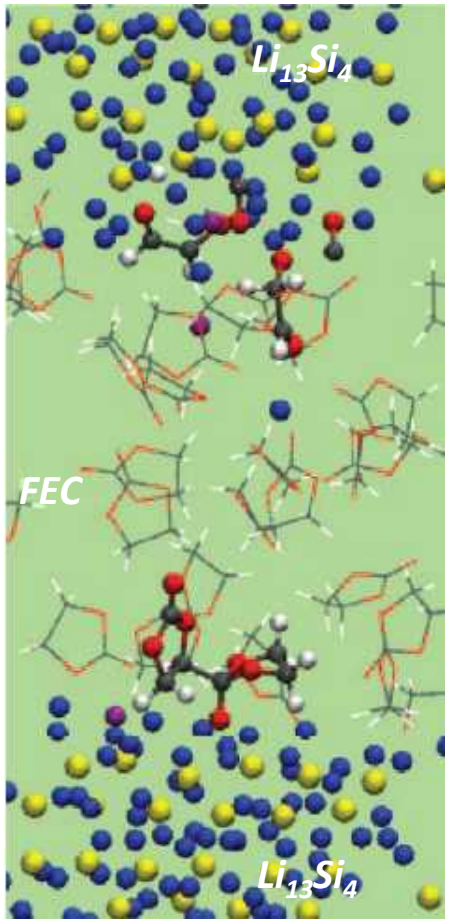


Close-up of electrode



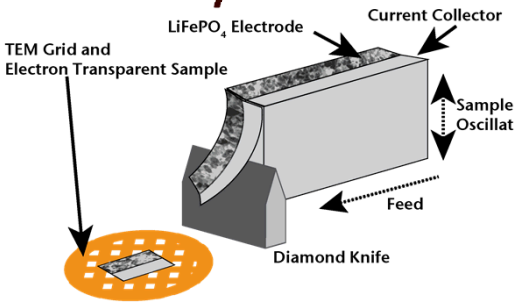
Li plating, Li stripping, SEI formation inside the TEM

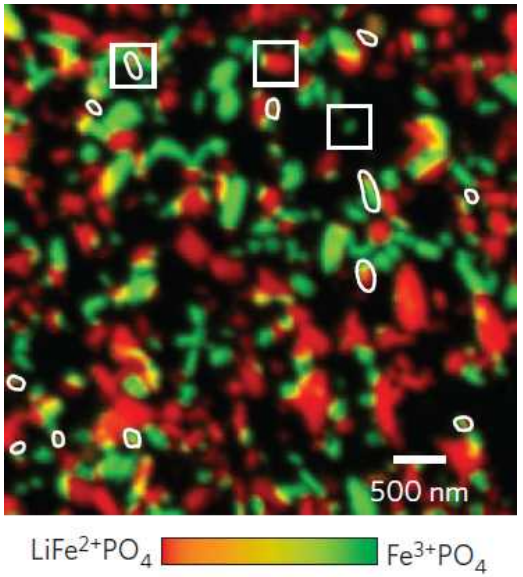
Atomistic modeling of electrolyte reduction



Ab initio modeling of electrolyte reduction on lithiated Si anodes

Scanning transmission x-ray microscopy maps of cathode particle SOC





Li concentration map at each $LiFePO_4$ particle.

Tom Harris, Katie Jungjohann, Andrew Leenheer, Kevin Lueng, Kevin Zavadil, Farid El Gabaly, John Sullivan - SNL

Modeling - Applying Sierra simulation tool to battery fire scenarios

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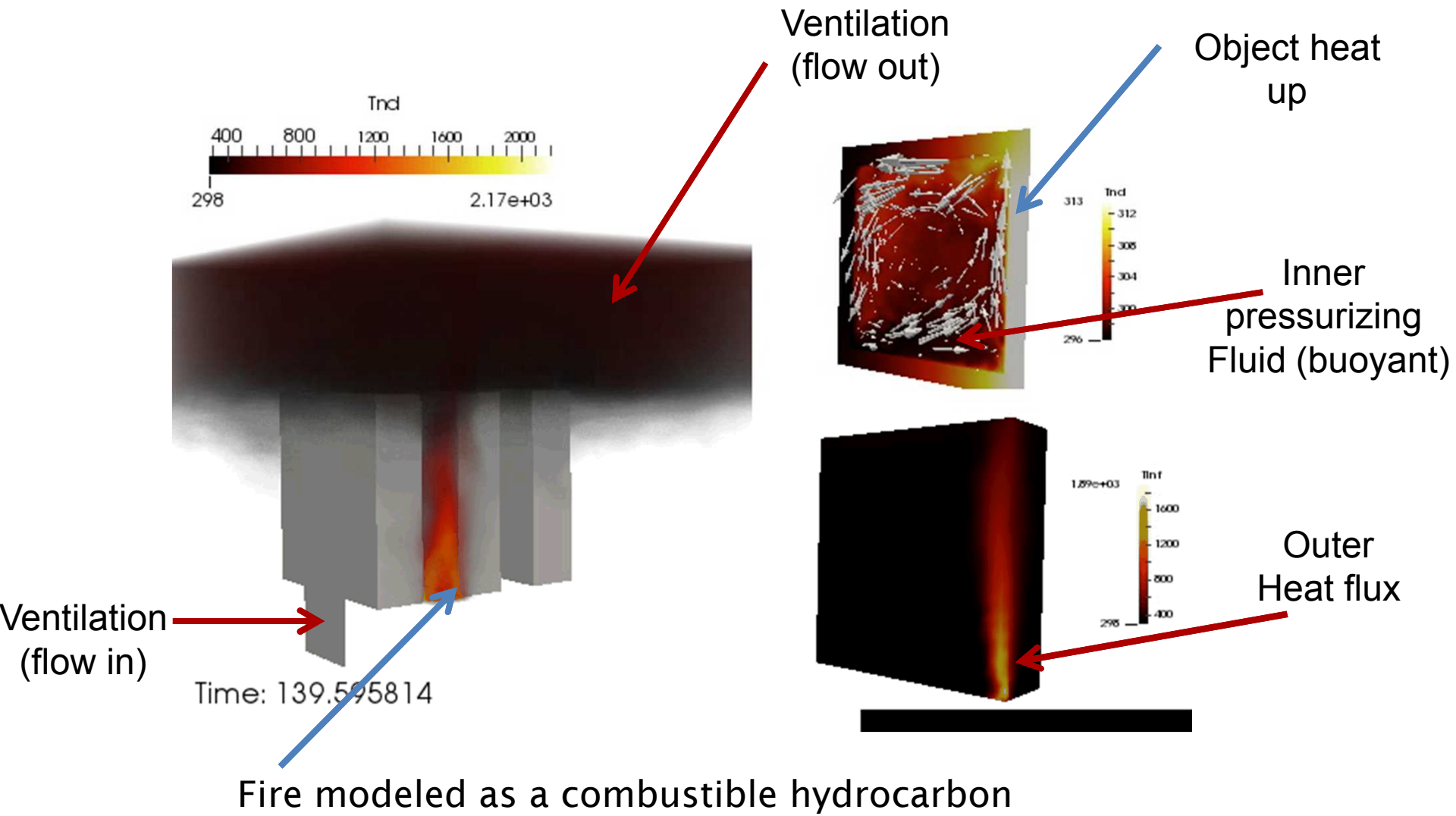
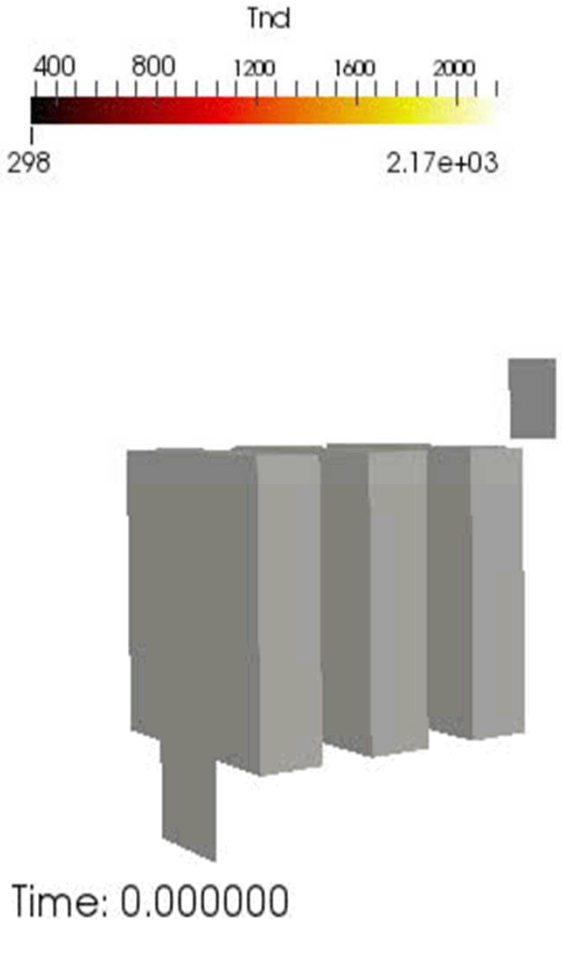
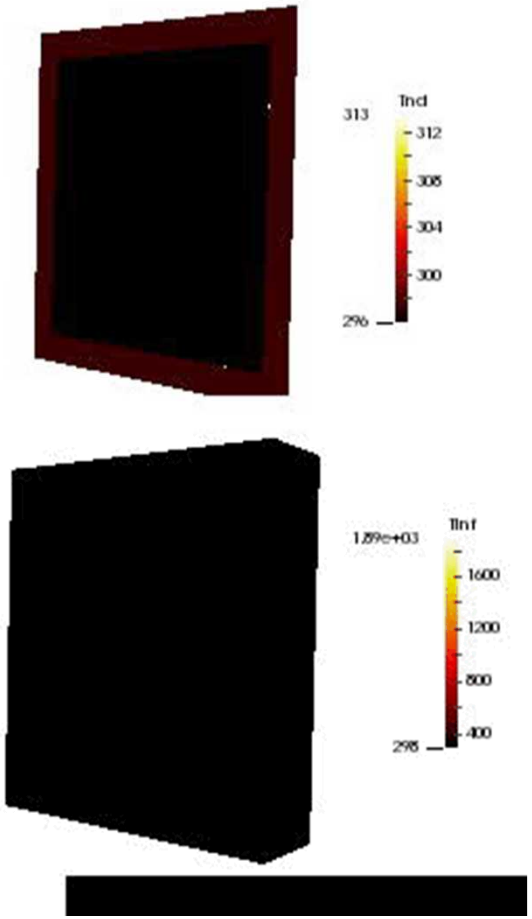


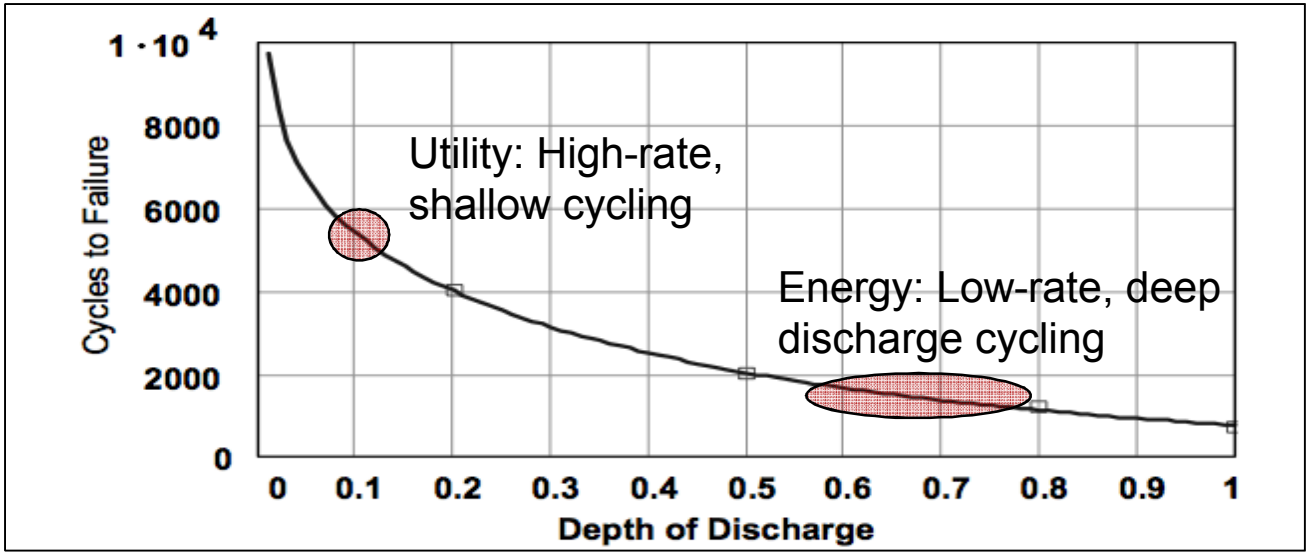
Modeling - Ventilation effect on fire plume dynamics (2/3)



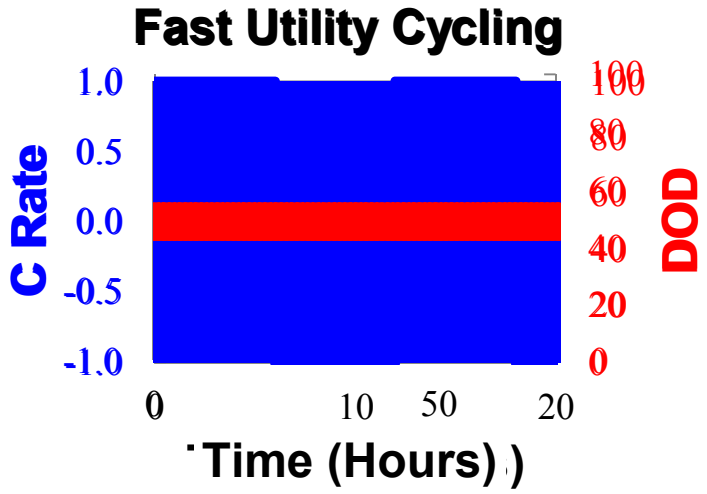


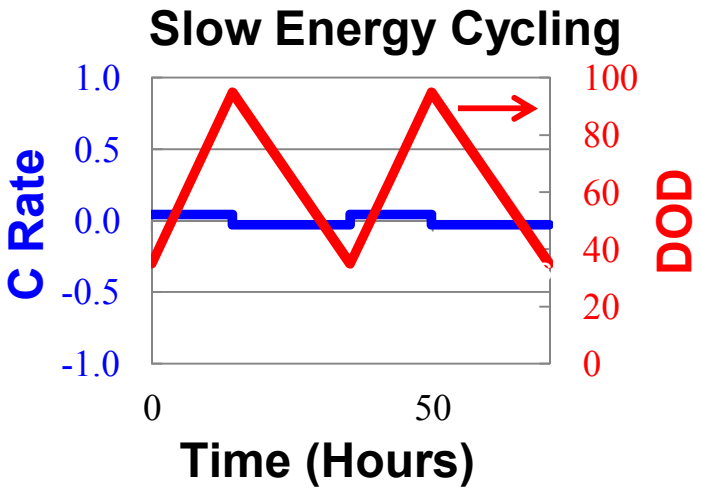
Ventilation is 1 m/s

Scale up and performance testing



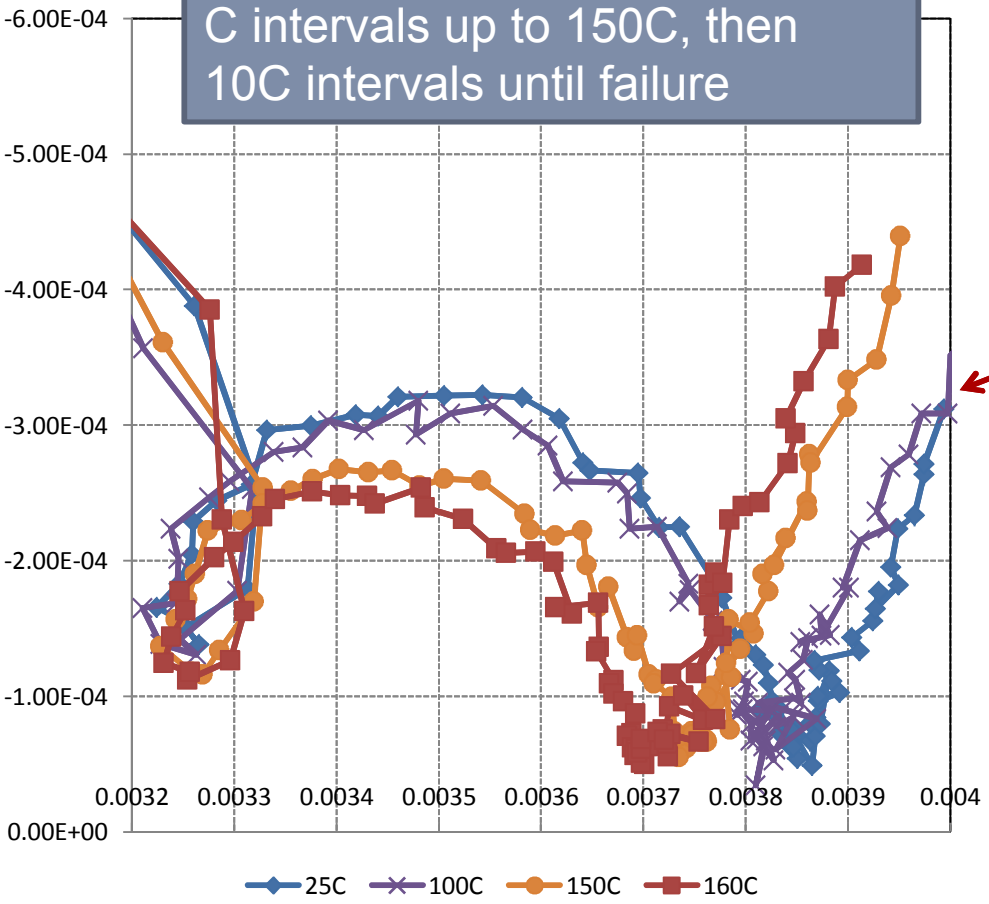
VRLA Life cycle data *S. Drouilhet, B.L. Johnson, 1997 NREL*

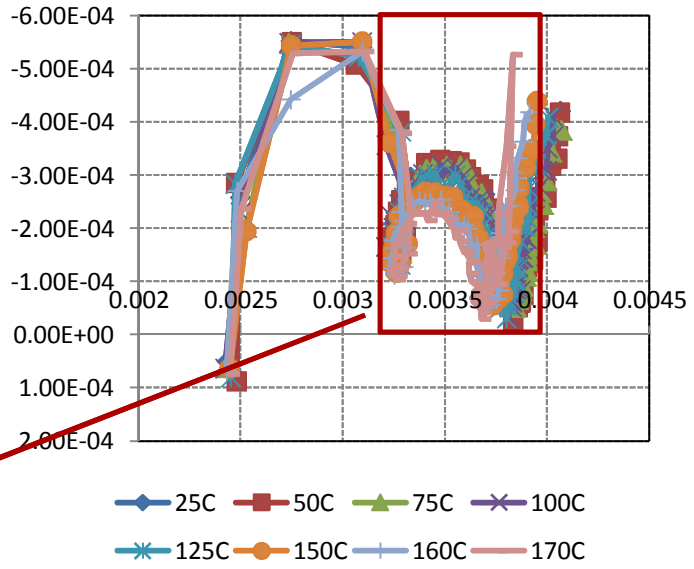




Safety testing - Advanced diagnostics of abused cells

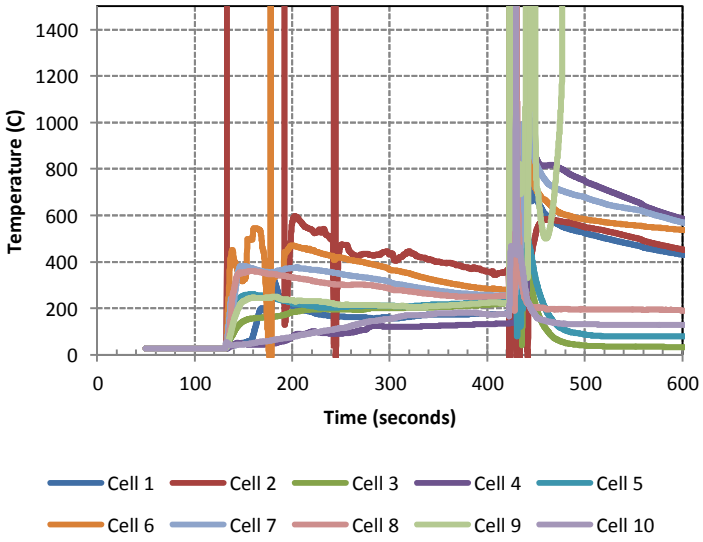
Impedance data collected at 25 C intervals up to 150C, then 10C intervals until failure



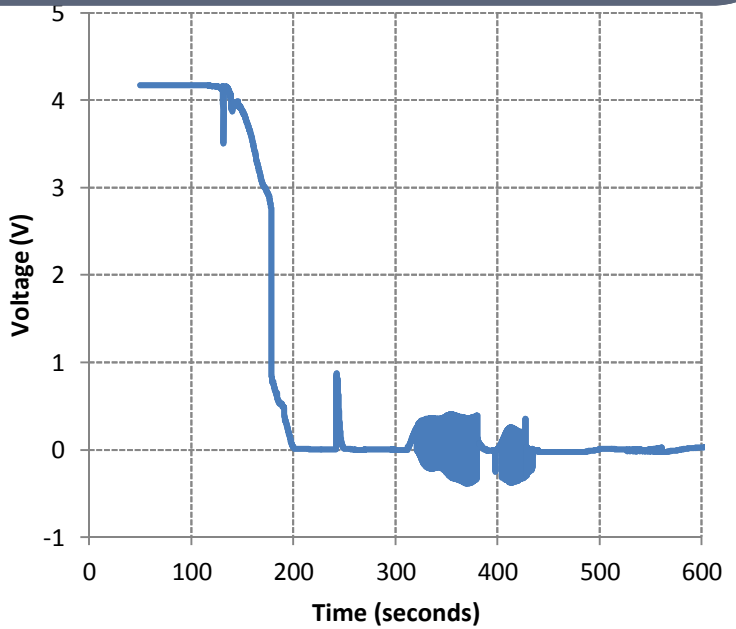


Little change observed up to 100C.
Shifts in R_{CT} observed as temperature increases above 100C.
Thermal runway observed during data collection at 170C

Safety Testing – Failure propagation in battery modules



- Successful initiation at Cell #6
- Propagation to adjacent cells first, followed by outlying cells
- Cascading failure to entire battery over 450s
- Some thermocouples (K-type) saturated during test



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- Andrew Leenheer
- Kevin Lueng
- Kevin Zavadil
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