Sandia National Laboratories

# Thermal Safety and Degradation of Li-Ion Cells Exposed to Thermal Gradients

Nathan B. Johnson, Loraine Torres-Castro, Alex M. Bates, Genaro Quintana, Jill Langendorf, Lucas Gray

## Motivation

Cells deployed in grid applications are often exposed to large temperature gradients during operation. The degradation pathway changes with temperature and the directionality of the temperature gradient-could change the thermal safety of the cell. This work quantifies the thermal stability of pouch cells exposed to 50°C temperature gradients. It is expected that plated lithium should reduce the onset temperature of thermal runaway but the capacity loss due to SEI formation and loss of active material should decrease the maximum heating rate and the maximum temperature.

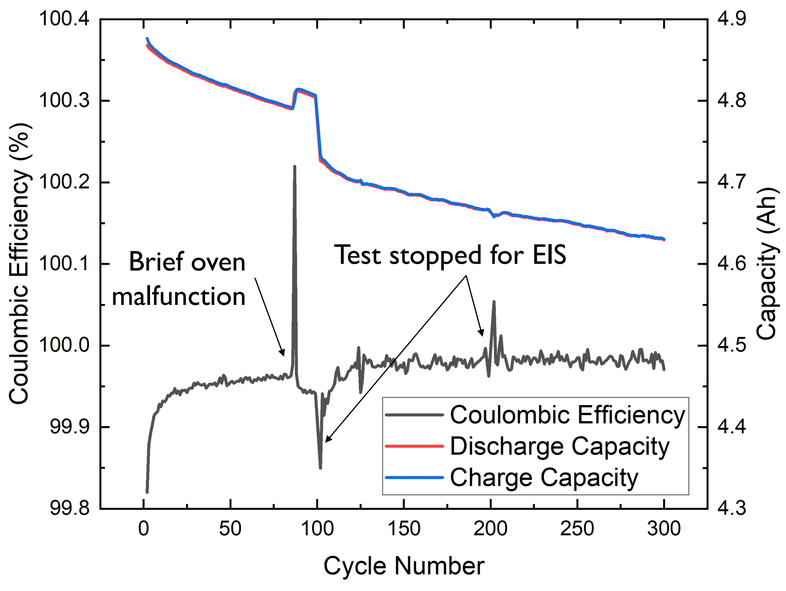

## Methods

- Cells are cycled in a 0°C environmental chamber with a 50°C hot plate on one side.
- EIS is performed at 0% SOC every 100 cycles.
- Cells are disassembled or subjected to an overtemperature test at 100 cycles and at 300 cycles

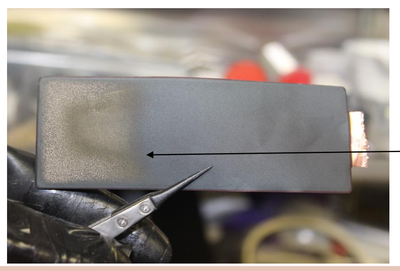
## Key Takeaways

- Electrochemical markers of lithium plating were not identified despite confirmed plated lithium through cell disassembly.
- Ohmic impedance and charge transfer impedance increase with cycling indicating SEI build up and capacity loss.
- Cells cycled with a thermal gradient saw a reduced maximum temperature and heating rate.
- Cycled cells had an earlier onset temperature for thermal runaway.
- Onset temperature was reduced for the cell with cycling.

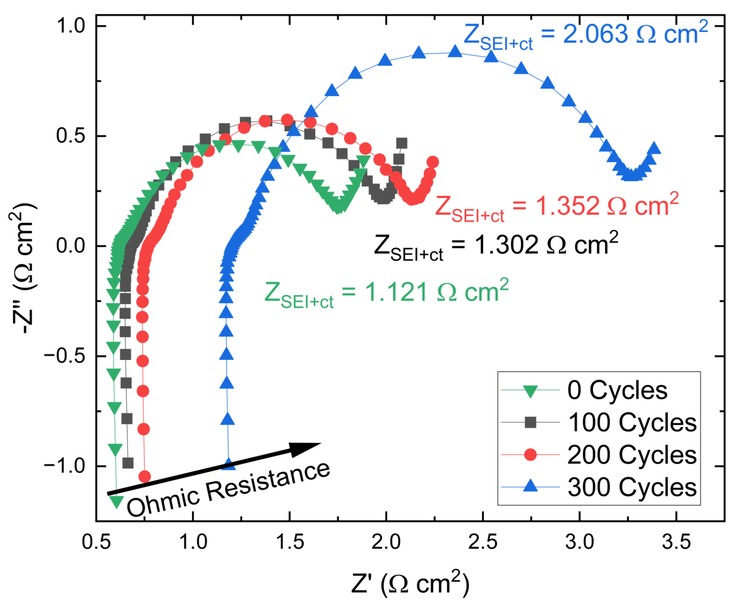
## Cycling



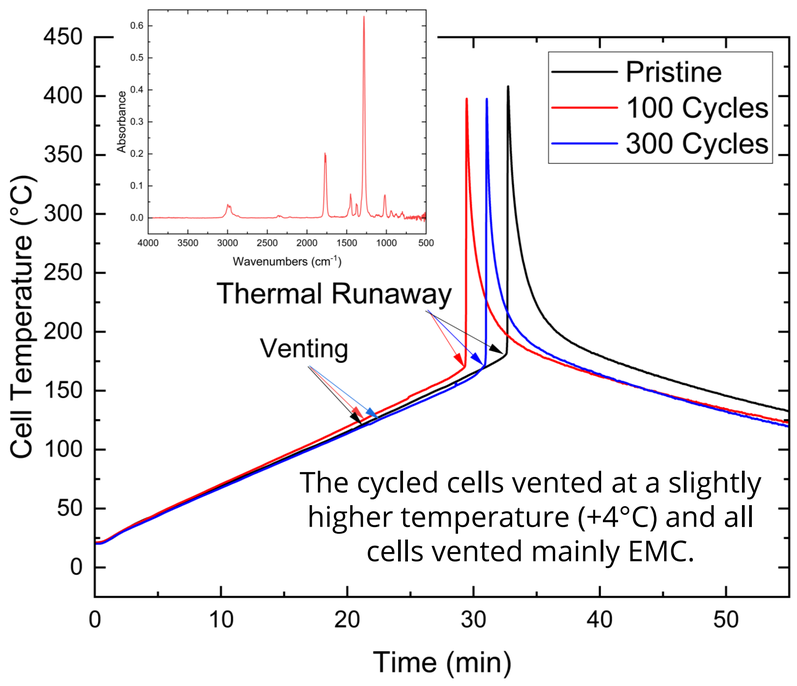

- Impedance increases with cycling consistent with SEI growth and capacity loss
- No signs of lithium plating in cycle data with dQ/dV, dV/dQ, dV/dt, or dI/dt
- Coulombic efficiency consistently remains above 99.8% during cycling



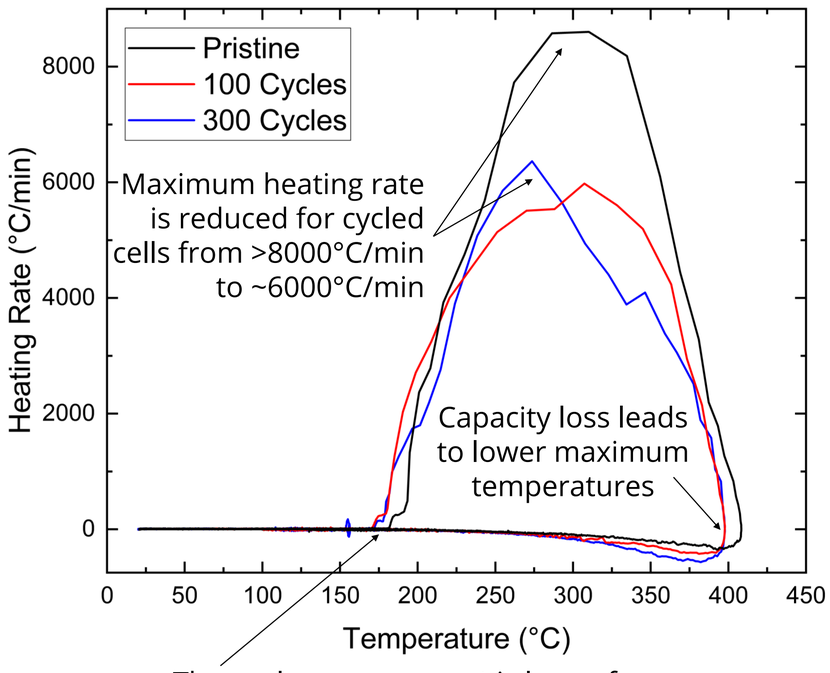
Lithium plating is observed upon disassembly after 100 cycles



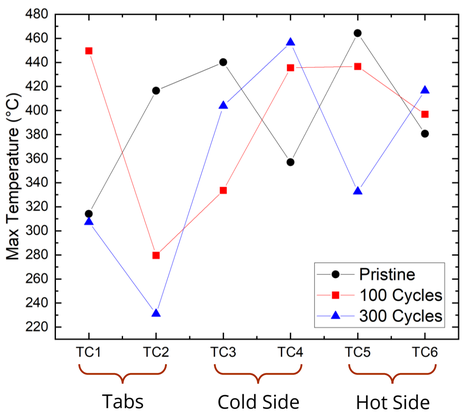

## Overtemperature Test



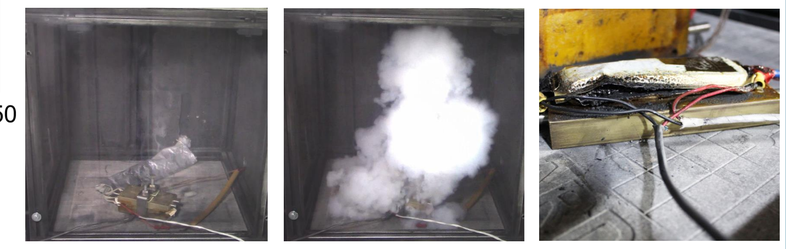

Average temperature for TC3 – TC6 during the overtemperature test




Thermal runaway onset is lower for cycled cells (~171°C vs 181°C) likely due to plated Li despite SEI growth




Maximum T at each TC



Thermal runaway of the pristine cell

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SAND2023-11255O