Sandia National Laboratories

MULTI-SCALE THERMAL CHARACTERIZATION OF SILICON-GRAPHITE||NMC811 BATTERY SAFETY

Bryan R. Wygant,[1] Randy Shurtz,[2] Nathan Johnson,[3] Noah Schorr,[3] Martin Salazar,[3] Loraine Torres-Castro[3]*

[1]Nanoscale Sciences, [2]Fire Science and Technology, [3]Power Sources Research and Development, Sandia National Laboratories, Albuquerque, New Mexico 87185, USA

PROJECT PROFILE
Topic: Safety and Reliability| Vertical: Safety and Reliability
Strategic Pathway: Grow
Project start and finish: FY25-FY26

PROBLEM

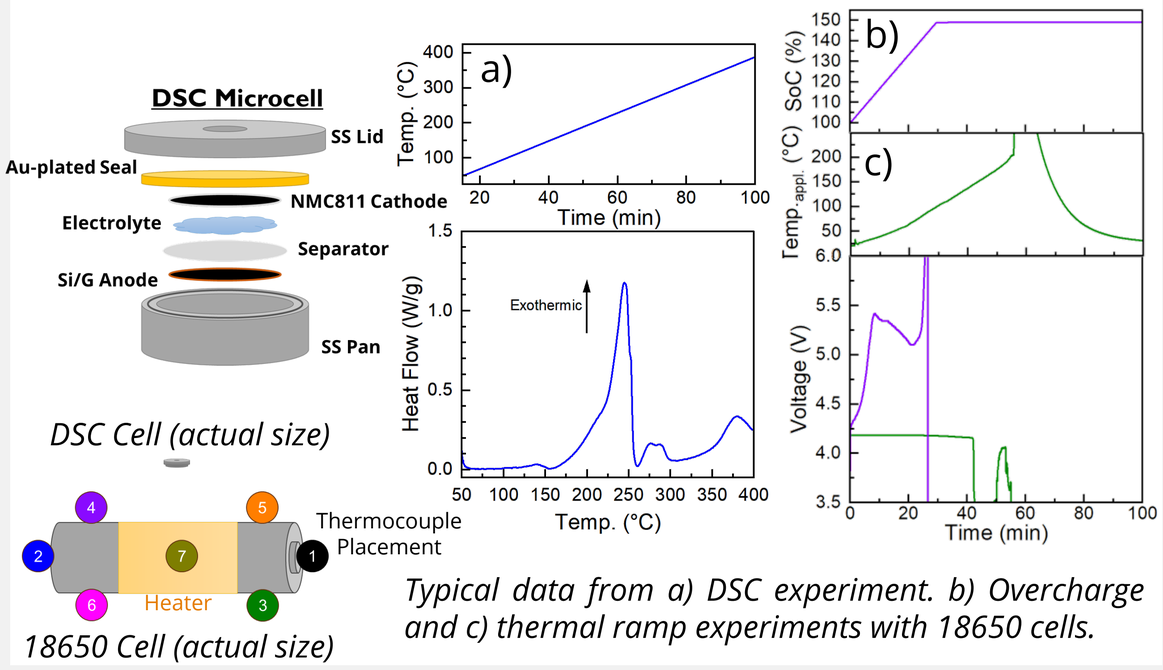
- Higher capacity/energy batteries are needed for uses ranging from grid storage to mobile electronics
- Existing chemistries (e.g., graphite) are nearly at their physical limit, leading to need for new materials
  - Replace graphite (360 mAh/g) with Si (3,600 mAh/g)
- Increasing stored energy in the cell likely to lead to increased safety hazards upon failure, leading to need for safety testing in concert with further development

APPROACH

- Using two-pronged approach to more efficiently evaluate the safety behavior of SiG||NMC811 based on Si/(G)rahpite ratio

  1. Quickly evaluate wide range of Si/G ratios using microcell differential scanning calorimetry (DSC) testing
  2. Scale promising Si/G ratios to full size 18650 cells to conduct range of common safety tests with a smaller subset of samples

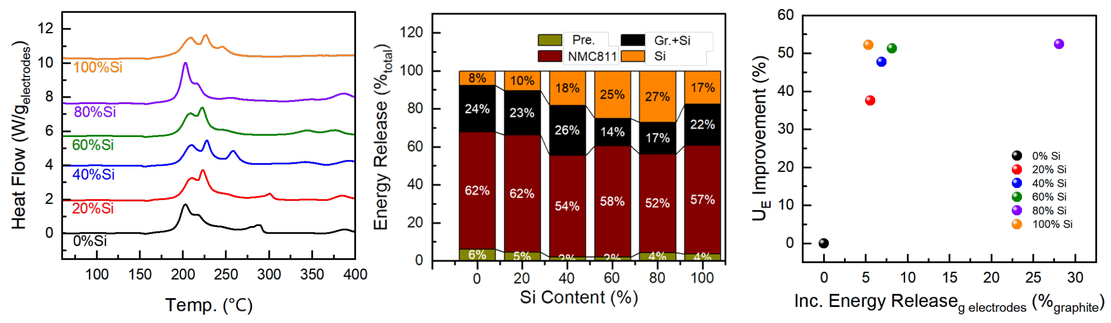
- Approach leverages SNL's expertise in both microcell DSC and the Battery Abuse Testing Lab (BATLab)
  - Commercial SiG and NMC811 electrodes for 18650 cells



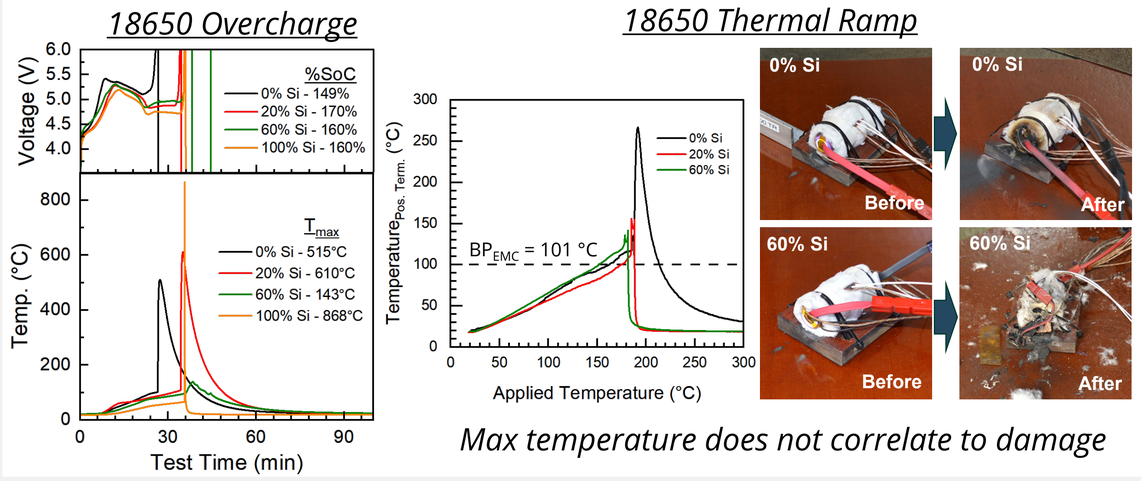
Typical data from a) DSC experiment. b) Overcharge and c) thermal ramp experiments with 18650 cells.

RESULTS

Microcell DSC results show that Si content influences the energy released during thermal runaway, but not the onset temperature



18650 Overcharge and Thermal Ramp results show onset is electrolyte-dependent, but temperature/damage appears Si%-related



Max temperature does not correlate to damage

CONCLUSIONS & IMPACT

1. DSC microcell testing enables safety testing to be conducted more quickly at lower expense, allowing more targeted testing of 18650 cells
2. Safety trends from DSC results consistent with those from 18650
   - Increased Si content → increased temperature/energy release
3. 18650 testing is more realistic, for both better and for worse
   - Cells tend to fail due to casing rather than materials

- Results demonstrate that multi-scale battery safety testing yields additional context that can be used to develop more intrinsically safe batteries
- For current generation of battery chemistry (layered metal oxides, organic electrolyte), recommend judicious use of Si to increase cell capacity and energy density while minimizing safety hazards

FUTURE DIRECTIONS

1. Finish 18650 testing with accelerating rate calorimetry (ARC) testing of each SiG composition to better compare with microcell DSC
2. Expand SiG microcell testing to SiG||$LiFePO_4$ (LFP) cells to better determine impact of anode on microcell safety
   - LFP expected to be less energetic/safer than NMC811

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