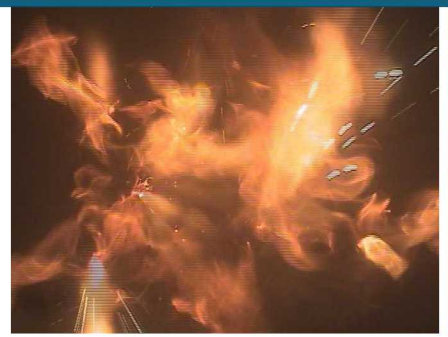
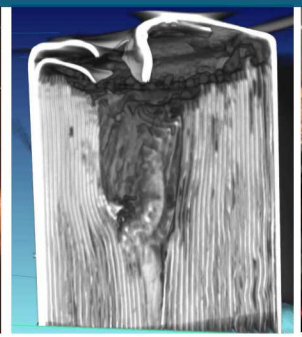
This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

SAND2019-12579C

Analyzing the Effect of Lithium Plating on the Safety Performance of Lithium-ion Batteries





PRESENTED BY

Eric Deichmann, Mohan Karulkar, Joshua Lamb, Jill Langendorf, Lucas Grey and Chris Grosso

PI: Loraine Torres-Castro

Academic advisor: Fernando Garzon

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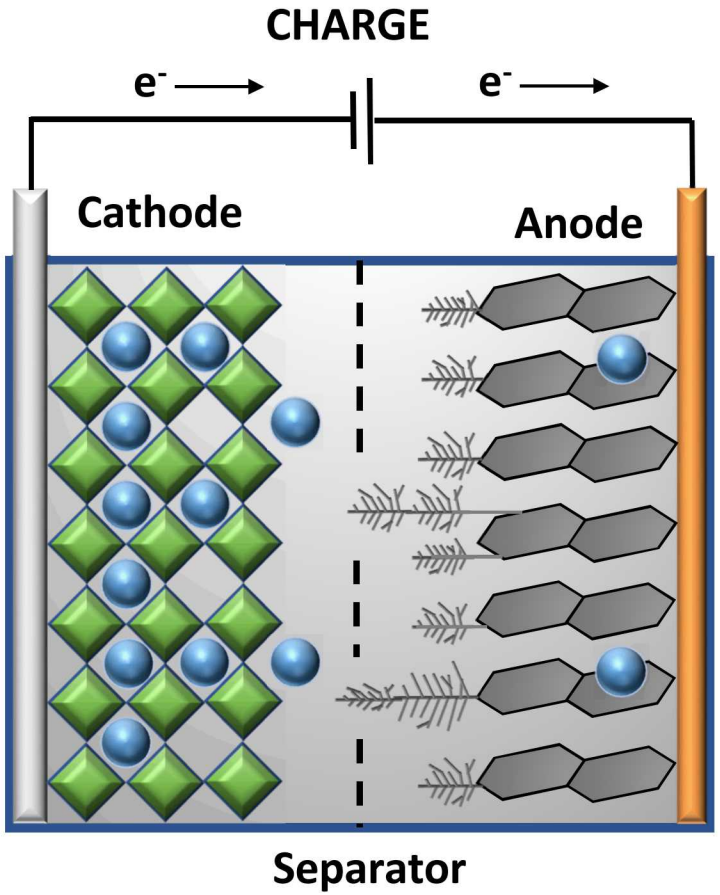
Lithium plating in Lithium-Ion Batteries



- Cell longevity decreased
  - Loss of lithium inventory
  - Higher anode overpotentials
  - Decreased cell capacity
- Safety concern - Exacerbated abuse response?
  - Short circuit can lead to thermal runaway
  - 180°C Melting Point of Li

Project Objectives

1. Develop a method for preferentially plating Li metal on anode

2. Investigate relationship between extent of Li plating and safety characteristics during abusive conditions
   - At what point does Li plating present quantifiable changes in abuse response
   - Determine whether a plateau exists beyond which Li will not continue plating

3. Investigate the effect of C-rate on extent of Li plating/stripping and exacerbated abuse response

Cradle-to-Grave Analysis

Cell Component Development → Cell Fabrication → High-Rate Cycling → Abuse / Teardown

Cathode:

94 wt% NMC 523
3 wt% Danka
3 wt% PVDF 1300

Anode:

92 wt% G8
4 wt% Danka
4 wt% PVDF 9300

*Variable NMP

Pouch cells: 1Ah

Variable n:p (1.2, 0.75, 0.5)

Added LMP (1.2)

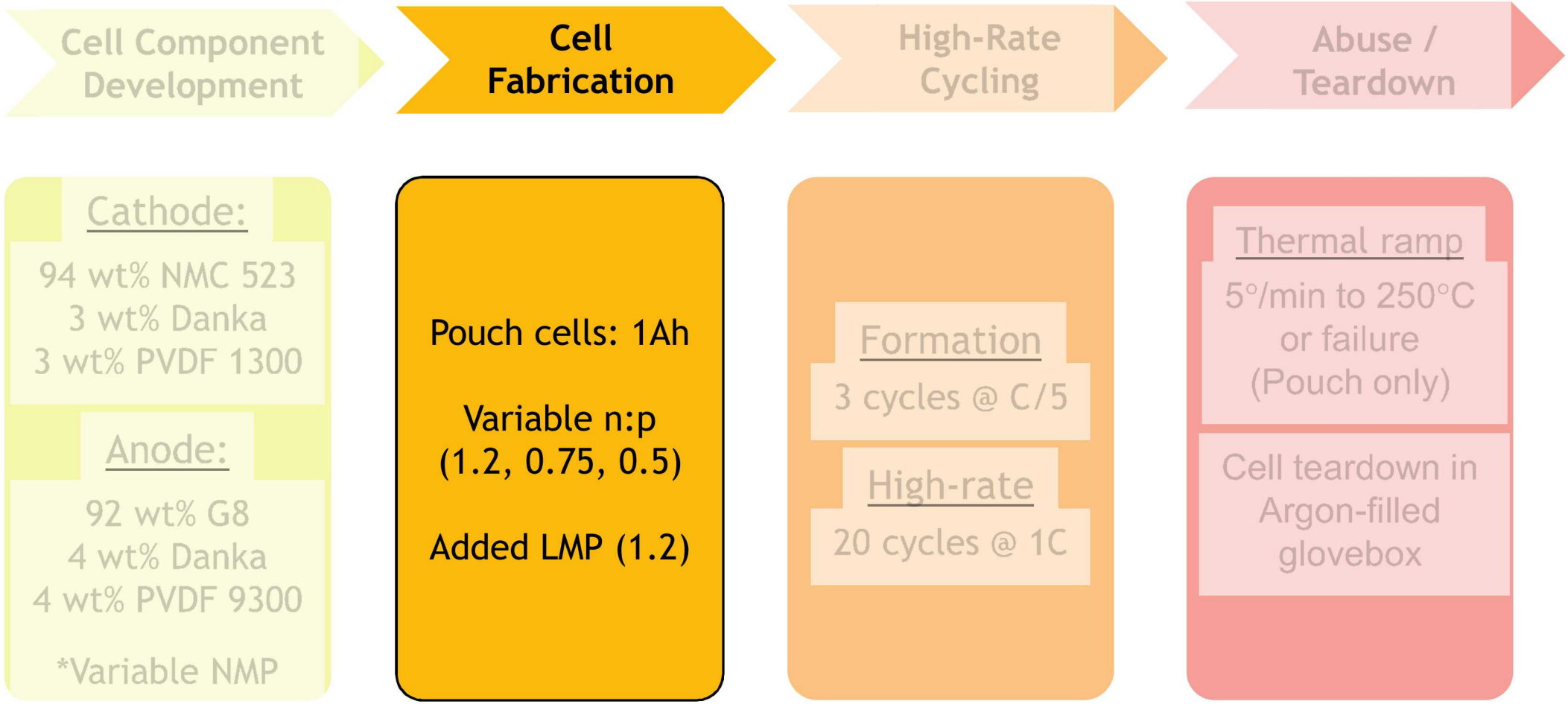
Formation
3 cycles @ C/5

High-rate
20 cycles @ 1C

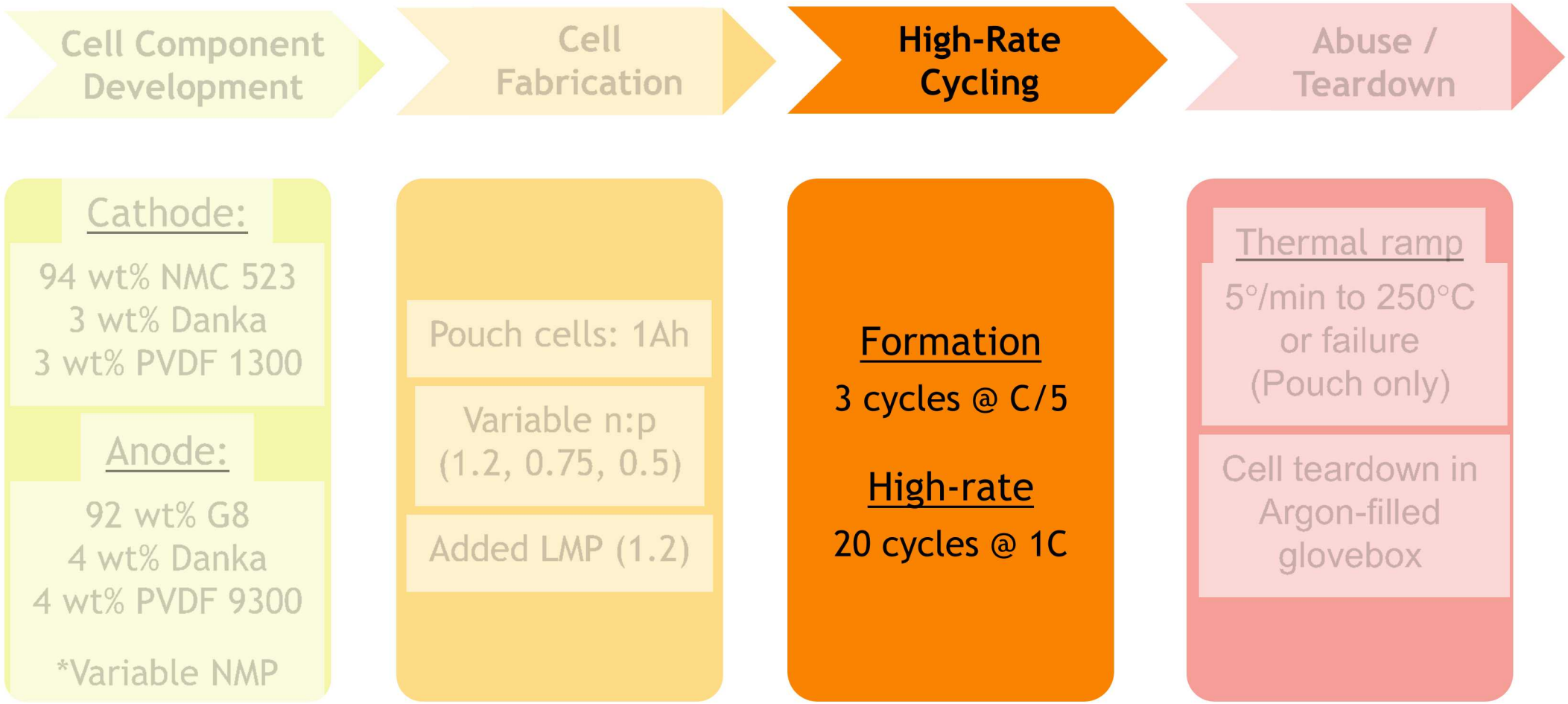
Thermal ramp
5°/min to 250°C or failure (Pouch only)

Cell teardown in Argon-filled glovebox

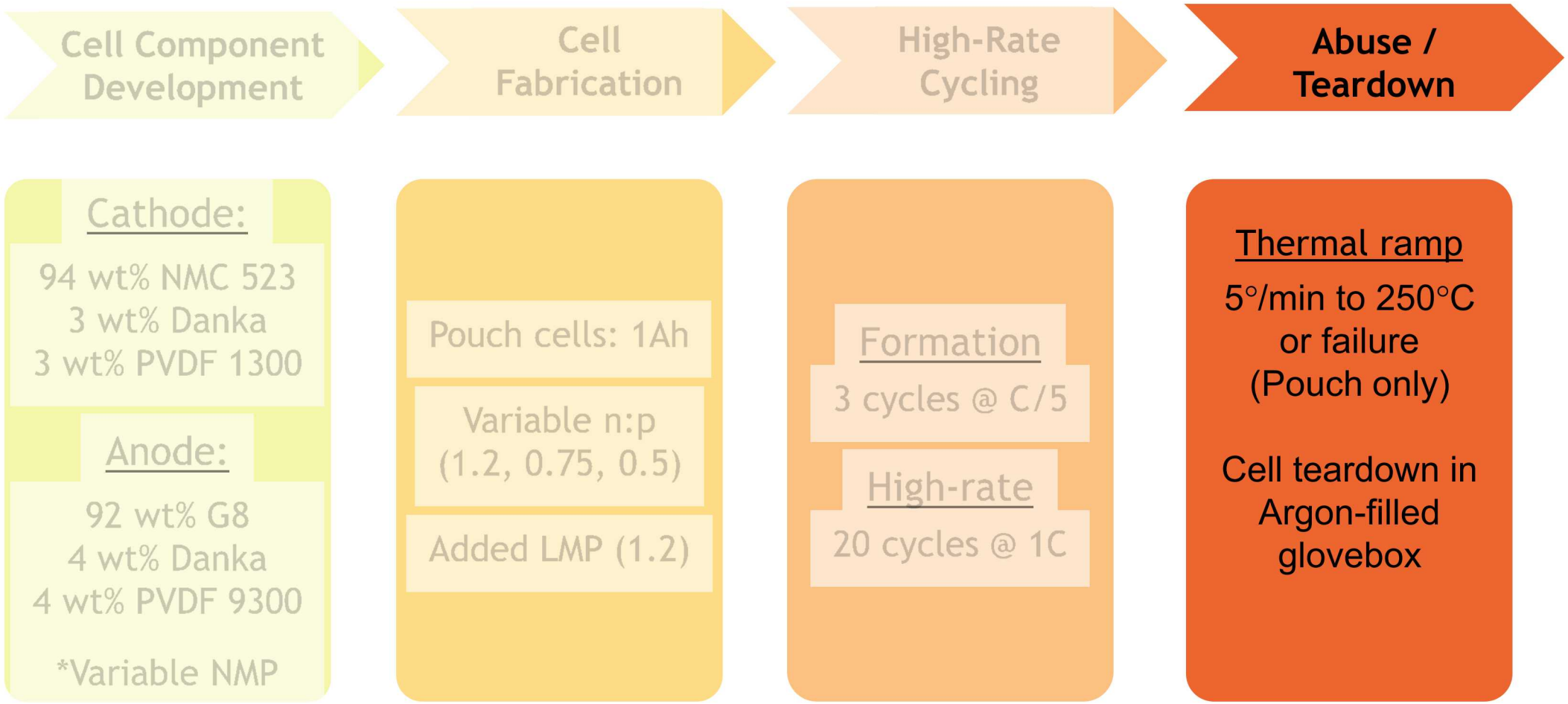
Cradle-to-Grave Analysis



Cradle-to-Grave Analysis



Cradle-to-Grave Analysis



Post-Cycling Coin Cell Tear-Down

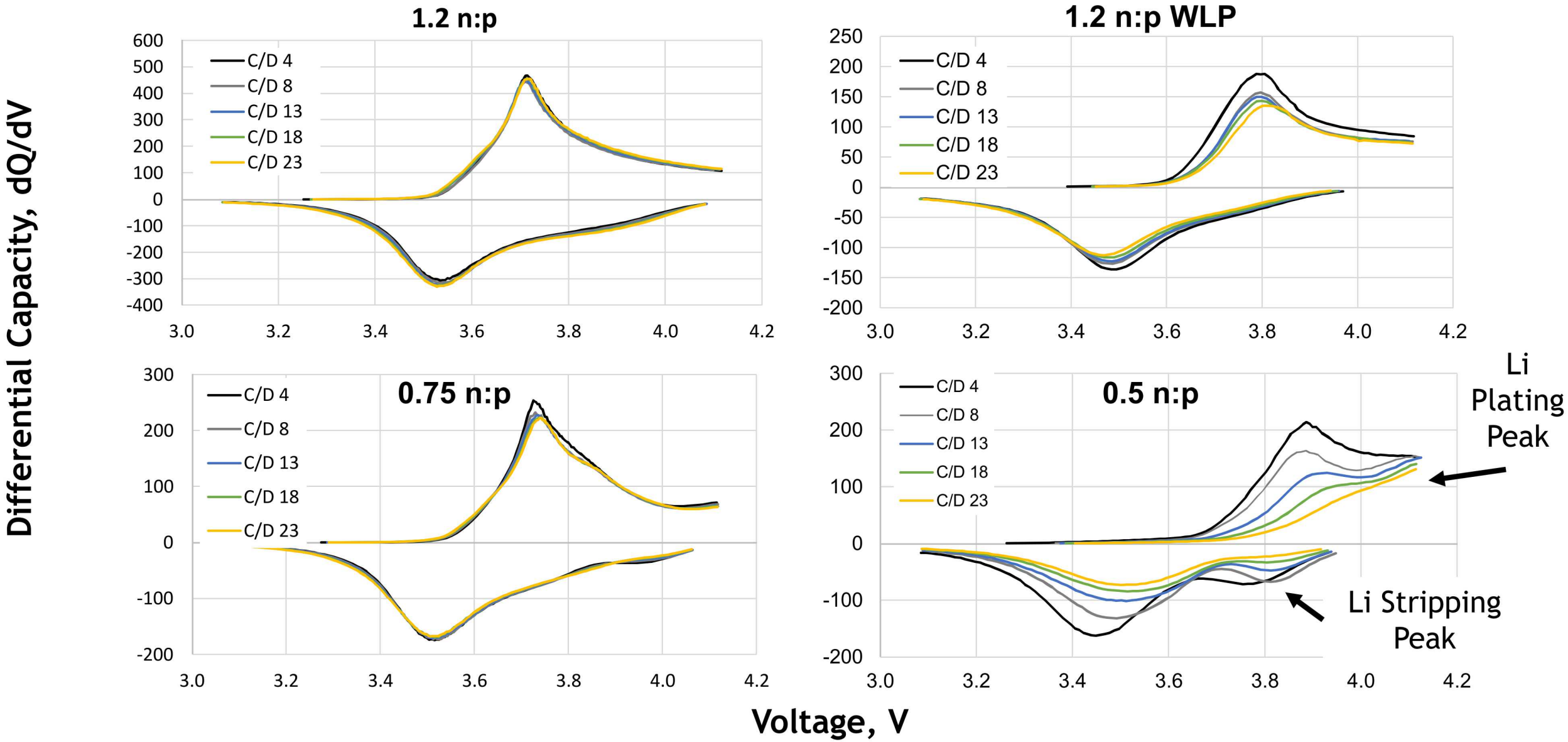
1.2 n:p (Control)

1.2 n:p WLP

0.75 n:p

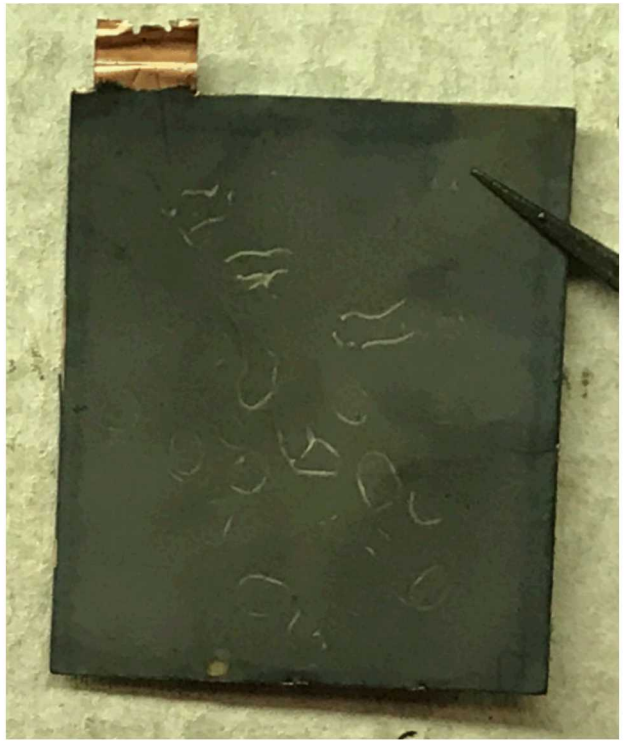
0.5 n:p

Results: Coin Cell High-Rate Cycling (1C)

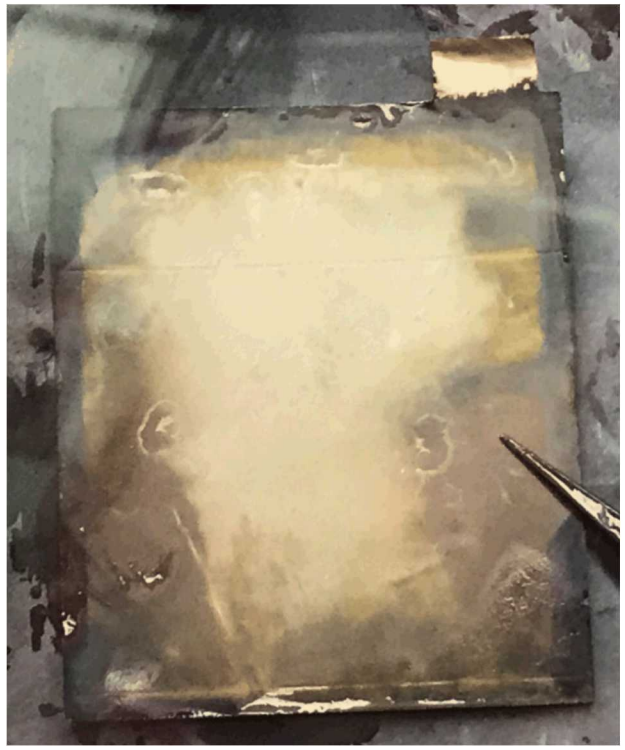


Post-Cycling Pouch Cell Tear-Down

1.2 n:p

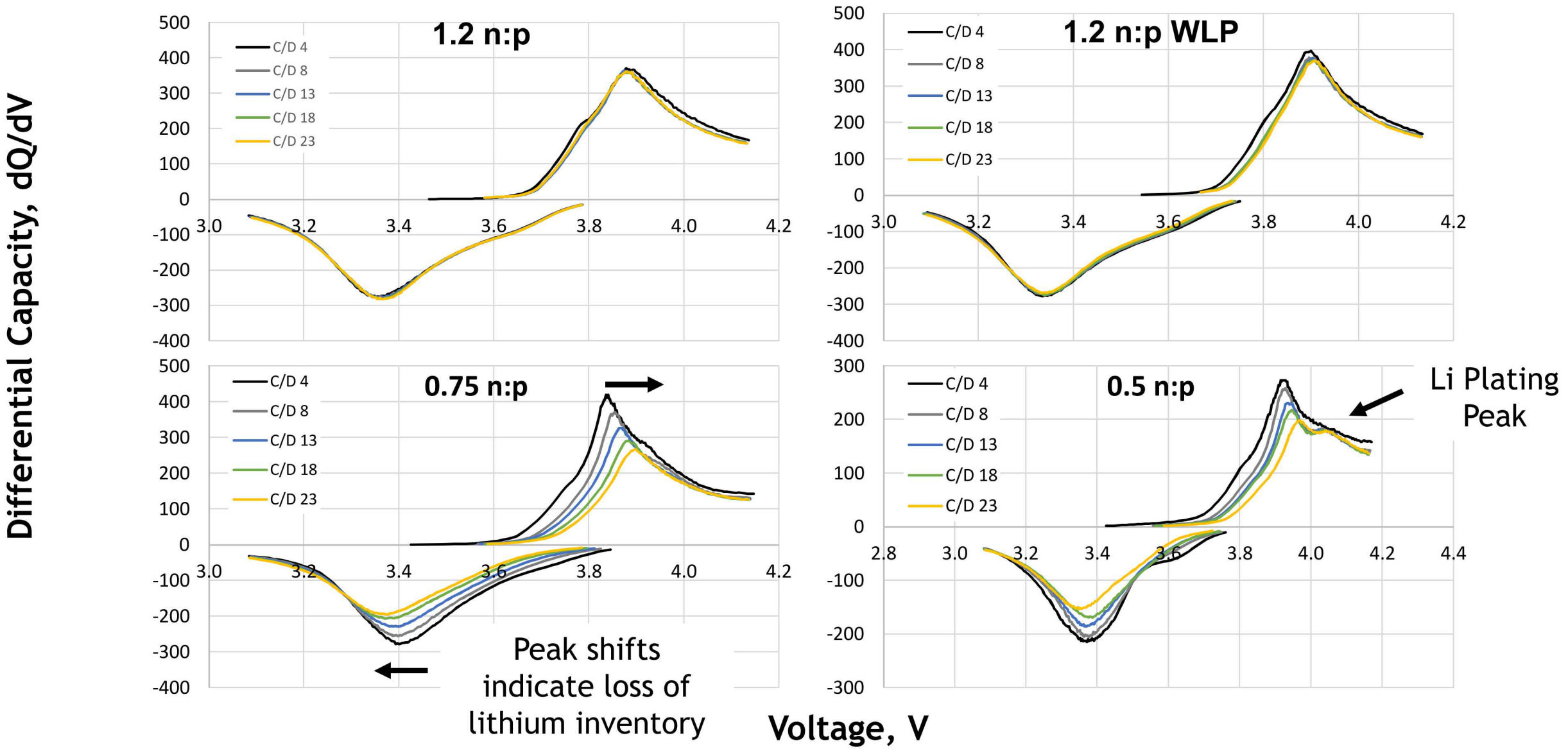


0.75 n:p

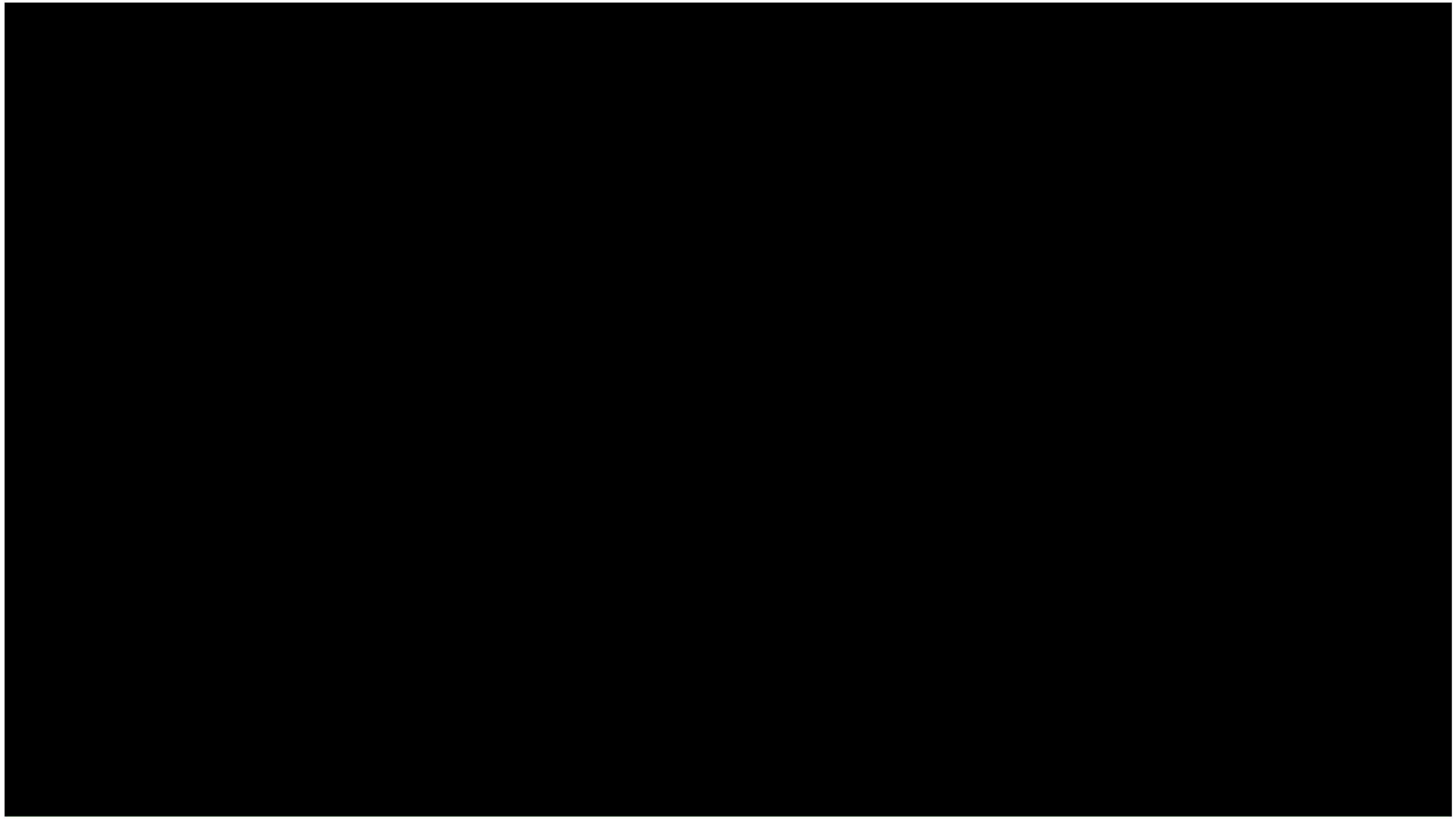


0.5 n:p

Results: Pouch Cell High-Rate Cycling (1C)

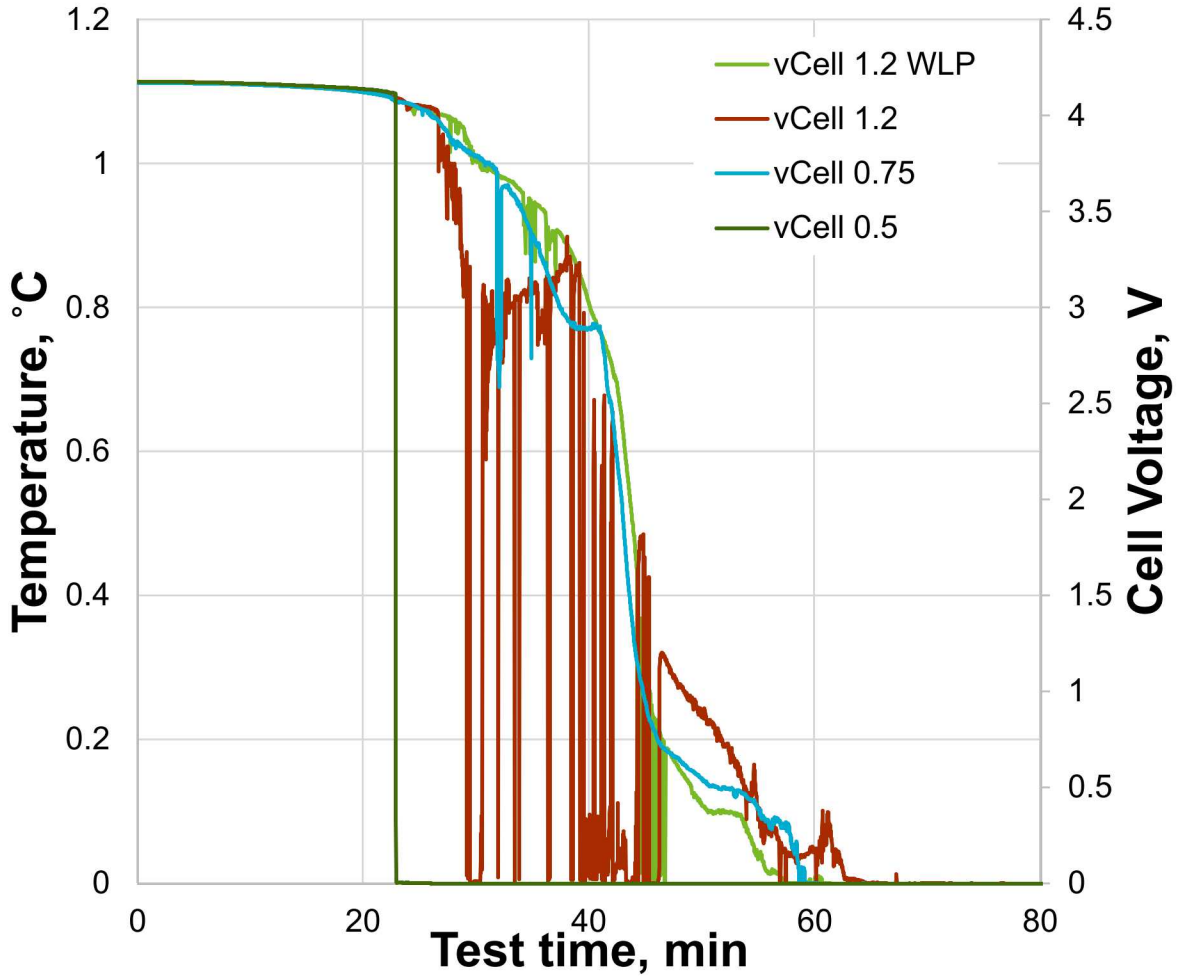


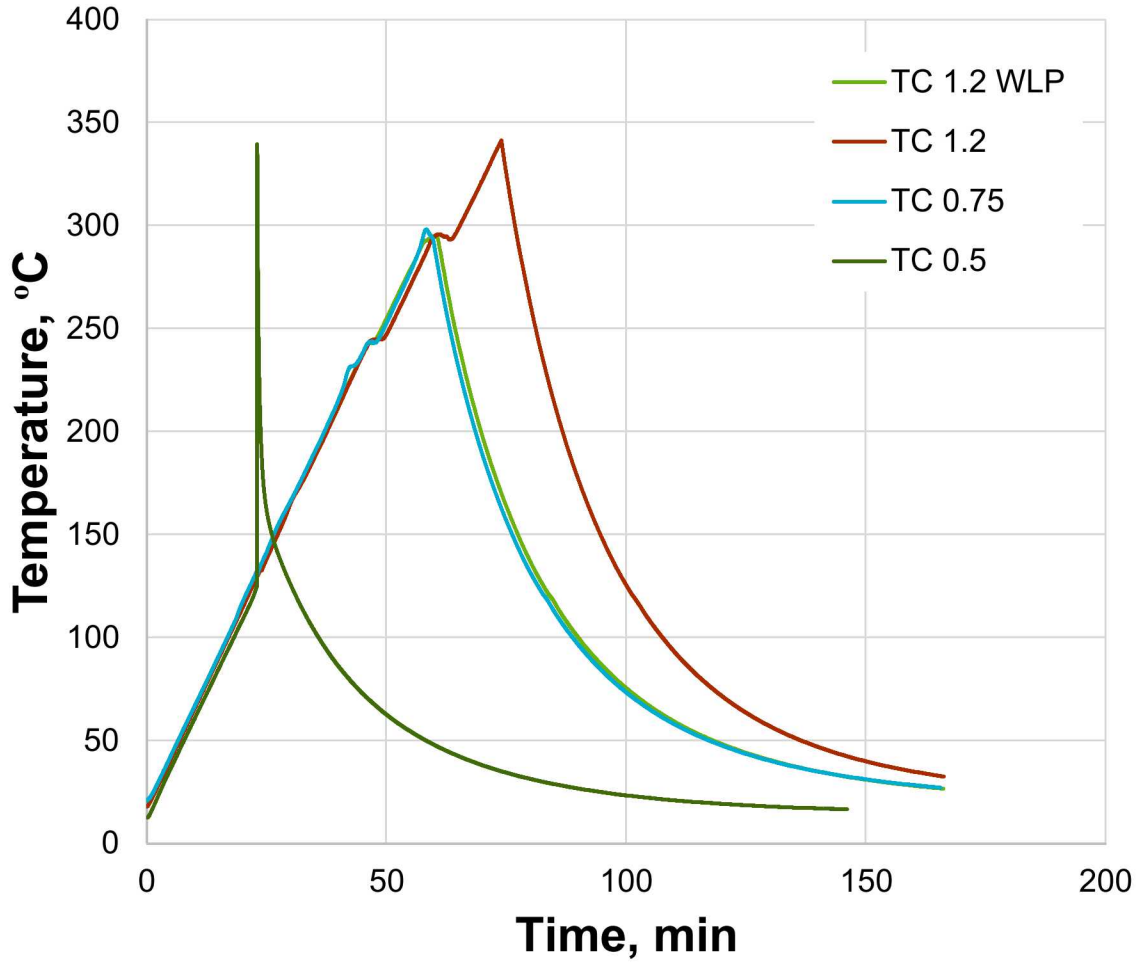
1.2 n:p Abuse response



0.5 n:p Abuse Response

Abuse Response





Summary

Varying n:p ratio serves as good method for preferentially plating Li

Addition of Li metal powder did not appear to exacerbate abuse response

High levels of Li plating **DOES** exaggerate abuse response in LIBs

Continued Work

Run high-rate cycling on high-precision tester

Conduct greater array of abuse tests on pouch cells (OC, NP, SC) at varying n:p

Develop cells with lower n:p ratio and higher LMP concentration to investigate potential Li plating plateau

Ex-situ analysis of anode

- XRD to further investigate electrode degradation as a function of cycle number
- SEM to inspect morphology of Li plating at varying cycle number
- Raman Spectroscopy

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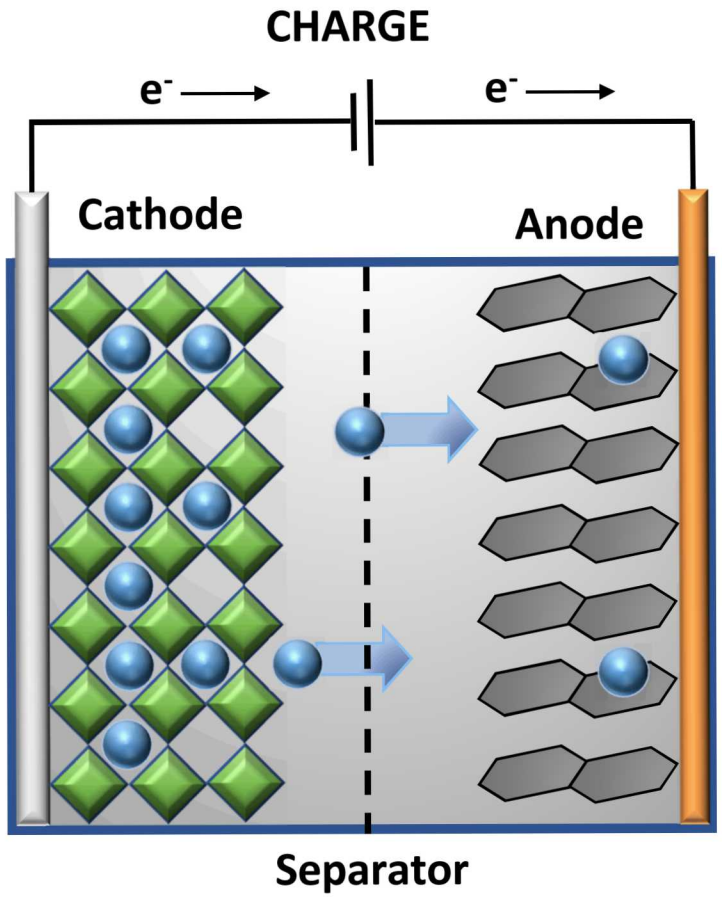
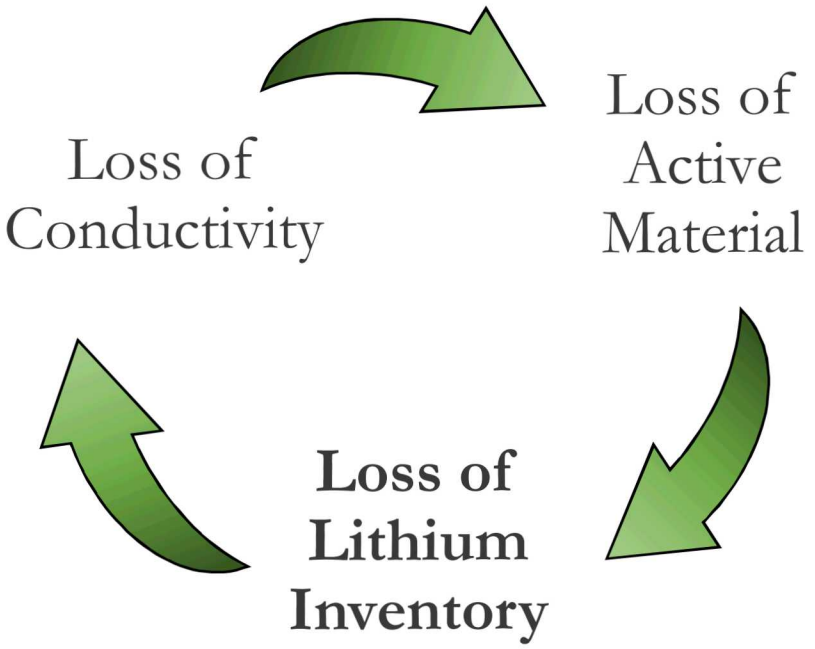
Questions?

Supplemental Slides

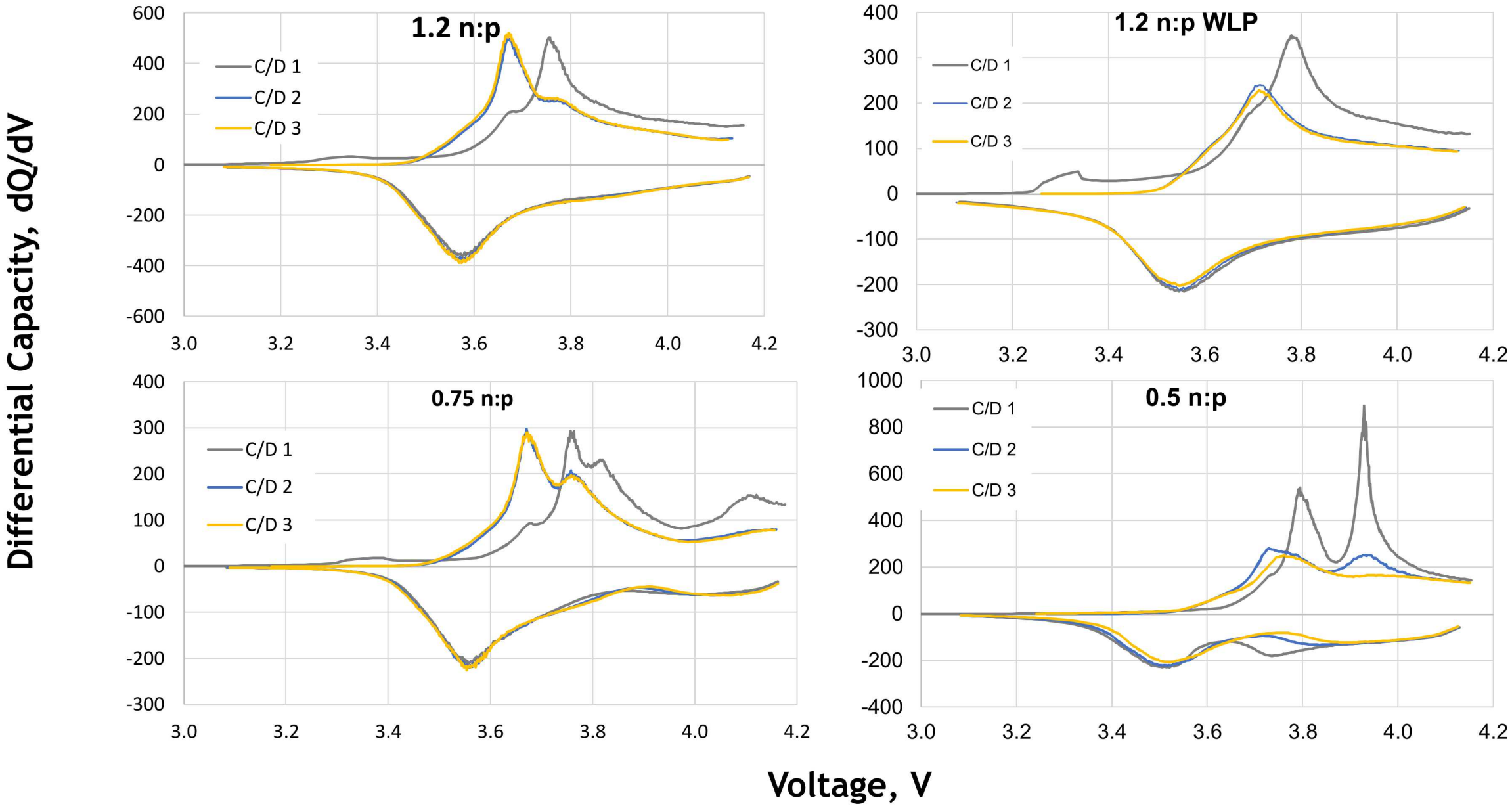
Degradation Modes in Lithium-Ion Batteries





- Long-term cycling
- High-rate charging
- Low temperature charging

Results: Coin Cell Formation Cycling



Results: Pouch Cell Formation Cycling