Process Optimization and Scale-Up of Next Gen Electrode Fabrication

Ipsha Patel, Neeharika Neti, Jack Cotter, Summer Collins, Andrea Guiley, Christopher Combs, Department of Chemical Engineering, University of Washington
Dr. Kevin Lee, Zach Wylie, JanuTech
Professor Lilo Pozzo, Pozzo Research Group

Motivation

Antimony sulfide nanoparticles unlock higher power capability that today's Li-ion batteries (LIBs) cannot provide. Promising half-cell performance must be validated in full-cells enabled by standardized electrode production methods to garner investor support.

Technical Background

Graphite is the LIB industry standard anode material, but it limits power and fast-charging performance. Adding **Sb_2S_3 nanoparticles (NPs)** facilitates **3D ion transport** versus graphite's 2D pathways.

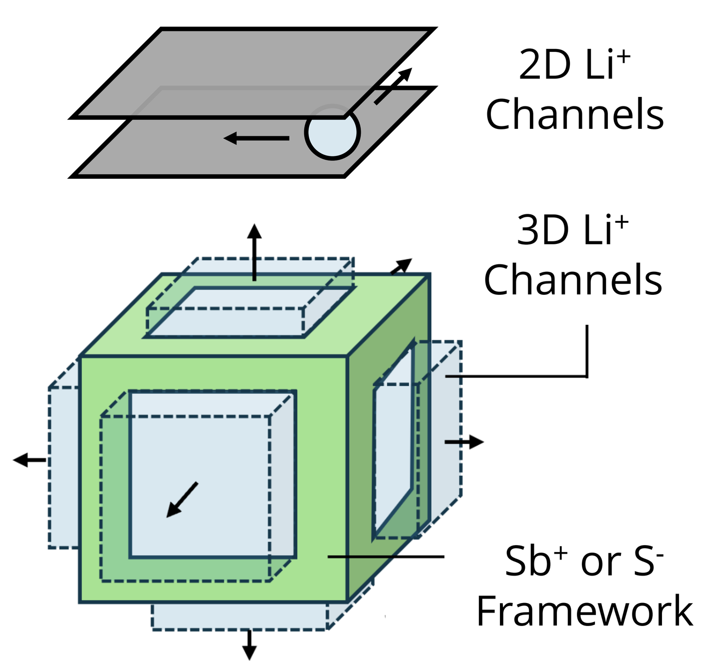
Preliminary half-cell data suggests NP-coated graphite anodes have:

- Increased ionic conductivity
- Energetically favorable reaction kinetics
- Improved capacity retention and **higher power capabilities**

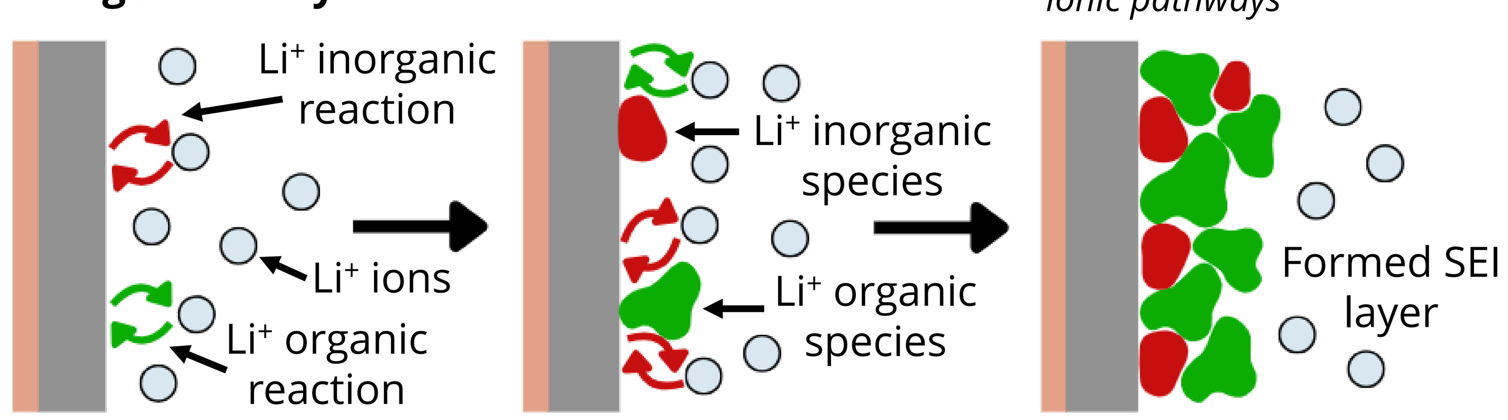
Sb_2S_3 NPs contribute to a more robust **solid electrolyte interphase (SEI)** by biasing the formation of inorganic Li^+ containing species.

This yields:

- Greater SEI stability
- Decreased internal resistance
- **Longer battery life**



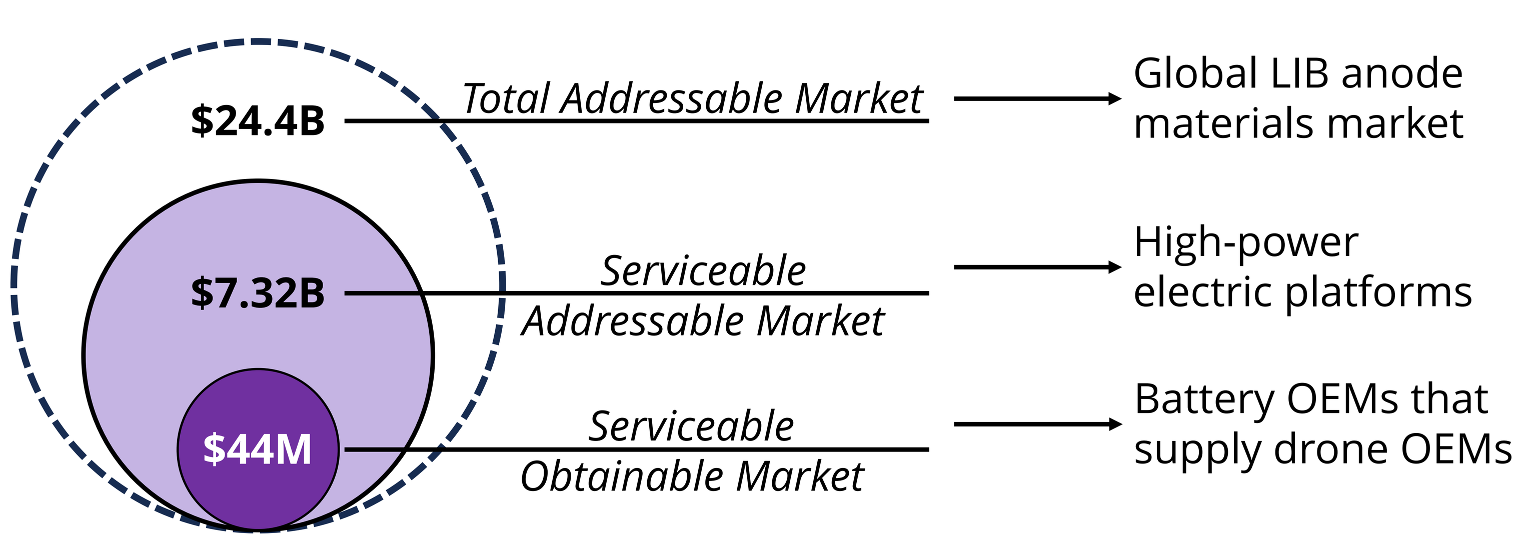
Traditional (top) vs NP-coated (bottom) ionic pathways



Formation of SEI layer on graphite anode during initial battery charge/discharge cycle

Target Applications & Validation Path

- **Material Application:** *Core-S* (Sb_2S_3 NPs coated graphite) is a scalable, drop-in anode material targeting high-power electrified technologies
- **B2B2I Commercial Pipeline:** Partner with domestic graphite producers → supply *Core-S*–enhanced graphite to battery OEMs → batteries deployed by **drone/EV/industrial OEMs**
- **Beachhead Market: Delivery drones**, then expand to other high-power applications (heavy EVs, industrial equipment) and anode materials
- **Validation Milestone:** Securing funding requires generating **repeatable, defensible performance data** in full-cells with commercial LIB cathodes



JanuTech projected market structure

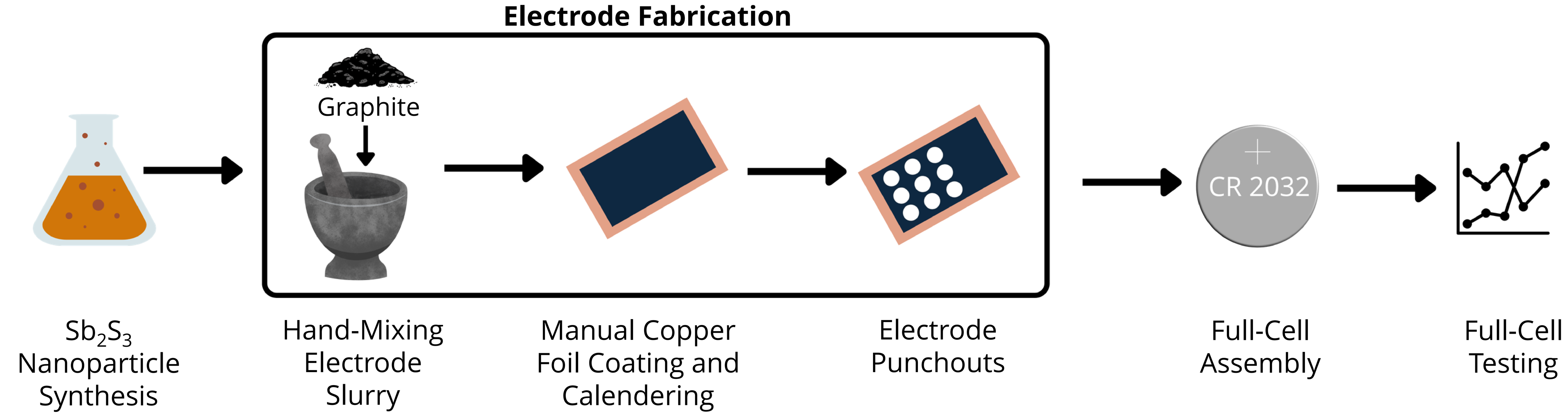
Process Workflow and Initial Challenges

Version 1 Electrode Protocol

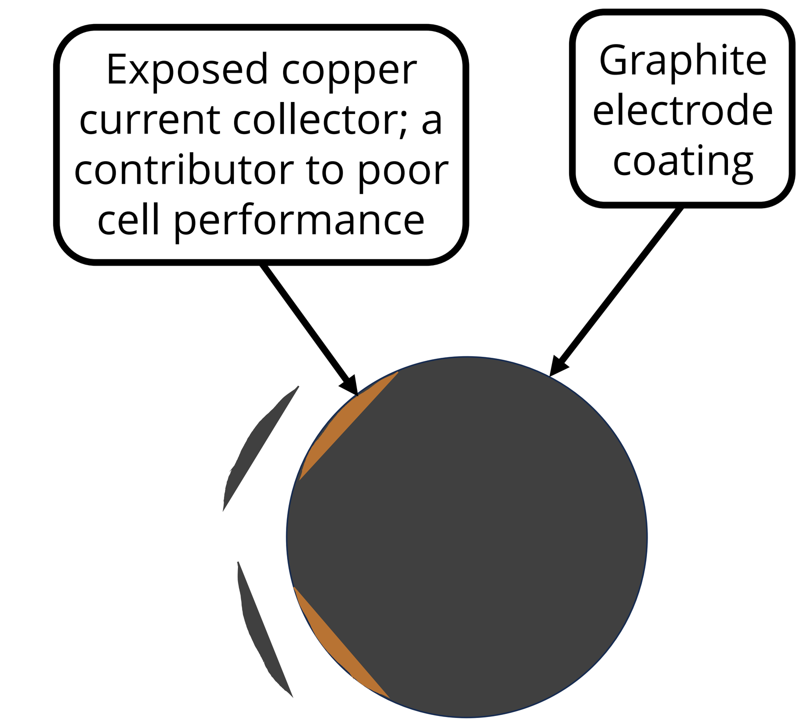
1. Measure solid reagents by mass
2. Measure liquid reagents by volume
3. Hand-mix components in mortar and pestle
4. Manually coat electrode slurry onto copper foil

Electrode Fabrication Challenges

- Highly variable electrode slurry viscosity
- Inconsistent coating thickness and mass loading
- Electrode flaking and surface cracking when creating punches for full-cells



JanuTech initial experimental workflow



Defective graphite negative electrode

Process Optimization

Electrode Reagent Loading

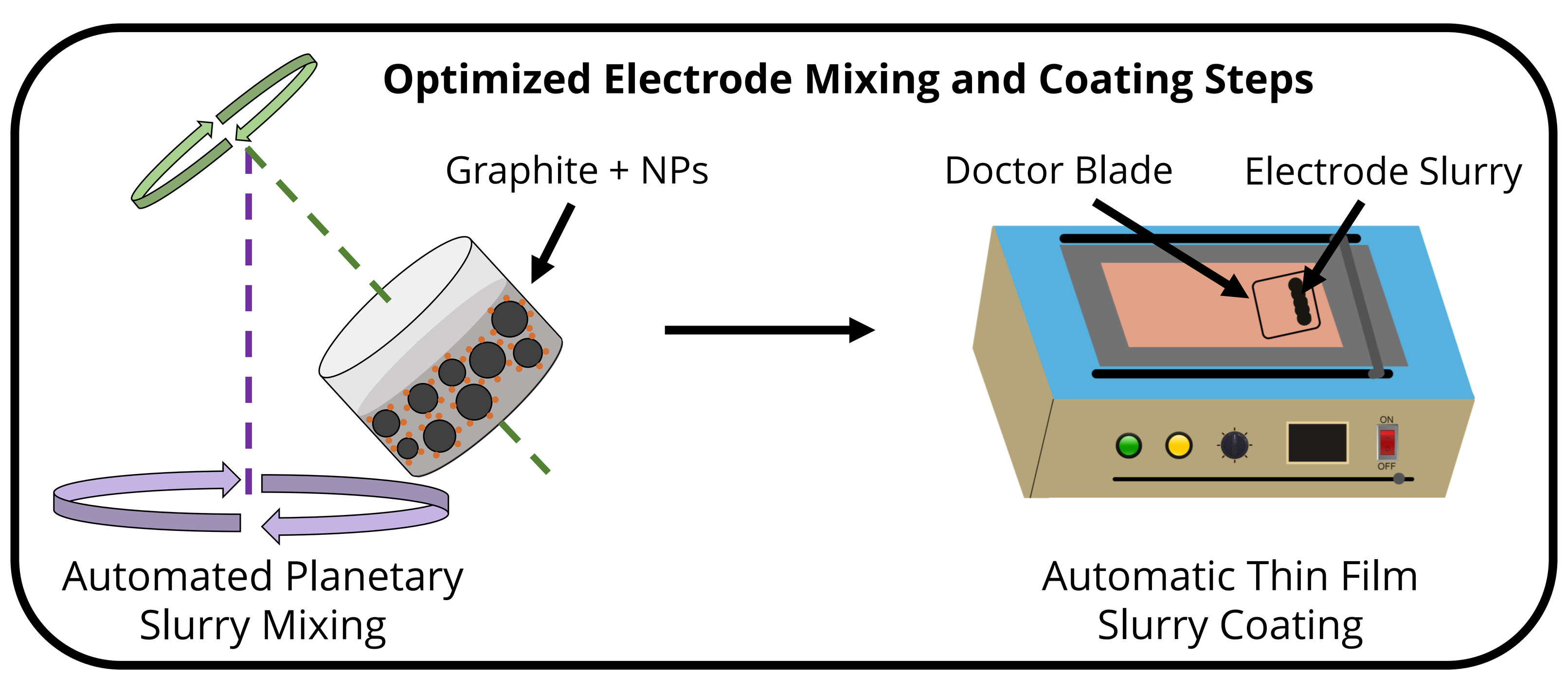
- Problem: inaccurate volumetric pipette measurements due to high liquid binder viscosity leading to variable reagent addition
- Solution: employ mass measurements for all slurry components

Batch-to-Batch Slurry Consistency

- Problem: inconsistent slurry viscosity between batches due to hand-mixing
- Solution: transition to automated planetary mixer

Copper Foil Coating Uniformity

- Problem: variations in thickness and coverage across foil due to hand-coating
- Solution: upgrade to an automatic thin film coater



Key updated electrode fabrication steps

Improved Process Outcomes

- The current protocol shows **tighter coating thickness control: ± 0.005 mm range** versus Version 1: **± 0.015 mm range**
- **Reduced electrode flaking** and **greater electrode yield per batch**
- The automated steps **significantly decrease operator variability**
- Planetary mixing settings and slurry solids weight percent are key parameters for viscosity control

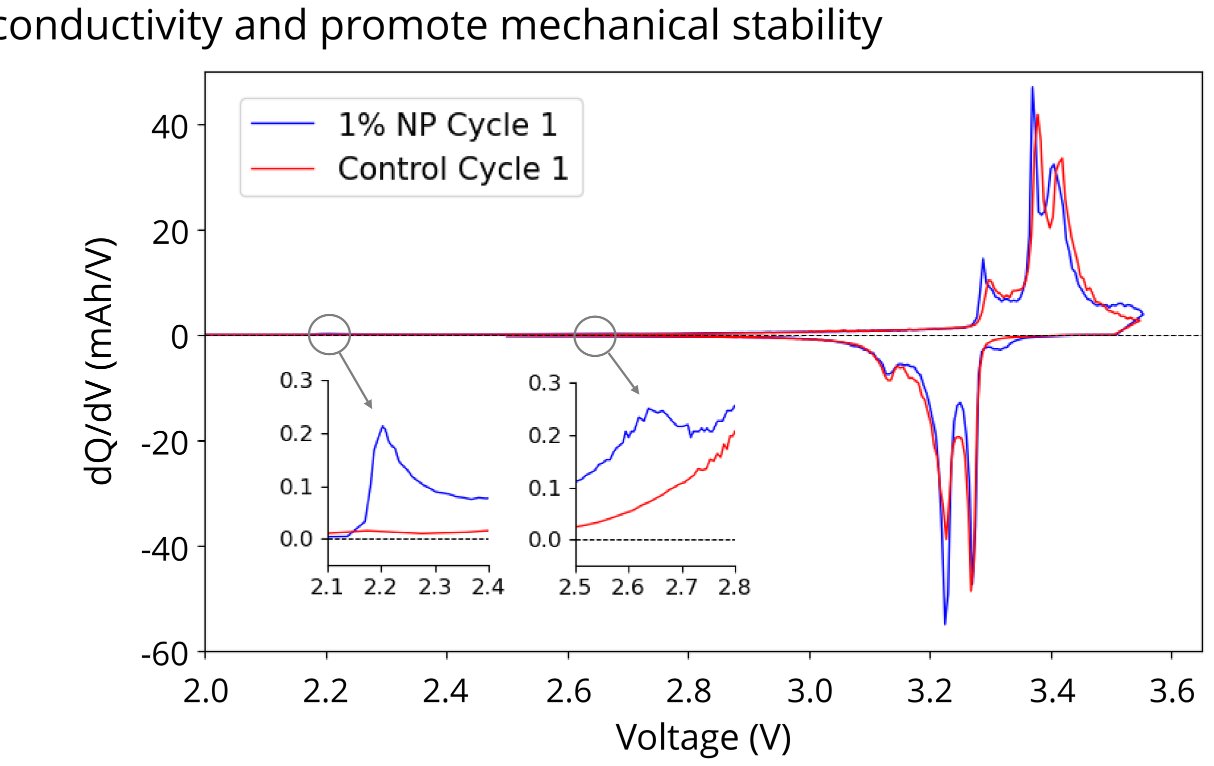
Preliminary Full-Cell Findings

Thermodynamically Favorable SEI Formation

- Differential capacity peaks shifted to slightly lower voltages for NP-coated graphite full-cell activation compared to control
- Supports electrochemical stability and capacity retention

Additional Inorganic Species Deposition

- Small differential capacity peaks at voltages corresponding to the reduction of Li_2S and Li_3Sb were observed for NP-coated graphite
- Both Li_2S and Li_3Sb are desired SEI species as they have high ionic conductivity and promote mechanical stability



Plot of differential capacity for full-cells with commercial LFP positive electrodes

Further Experimentation is Required

- These results were observed in n = 4 full-cells using Version 1 fabrication → need to test more cells with the updated protocol for validation

Future Work

- Finalize and validate the optimized electrode fabrication protocol
- Add viscosity control (rheometer) to further reduce slurry variability
- Produce repeatable full coin cell results (graphite vs Sb_2S_3 NP-graphite) with commercial cathodes (LFP/NCA)
- Transition to higher capacity pouch-cell testing with streamlined processes