



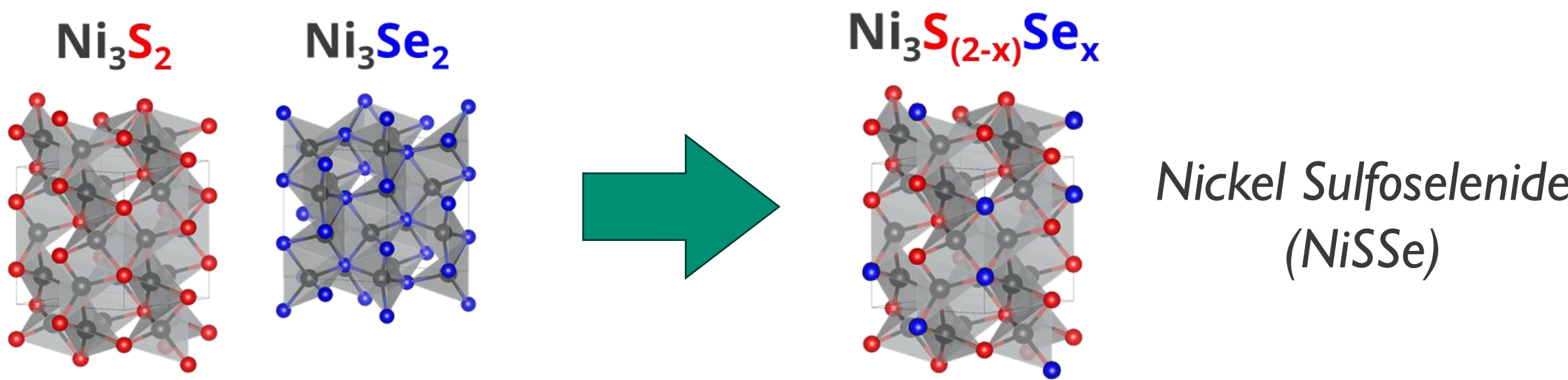
# NICKEL SULFOSELENIDE ELECTROCATALYSTS FOR FLOWING ZINC-AIR BATTERIES

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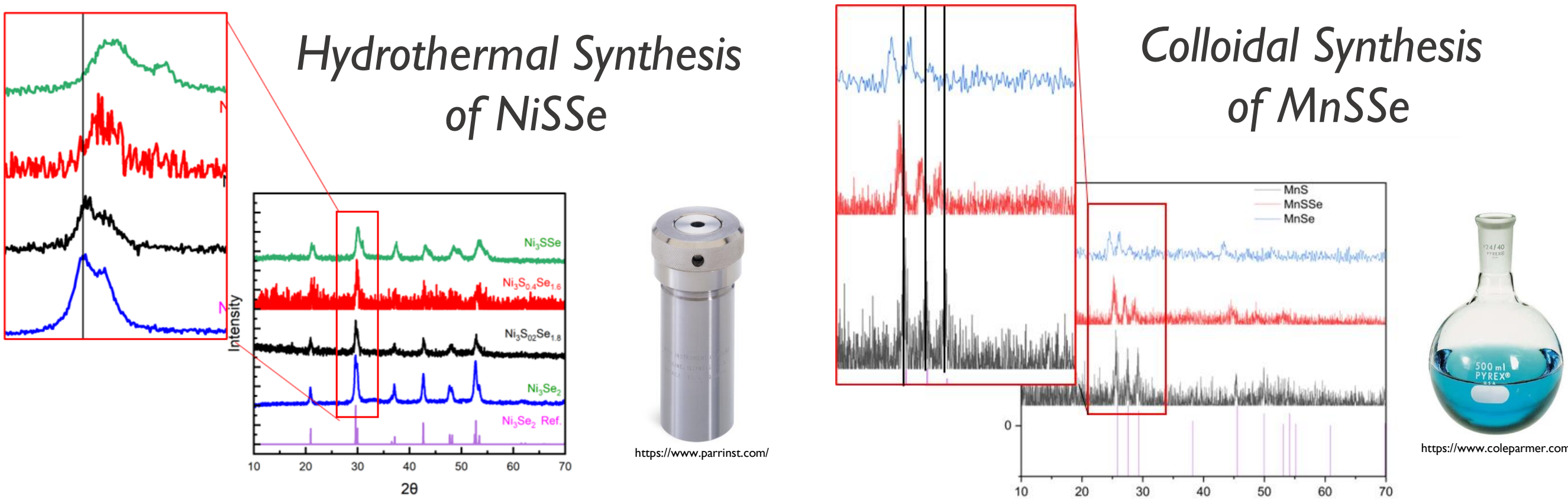
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## Background

Project Goal	Study nickel mixed chalcogenides electrocatalysts to enable <b>rechargeable</b> Zn-air batteries to determine <b>what</b> S/Se mixture provides the best performance and <b>why</b> .
Current Practice	Zn-air batteries are <b>non-rechargeable low-current cells</b> , or else rely on expensive electrocatalysts for recharge. Batteries limited to <b>single-use</b> or <b>cost prohibitive</b> to build at scale.
Why SNL?:	Sandia has institutional knowledge of Zn-based batteries and researchers with extensive experience bridging electrocatalyst materials and battery research.
Innovation	We are exploring hitherto <b>understudied metal sulfoselenides</b> as electrocatalysts alongside the use of flow cell architecture to improve battery performance.
Impact	Battery startups working on Zn-air batteries would benefit from <b>precious metal-free electrocatalysts</b> . New electrocatalysts have broad use in many <b>energy storage and production technologies</b> (batteries, fuel cells, electrolyzers).
Alignment	Zn-air batteries use earth-abundant metals ( <i>affordable, secure</i> ) to <b>reliably</b> deliver electricity, while bolstering American scientific innovation and improving supply chain security ( <i>Unleash American Energy Innovation</i> ) to provide <b>reliable and safe energy generation</b> for the US electrical grid ( <i>Strengthen Grid Reliability and Security</i> ).

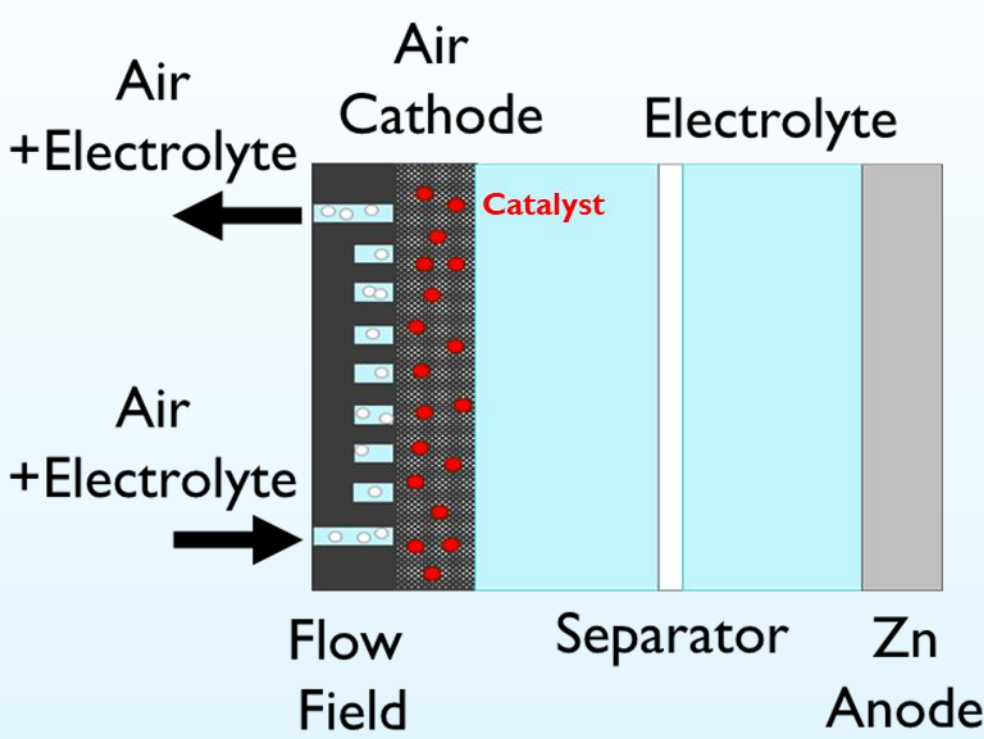
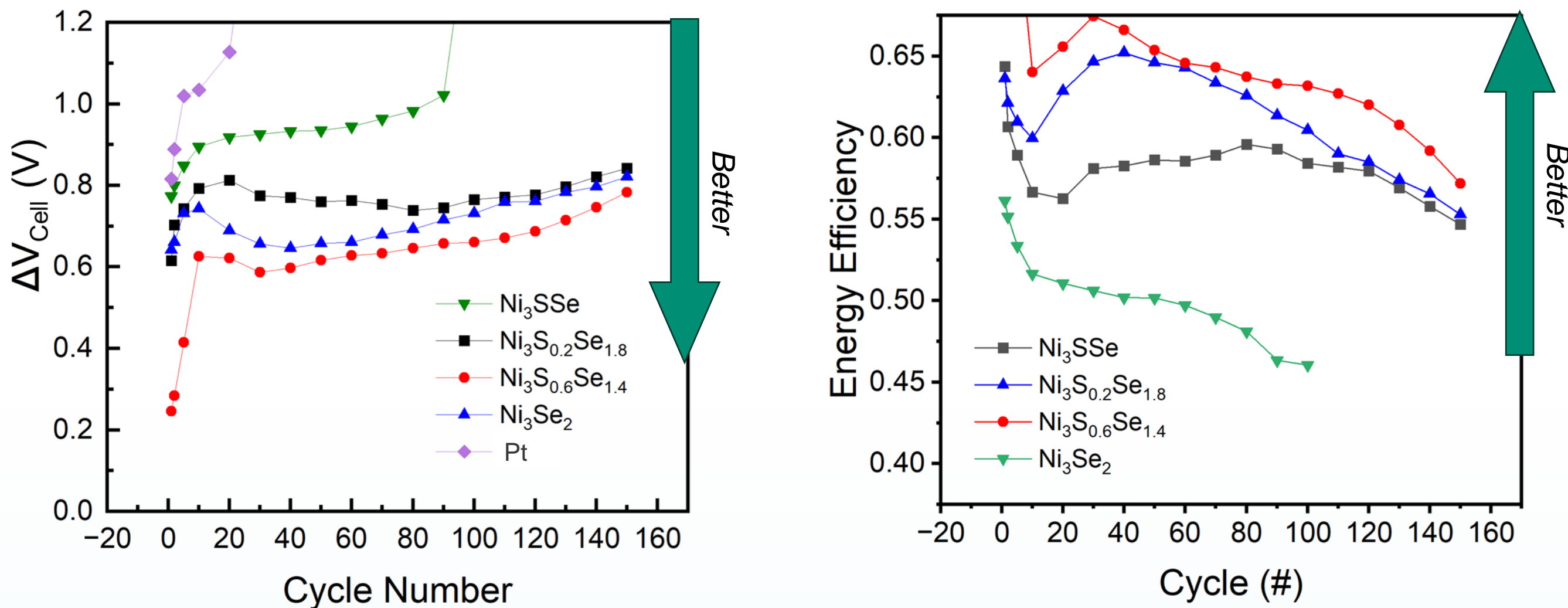


## Synthesis of Metal Chalcogenides



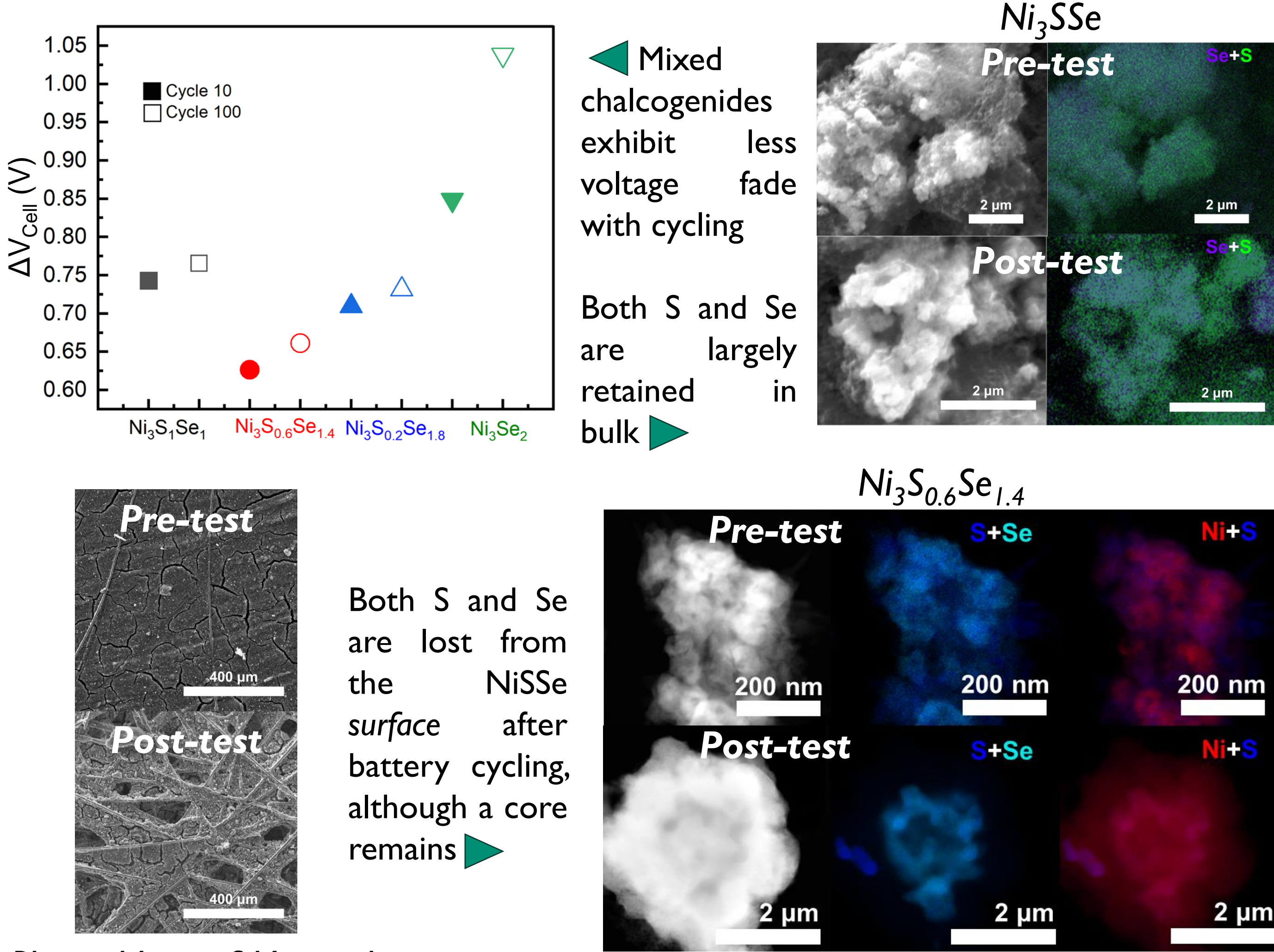
Using both hydrothermal and colloidal methods, we are able to synthesize different phase pure metal sulfoselenides (M= Ni, Mn) with variable concentrations of selenium and sulfur.

## Flowing NiSSe Zn-Air Batteries

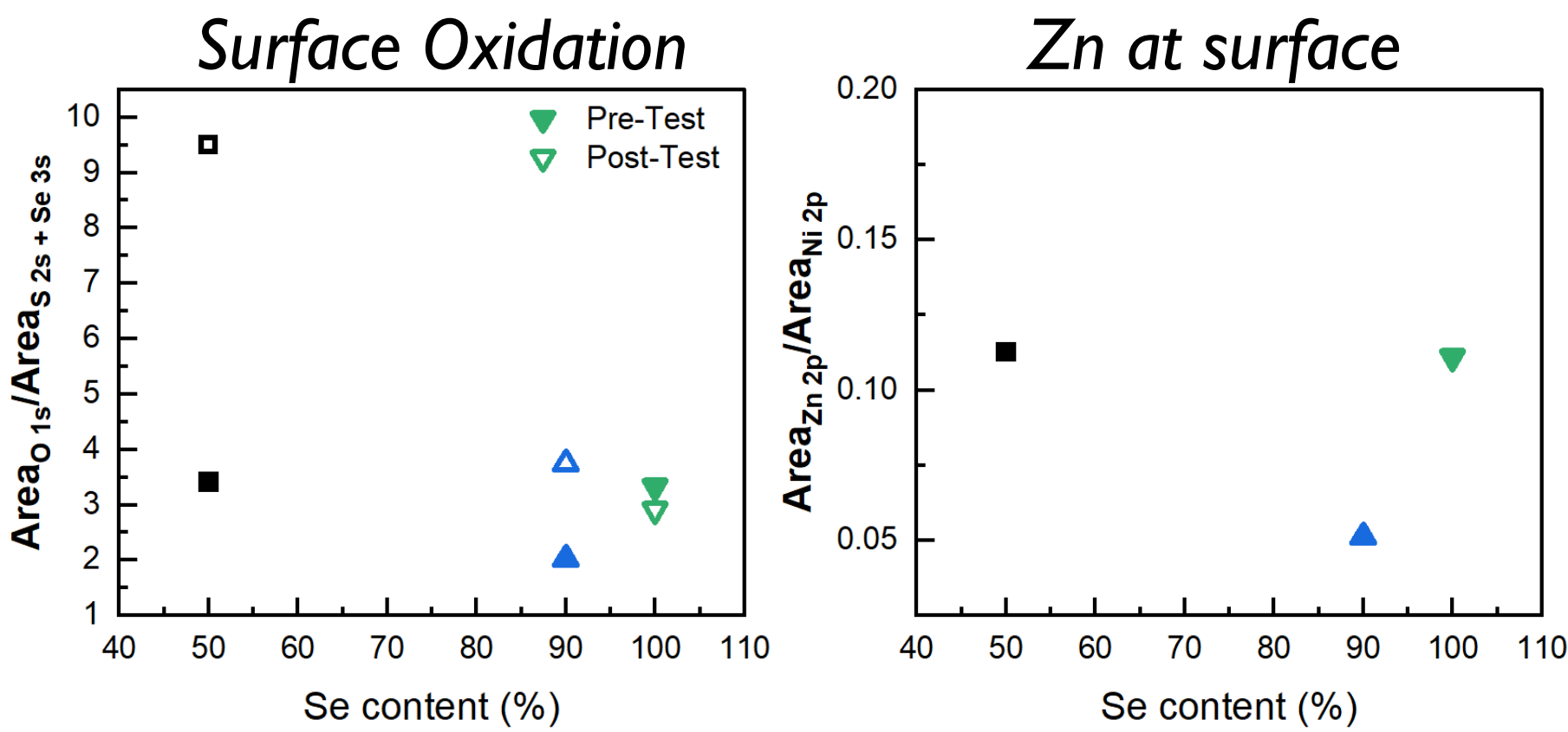


- When tested in air (not pure O<sub>2</sub>), all NiSSe out-performed Pt/C
- $\Delta V_{Cell} = V_{Chg.} - V_{Dis.}$ , measure of **overall** catalyst performance, is **lower** for moderate S incorporation
- Energy efficiency is **higher** for moderate S incorporation

## Stability of NiSSe Electrocatalysts

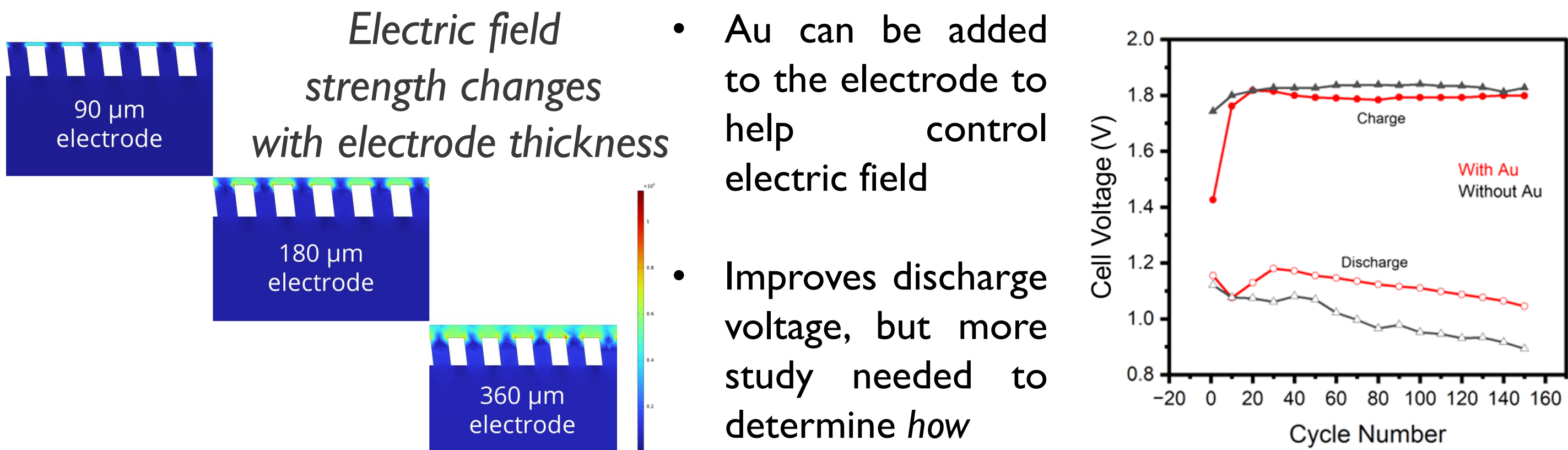


Physical Loss of Material with Cycling



X-ray photoelectron spectroscopy (XPS) confirms a) NiSSe surface oxidation trends with Se content and b) Zn is adsorbed to the electrode surface

## Electric Field Modulation with Au



## Conclusions + Future Directions

- NiSSe BOEs can be used with the SNL fZABs, and demonstrate better performance than Pt/C through S/Se tuning.
  - Moderate S incorporation in Ni<sub>3</sub>Se<sub>2</sub> shows best performance and stability
  - Decreased performance over time could be due to: a) Loss of catalyst, b) excessive catalyst oxidation, c) surface fouling with Zn
  - Adding a small quantity of gold to the electrode improves performance by 10%
- What next?**
- Test the cells for longer periods of time with higher capacity cycles
  - Development of Mn-based sulfoselenides to replace Ni
  - Understanding why gold improves performance of NiSSe