NaSICON Interfacial Limitations from Molten to Solid Phase Sodium

Ethan J. Lauricella(ethan.lauricella@uky.edu)[1], Isaac D. Dyer[2], Amanda S. Peretti[2], Leo J. Small[2] and Yang-Tse Cheng[1]

[1]Department of Materials and Chemical Engineering, University of Kentucky, KY, USA
[2]Sandia National Laboratories, Albuquerque, NM, USA

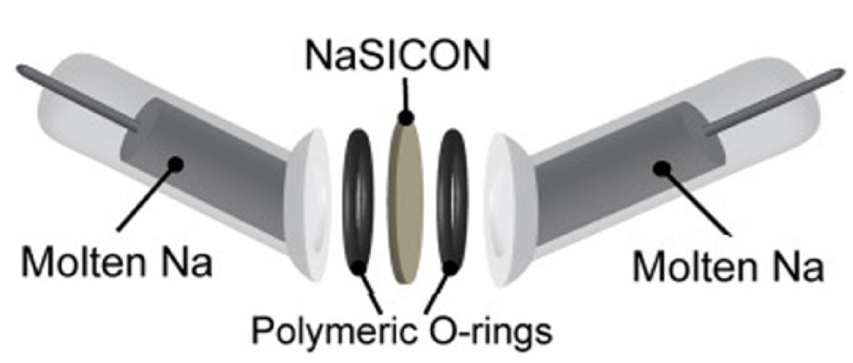
PROJECT PROFILE
Topic: Sodium Batteries Vertical: Materials and Systems Innovation Strategic Pathway: Grow Project start and finish: FY2025-26

Problem

- Molten vs. Solid Na: Molten gives low resistance + good wetting; solid causes high resistance + loss of contact.
- Solid state systems more desirable to commercial viability, along with sodium metals abundance.
- Pressure and coating modifications help temporarily, costly, and often fail in the solid-state system.

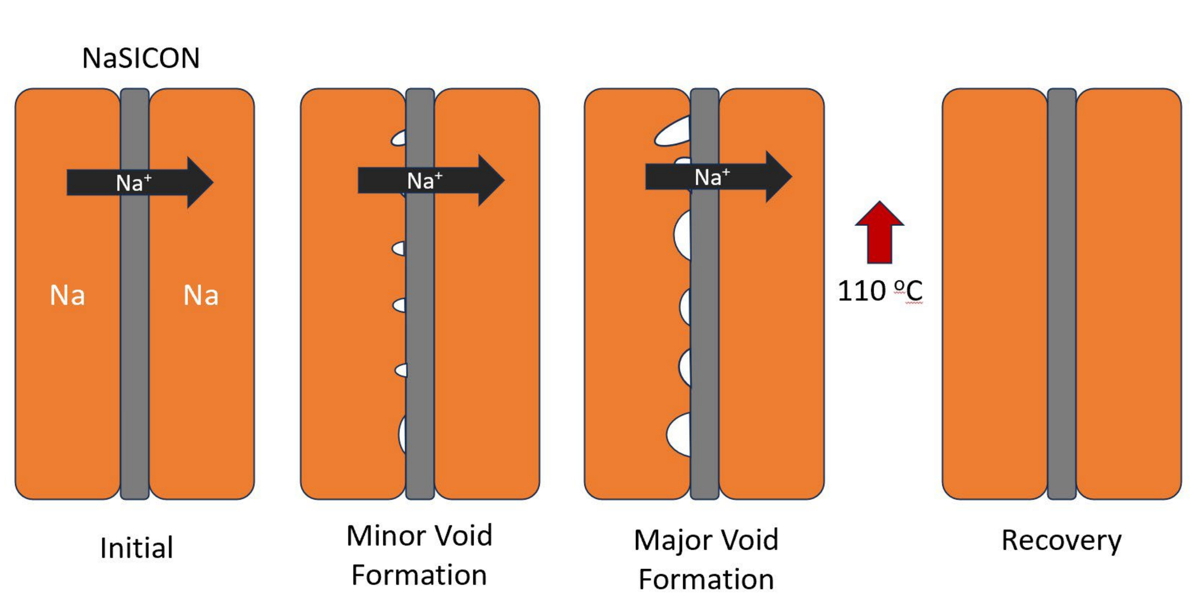
Approach

- Assemble molten symmetric cell of 1 mm NaSICON disks.
- Condition cells: +/- 10 mA cm^{-2} for 1 hour for 10 cycles at 110 °C.
- Solidify at 90 °C, apply unidirectional current to accelerate failure.
- CV and EIS testing to determine resistance change over time.



Failure expected due to:

- High local current density
- Loss of contact



Results

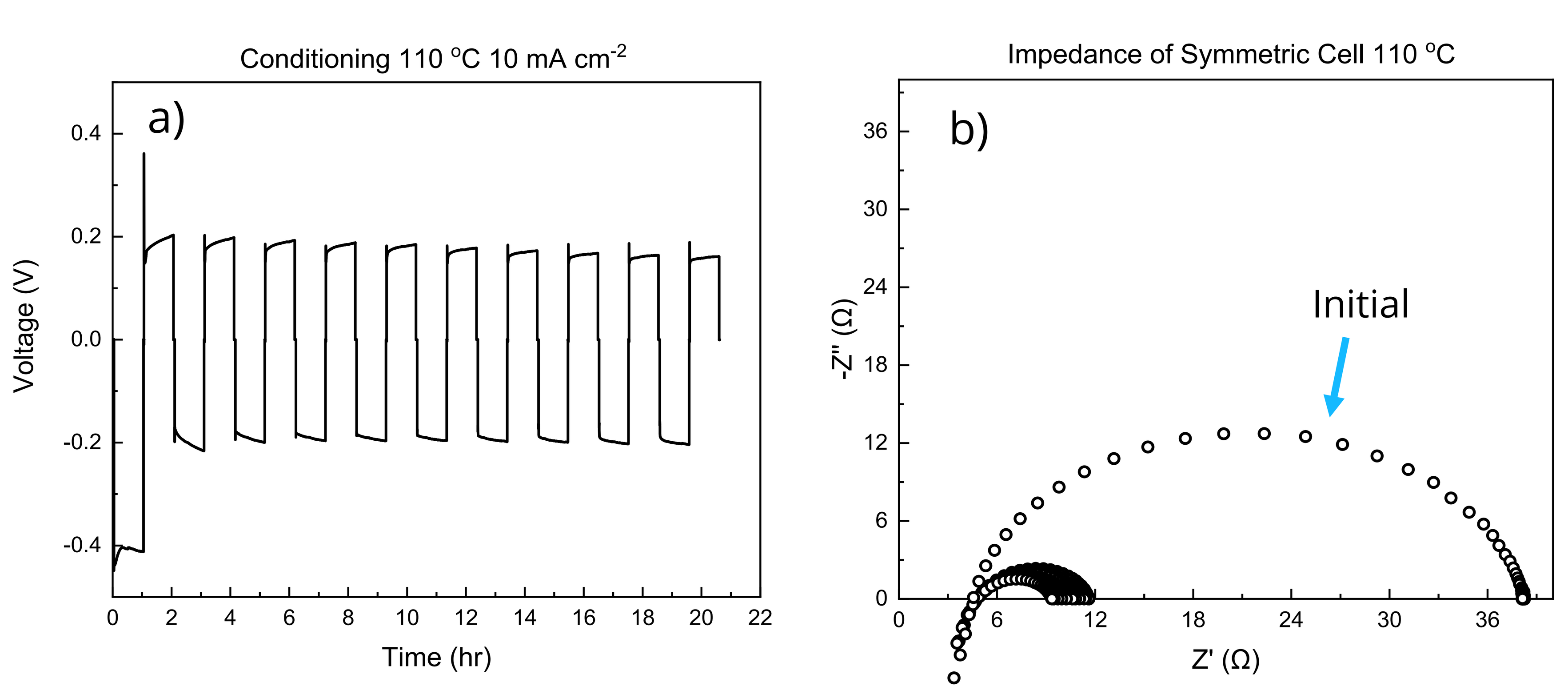


Fig. 1. NaSICON symmetric glass half cells a) initial conditioning cycling at 110 °C b) EIS after each sequential cycle at 110 °C.

Results Cont.

Applying unidirectional current highlights the solid-sodium mass-transport bottleneck that triggers rapid failure in NaSICON symmetric cells.

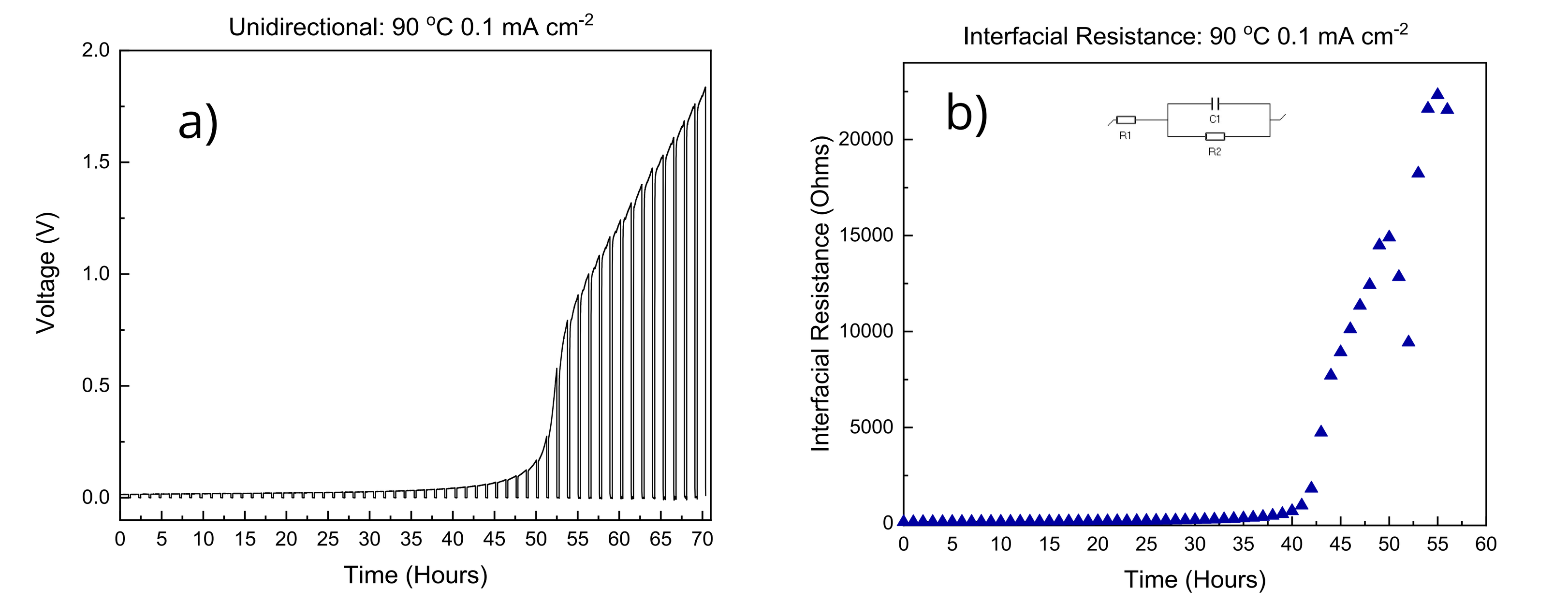


Fig. 2. NaSICON symmetric cell unidirectionally cycled showing a) unidirectional current voltage with vertical lines connecting to 10 mV perturbation from EIS and b) resulting EIS fit interfacial resistance (R2).

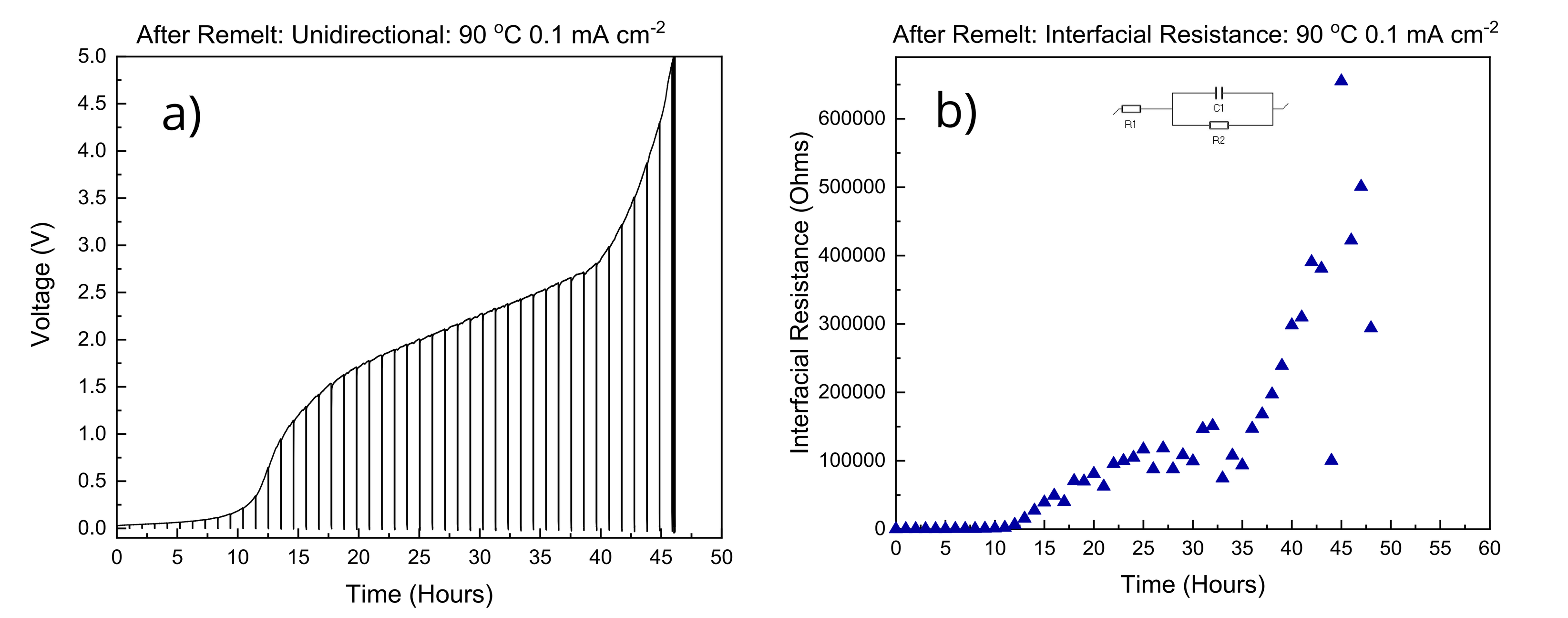
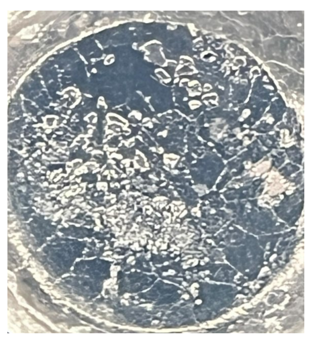
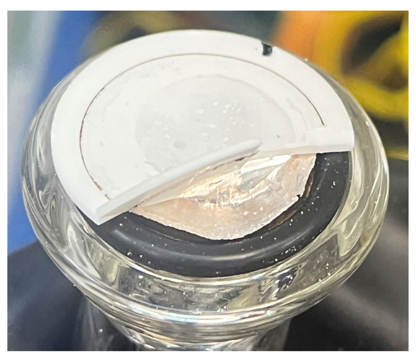


Fig. 3. Remelted at 110 °C, cooled to 90 °C a) unidirectional current and b) fitted interfacial resistance.



Stripped

Cooled to RT, the stripped side shows cracking/pitting at the interface, while plated side demonstrates "welding" to the NaSICON.



Plated

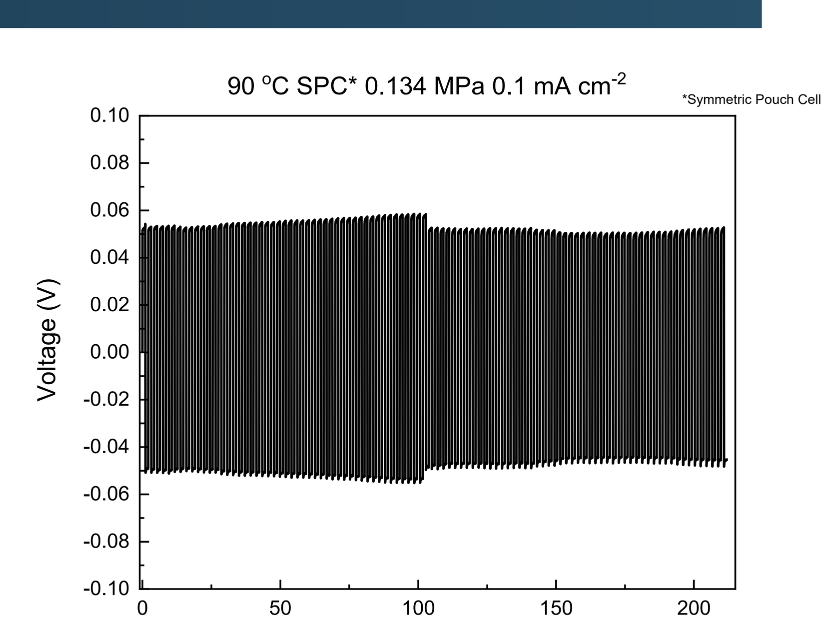
Conclusion and Impact

- Dropping from 110 °C (molten) to 90 °C (solid) causes a rapid increase in resistance resulting in lower capacity while temperature change is minimal.
- Remelting the system does not provide a rewetted surface to the NaSICON, leading to faster failure at the interface.
- Highlights the need for a modified interface to maintain stable contact and shows that mass transport in solid sodium remains limiting even near its melting point.

Future Directions

Test low stack pressure on symmetric pouch cell at elevated temperatures.

Exploring interfacial modification and targeted conditioning methods to establish and maintain uniform Na|NaSICON contact, addressing the irreversible loss of interface quality that occurs upon solidification.



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