

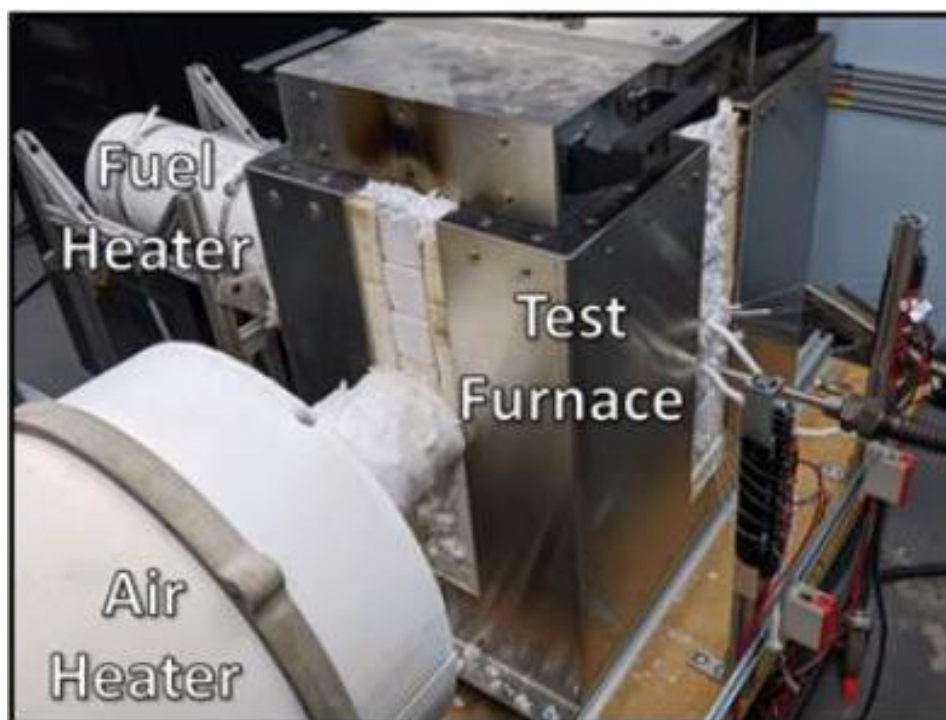
## Motivation

In 2021, fossil fuels were the primary source of energy for grid systems in the United States.<sup>1</sup> Fossil fuels are a nonrenewable energy source meaning the sources of these fuels are limited.



Alternatives like solar and wind power are only reliable in time of surplus energy which makes it difficult to balance the needs of the energy grid systems in the US.

Reversible solid oxide cell (RSOC) systems provide a pathway to continuously convert between electricity and green fuel depending grid demand.



Through fuel production mode, RSOC systems create fuel to be used in power generation mode. This can be done during times of renewable energy surplus. In power generation mode, RSOC systems can continuously supply electricity to compensate for times of renewable energy deficiencies.

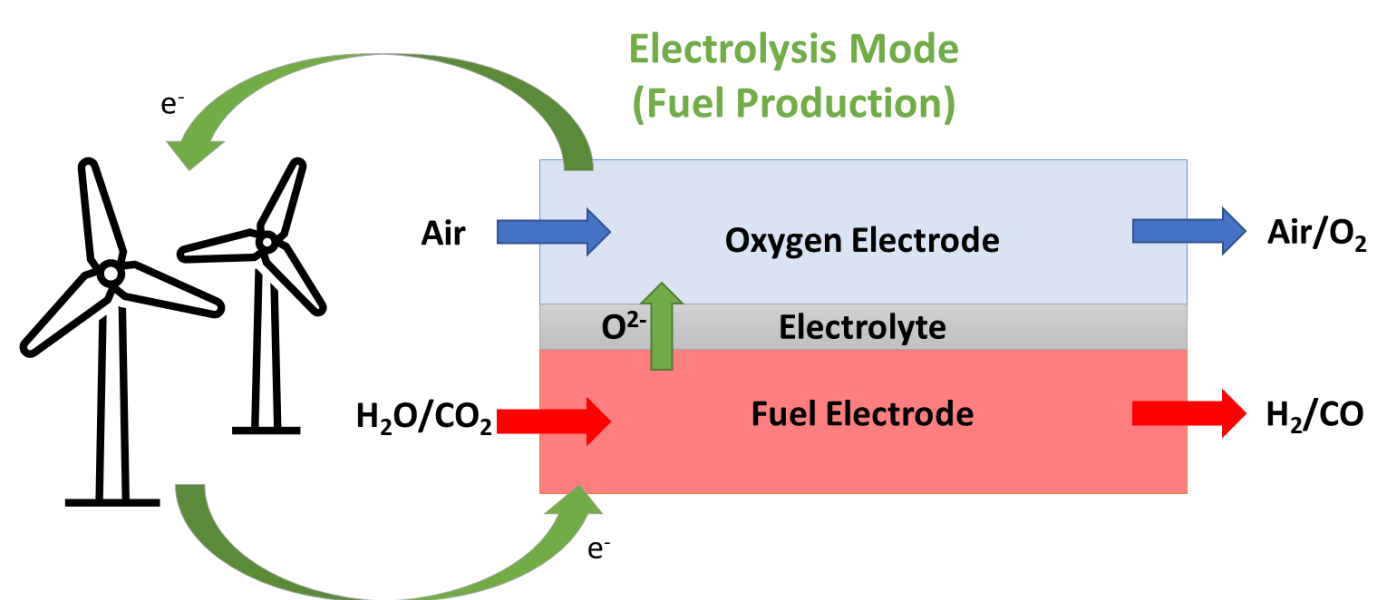
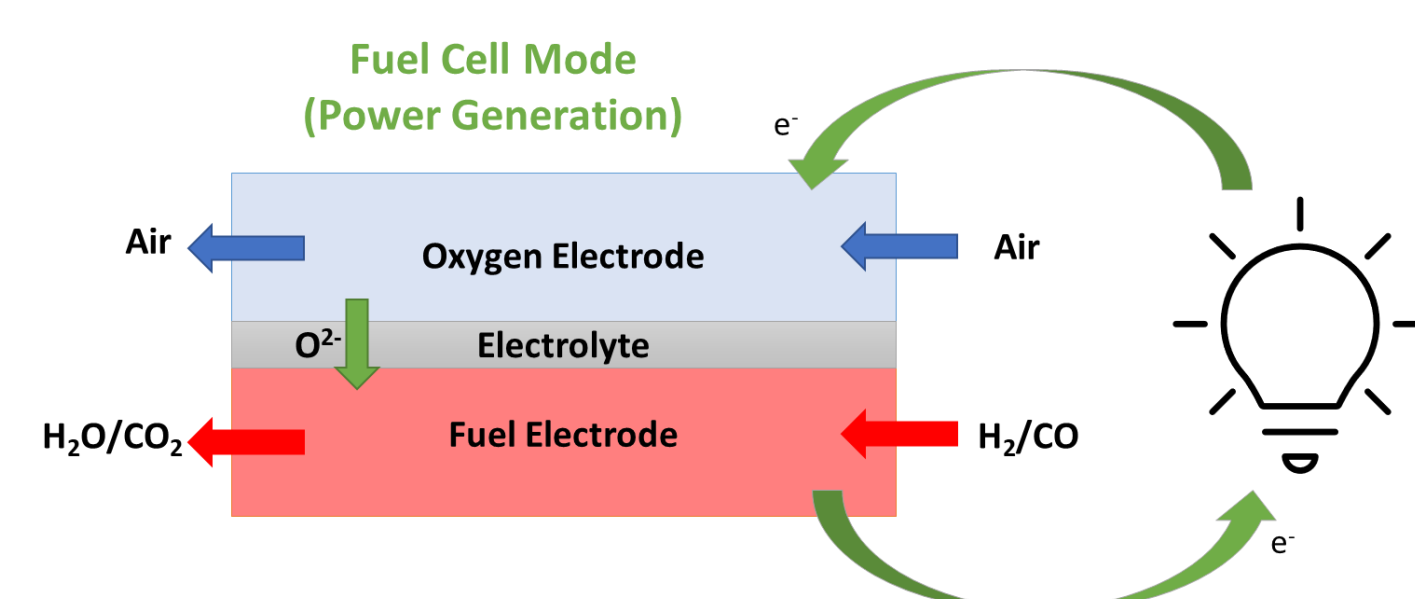
## Background

High temperature (~800°C) electrolysis using solid oxide cells is being developed globally to help support the growing hydrogen economy by providing the most efficient pathway toward green hydrogen generation.<sup>2</sup>

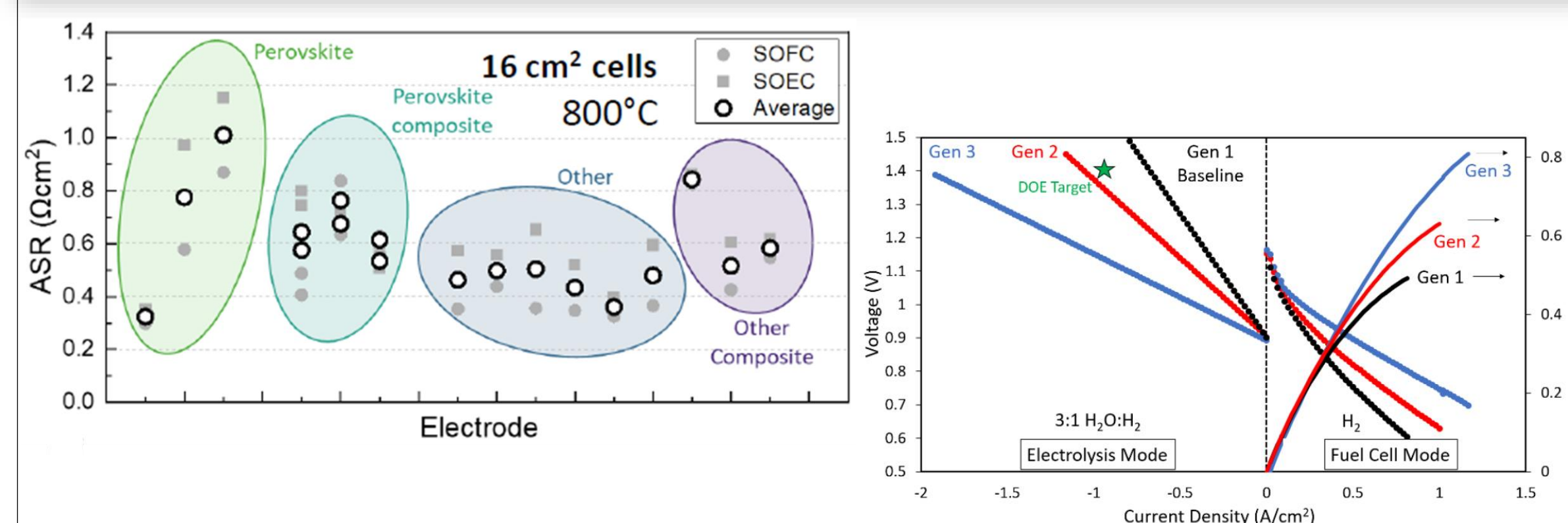
High temperature accelerates kinetics to allow the use of cheap electrode materials such as Ni-based fuel electrodes and metal oxide oxygen electrodes.<sup>3</sup>

However, material instability at these temperatures limits commercial adoption of this technology due to expensive manufacturing.<sup>3</sup>

This work focuses on the identification, scalability, and validation of high performing and electrochemically stable electrodes.



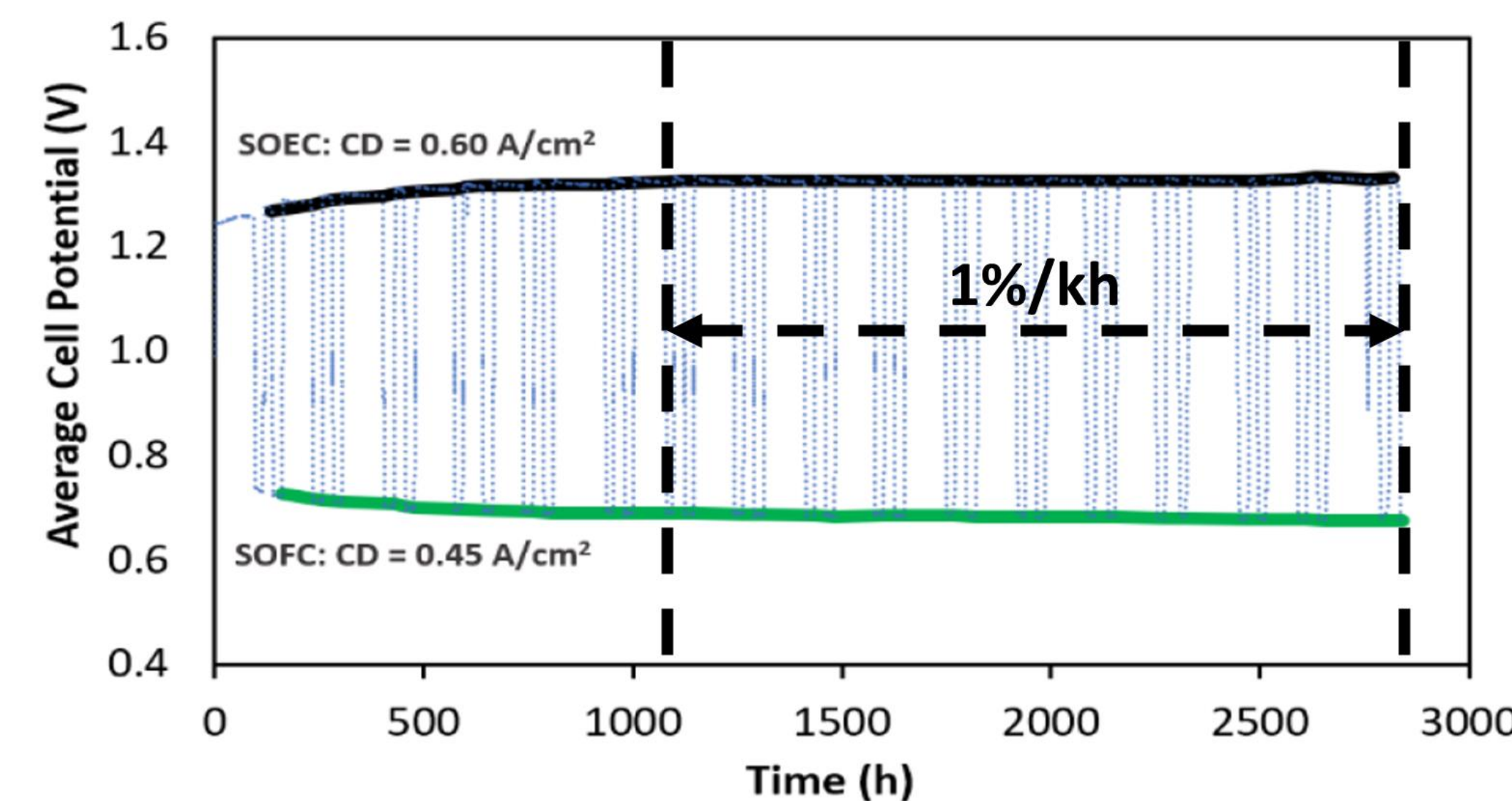
## Research and Discussion



15 air electrodes were screened on 5x5cm electrolyte supported cells.

Chemistries were down-selected based on area specific resistance (ASR) in both SOFC & SOEC modes.

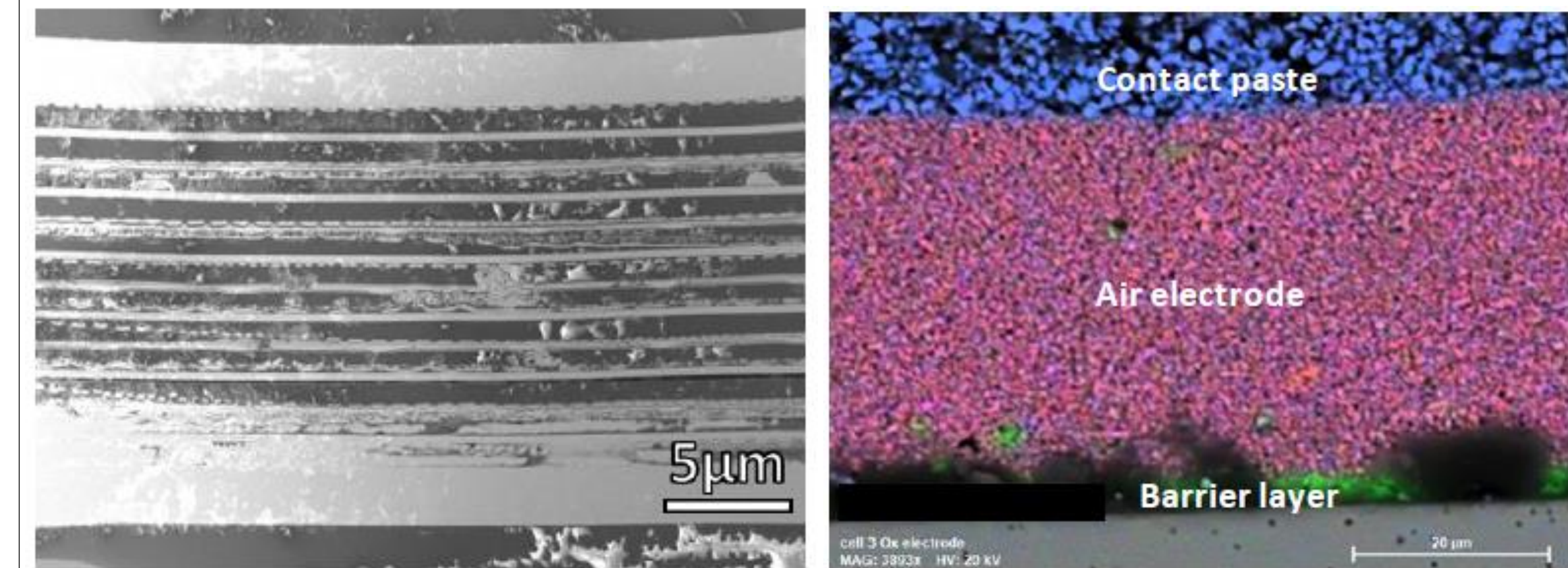
Demonstrated cell ASR of 0.29 Ω·cm² in SOEC mode and 0.35 Ω·cm² in SOFC mode at 800°C. Single cells had 3X improvement with generation 3 improvements such as interlayer and interface development.



A short stack was tested reversibly for 3000 hours of operation at 800°C (fixed current density of -0.60 A/cm² SOEC mode and +0.45 A/cm² in SOFC mode). Reactant contents were 75% steam/25% hydrogen in SOEC mode and 25% steam/75% hydrogen in SOFC mode.

This stack included four different oxygen electrodes while keeping the fuel electrodes consistent. Cells 1 and 5 were the same electrode to be used as controls for the experiment. After approximately 1000 hours of operation, counted as the beak-in period, the stack degradation rate was ~1%/kh.

## Conclusions

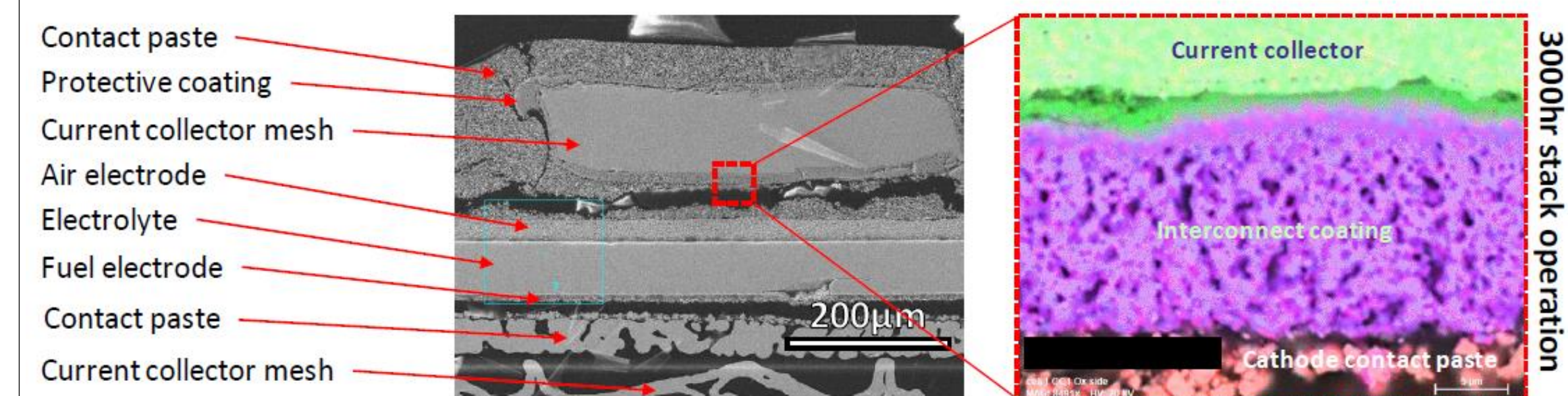


Extensive testing with dynamic switching between power generation and fuel production modes was demonstrated and resulted in very low degradation of cells in reversible operation.

Screening of electrodes and oxygen current pastes was conducted to down select a robust configuration of electrodes used in the short stack test.

Prolonged short stack operation of ~3,000 hours with dynamic switching between power generation (~0.7 V) and energy storage (~1.3 V) modes was demonstrated with total stack degradation rate of 1%/kh after the break-in period of ~1,000 hours.

Preliminary post-test analysis showed that the use of protected MCO coatings was stable. Post-test cells showed very little evidence of chromium due to the use of these coatings. Future collaboration is planned with PNNL for detailed microscopy.

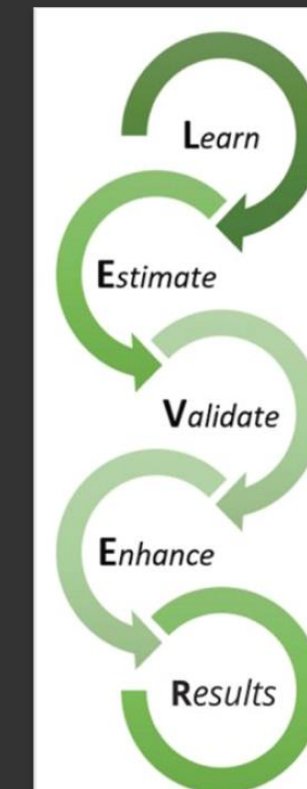
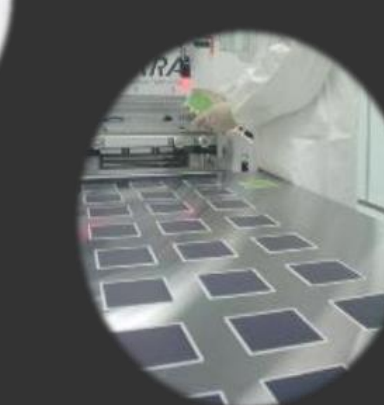


## References

- U. S. Energy Information Administration (EIA) / Monthly Energy Review September 2022
- Liu, M. & Yu, B. & Xu, J.. (2009). Efficiency of solid oxide water electrolysis system for hydrogen production.
- Green Car Congress. KIST team develops low-temperature high-performance solid-oxide fuel cell that operates on butane gas; possible EV applications. 28 April 2020

## Vertically Integrated for SOC Development

- Material and component supply available through [fuelcellmaterials.com](http://fuelcellmaterials.com)
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- Accelerate customer development timelines at material, cell, and stack levels



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