Powering Forward: The Latest in Solid Oxide Stack Technology at Nexceris

OFCHC Solid Oxide Forum
September 9th, 2025

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Premier Solution Provider to the Climate Tech Industry

Vertically Integrated Material Science and Engineering Firm

- Over 30 years of continuous business operations.
- Servicing the industry with products and services since 2000.
- Electrochemical products through Fuel Cell Materials (FCM).
- Catalyst services through HeatPath Solutions.
- Battery safety through Li-ion Tamer.

FCM

HeatPath SOLUTIONS

LI-ION TAMER®

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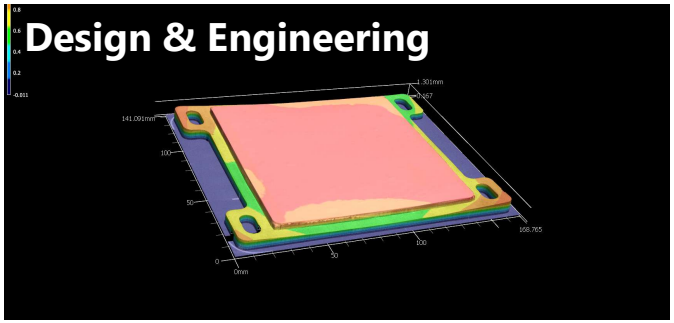
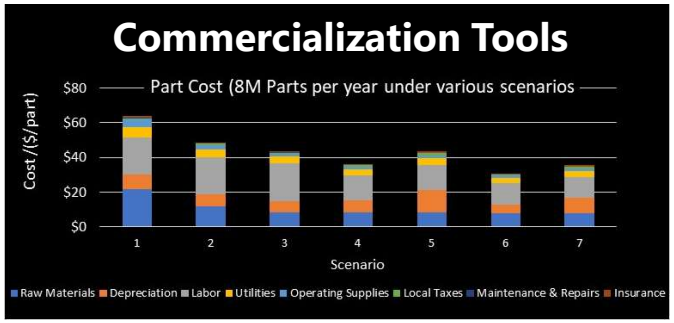
Nexceris Capabilities

Connecting Technology Interfaces with Nexceris Capabilities to Provide Value





- The best solutions come from the use of multiple capabilities.

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Nexceris – a vertically integrated SOC technology provider

Nexceris is vertically integrated – from materials and cells to stacks and breadboard systems.

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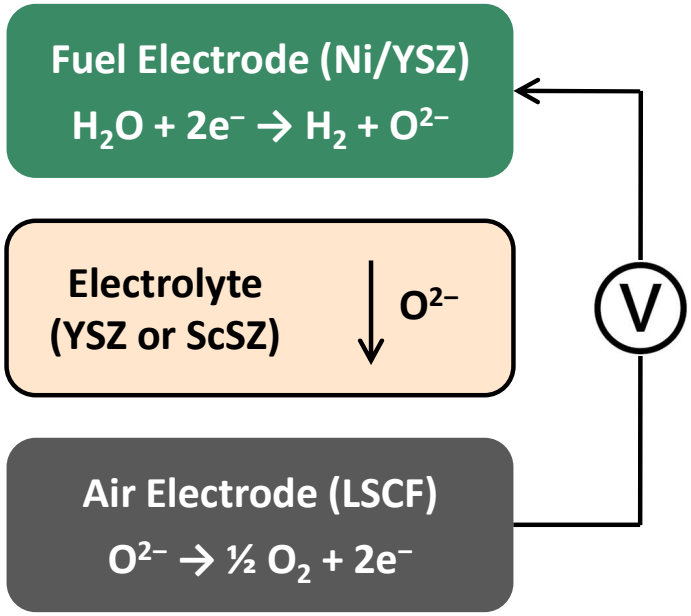
Alternative Electrolysis Technologies

Attribute	SOEC	PEM	Alkaline
Electrolyte	Ceramic	Polymer	KOH
System Efficiency (KWh/kgH_2)	**37-48**	**50-60**	**50-60**
Stack Life (hours)	50k	50-90k	60-100k
Operating T (°C)	600-800	50-80	70-90
Co-Electrolysis (syngas)	**Yes**	**No**	**No**



SOEC provides a path to ultra-high electrical efficiencies with versatility for alternative fuels and power generation (ReSOC)

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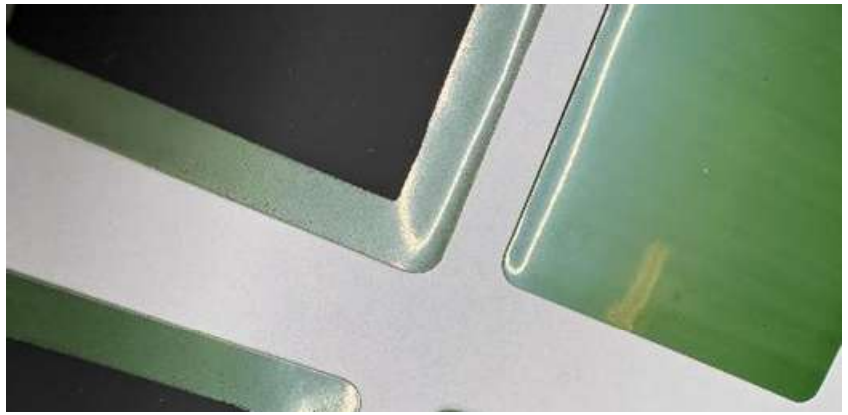
Cell Design Options for Planar SOEC Stacks

Electrolyte Supported Cells

- Membrane thickness: 100-200 microns.
- High conductivity (ScSz) electrolyte membrane.
- Operating Temperature: 750 to 850 °C.
- Dense cell periphery makes stack sealing easier.
- Thin fuel electrode reduces mass-transport limitations
- Manufacturers: Nexceris, Bloom, Oxeon, Sunfire.



Fuel Electrode Supported Cells

- Membrane thickness: 3-10 microns.
- High intrinsic performance (thin electrolyte membrane).
- Operating Temperature: 600 to 700 °C.
- Stack sealing can be challenging (porous support layer).
- Suffer from Mass-transport limitations
- Manufacturers: FCE, Topsoe, Elcogen, SolydEra.

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Electrolysis Specific SOEC Stack Design

Designing a SOEC stack

Stack Design Approach

- It's not as simple as running a fuel cell stack in reverse!
- Nexceris established the following hierarchy of stack design goals: Durability > Performance > Cost.
- Clean-Slate. All historical stack design decisions were questioned: Were they legacy to fuel cell operation? Are they still valid for electrolysis?

Stack Design and Validation Progress

- Core stack design established.
- SOEC-specific electrode materials sets established.
- CFD modeling to optimize reactant flow distribution uniformity.
- Components fabricated and several test iterations completed.

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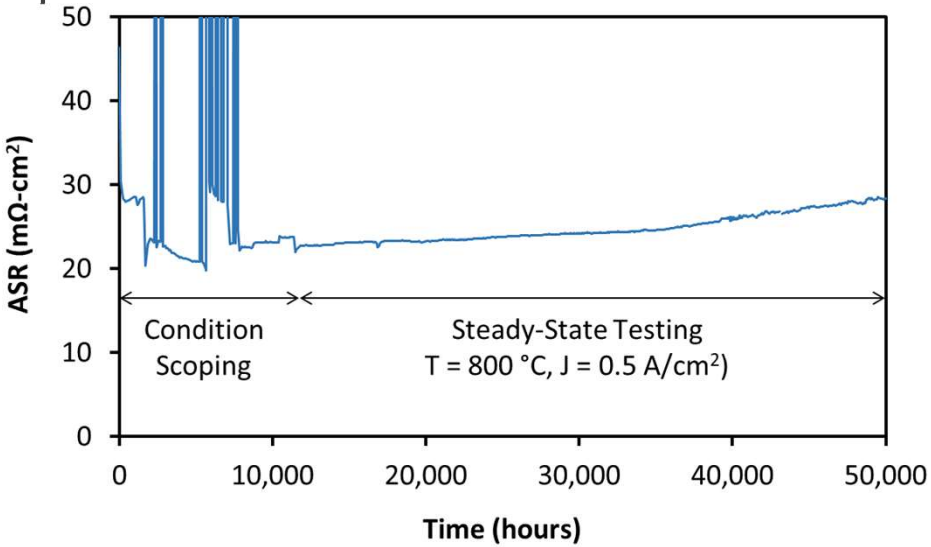
Electrolysis Specific SOEC Stack Design

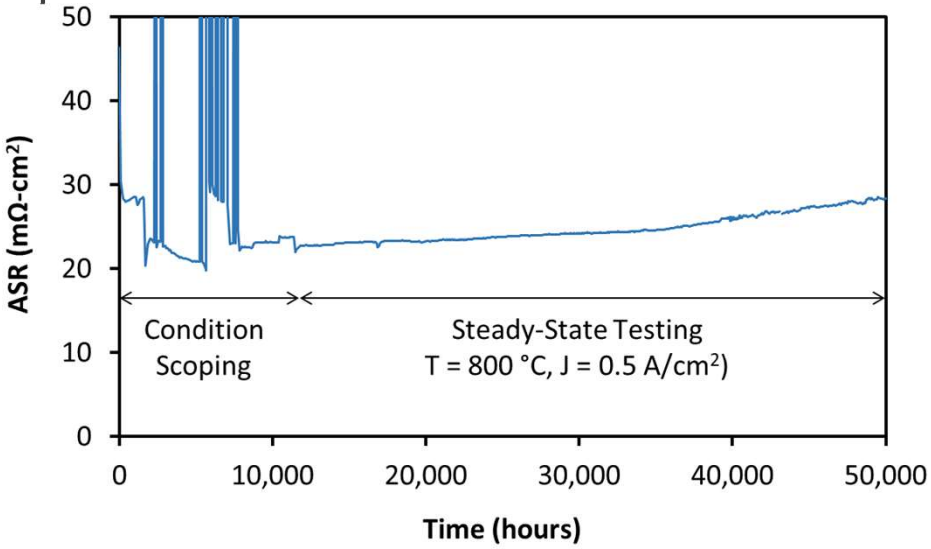
Optimal materials for SOEC



- ChromLok™ coatings on ferritic steel interconnects and current collectors mitigate corrosion, reducing stack degradation

Electrolysis Specific SOEC Stack Design

Optimal materials for SOEC



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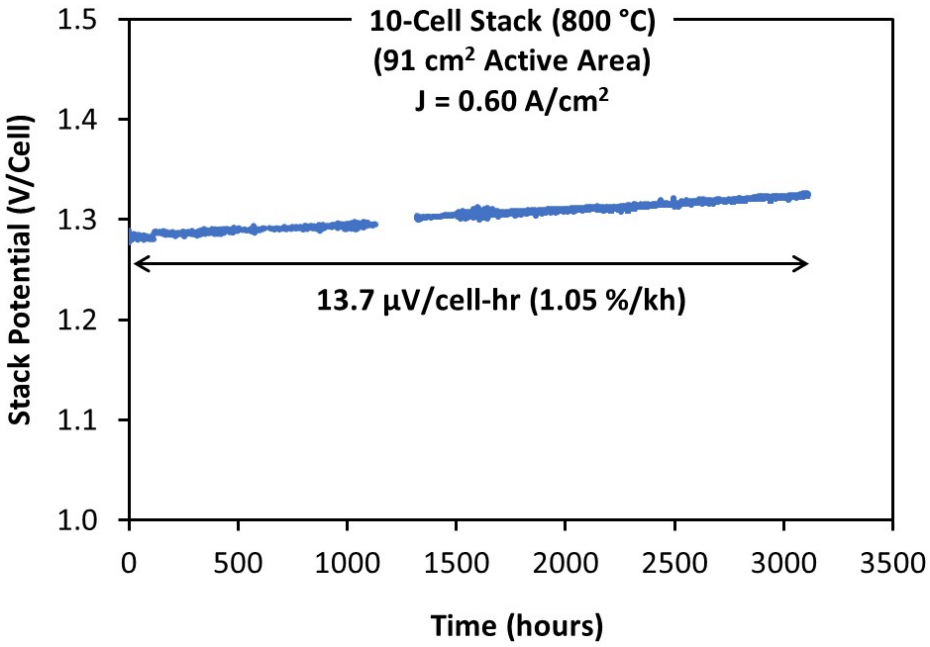

- Over 3,000 hours of SOEC durability completed with optimized electrodes and coatings

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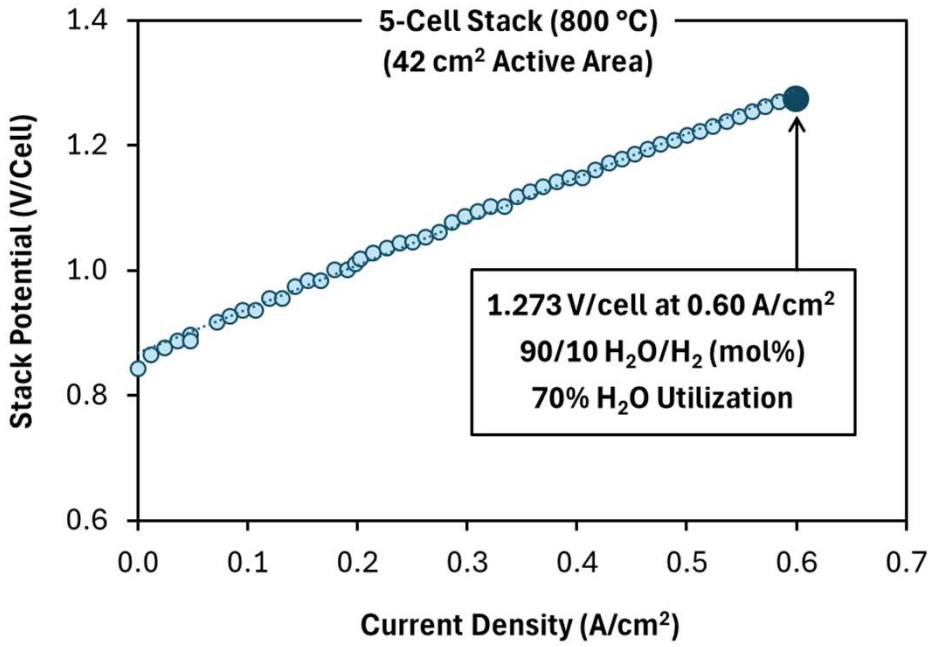
Electrolysis Specific SOEC Stack Design



- Previous generation stack optimized for SOFC

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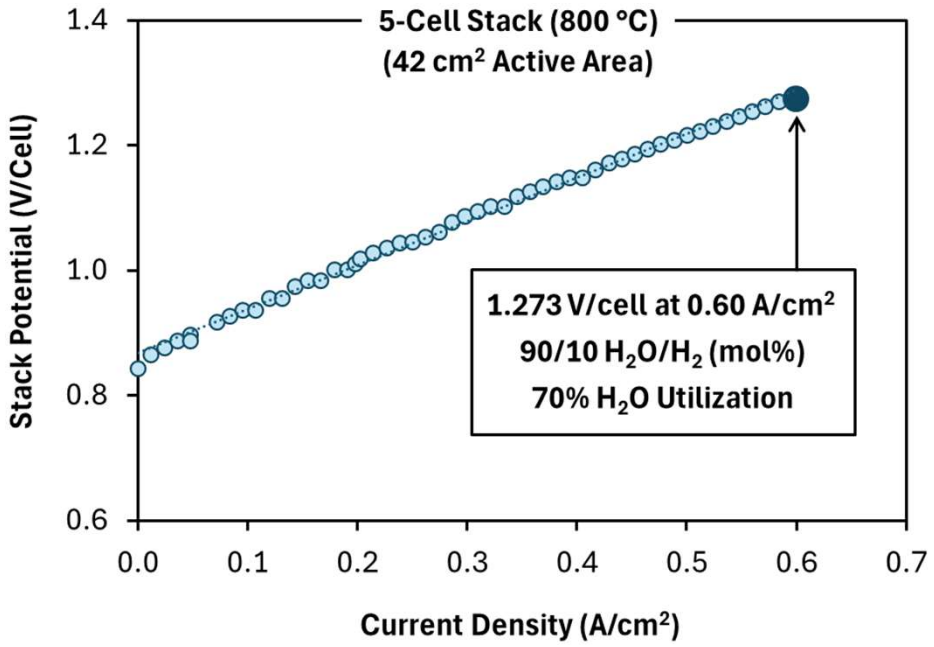
Electrolysis Specific SOEC Stack Design



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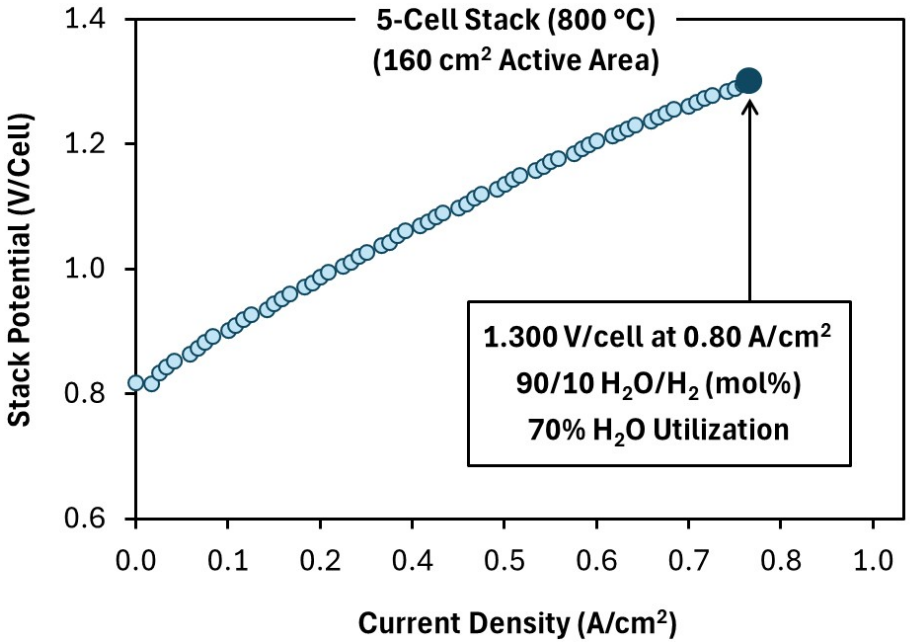

- SOEC optimized stack design provides significant performance improvement

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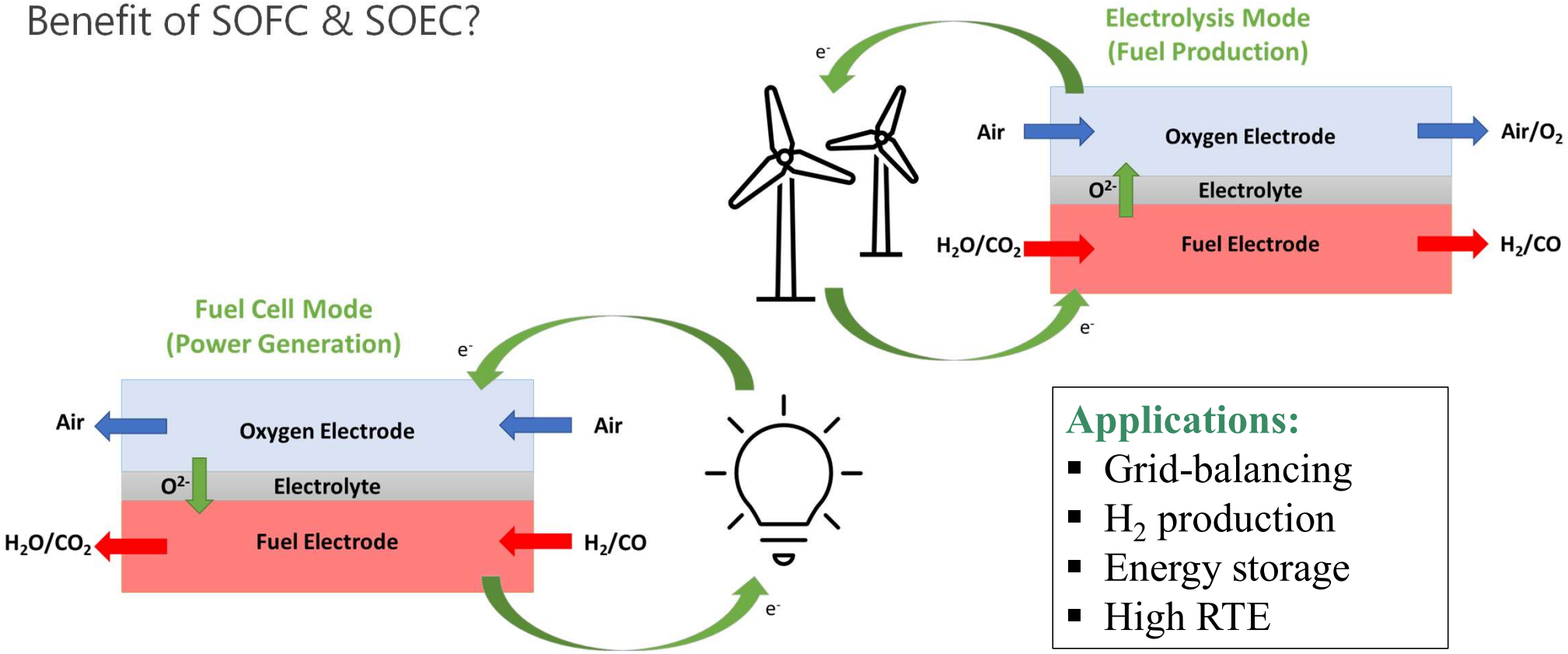
Reversible Solid Oxide Technology

Benefit of SOFC & SOEC?

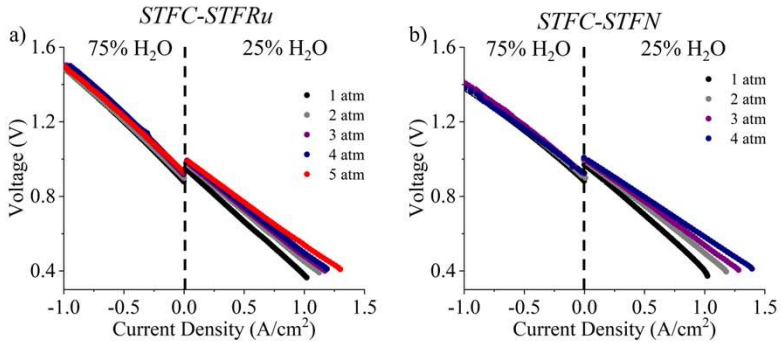


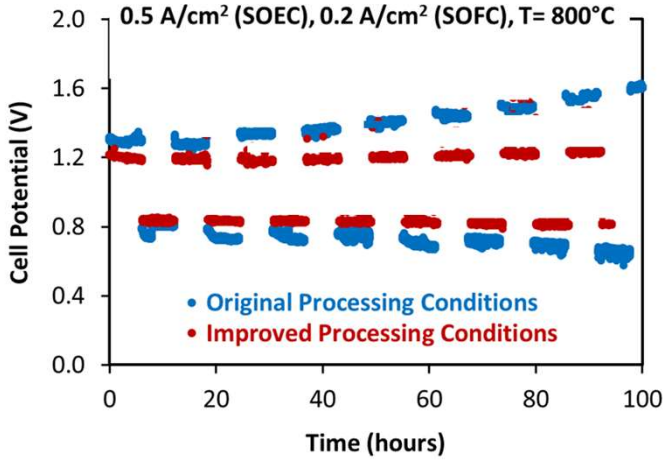
Applications:

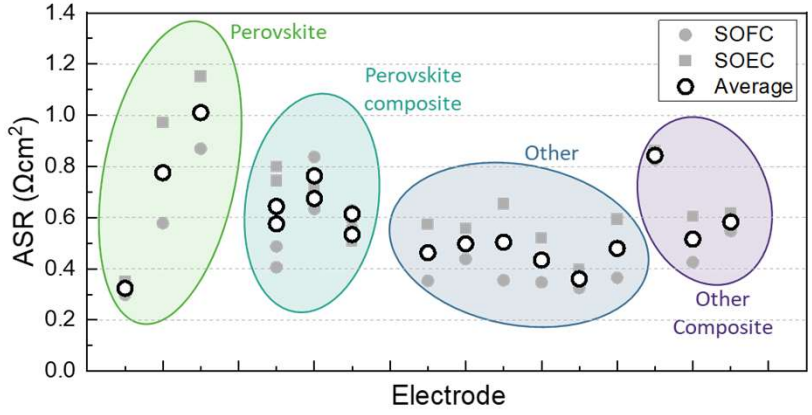
- Grid-balancing
- H_2 production
- Energy storage
- High RTE

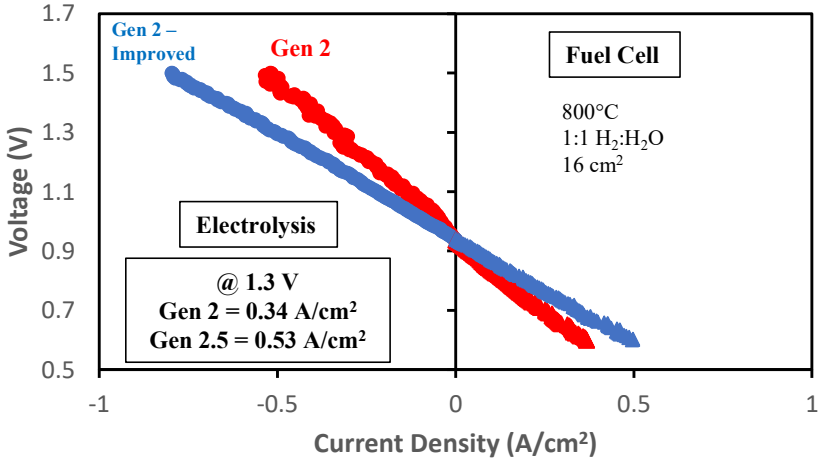
Reversible Solid Oxide Technology

Versatile Materials for ReSOC









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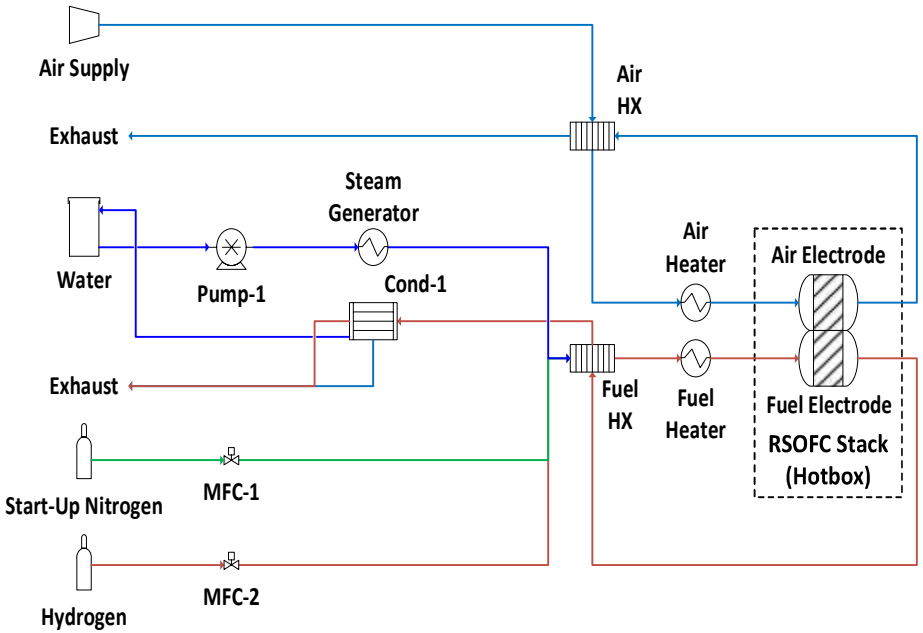
Reversible Solid Oxide Technology

Lab-Scale Validation of Technology



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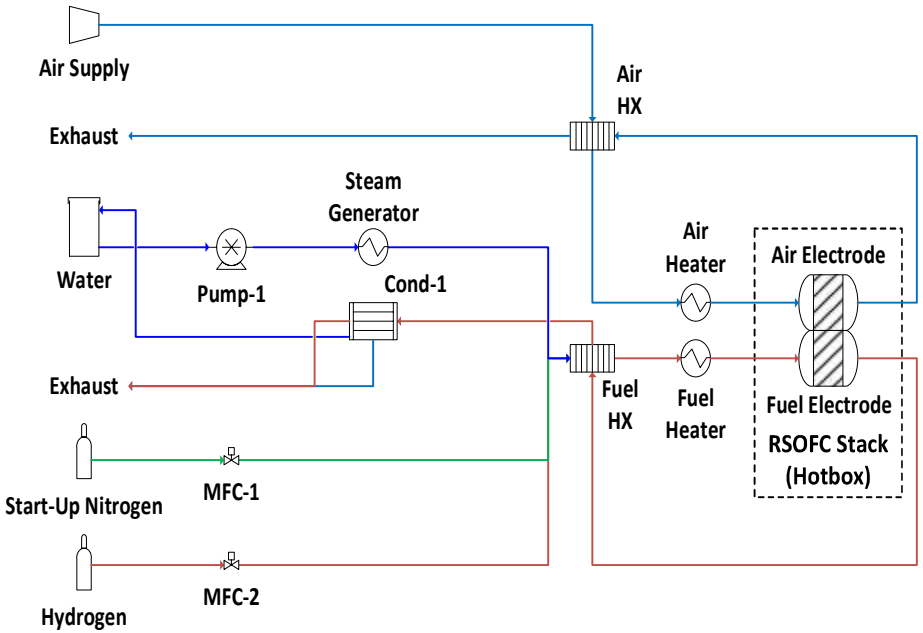

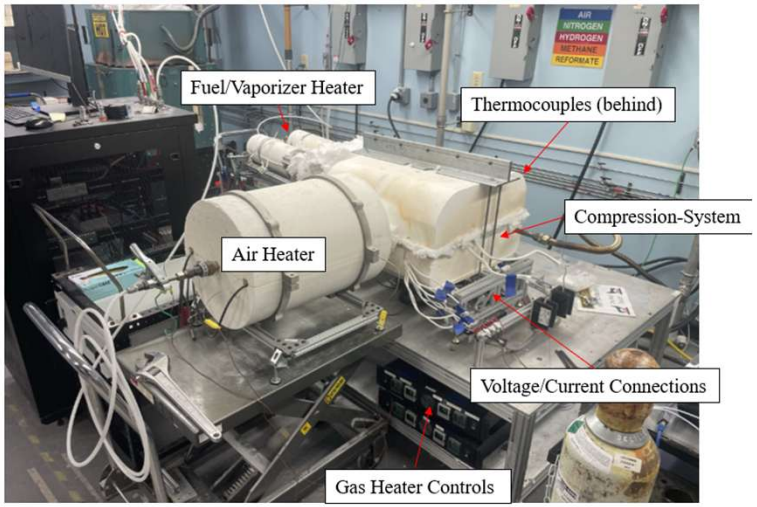

Reversible Solid Oxide Technology

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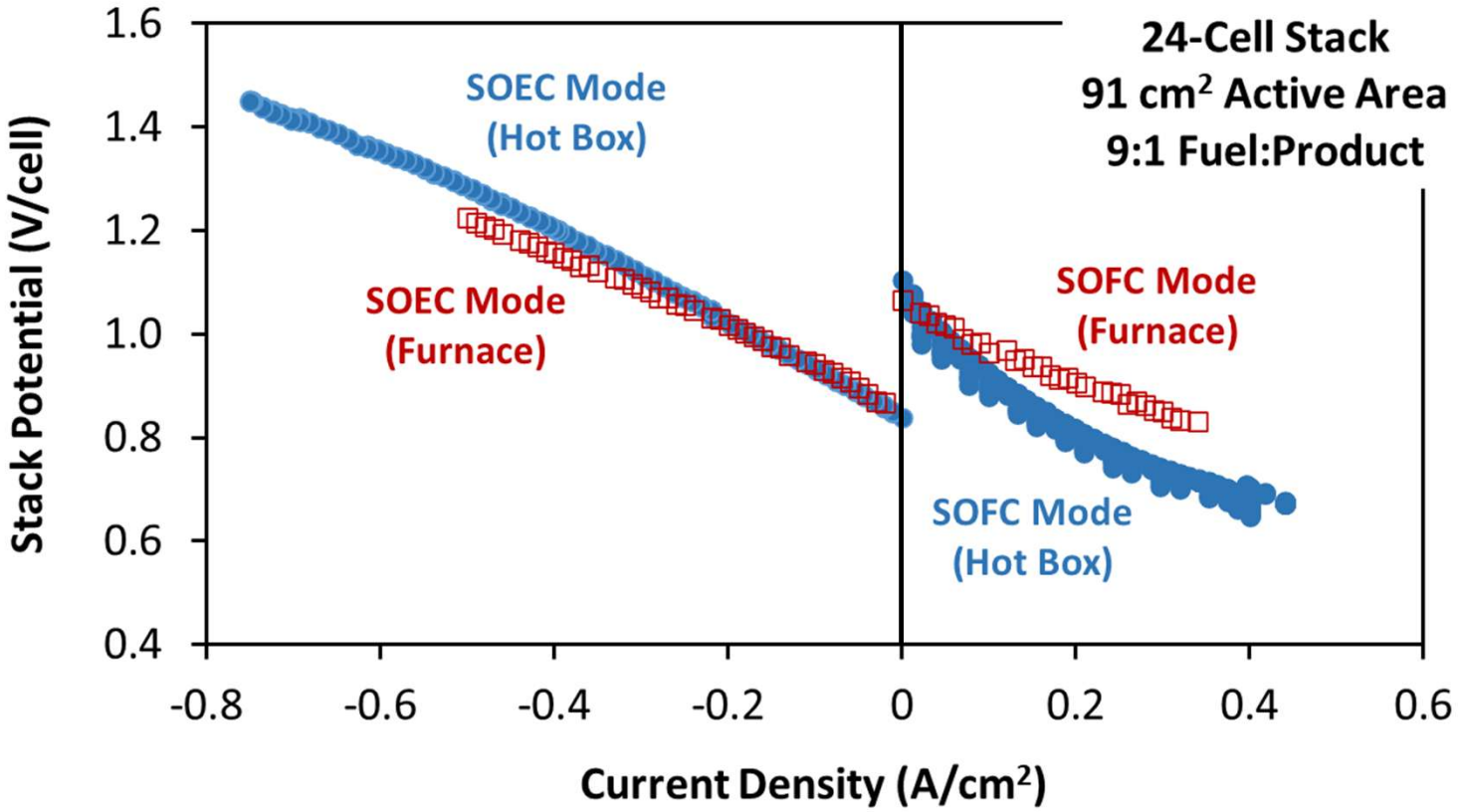

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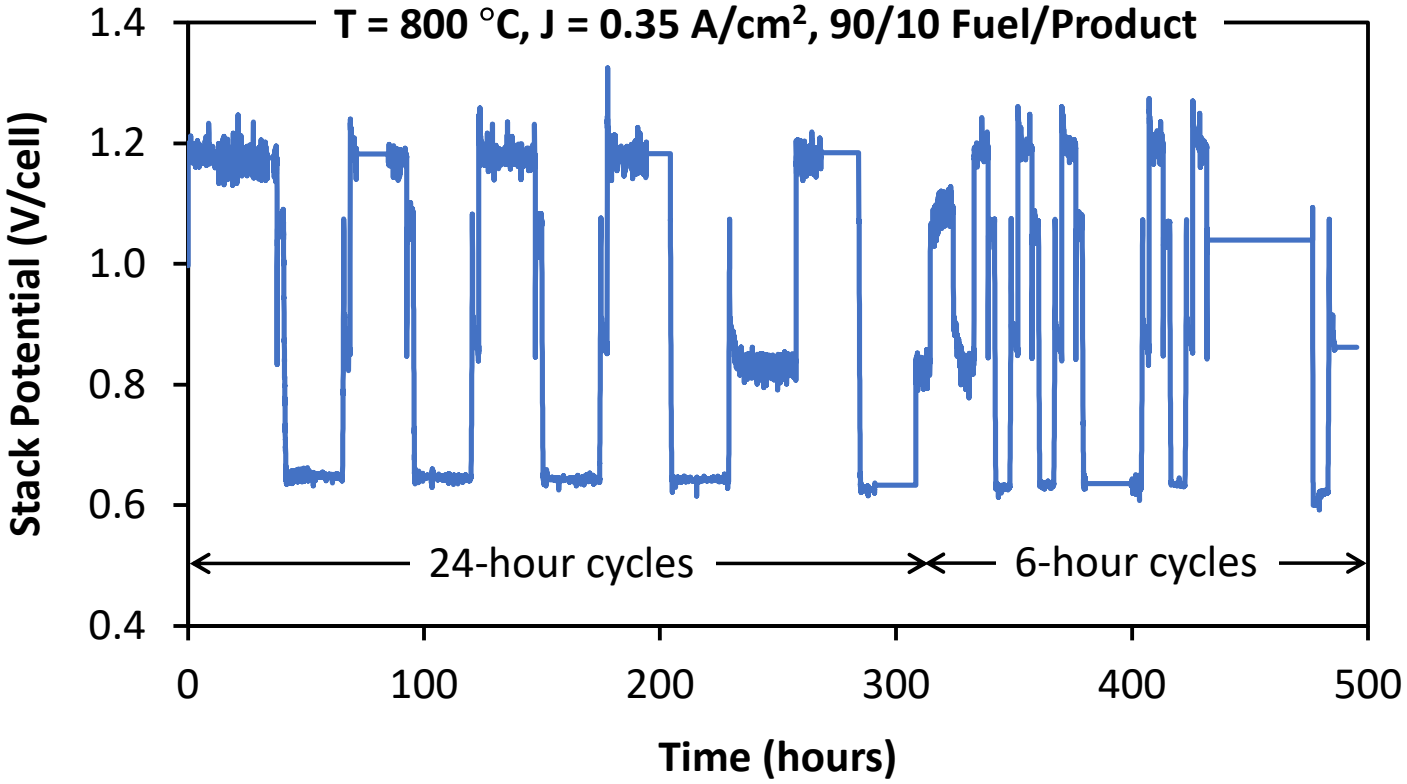

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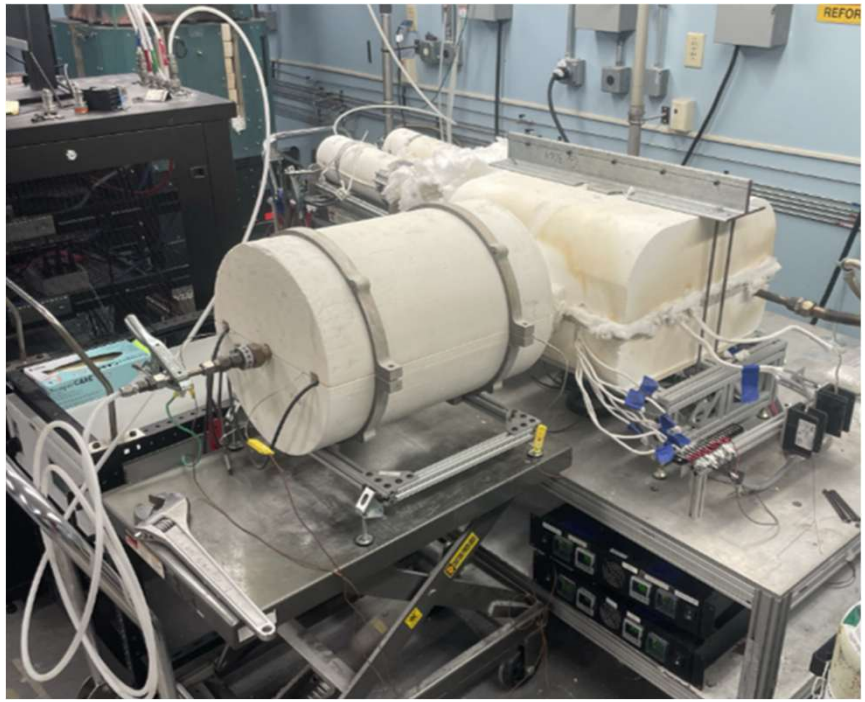
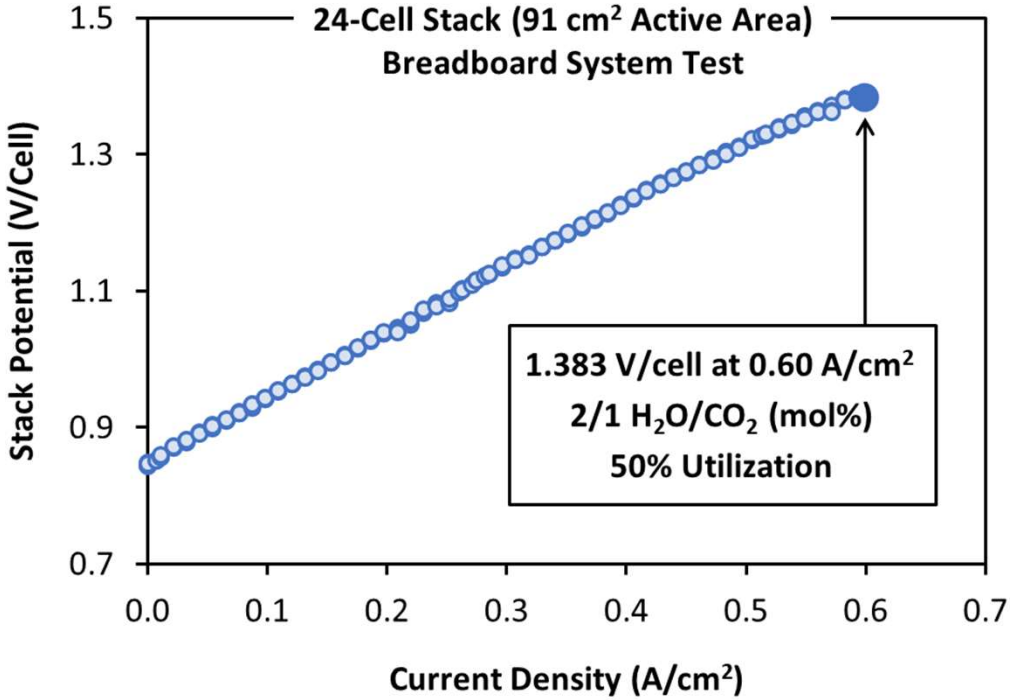
Co-Electrolysis Stack Testing in Breadboard System





Reversible Solid Oxide Technology

Publication from Colorado School of Mines

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International Journal of Hydrogen Energy

journal homepage: www.elsevier.com/locate/he

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Performance analysis of a 1 MW reversible solid oxide system for flexible hydrogen and electricity production

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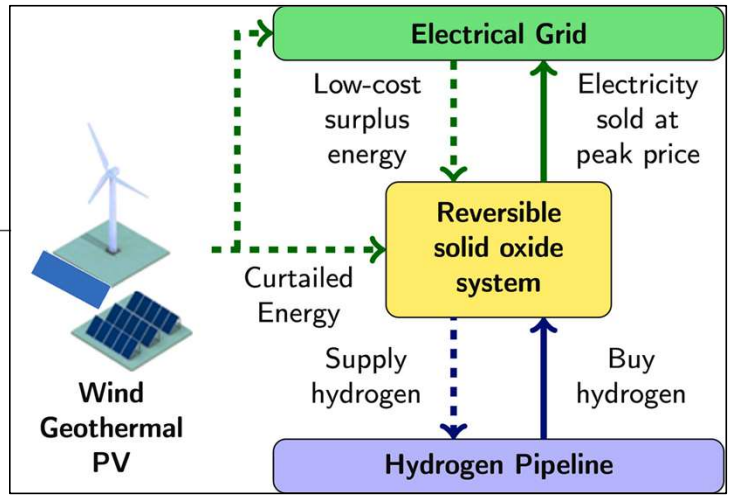
[b] Solid Oxide Business Unit, Nexceris LLC, Lewis Center, 43035, OH, United States of America



SOFC – Ultrahigh Performance

Background

The utility of ultra-high powered SOFC for various applications

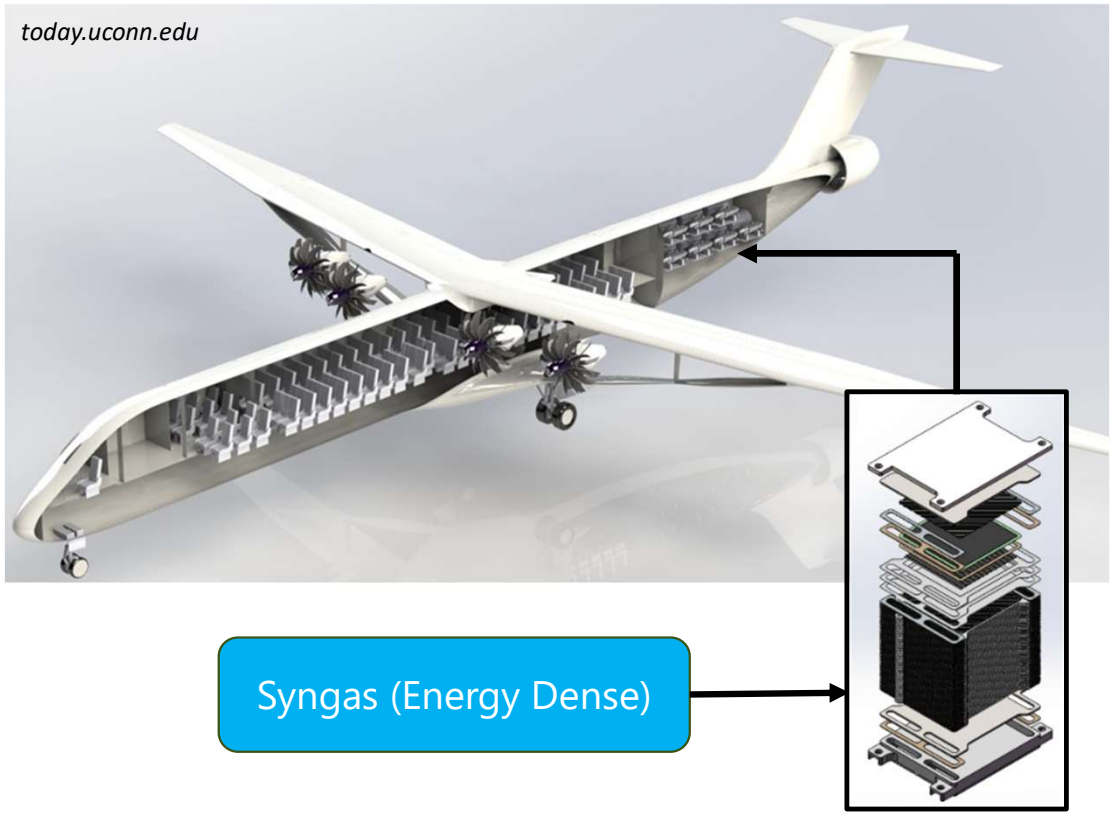
- Natural gas, data centers, flight-extension, etc.

SOFC for flight-extension

- Weight of SOA batteries are limiting
- SOFC ability to convert energy-dense fuels opens path for hybrid-electric powertrains

What's the challenge?

- Ultra-high performance
- Thermal cycling
- Weight



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SOFC – Ultrahigh Performance

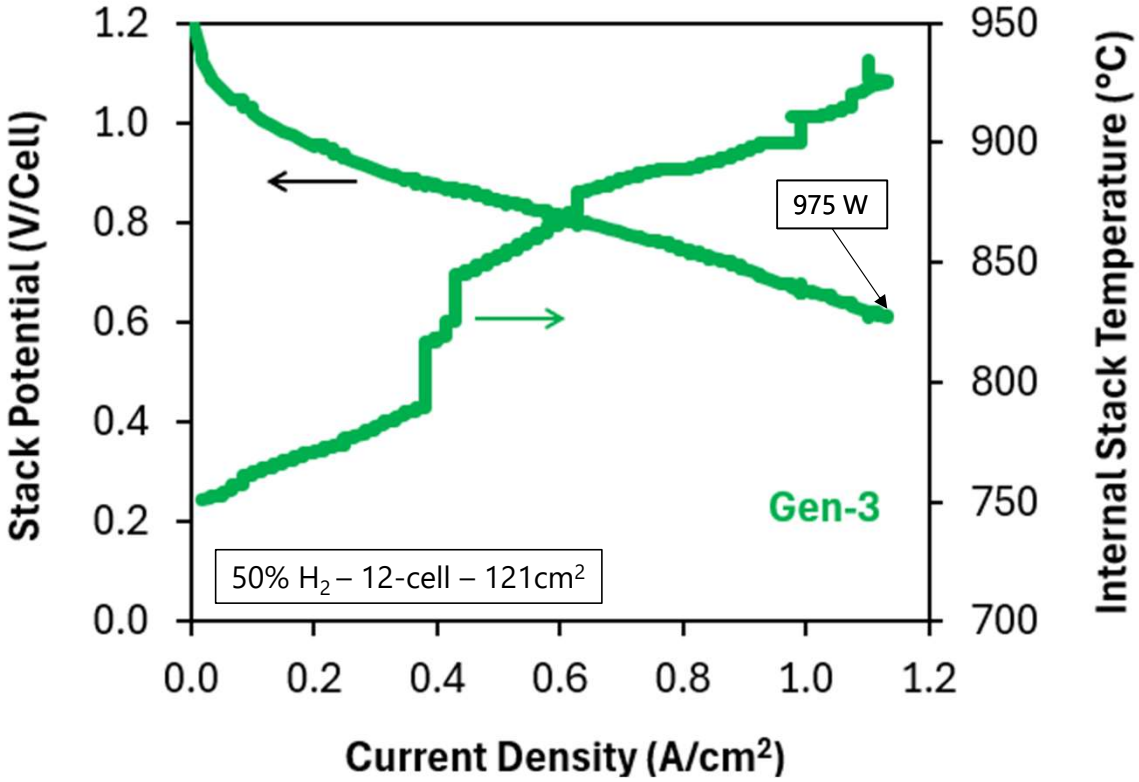
Challenges with High-Performance SOFC Stacks

Pushing a stack to a target Current Density is easy; thermal management is hard

$$Q_{stack} = I^2R + I\left[\left(\frac{\Delta H_{rxn}}{nF}\right) - V_{cell}\right]$$

Mitigation methods

- Higher Performance; lower ASR
- Mass flow rate of air
- Alter stack design

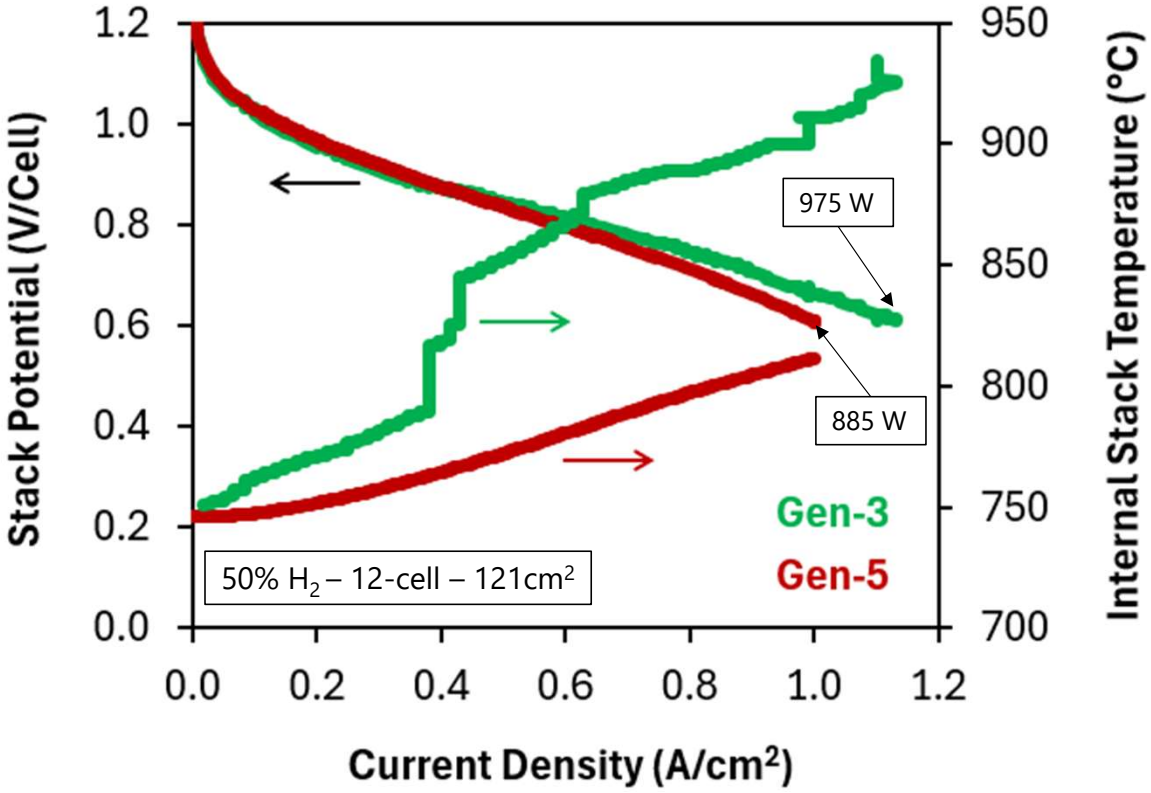


SOFC – Ultrahigh Performance

Challenges with High-Performance SOFC Stacks

Modification of the sealing approach and air cavity allowed much greater temperature control

Stack Platform	Voltage [V]	Current Density [A/cm²]	Total Stack Power [W]	Temperature [°C]
Gen-3	0.660	1.0	950	908
Gen-5	0.607	1.0	885	811



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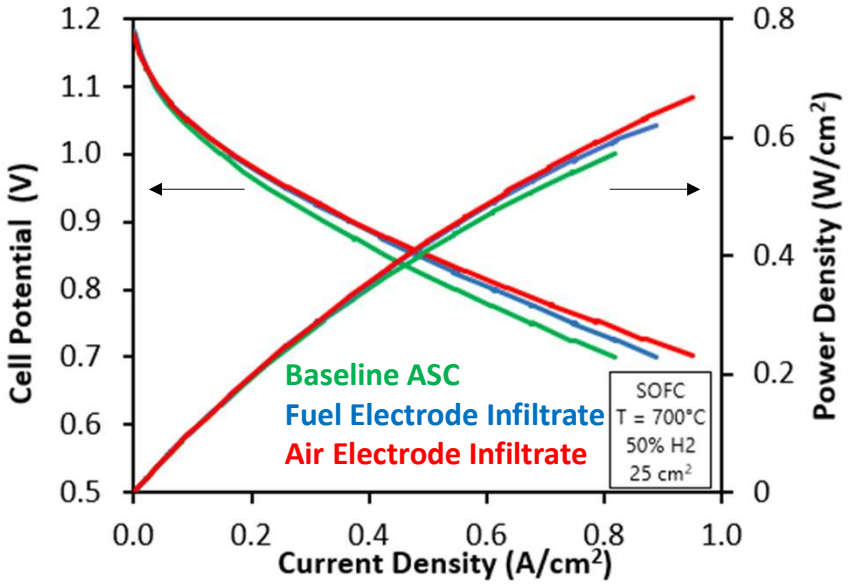
SOFC – Ultrahigh Performance

Methods to Increase Performance

Metal-Nitrate infiltration can improve performance



- Baseline ASC – 0.857 A/cm^2
- Fuel Infiltrate – 0.894 A/cm^2; +4.3%
- Air Infiltrate – 0.962 A/cm^2; +12.3%
- Air + Fuel Infiltrate - ???

Slide 23

AV1 Make iV lines or trendlines and change to primary colors. Legend color matched

Alex Vaeth, 2025-08-22T17:36:26.215

SOFC – Ultrahigh Performance

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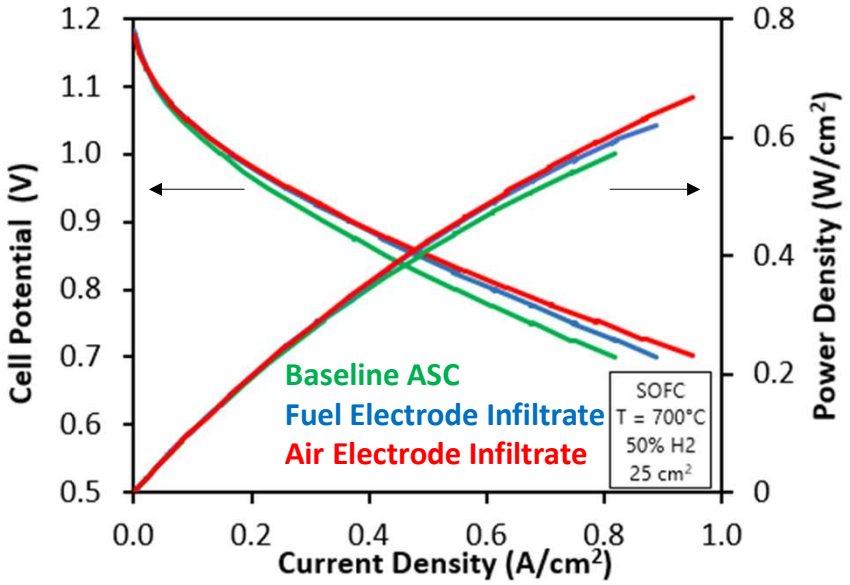

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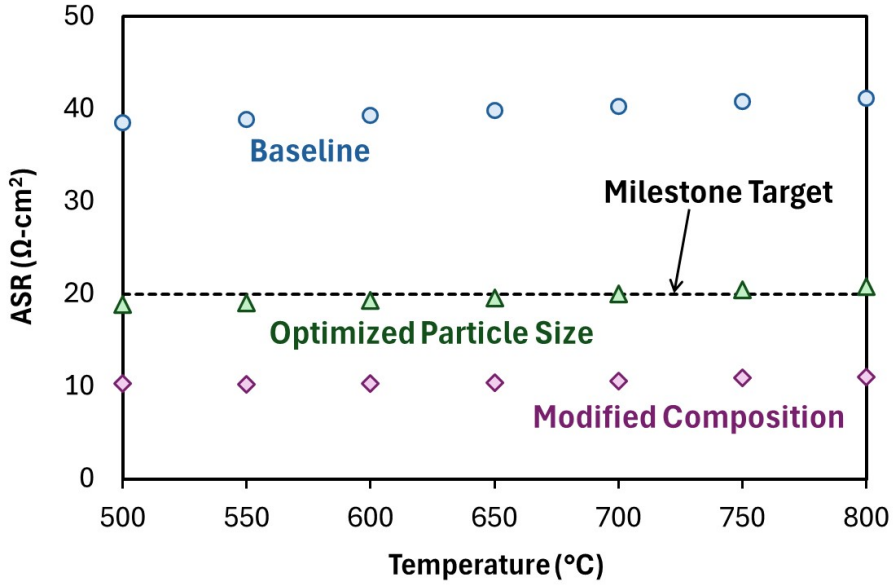
Contact-Paste Optimization to reduce ASR



- Through particle size and surface area modification can reduce ASR by almost 50%
- Further reduction can be achieved through compositional changes (conductive species)

Acknowledgements

Nexceris Colleagues

- Gabe Slupski – Stack Engineer
- Mike Funk – Stack Technician
- Elliot Hinsey – Stack Technician
- Joshua Emerick – Lead EE
- Meghan Stout – Lead Chemist
- Joshua Welsh – Component Fabrication
- Lura Armbruster – SOC Production
- And many others

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- Xiao-Dong Zhou
- Yudong Wang
- Nengneng Xu

Colorado School of Mines

- Robert Braun
- Aadarsh Parashar

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We collaborate with leading global customers and partners to transform powerful ideas into solutions that make energy production safer, more efficient, and environmentally responsible.

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