DOE 22nd Annual SOFC Project Review 16-Nov-2021

Contract: DE-FE0031674

Next Generation Durable, Cost Effective, Energy Efficient Tubular Solid Oxide Fuel Cell

Special Power Sources

Objective

- Develop and optimize a YSZ electrolyte-based solid oxide fuel cell (SOFC) technology for low cost, low temperature (550~650°C), and high energy efficiency operation.
- The developed technology will be implemented and demonstrated in a high efficiency 2~3kW SOFC with applicability to sub-MW system.
- Contract extended from Sept 2021 to end-Sept 2022

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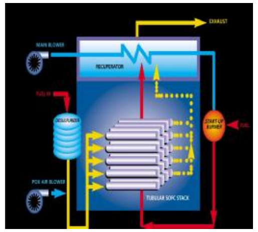
2000 | 2001 | 2005 | 2011 – 2012 | 2016 | 2019 | 2021

2000

SOFC Division started at Acumentrics formed in Westland, MA

10 Watts

25 Watts



2001

1st 1kW NG Prototype

2002

5000W APU Core Module

2005

5kW NG Prototype

2009

1st Remote Demonstration on NG

2011 - 2012

1st Commercial Sales & SOFC Product Suite (2012)

250W to 1.5kW

Acumentrics
TRUSTED POWER INNOVATIONS®

ATREX ENERGY
POWERFUL POSSIBILITIES

2016

Acumentrics SOFC becomes Atrex Energy

CSA Certification for NG & LPG Systems

SPS Special Power Sources
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2019

Special Power Sources purchases Atrex Energy

Enters in Strategic Partnership with Advanced Tech Works (ATW) for Manufacturing and Field Services

Relocates assets to Alliance OH

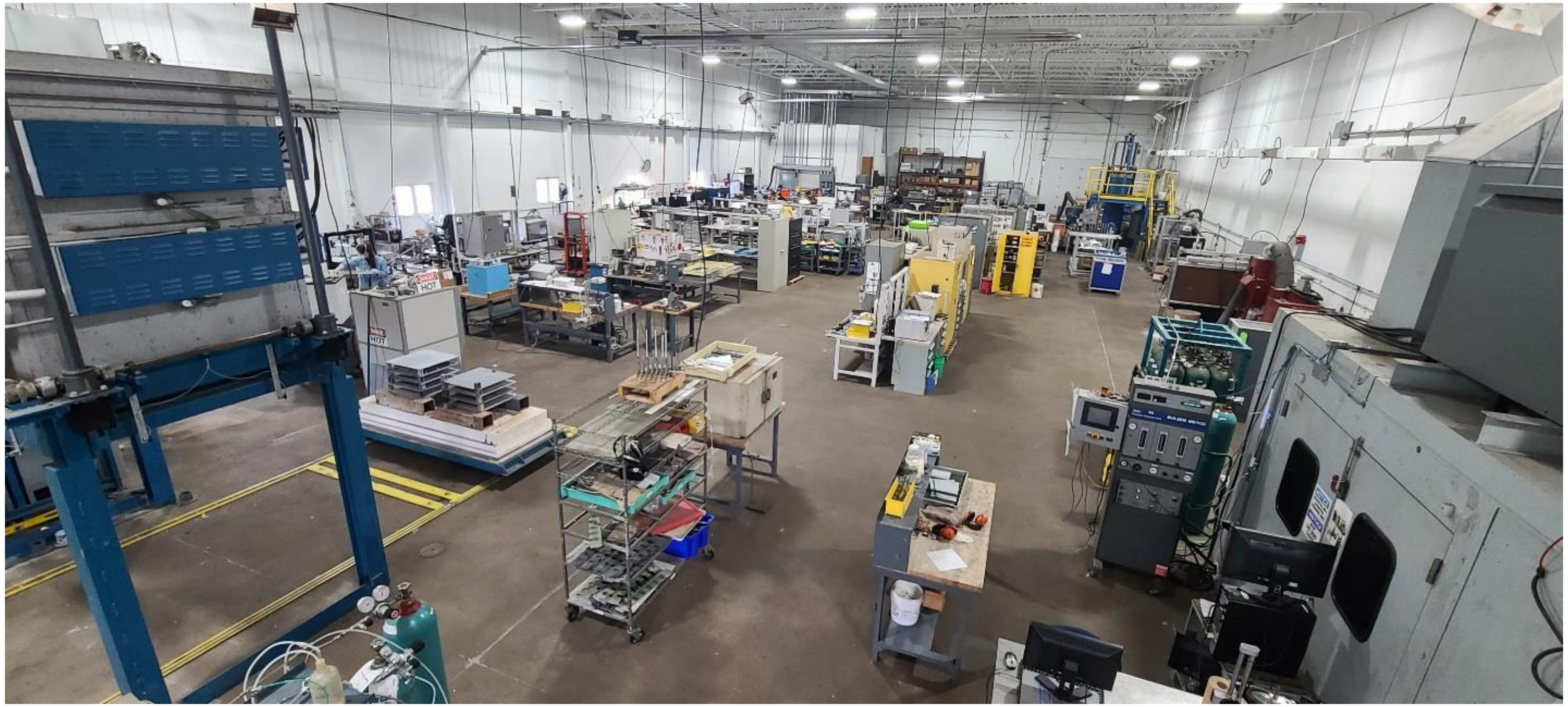
2021

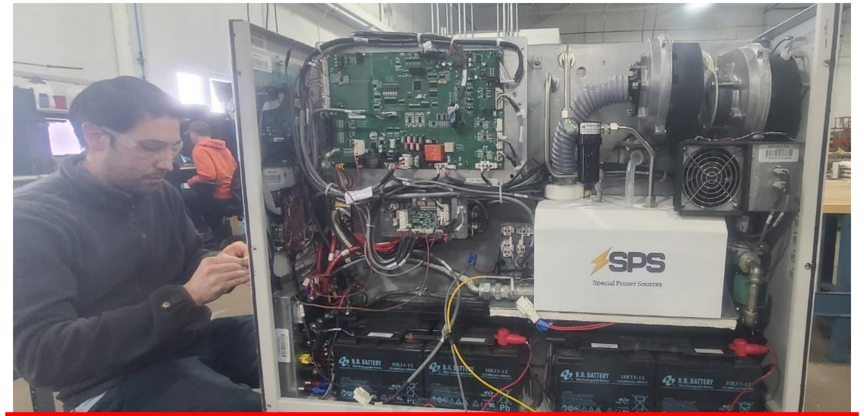
Fully operational cell manufacturing floor and field services for existing fuel cell customers. Growing R&D operation with DOE, DOD, and NASA contracts.

Our first new order is pending!

Current activities

- 22 full-time, 2 part-time employees
- 8 active R&D contracts with DOE/DOD
- First commercial contract pending
- Ongoing field support of legacy units





Thin Electrolyte Development

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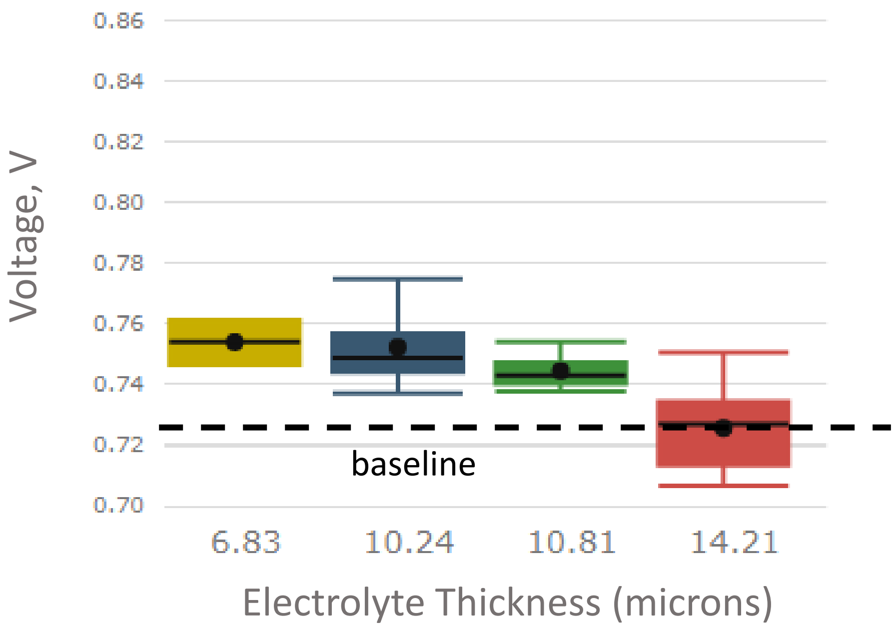
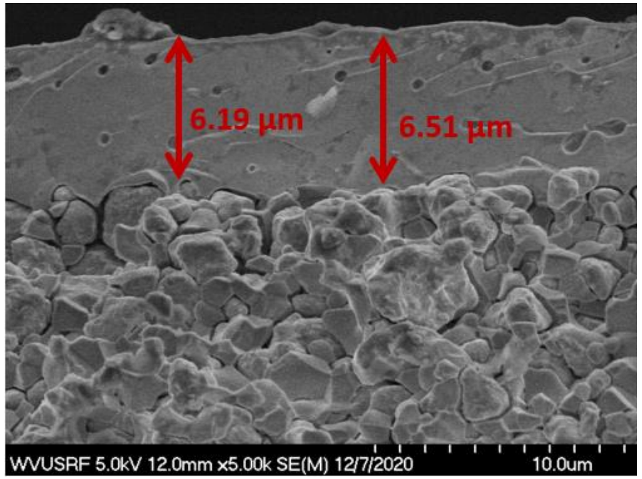
Voltage at 50A, 650C (O/C=1.2, U_f=75%)

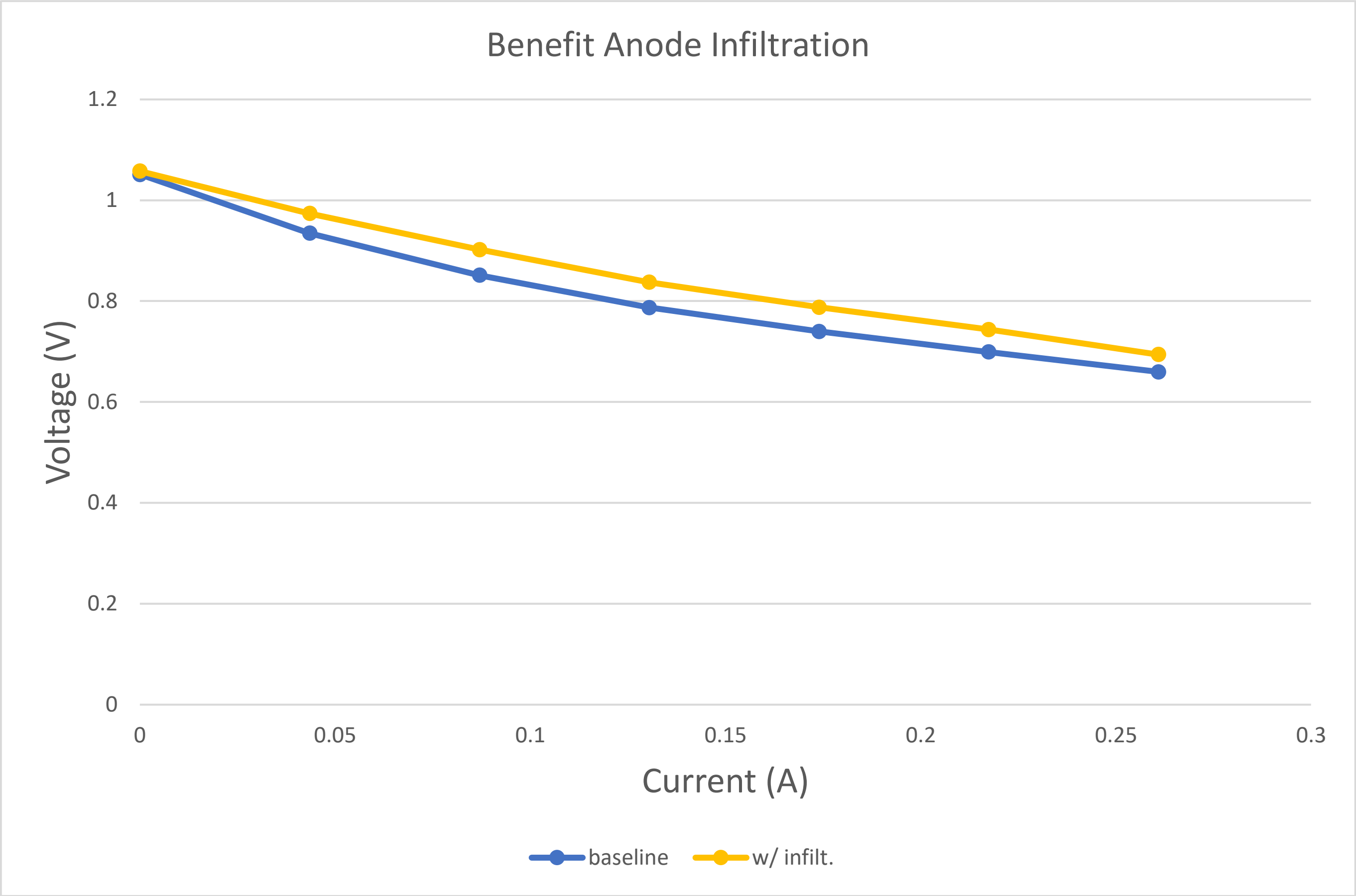


- **Electrolyte slurry formulated with different solids loading and applied with different translations speeds during spraying**
- **Clean room has been installed to minimize possible defects caused by the processing environment**



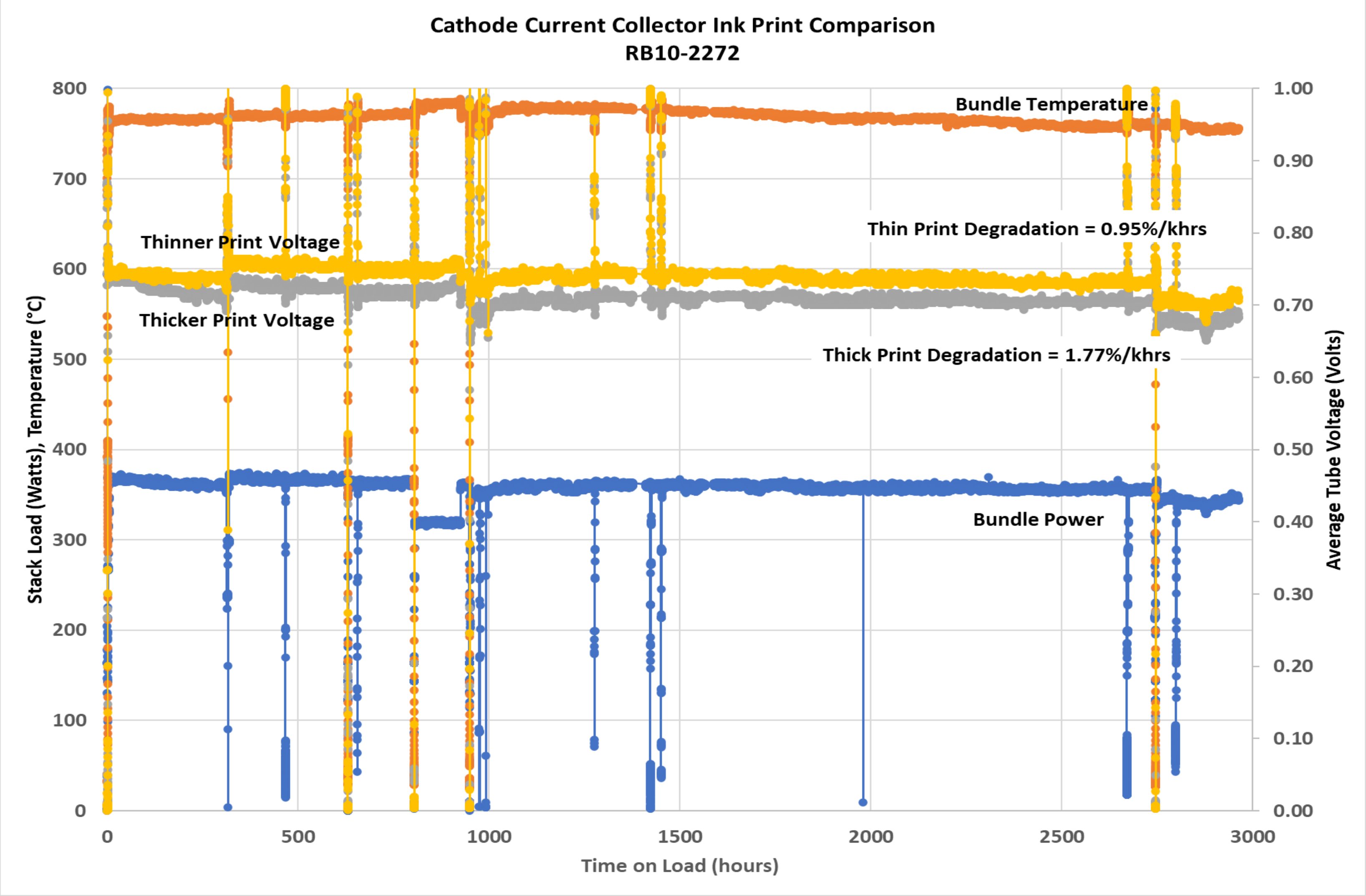
Anode Development

- Investigating ceria infiltration of anodes for lower temperature operation
- ~0.04V benefit for initial concentration, and number of infiltrations



Cathode Development

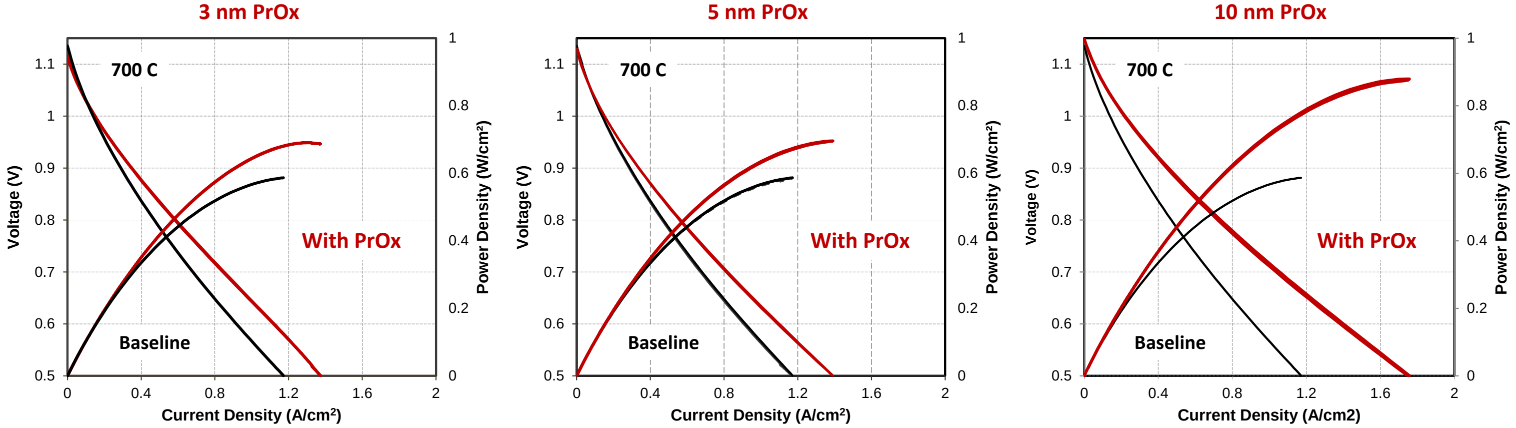
- New screen patterns evaluated for improved printing of Ag current collector mesh pattern
- Screen parameters optimized
- Long-term bundle test shows improved and stable performance
- New manufacturing specification being developed to reduce cost



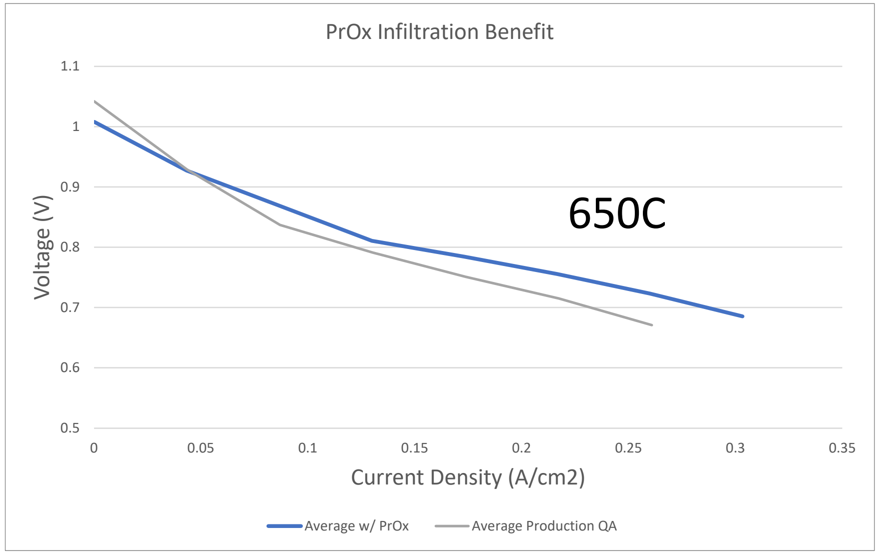
Cathode Development

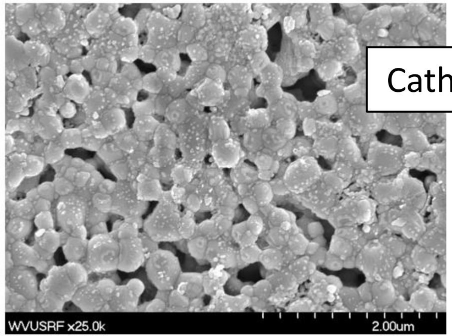
- Evaluate benefits of atomic layer deposition and solution infiltration
- PrO_x selected for evaluation
- ALD coated tubes to be supplied by WVU, comparison to SPS soln. infilt.

Univ. West Virginia (Dr. Xueyan Song) – PrOx applied by ALD



SPS Evaluation – Minor Improvement



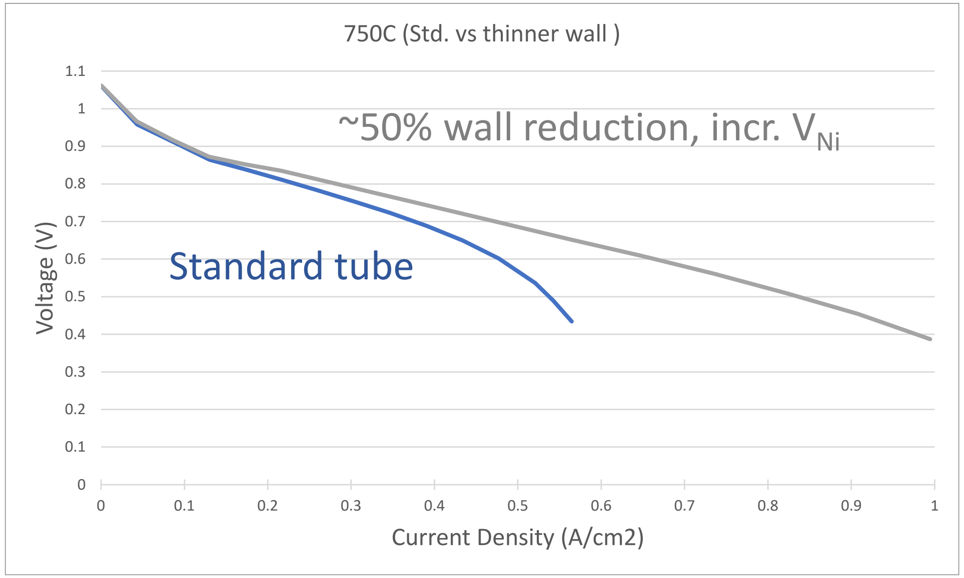


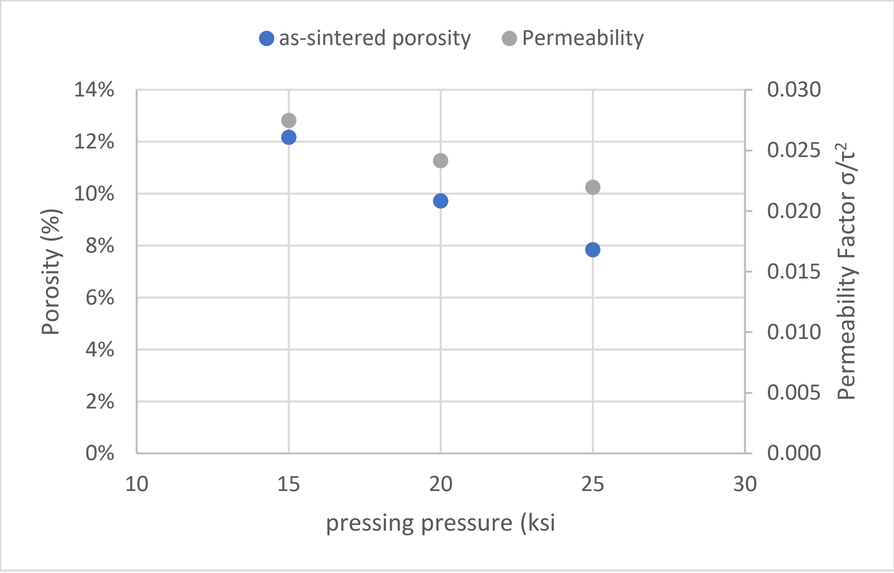
Cathode surface

Requires optimization of infiltration process to affect TPB

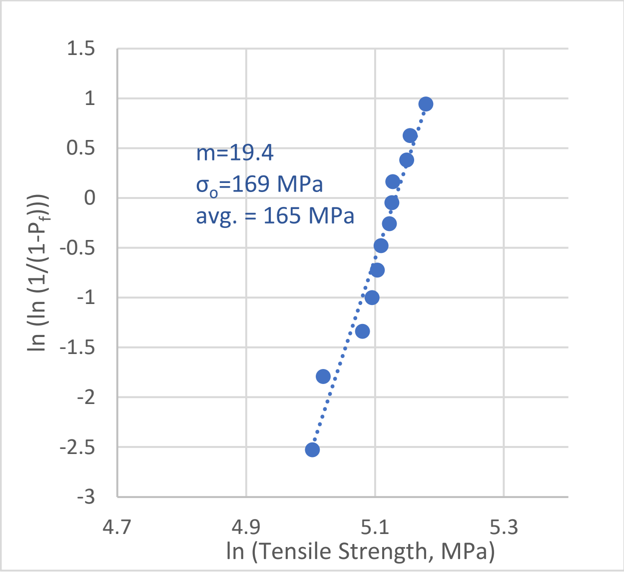
Tube Development

- Thinner tube wall and increased permeability to push out current density
- Further work to set specification: balance thickness, permeability, conductance while maintaining mechanical robustness





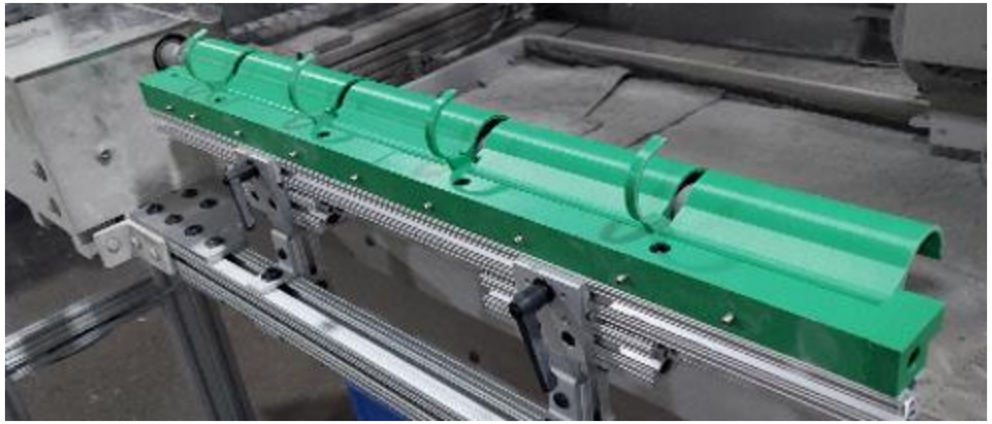
(σ/τ²) = porosity/tortuosity²

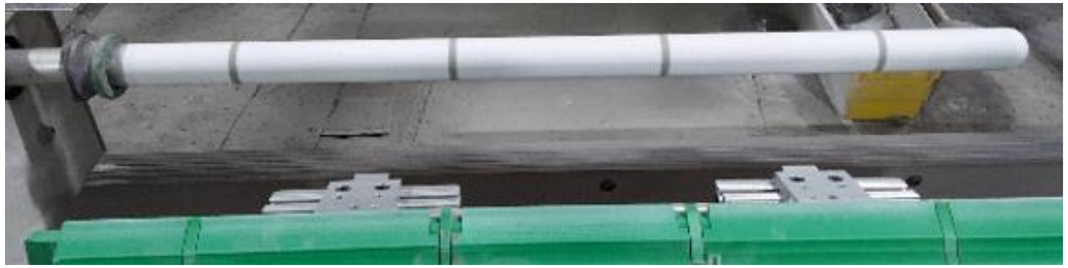


ASTM C1323 (C-ring)

Interconnect Development

Applying SYTN Bands on a Green Tube and Co-sintering





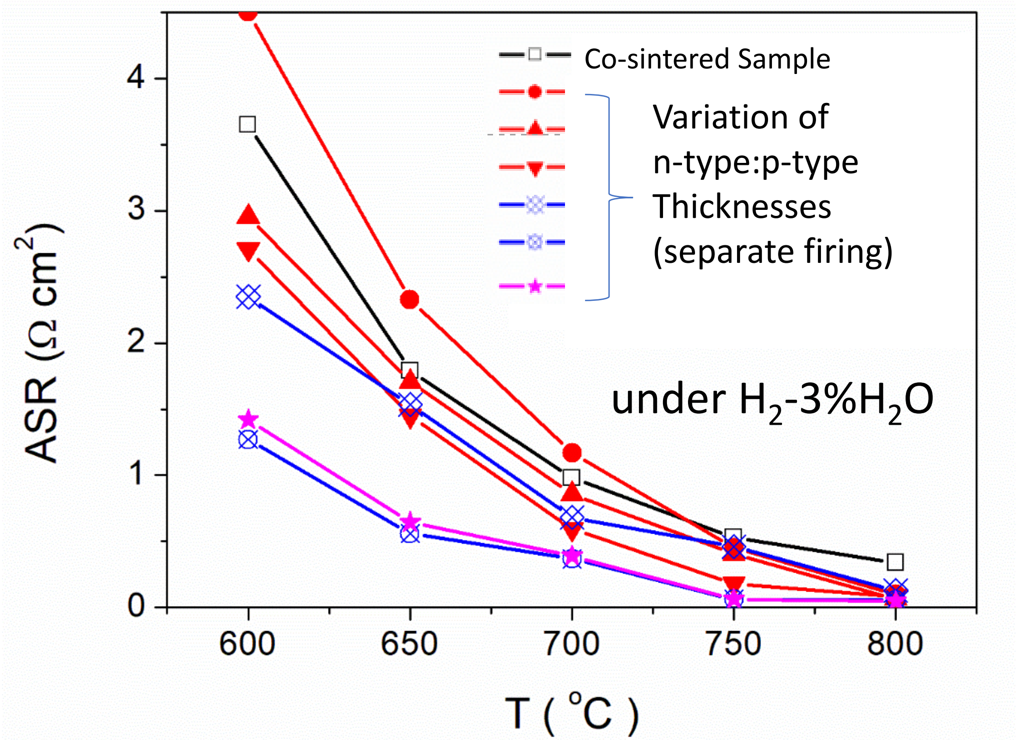
Applying the IC Bands on a Sintered and Grit Blasted Tube

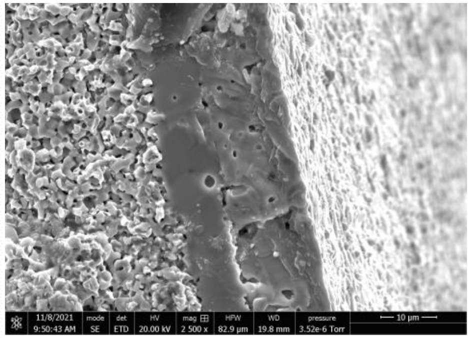
Applying the IC bands with a mask would allow for the elimination of the grit blast process, plasma spray process and a sintering step, post plasma spraying.

Co-Sintered Interconnect Materials

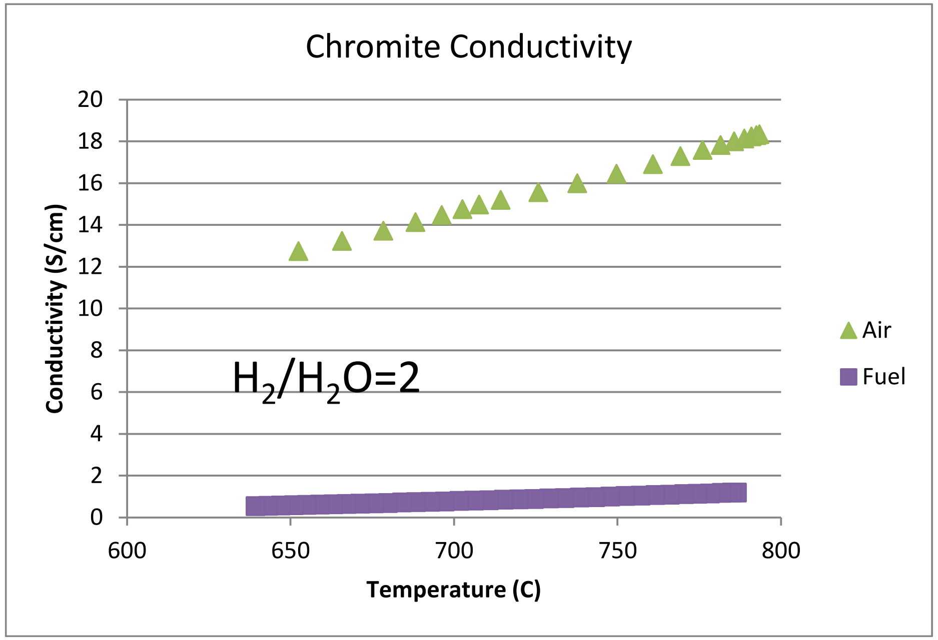
- Target interconnect ASR at 750C of ~0.06 ohm-cm^2. Bilayer interconnect studies by USC.
- Thin n-type and thick p-type meet AST targets under H_2-H_2O. Challenge of bilayer meeting target under realistic U_f
- Additional testing of USC bilayers at SPS as function of layer thickness and U_f
- Evaluating sinterable chromites

Univ. South Carolina (Dr. Kevin Huang)





SPS Material Studies



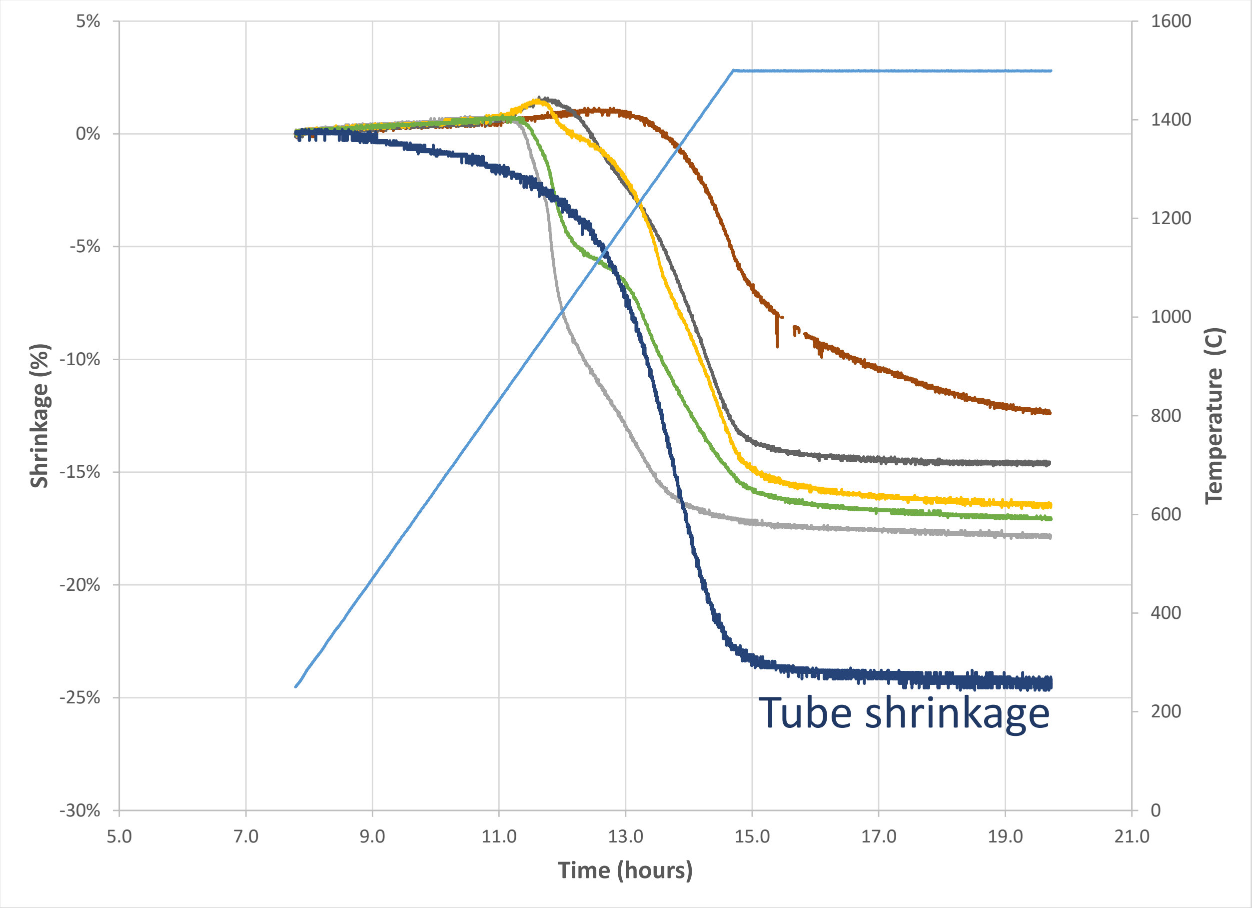
Manufacturing Development

Shrinkage Measuring System

- **Developed for tube process control**
- **Also useful for co-sintering material development**

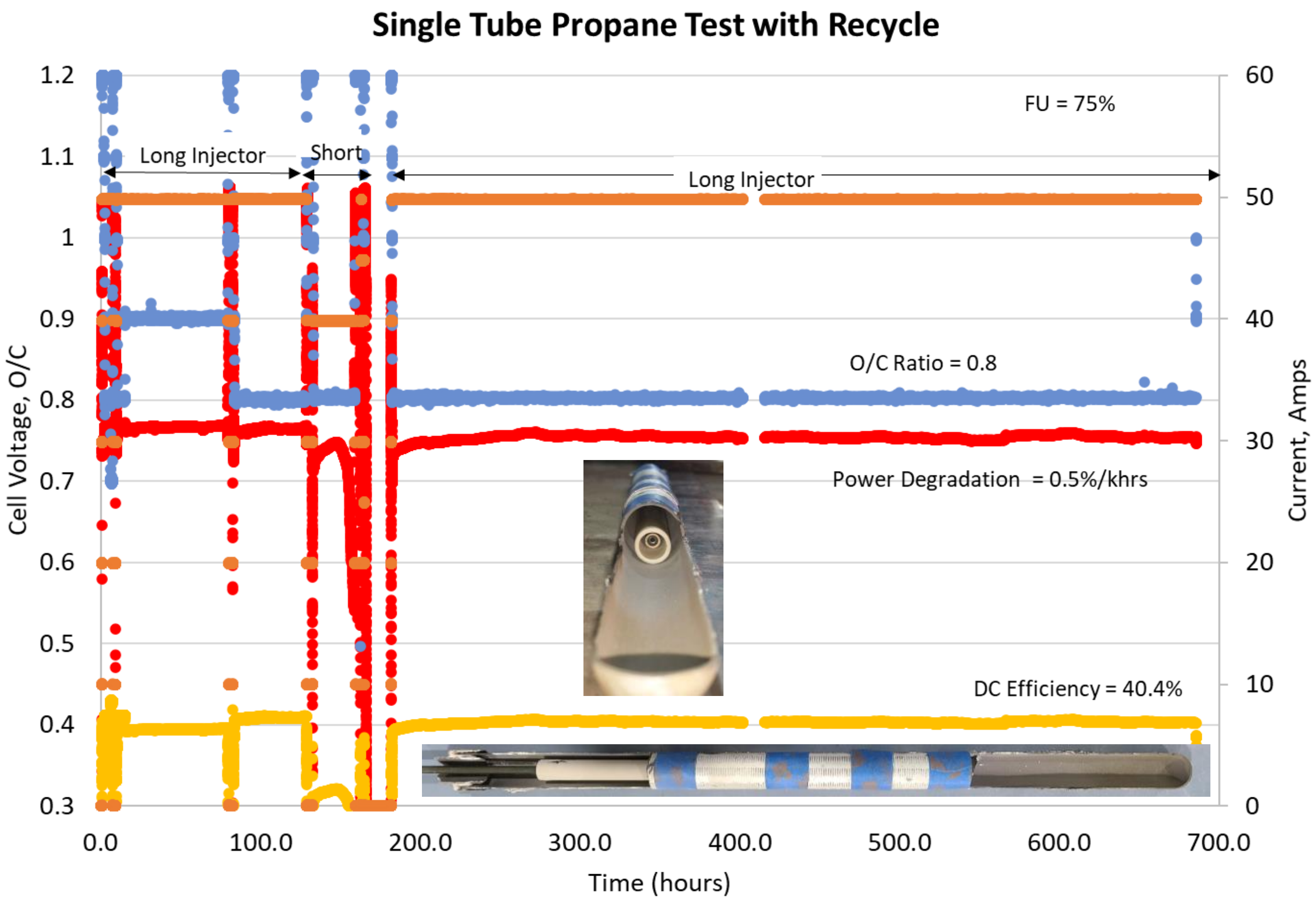
Critical for qualifying new co-sinterable materials with tube changes

Chromite Interconnect Material Candidates



Internal Reforming – Low O/C propane testing

- An internal anode recycle arrangement developed which allows low O/C
- Efficiency increased to 40% with an O/C of 0.8 – stable over 500 hours without carbon on a single tube
- Transferred to 1500W bundle test, which demonstrated 39% efficiency at this O/C and 70% UF (CRREL program*)



*Army ERDC/CRREL Contract W913E52020002

Lower Temperature Technology Integration and Demonstration

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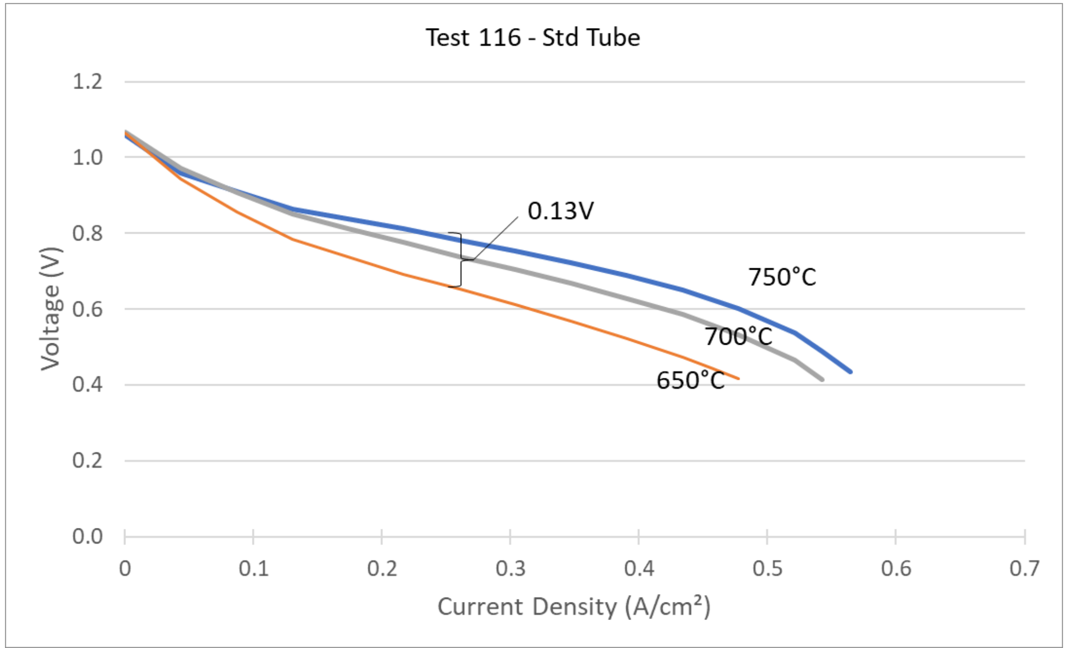
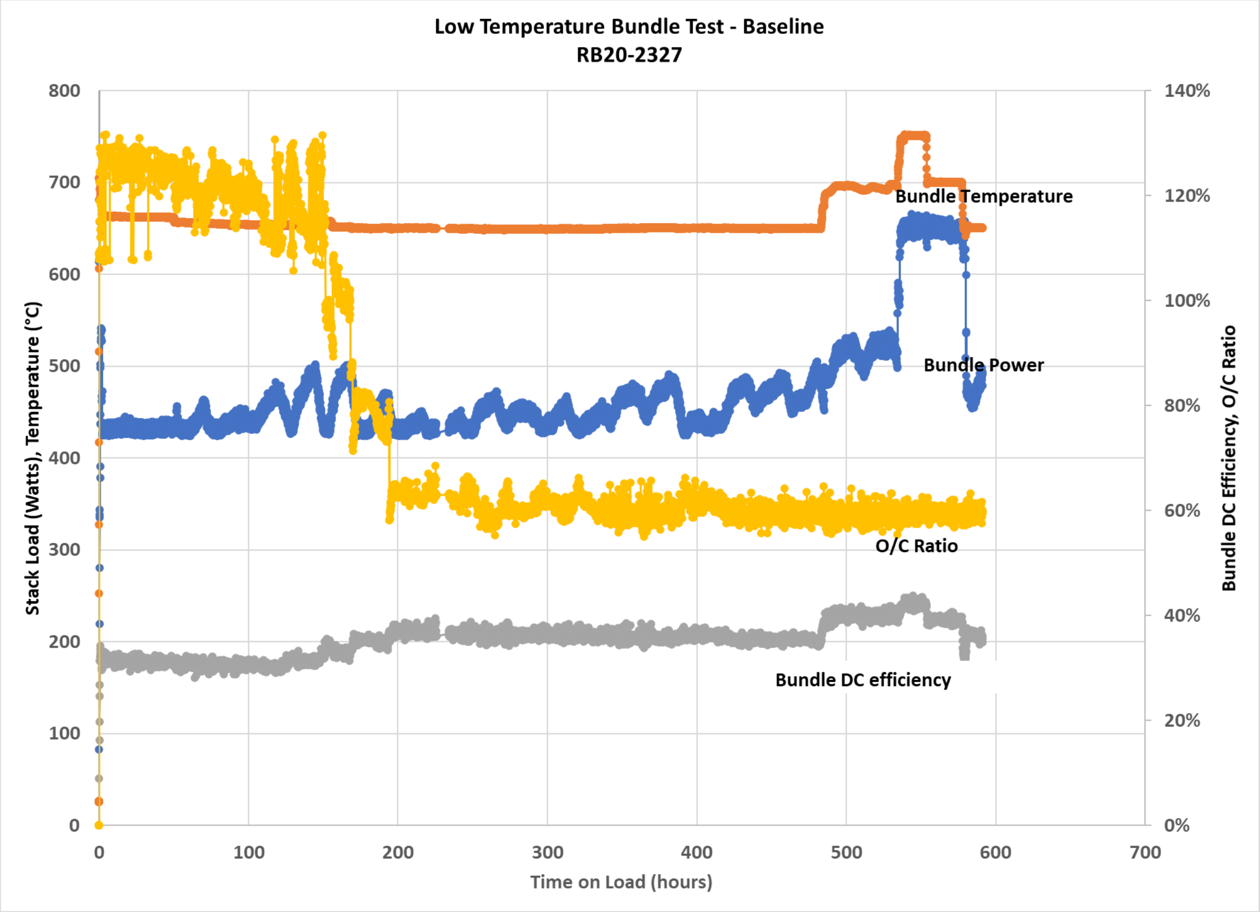
- A legacy system has been converted to run at temperatures down to 650°C average
- Baseline production tubes running at low O/C = 0.6 on natural gas.
- Final selection of technologies will go into this test stand next month





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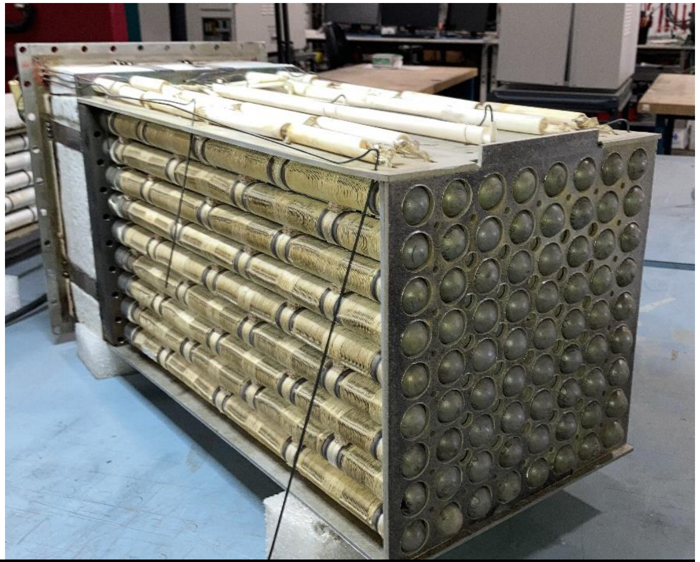
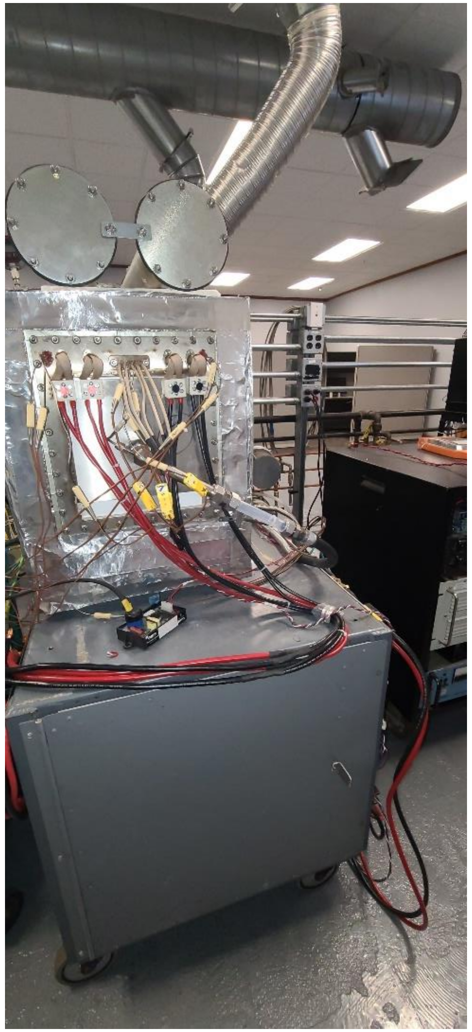
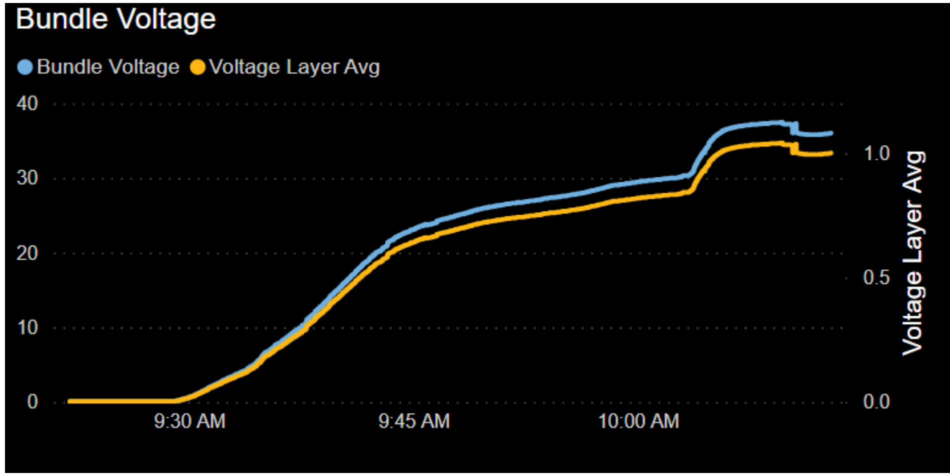
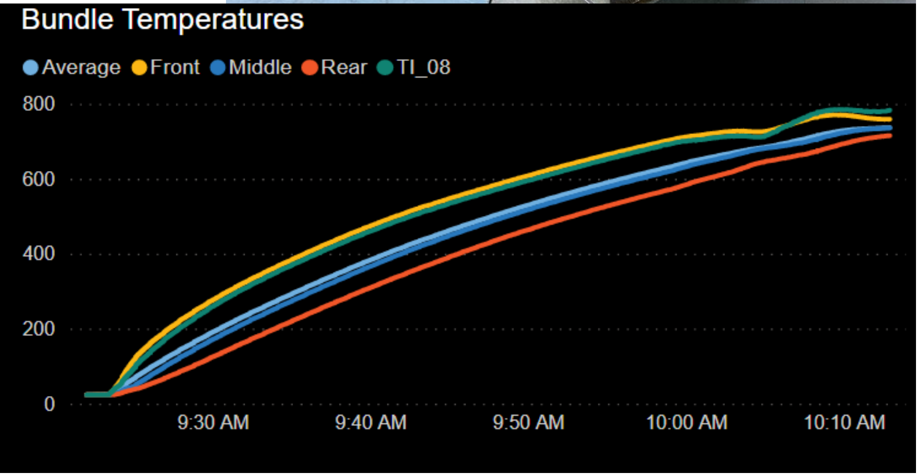
2.5kW Final Demonstration

- SPS is re-commissioning a rig to test a 2.5kW stack
- Two different systems available, both of which have been made functional.
- Unit light-off and warm-up demonstrated
- An unresolved controls issue has prevented going to full load









Summary

- SPS operation has re-established production, R&D, and field service operations
- Testing platforms have been brought on-line to test improvements to cell technology
- Current collection designs being cost-reduced through reduction of silver usage and elimination of plasma spray process
- Looking at improvements which can provide 0.13V at 650°C to maintain high efficiencies

Acknowledgement

- Special thanks to DOE project managers Shailesh Vora, Jason Montgomery and the entire SOFC program management team

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