

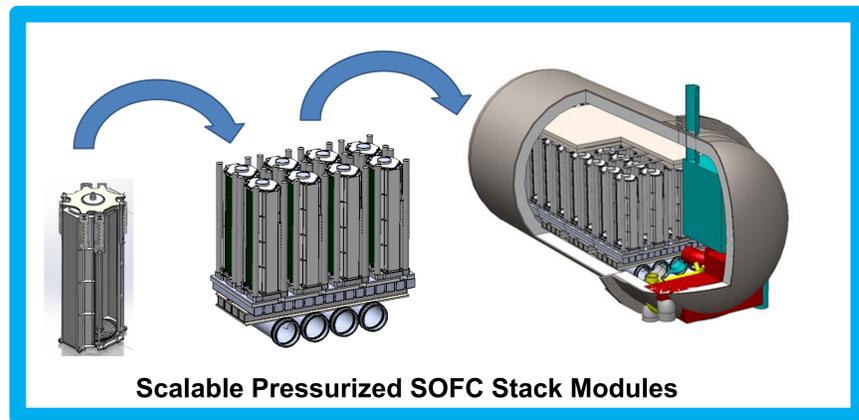
Adaptive SOFC for Ultra High Efficiency Power Systems

Fred Jahnke, Hossein Ghezel-Ayagh, Eric Tang, Michael Pastula, Casey Brown: FuelCell Energy (FCE)

Jack Brouwer: University of California, Irvine (UCI)

Goal:

Develop a novel Solid Oxide Fuel Cell stack and module technology adaptable to support ultra-high efficiency hybrid power plants achieving greater than 70% electric efficiency based on the lower heating value of natural gas



Approach:

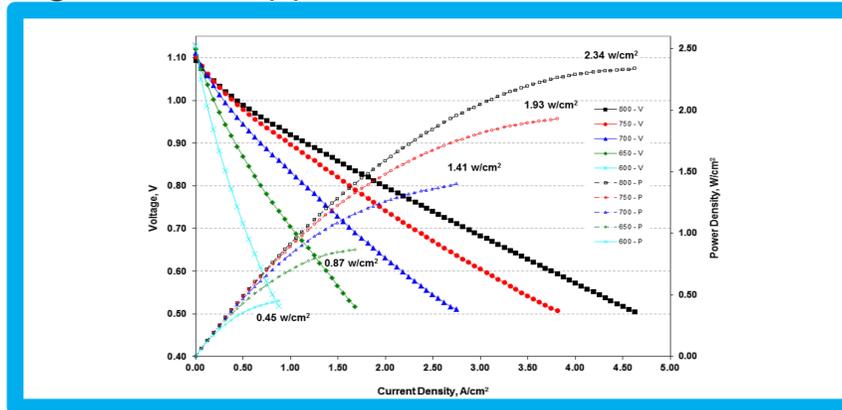
Advance anode-supported cell and stack technology capable of pressurized operation (up to 4 bar) with flexibility for scale-up and integration with a variety of engines

Significant progress has been achieved in SOFC core material set

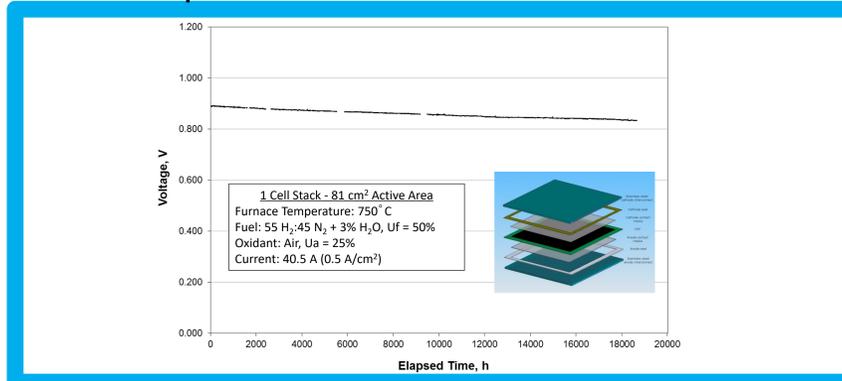
Component	Materials	Thickness	Porosity	Process
Anode	Ni/YSZ	0.3 - 0.6 mm	~40%	Tape casting
Electrolyte	YSZ	5 - 10 μm	< 5%	Screen printing
Cathode	Conducting ceramic	10 - 50 μm	~30%	Screen printing

State-of-the-Art:

SOFC technology with high power density has been tested at atmospheric pressure, achieving $>2.3 \text{ W/cm}^2$ at 4.7 A/cm^2



Long term performance of anode-supported cell has shown low degradation in atmospheric pressure operation



The Compact SOFC Architecture (CSA) platform will be utilized as the building block for the stack modules

350 cell CSA Stack	
250 mW/cm ²	
Gross Power (kW)	7.1
Power to Weight Ratio (W/kg)	> 500
Power to Volume Ratio (W/L)	> 700

45-cell CSA Stack in Test Station

CSA offers low material content & low cost stack for commercialization

FCE has been successful in scale-up, manufacturing and commercialization of fuel-cell and electrochemical systems

- Pilot Manufacturing of Solid Oxide Fuel Cell (SOFC) and stacks
- Tape casting/Screen Printing/Co-firing (TSC) fabrication process has been scaled up to 1000 cm²
- Existing production volumes of 500 kW annually

Resolving Remaining Challenges:

- In-stack reforming of natural gas at high pressure
- Cr poisoning of cathode due to high steam partial pressure
- Materials degradation and reduced stability at high pressure
- Imparting robustness to tolerate pressure differentials
- Installed cost of \$1800/kW for pressurized systems
- Impact of system dynamics and severe transients

Technology Applications:

Low cost and ultra high efficiency systems using adaptive SOFC combined with other power cycles provide a superior alternative for distributed electricity generation in near term markets:

- On-site
- Grid-support

50 kW SOFC System 200 kW SOFC Power Plant 300 kW Hybrid MCFC/Capstone MTG