Low Cost PEM Fuel Cell Metal Bipolar Plates

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Project ID# : FC023

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Overview

Timeline

- Project Start Date: Sept. 1, 2009
- Project End Date: Aug. 31, 2011
- Percent Complete: 30%

Barriers

- Barriers Addressed : Bipolar Plate Durability and cost
  - Cost: < $3/kW (2015)
  - resistivity < 10 mohm-cm^2
  - corrosion < 1 x10^{-6}A/cm^2

Budget

- Total Project Funding: $2,525,063
  - DOE Shares: $2,000,504
  - Contractor Shares: $525,013
- Funding Received in FY09: $125,475
- Funding for FY 10: $1,840,156

Partners

- Gas Technology Institute
- Oak Ridge National Laboratory
- SUNY, Stony Brook
- IBIS Associations, Inc.

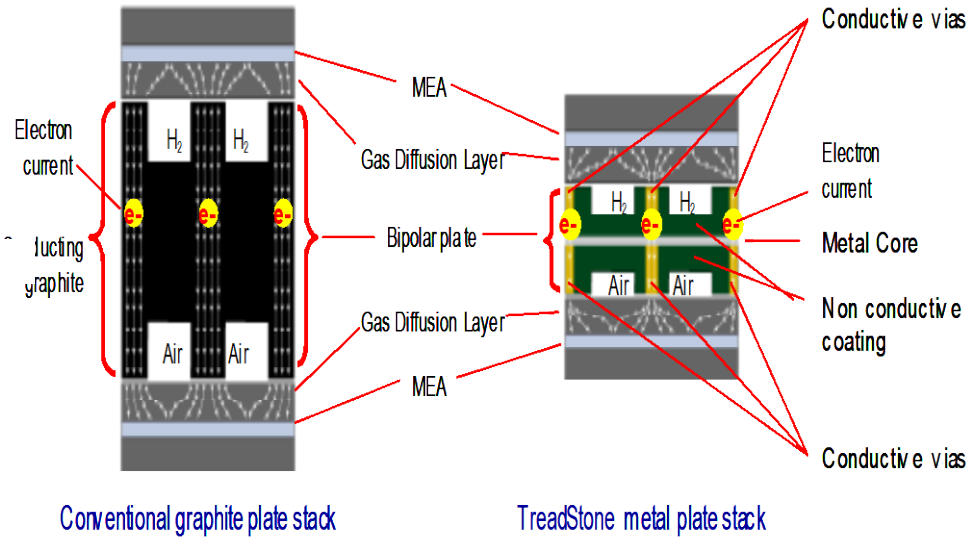
Relevance

Objective

- Objective (June 09 - May 10): Develop low cost metal bipolar plates to meet 2015 performance target and cost target (<$3/kW)
  - Develop C-steel, reduce or eliminate Au usage.
  - Demonstrate our metal plate applications in portable, stationary and automobile fuel cell stacks.

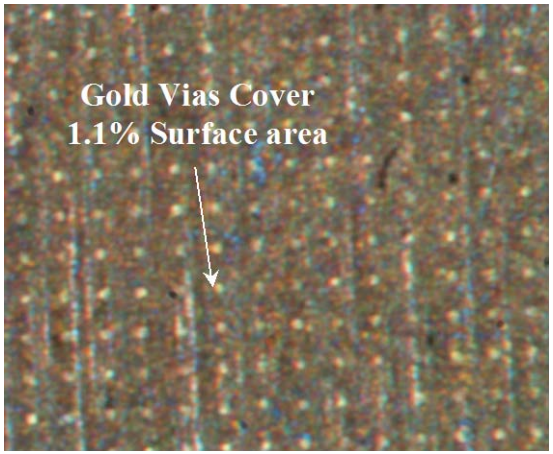
Characteristic	Unit	2010 Target	2015 Target
Cost	$ /kW	5	**3**
Corrosion	mA/cm^2	<1	**<1**
Resistivity	$ohm.cm^2$	<0.01	**<0.01**

Approaches

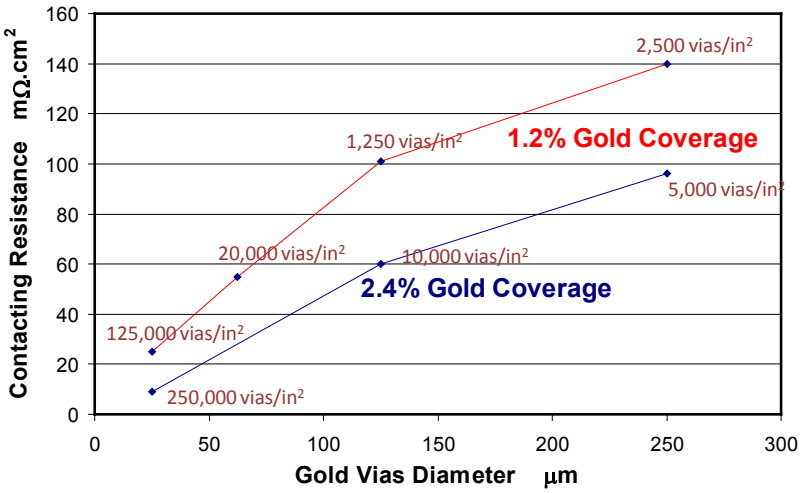


Conventional graphite plate stack

TreadStone metal plate stack



- Use small conductive, corrosion resistant materials as conductive points (conductive vias) to cover a small portion of metal surface
- Use non-conductive, corrosion resistant materials to cover majority surface of the metal plates



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Approach

Plan and Milestones (FY09 & FY 10)

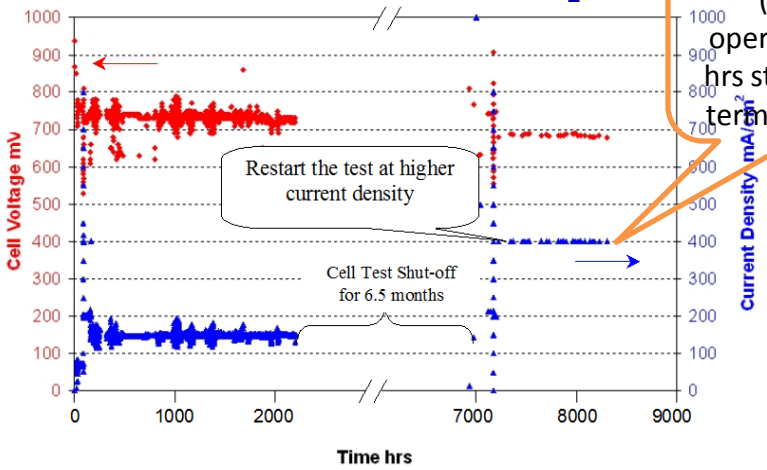
Milestones	Month/Year	% Comp.
Task 1: Conductive Via Processing Development		
• Palladium Vias Processing Development	12/09	100%
• Carbon Nanotube Conductive Via Development	4/10	50%
• Conductive Carbide Via Development	8/10	30%
Task 2: Carbon Steel and Aluminum Based Plates Development		
• Carbon Steel Plate Baseline Process Demonstration	03/10	100%
• Carbon Steel Plate Process Development	08/10	20%
Task 3. Fuel Cell Stack Application Demonstration		
•2 00W Stack Initial Performance Test	02/10	100%
• Optimized 200W Stack Performance Demonstration	08/10	0%
• 1kW Stack Initial Performance Test	02/11	100%
• Metal Plates Demonstration for Auto. Applications	08/11	30%

Technical Accomplishments

Previous Accomplishment

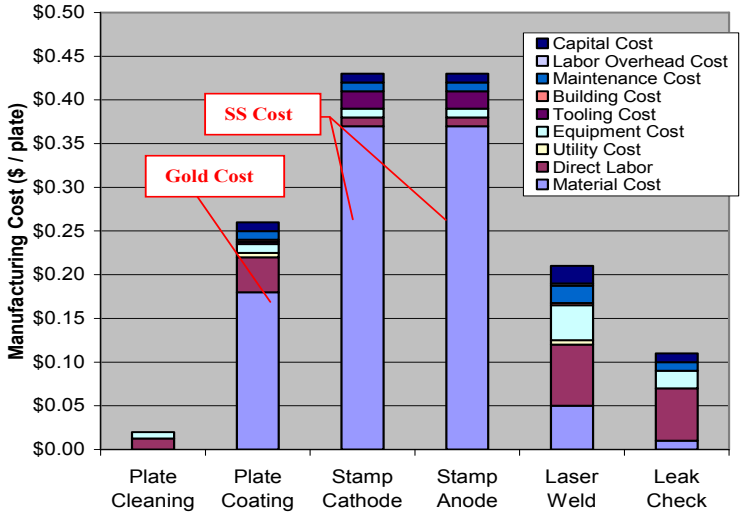
- Proved the concept of TreadStone's metal plate technology
- Demonstrated in small single cell long-term operation
- Developed a low cost fabrication process for corrosion resistant metal plates

Single Cell 16cm^2, coated SS, H_2/air



- Bipolar plate cost: $1.41/plate
  -- $3.53/kW (based on 1000mW/cm^2)
- Meet 2010 Target < $5/kW
- **Need Improvements to meet 2015 Target < $3/kW**

Cost Breakdown of SS Based Plates



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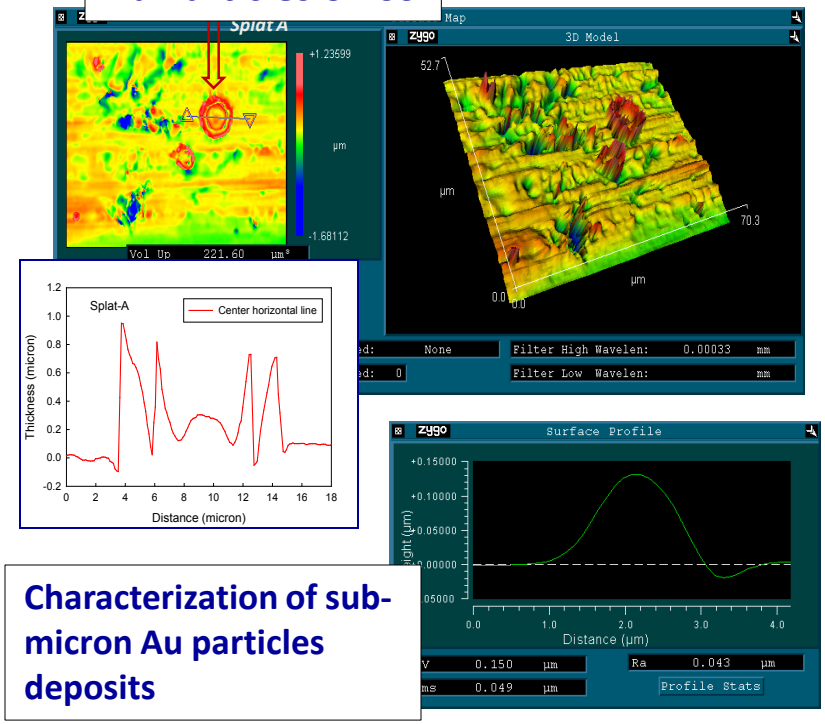
Technical Accomplishments

Fabrication Process Charaterization and Optimization

3-D Au Particle Morphology

(Detail & Statistical)

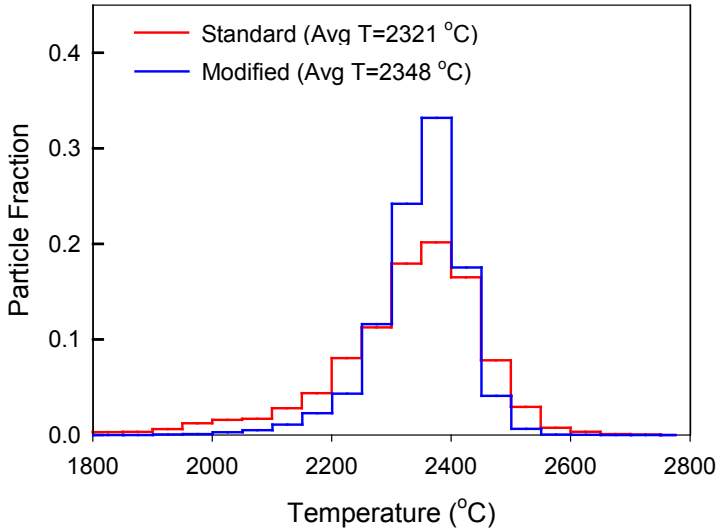
Au Particles on SS

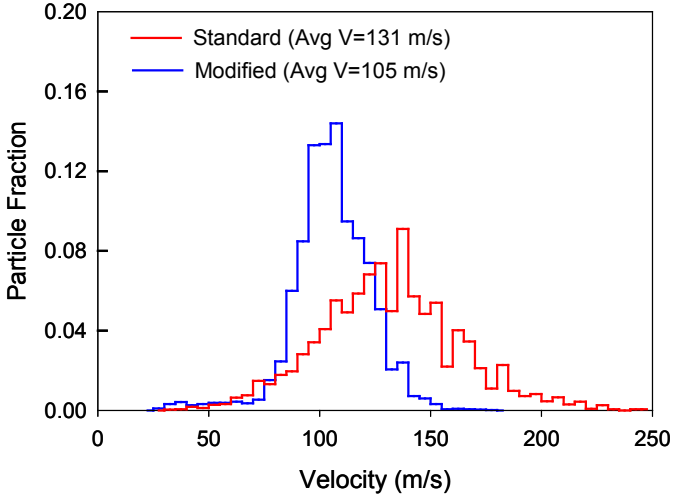


Characterization of sub-micron Au particles deposits

On-line Process Optimization

(In-situ & informative)





- Understanding relationships between process control and particle microstructure to improve performance

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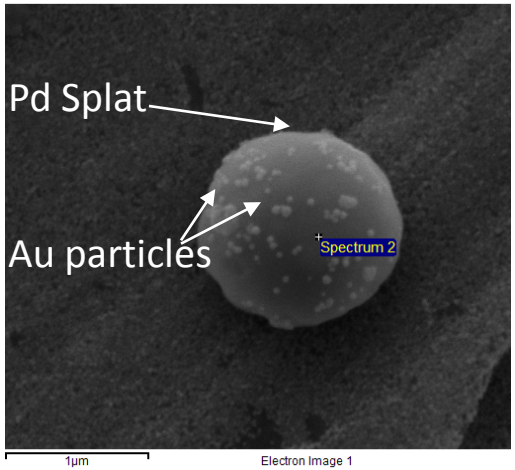
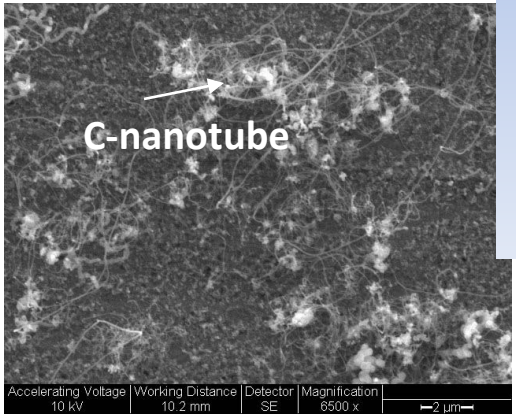
Technical Accomplishments

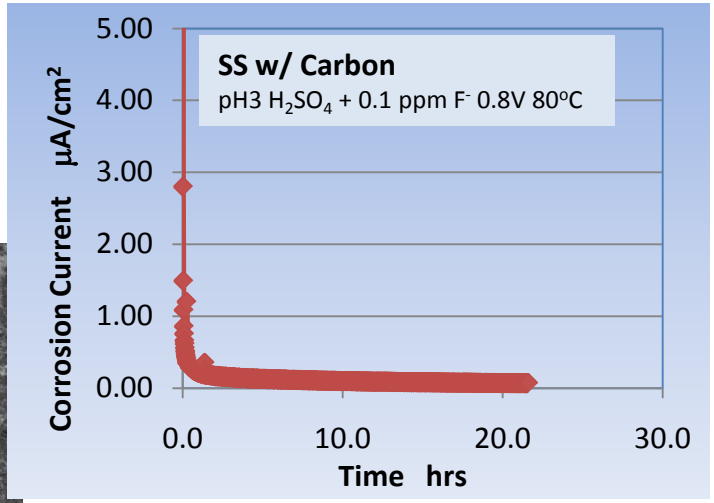
Lower Cost Material Development

Pd dots with Au on surface

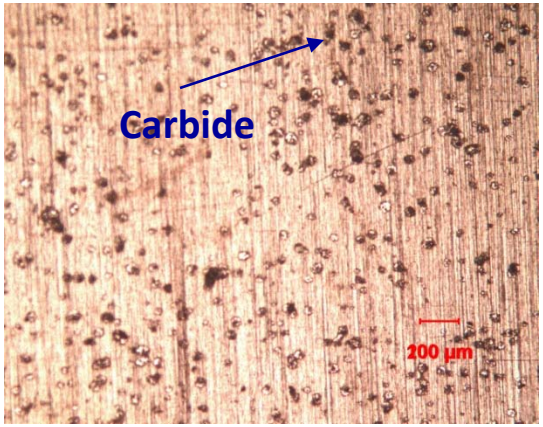


Carbon nanotube on SS





Carbides particles on SS



- Low Cost Material Processing Technologies have been developed
- Performance Evaluation is on-going

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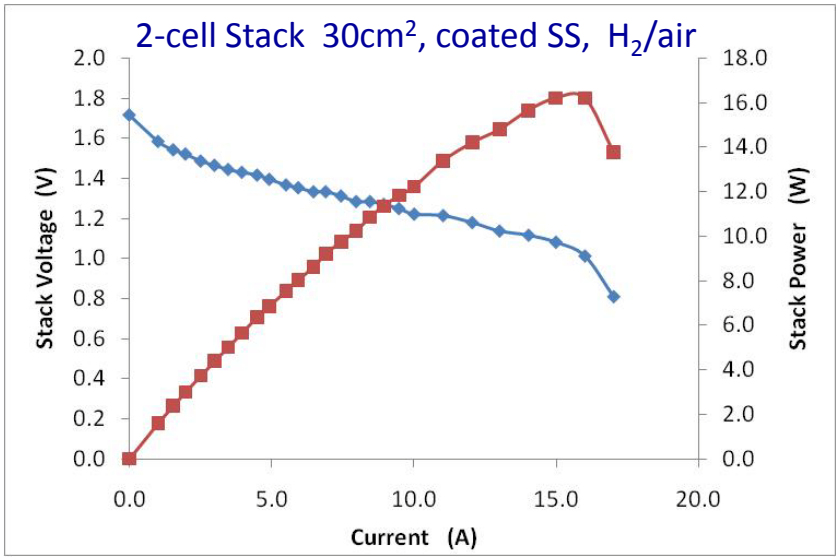
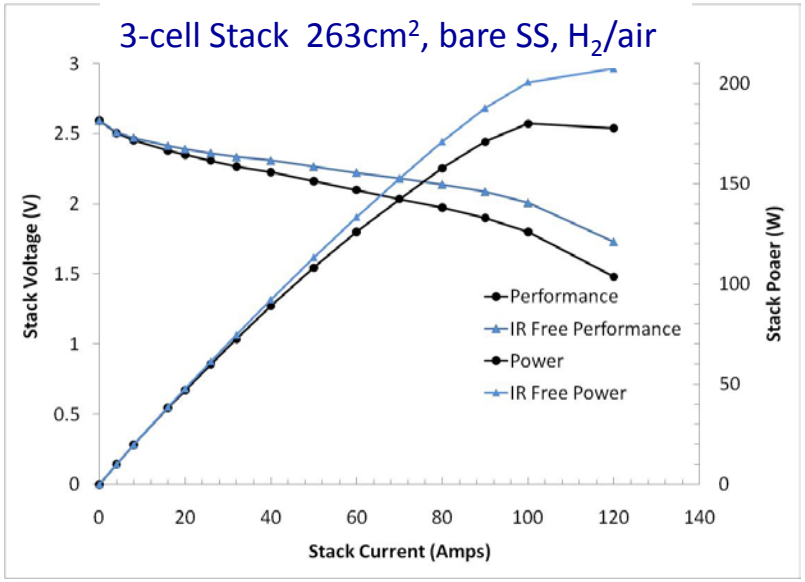
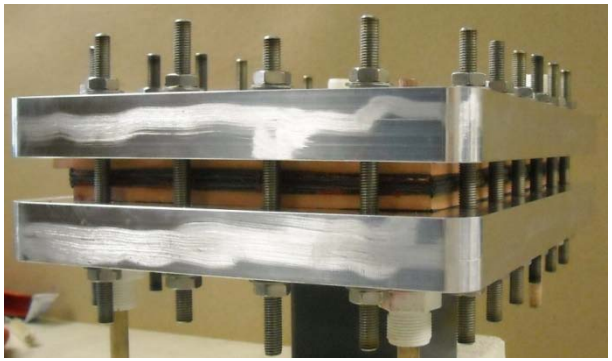
Technical Accomplishments

Stack Demonstration for Portable and Stationary Applications



The designs of the 200W portable and 1kW stationary stacks are finished and evaluated.





263cm² 3-cell, Stack

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Technical Accomplishments

TreadStone SS Plate w/Au-Dots Evaluation at Ford

Attribute	Metric	Unit	2015 DOE Target	Ford Data on Au-Dots
Corrosion anode	**Current density at active peak in CV**	$\mu A/cm^2$	<1	No active peak
Corrosion cathode	**Current density at 0.8 V_{NHE} in potentiostatic expt.**	$\mu A/cm^2$	<1	~0.1
Area Specific Resistance	**ASR (measured through plane) at 6 bar contact pressure** (includes both side surface; doesn't include carbon paper contribution)	$mOhm.cm^2$	<20	8.70 (as-recd flat samples)
Electrical Conductivity	**In-plane electrical conductivity (4-point probe)**	S/cm	>100	34 kS/cm
Formability	**% elongation (ASTM E8M-01)**	%	>40%	53(|| to RD*)/ 64 (⊥ to RD)
Weight	**Weight per unit net power** (80 kWnet system)	Kg/kW	<0.4	<0.30

*RD: Rolling Direction

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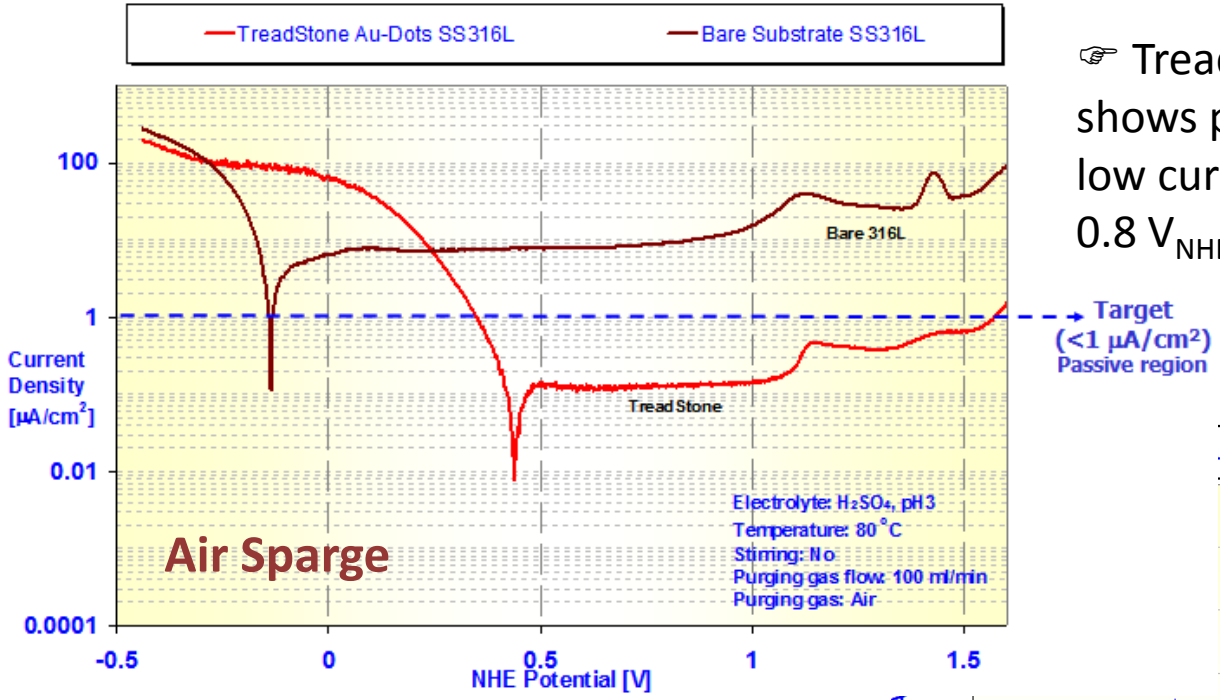
Ford

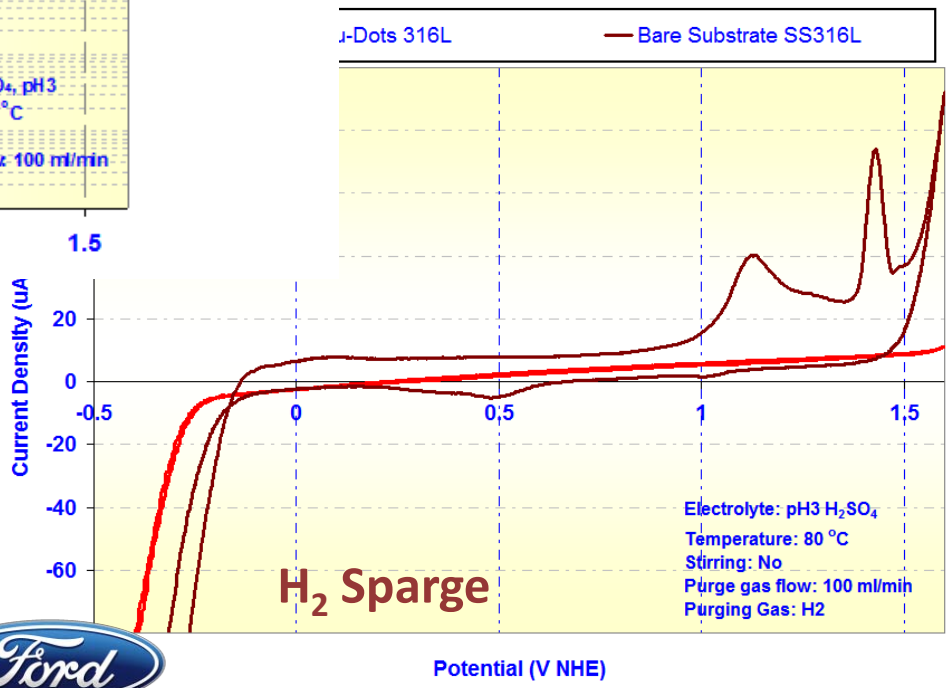
Technical Accomplishments

Cyclic Voltammetry of SS Plate w/gold dots at Ford



☞ TreadStone SS w/Au-Dots plate shows passive region up to 1 V, and low current density (< 1 uA/cm2) at 0.8 V_{NHE} (air).

☞ TreadStone Au-Dots material do not exhibit any active peaks around 0 V in anode (H_2) condition



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Technical Accomplishments

Short Stack in-situ Testing at Ford

- TreadStone SS plates w/ Au dots were tested in-situ for durability at Ford Motor Company.
- Ford designed metallic bipolar plate w/SS316L as base substrate,
  - *300 cm^2 active area, with TreadStone's coating*
  - A 10-cell, 2.5 kW short stack was assembled
- Durability Cycle:
  - The stack is being tested for durability utilizing durability cycle (which includes FTP cycle along with others) mimicking real world driving conditions.
- Results
  - To date stack has achieved 800 hrs and continue to operate.

Ford short stack with metal bipolar plates

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Ford

Collaborations

Gas Technology Institute

- Stack Design and Demonstration using Metal Plates for Portable and Stationary Applications

Dr. Chinbay Fan

SUNY, Stony Brook

- Thermal Spray Process Development for Metal Plate Fabrication

Prof. Sanjay Sampath

Oak Ridge National Lab.

- Corrosion Mechanism and Failure Model Study

Dr. Dane Wilson

IBIS Associates, Inc.

- Fabrication cost analysis

Mr. Tony Mascarin

Industrial Partners

- Metal plate evaluation in their specific applications

Proposed Future Work

- **FY10**
  - Process optimization and performance evaluation of C-nanotube, carbide conductive vias and carbon steel based plates.
  - Fabrication cost analysis.
  - Corrosion mechanism and failure mode study
  - Optimized 200W portable stack demonstration.
  - 1 kW stationary initial demonstration.
  - Further collaboration with industrial partners.
- **FY11**
  - Scale up the fabrication process.
  - Full performance evaluation of the plates produced with the scale-up process.
  - Aluminum based plate development.
  - Optimized 1 kW stationary stack demonstration.
  - Demonstration for automobile applications.

Summary

- ***Relevance:*** Reduce the metal bipolar plate cost to meet FY15 requirements.
- ***Approach:*** Use lower cost material and Treadstone's proprietary metal plate design and low cost fabrication technology.
- ***Accomplishment:*** Developed the fabrication process for low cost material metal plates; demonstrated TreadStone's metal plates in stacks for portable, stationary and automobile applications; long-term durability tests are on going.
- ***Collaborations:*** Closely work with other team members to ensure the on-time, on-budget delivery; actively work with industrial partners to accelerate the technology commercialization.
- ***Future Work:*** Optimize and scale up the low cost metal plate fabrication process; demonstrate the long term stable operation in portable, stationary and automobile stacks.