Low Cost PEM Fuel Cell Metal Bipolar Plates

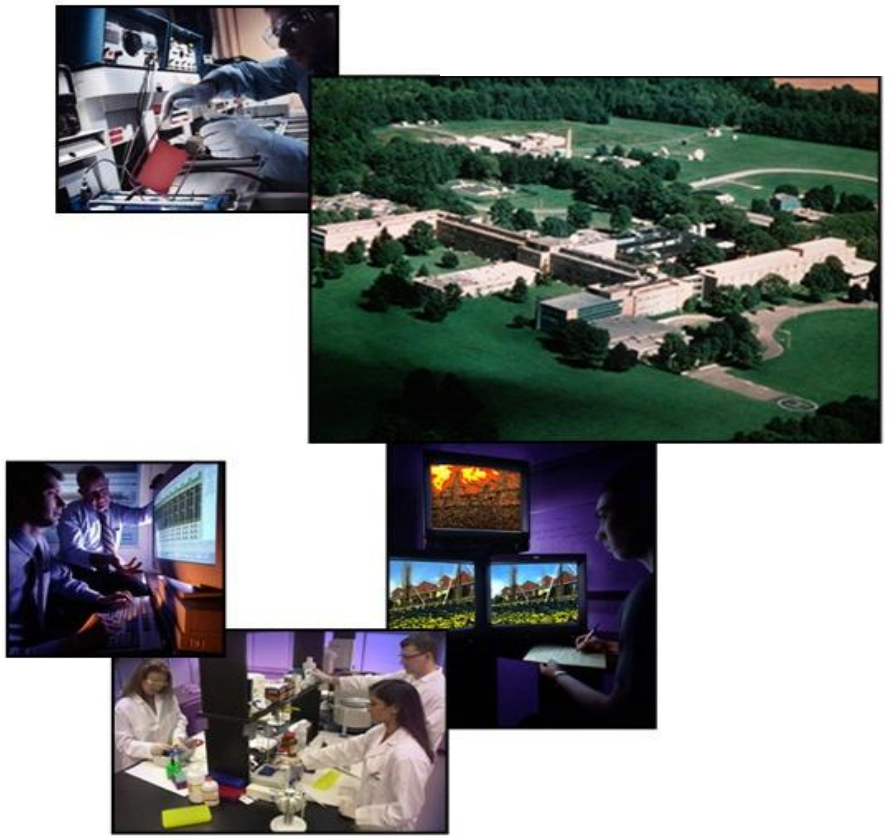
CH Wang
TreadStone Technologies, Inc.

Fuel Cell Project Kickoff Meeting
Oct. 1, 2009

TreadStone Background and Mission

Corporate Background

- *TreadStone is a small business technology spin-out of Sarnoff Corporation in March 2006*
- *The metal corrosion protection technology has been developed for over 5 years. The US Patent (US 7,309,540) was issued on Dec. 8, 2007. More patent applications have been filed.*
- *The technology has been evaluated by various clients and used in portable fuel cell power systems.*



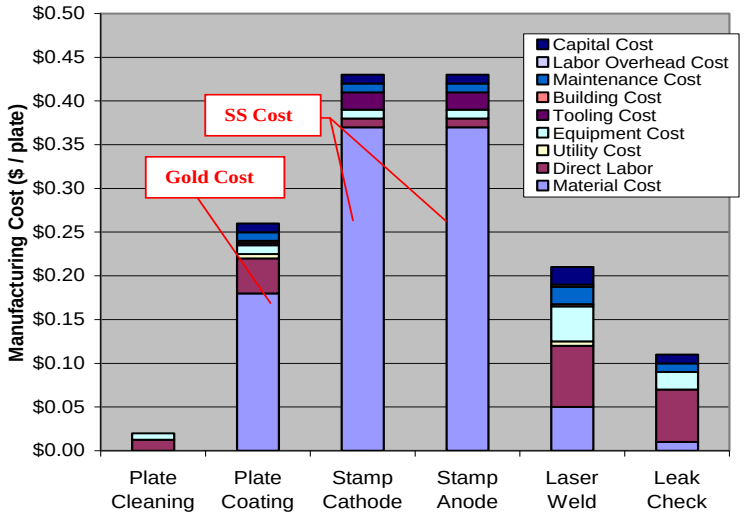
Corporate Mission

Achieving continuous growth in profits, revenue and net worth through the commercialization of new technologies for the energy market.

Project Objectives

- Overall Objective: Develop lower cost metal bipolar plates to meet performance target and 2015 cost target (<$3/kW)
  - Develop C-steel or Al based metal bipolar plates.
  - Reduce or eliminate Au usage.
  - Optimize the process for large scale manufacture.
  - Demonstrate our metal plate application in portable, stationary and automobile fuel cell systems.

Cost Breakdown of TreadStone's Current SS Plate



- 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

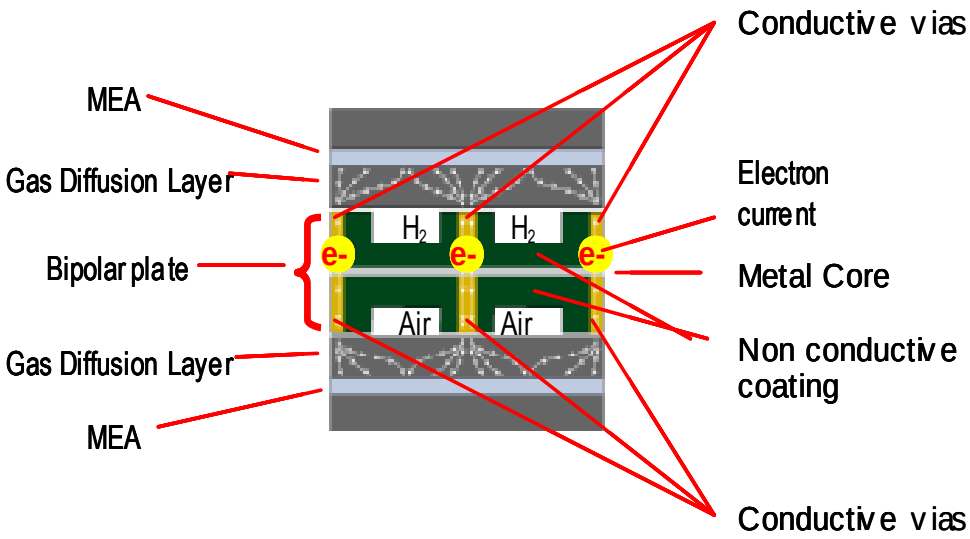
TreadStone Technologies, Inc.

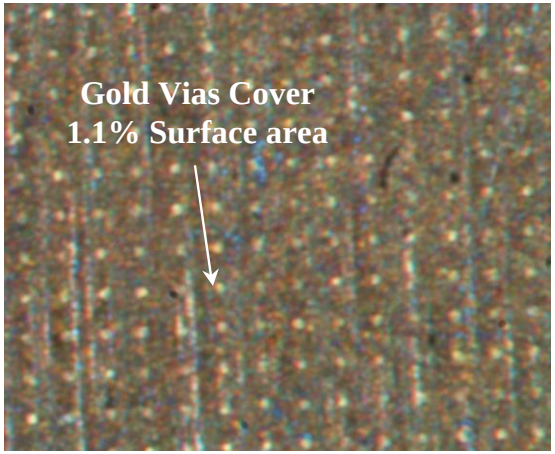
Technical Targets

Characteristic	Unit	2010 Target	2015 Target
Cost	**$ /kW**	**5**	**3**
Weight	kg/kW	<0.4	<0.4
H_2 Permeation Flux	$cm^3.sec^{-1}.cm^{-2}$	$<2 \times 10^{-6}$	$<2 \times 10^{-6}$
Corrosion	**$\mu A/cm^2$**	**<1**	**<1**
Electrical Conductivity	S /cm	>100	>100
Resistivity	**οημ.cm**	**<0.01**	**<0.01**
Flexural Strength	MPa	>25	>25
Flexibility	% deflection at mid-span	3-5	3-5

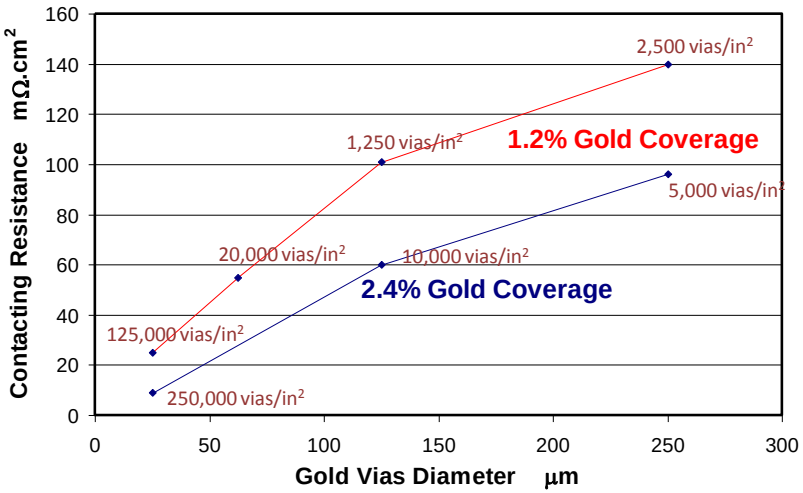
- It is proven that metal plates can reduce the fuel cell stack weight and volume.
- Key barriers for metal bipolar plates: corrosion resistance and resistivity at low cost

Technical Approaches

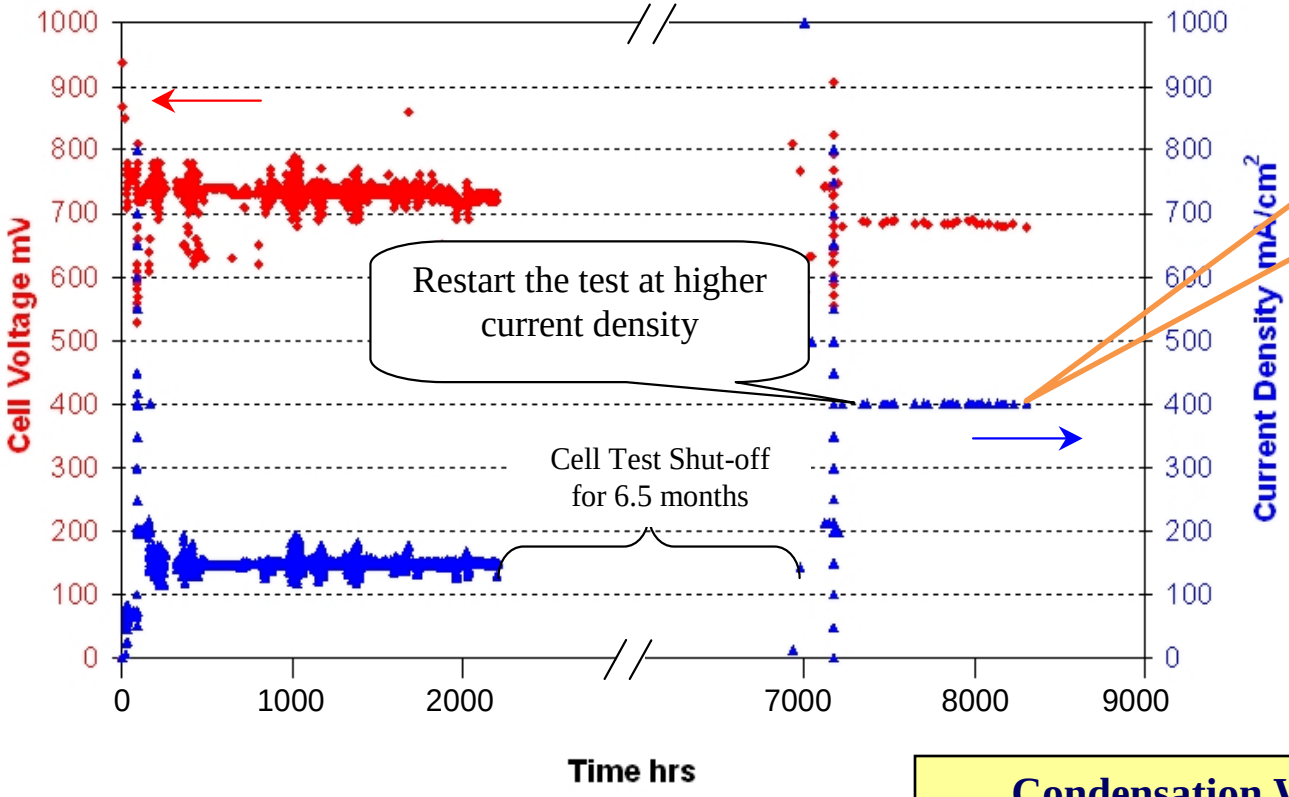




- Use small conductive, corrosion resistant materials as conductive points (conductive vias) to cover a small portion of metal surface
- Use non-conductive, corrosion resistant materials to cover majority surface of the metal plates



Single Cell Performance using Treadstone's SS Plate



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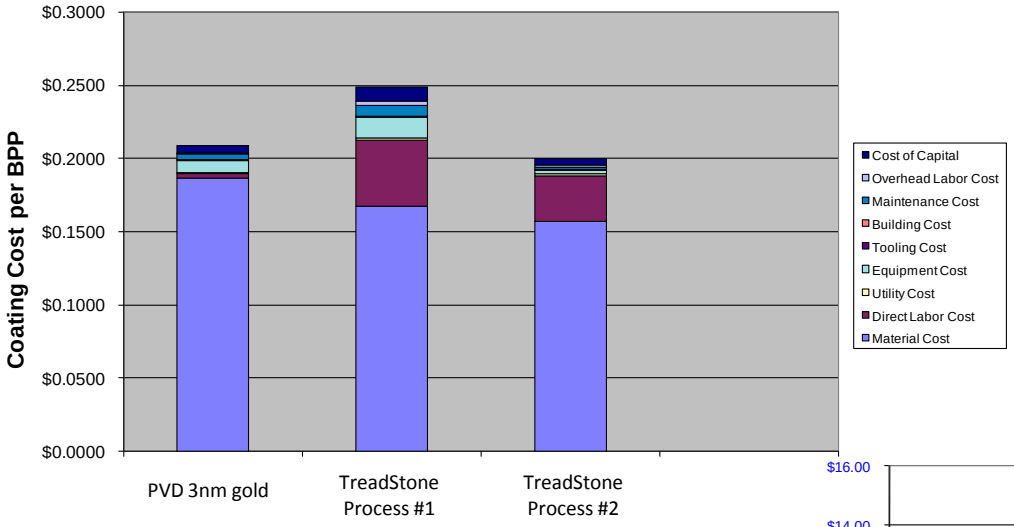
Condensation Water Analysis

Ion Content (mg/l)	TreadStone SS Plate		Standard SS Plate	
	Anode	Cathode	Anode	Cathode
Chromium	< 0.01	< 0.01	< 0.01	< 0.01
Iron	< 0.01	< 0.01	< 0.01	0.04
Nickel	< 0.01	< 0.01	0.15	0.38

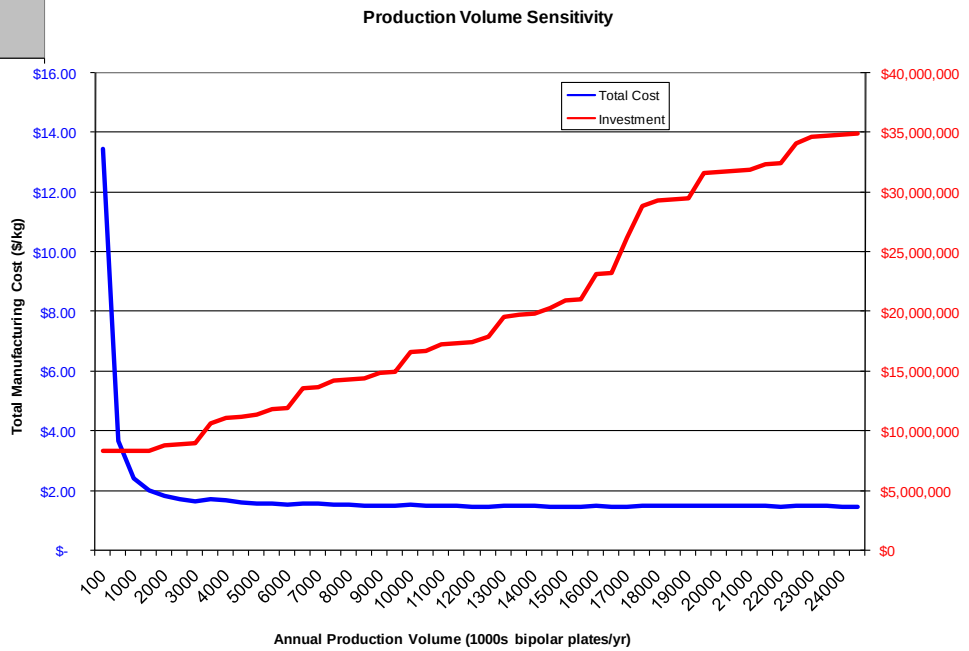
Cost Study of TreadStone's SS Plate

Large Scale Manufacturing Cost Analysis



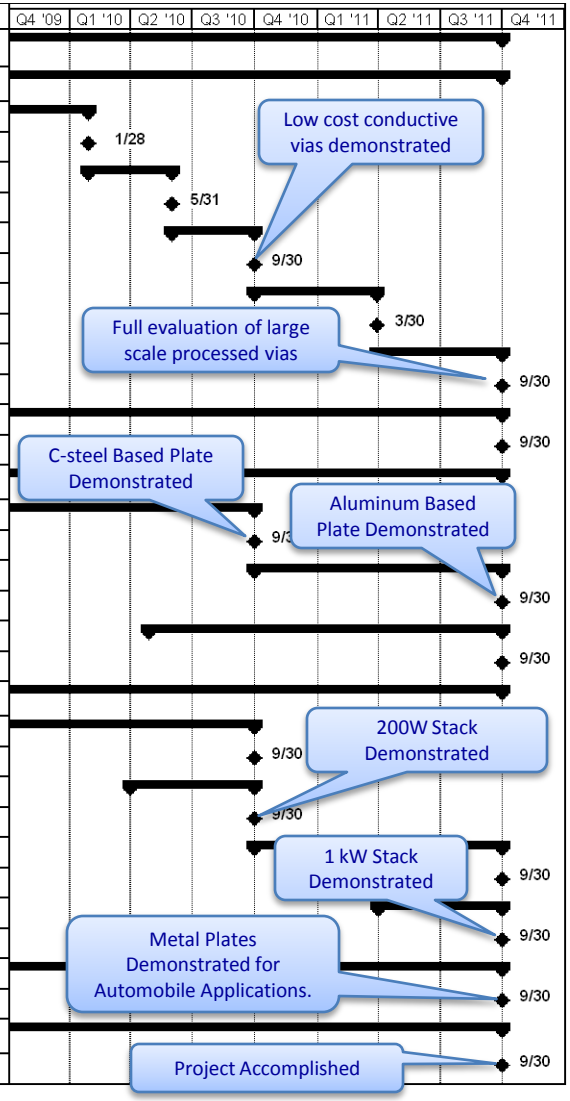
For Automobile Plate Size…

- *Cost <$2.00/plate at >2M plates/yr volume*
- *Cost $1.41/plate at 200M plates/yr volume*

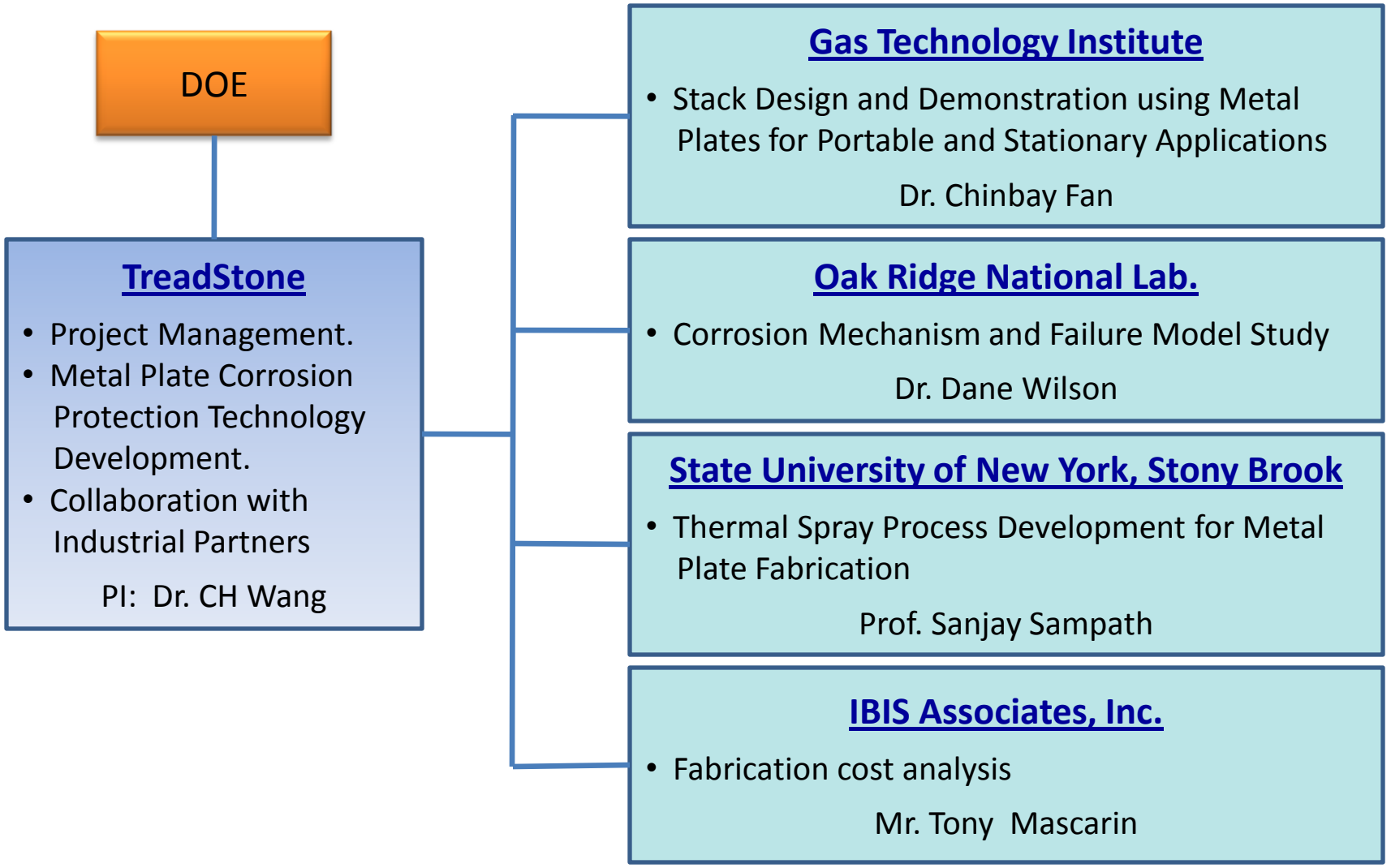


Project Timeline

ID	Task Name
1	**Low Cost PEM Fuel Cell Metal Bipolar Plates**
2	**Task 1 Conductive Via Processing Development**
3	**1.1 Palladium Conductive Vias Processing Development**
7	*Milestone: Palladium Vias Processing Developed*
8	**1.2 Carbon Nanotube Conductive Vias Processing Development**
12	*Milestone: Carbon Nanotube Conductive Via Developed*
13	**1.3 Metallic Carbide Vias Processing Development**
17	*Milestone: Conductive Carbide Via Developed*
18	**1.4 Conductive Vias Processing Scale-up and Optimization**
22	*Milestone: Conductive Vias Fabrication Processing Optimized*
23	**1.5 Full Evaluation of the Performance**
26	*Milestone: Metal Plate Performance Verified*
27	**1.6 Corrosion Mechanism and Long-term Stability Evaluation**
32	*Milestone: Long-term Stability and Corrosion Mechanism Studied*
33	**Task 2 Carbon Steel and Aluminum Based Plates Development**
34	**2.1 Carbon Steel Based Metal Plate Development**
43	*Milestone: Carbon Steel Plate Process Developed*
44	**2.2 Aluminum Based Metal Plate Development**
52	*Milestone: Aluminum Plate Process Developed*
53	**2.3 Corrosion Mechanism and Long-term Stability Evaluation**
58	*Milestone: Long-term Stability and Corrosion Mechanism Studied*
59	**Task 3. Fuel Cell Stack Application Demonstration**
60	**3.1 200W Stack Development for Portable Applications**
67	*Milestone: 200W Stack Lifetime Performance Test Finished*
68	**3.2 200W Stack Optimization and Demonstration**
74	*Milestone: 200W Stack Demonstration in Client's Power System.*
75	**3.3 Metal Plate Based PEM Fuel Cell Stack Scale up to 1 kW**
82	*Milestone: 1kW Stack Lifetime Performance Test Finished*
83	**3.4 1kW Stack Optimization and Demonstration**
89	*Milestone: 1kW Stack Demonstration in Client's Power System.*
90	**3.5 Metal Plate Evaluation for Automobile Applications**
95	*Milestone: Meal Plates Demonstrated for Automobile Applications*
96	**Task 4. Deliverables**
99	*Milestone: Final delivery stack ready*



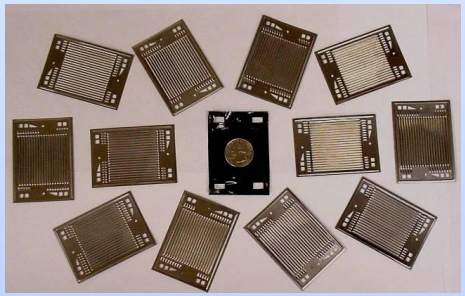
Team Members



gti®: PEM Fuel Cells Development & Testing

50+ years in fuel cell technology development

- Molded graphite plates
- Low-cost metal alloy plates for high power density
- High performance metal plate stacks

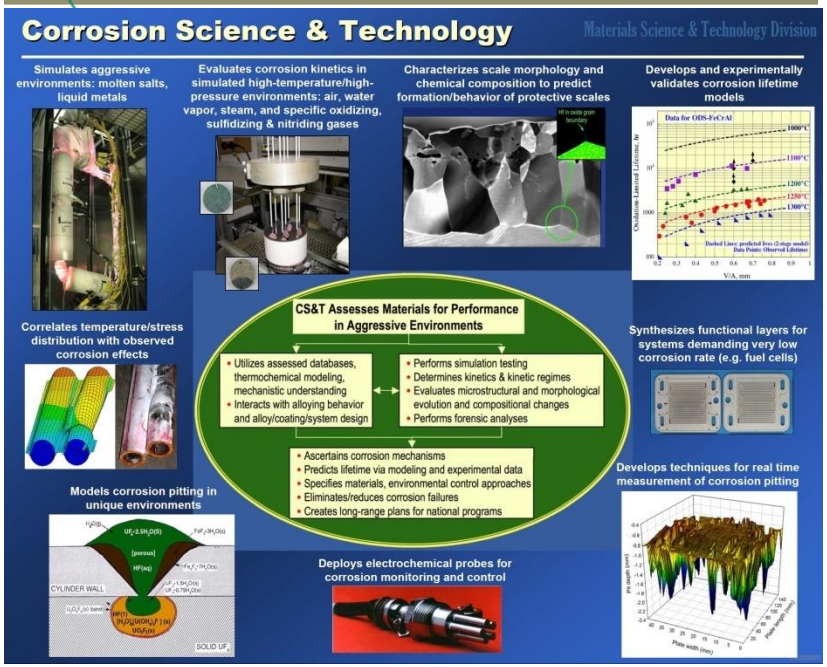


- Extensive experience designing & making PEMFC stacks
  - Vertically integrated in-house stack prototyping
- Comprehensive testing facilities
  - Wide variety of test cells and stands

ORNL, SUNY Stony Brook, and IBIS Overview

OAK RIDGE NATIONAL LABORATORY

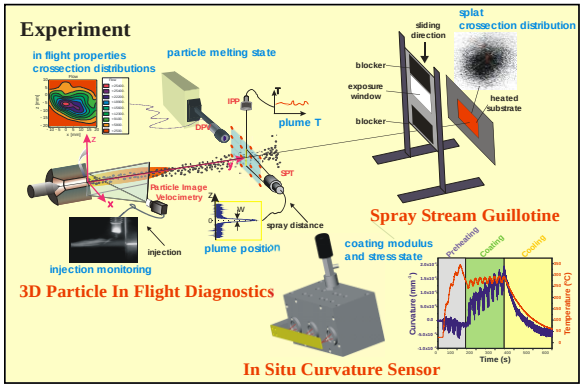
Managed by UT-Battelle for the Department of Energy



STONY BROOK UNIVERSITY

Center for Thermal Spray Research

- Established in 1996 as a Materials Research Science and Engineering Center funded by NSF
- Host of an industrial consortium for thermal spray technology with 26 companies.
- Integrated thermal spray systems, process diagnostics and characterization capabilities



IBIS Associates, Inc.

Technology Strategy and Business Development Consulting

- Founded in 1987 by MIT professor
- Experienced in materials and manufacturing technologies analysis

Sample of Major Clients

FreedomCAR Fuel Partnership, USCAR, GE, Ford, GM, DARPA

TreadStone Technologies, Inc.

FY2010 Budget and Go/no-go Decision

Project Budget

- Total Project Budget for 2 years: $2,625,063
  - Anticipated Funding for FY'10: $1,694,395
  - Anticipated Funding for FY'11: $930,668
- Total Budget Break-down by Organization:
  - TreadStone: $1,970,631
  - GTI: $321,033
  - ORNL: $100,000
  - SUNY Stony Brook: $158,399
  - IBIS: $75,000

Go/no-go Decision:

- By Sept. 30, 2010, the Go/no-go will be made based on following criteria
  - At least one of the low cost conductive vias approaches can meet DOE's target
  - C-steel based metal plates meet DOE 2015 target
  - The baseline short stack meets the power density and long-term stability requirements

Acknowledgements

- DOE EERE Fuel Cell Team.
- Team Members. GTI, ORNL, SUNY-Stony Brook, IBIS
- Industrial Partners.