6th Annual International Conference

Fuel Cells DURABILITY & PERFORMANCE 2010

- **Automotive**
- **Stationary**
- **Portable**

Real World Solutions to the Most Significant Challenges Facing Fuel Cells Commercialization

December 9-10, 2010 • Boston, MA USA

PRESENTED BY:

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6th Annual International Conference

Fuel Cells DURABILITY & PERFORMANCE 2010

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CALL FOR POSTER PRESENTATIONS

Industry and academic scientists are encouraged to submit poster titles for this event. One-page abstracts (8 1/2" x 11" with 1-inch margins) must be submitted by email to submit@knowledgefoundation.com no later than **November 8, 2010** for inclusion in conference documentation. Additional poster submissions will be accepted until **December 1, 2010** but may not be included in conference documentation. *Note: If you are submitting a poster, you MUST be registered and paid in advance to ensure that a posterboard is reserved for you.*

COMPREHENSIVE DOCUMENTATION AVAILABLE

Nothing can substitute the benefits derived from attending **Fuel Cells Durability & Performance 2010**. But if your schedule prevents you from attending, this invaluable resource is available to you. Please allow 3-4 weeks after the conference date for delivery. *Note: Documentation is included with conference fee for registered delegates.*

Thursday, December 9, 2010

8:00 *Registration, Exhibit Viewing/Poster Setup, Coffee and Pastries*

8:55 **Organizer's Welcome and Opening Remarks**

9:00 **Gas Diffusion Layers: Durability and Water Management**

Peter Wilde, PhD, Director, Fuel Cell Components, SGL Group - The Carbon Company, SGL Technologies GmbH, Germany

This paper summarizes the work performed at SGL on GDL degradation. Key findings and mitigation strategies from collaborative projects will be presented. In a second part, SGL Carbon's concept of engineered water management will be discussed. GDL flooding can be inhibited to a very large extent by materials engineering and this can enable operation at very high current and power densities. Preliminary experimental results illustrate the promising nature of the concept as confirmed by independent laboratories. Recent progress with taking this approach further leading to further performance enhancement is presented and discussed.

9:30 **Durable Catalysts for Transient Conditions**

Radoslav Atanasoski, PhD, Advanced Senior Specialist - Electrochemistry, 3M Corporate R & D - Fuel Cells, 3M Company

Multiple stop-start events and fuel starvation are the major causes for the catalysts degradation. During such events, either of the catalyst layers can be subjected to high potentials (>1.5 V vs RHE). This can result in dissolution of platinum and degradation of the catalysts supports, gas diffusion layer (GDL) etc., leading to significant losses in fuel cell performance. We have adopted materials science approach to produce multi-functional catalysts for both electrodes. For the anode a catalyst that has low oxygen reduction (ORR) activity while preserving the high activity for hydrogen oxidation is desirable. For the cathode a catalyst with high activity for water oxidation with no interference with the ORR is needed. Examples of how this might be achieved will be presented and discussed. Closely related to the materials development is the electrochemical methodology for the catalysts evaluation which we believe can be universally applied.

10:00 **The Role of Interfacial Structure and MicroPorous Layer on Water Management in PEFCs**

Ahmet Turhan, PhD, Research Assistant Professor, University of Tennessee Knoxville; and

Matthew M. Mench, PhD, Professor of Mechanical and Chemical Engineering, Dept of Mechanical, Aerospace and Biomedical Engineering, Joint Faculty at Oak Ridge National Lab and University of Tennessee Knoxville

In this talk, recent studies on the impact of the micro-porous layer (MPL) and MPL/catalyst layer interface will be summarized. In particular, the impact of the surface roughness, compression, interfacial cracking, and attempts to engineer this interface for better performance will be discussed.

10:30 *Networking Refreshment Break, Exhibit/Poster Viewing*

11:00 **Degradation Mechanisms and Accelerated Testing in PEM Fuel Cells**

Rodney L. Borup, PhD, Principal Investigator, Fuel Cell Team Leader, and

Rangachary Mukundan, PhD, Principal Investigator, Los Alamos National Laboratory

The durability of polymer electrolyte membrane (PEM) fuel cells is a major barrier to the commercialization for transportation and stationary power applications. Although there has been recent progress in improving durability, further improvements are needed to meet the commercialization targets. Past improvements have largely been made possible because of the fundamental understanding of the underlying degradation mechanisms. By investigating component and cell degradation modes; defining the fundamental degradation mechanisms of components and component interactions new materials can be designed to improve durability. To rapidly evaluate materials requires relevant Accelerated Stress Tests (ASTs), the design of which relies on understanding the degradation mechanism. The materials which tend to limit the fuel cell durability include the electrocatalyst, ionomeric materials and carbon. Topics that will be discussion include durability testing methods including accelerated stress testing (AST) and the effect of operating conditions on durability with focus on the various component materials.

11:30 **On-Line *In-Situ* Diagnostics of Gases within PEM Fuel Cells by Multi-Fiber Raman Spectroscopy**

Hans Bettermann, Prof Dr, Group Head - Liquid Phase Laser Spectroscopy, Institute for Physical Chemistry, Heinrich-Heine-University of Dusseldorf, Germany

A PEM fuel cell was equipped with a multiple-fiber Raman spectrometer that measured partial pressures of gases and water vapor and their time-dependent interdependences at selected sites along flow field meanders during normal and anomalous cell operations. The setup also studied the response of process gases after poising of the catalysts by carbon monoxide. Impedance spectroscopy and local current density measurements accompanied the Raman measurements.

12:00 **Novel ORR Catalyst Demonstrating Peroxide Radical Decomposition and Inhibition**

Roger van Boeyen, PhD, Principal Investigator/Project Manager, Lynntech, Inc.

Conventional ORR electrocatalysts generate peroxide

radicals during the ORR and are ineffective in decomposing peroxide radicals. Peroxide radicals attack the membrane and reduce the membrane integrity. Lynntech's ORR electrocatalyst has demonstrated a 20-fold reduction in the fluoride ion release rate from the membrane. This is expected to correlate to a 20-fold increase in membrane lifetime, and was achieved without loss of ORR catalytic surface area or activity.

12:30 *Luncheon Sponsored by the Knowledge Foundation Membership Program*

2:00 **Advanced Single Cell Test Fixture**

Benjamin S. Lunt, Project Manager, Nuvera Fuel Cells

A new test fixture has been developed to advance the understanding of the effects of active area pressure and current density distribution on fuel cell performance and durability with the goal of optimizing fuel cell stack design. The talk will focus on design features and capabilities of new fixture and results of validation testing.

2:30 **PEM Fuel Cell Losses due to Vibration**

Parsaoran Hutapea, PhD, Associate Professor of Mechanical Engineering, Temple University

PEM fuel cells use carbon supported platinum (Pt) catalyst in their electrodes to promote the chemical reactions that generate electrical energy. Performance loss of PEM fuel cells is due to a loss of electrochemically active surface area of the platinum cathode electrocatalyst. These particle growth mechanisms and their rates may vary as a function of electrode potential, cell voltage cycling conditions, current density, particle size and shape, the hydration state of the membrane, and the operating conditions (as in our case, vibration). Our main focus is to investigate the influence of vibration on the loss of electrochemically active surface. We hypothesize that vibration accelerates Pt particle growth and causes corrosion of the carbon support.

3:00 **Competition and Synergies between Materials Aging Mechanisms in PEMFCs: Multi-Scale Modeling Insights and Challenges**

Alejandro A. Franco, PhD, Modeling Group Leader, DRT-LITEN-DEHT/Laboratory of Components for Fuel Cells and Electrolysers and Modeling (LCPEM), French Atomic Energy & Alternative Energies Commission - CEA, France

In this talk we present, on the basis of a multiscale physical modeling approach, new insights on the competitions and synergies between MEA materials aging mechanisms for different automotive-like PEMFC operation modes. This approach allows predicting the evolving materials reactivity, stability and transport properties and their impact on the overall MEA durability. In particular, the use of CO anode pollution as a mitigation method of cathode C corrosion and membrane degradation is discussed. The role of water transport on competing aging phenomena is highlighted in comparison with dedicated experiments.

3:30 *Networking Refreshment Break, Exhibit/Poster Viewing*

4:00 **Layer-by-Layer Assembly of Composite Membrane/Electrode for Fuel Cell Applications**

Speaker to be confirmed

Abstract is not available at time of publishing. Please visit www.KnowledgeFoundation.com for the latest Program updates.

4:30 **The Role of Operating Conditions on PEMFC Cathode Catalyst Durability**

Vesna Colbow, PhD, Senior Research Scientist, Ballard Power Systems, Canada

Improved durability under a wide range of operating conditions is required for the commercialization of fuel cells. Despite advancements in the fuel cell community in identifying catalyst degradation mechanisms, many gaps with respect to catalyst layer degradation and its driving mechanisms still exist. This study examines the impact of different operating conditions on cathode catalyst and catalyst layer degradation rates and mechanisms. An empirical model that predicts ECSA loss as a function of operating conditions is linked to product degradation.

5:00 **Knowledge to Enhance the Endurance of PEM Fuel Cells by Accelerated LIfetime Verification Experiments: *KEEPEMALIVE***

Gaby J.M. Janssen, PhD, Unit Hydrogen and Clean Fossil Fuels, Energy Research Centre of the Netherlands - ECN, The Netherlands

Keepemalive is an FCH JU funded project that aims to establish improved understanding of degradation and failure mechanisms, accelerated stress test protocols, sensitivity matrix and lifetime prediction models for LT-PEMFC to enable a lifetime of 40 000h at realistic operation conditions for stationary systems, in compliance with performance and costs targets. The project combines the efforts of nine European partners from industry, research organizations and academia.

5:30 **Moderated Discussion**

Fuel Cells Durability - Issues and Solutions:

- From Materials/Components Degradation Control
- Through Stack Management/System Integration
- To Reliability and Cost Reduction

6:00 *End of Day One*

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Friday, December 10, 2010

8:00 *Exhibit/Poster Viewing, Coffee and Pastries*

9:00 **Managing Quality and Reliability in Portable SOFCs**

Tim LaBreche, Director of Technology, Adaptive Materials, Inc.

Adaptive Materials Inc. develops portable solid oxide fuel cells (SOFC) for portable military and unmanned aerial and ground systems. Systems in the 50 to 300 watt range are being manufactured with statistical process methods and controls. Testing volume and synthesis is limited by resources, therefore compromises between statistical significance and financial resources are made. Methodologies used for managing quality and reliability in portable propane fueled SOFC systems are presented.

9:30 **Direct Alcohol Fuel Cells Using Alkaline Anion Exchange Membranes**

Carsten Cremers, PhD, Team Leader Fuel Cells, Dept for Applied Electrochemistry, Fraunhofer Institute for Chemical Technology - ICT, Germany*

Alcohol electro-oxidation is generally enhanced in an alkaline environment. Thus, even higher alcohols such as ethanol and ethylene glycol can be oxidized efficiently. Furthermore, the alkaline environment enables the use of non-platinum metals as catalyst. In this contribution the current status of alkaline direct alcohol fuel cells using anion exchange membranes as electrolyte will be reviewed. Particular attention will be given to electro-catalytic conversion processes to show which fuels can be used and which performance can be expected.
*In collaboration with: D.Bayer, B.Kintzel, S.Berenger, J.Tübke

10:00 **High Performance Bulk Metallic Glass Nanowires for Direct Alcohol Fuel Cell Applications**

André D. Taylor, PhD, Assistant Professor, Chemical Engineering Department, Yale University

Fuel cells were once championed as viable alternatives over existing battery technology for portable electronic devices; however, a key remaining issue is the meager performance of these devices due to poor efficiency and durability of the catalysts. Developing a new class of materials that can circumvent Pt-based anode poisoning and the agglomeration/dissolution of supported catalysts during long-term operation is of critical importance. Here we report a CMOS compatible approach using $Pt_{58}Cu_{15}Ni_5P_{22}$ bulk metallic glass (BMG) to create a new class of high performance nanowire catalysts for fuel cells.

10:30 *Networking Refreshment Break, Exhibit/Poster Viewing*

11:00 **Heterogeneous Low-Pt or Pt-Free Nano-Catalysts for Low Temperature Fuel Cells**

Speaker to be confirmed

Abstract is not available at time of publishing. Please visit www.KnowledgeFoundation.com for the latest Program updates.

11:30 **Short Side Chains PFSA and Polyaromatic Ionomers in Catalyst Layers: Performance and Degradation Mechanisms**

Jennifer Peron, PhD, Laboratory of Condensed Matter Chemistry, UPMC - Site College de France, France

The incorporation of long side chains perfluorosulfonic acids (LSC-PFSA), such as Nafion, in catalyst layers limits the utilization of MEA in fuel cells at high temperature and low RH; moreover LSC-PFSA are degraded in fuel cell under operation at high potential. In this presentation, the influence of the type of ionomer introduced in the catalyst layer on fuel cell performance and durability will be presented. The improvement of FC performance by introducing short-side chains PFSA and modification of degradation mechanisms by introducing polyaromatic ionomers in catalyst layers will be shown.

12:00 **Thermo-Hydrolytic and Oxidative Aging of Poly-Aromatic Membranes: Molecular Structure and Operating Conditions Effects**

Pauline Legrand, PhD, INAC/SPrAM/PCI, Institute for Nanoscience & Cryogenics, French Atomic Energy & Alternative Energies Commission - CEA, France

The degradation origins and mechanisms of the membrane in fuel cell are investigated. Both depend on the membrane molecular structure and the operating conditions. The samples are poly-aromatic polymers (sPEEK), which are analyzed through complementary tests: thermo-hydrolytic and chemical degradation (H_2O_2) in laboratory conditions, and aging in a fuel cell test bench. The laboratory tests showed that both the membrane conductivity and mechanical properties decrease with time. The correlation between operating conditions with their effects on membrane behavior will be discussed.

12:30 *Lunch on Your Own*

2:00 **High Performance MEAs Running on Dry Gases**

Renaut Mosdale, PhD, CEO, PaxiTech, France

Since the PaxiTech Company is involved in both air breathing portable fuel cells and Membrane/Electrodes Assemblies (MEAs), specific MEAs working with dry or under-humidified gases have naturally been developed. These components are now commercialized and integrated in many other types of fuel cells applications, since they can lead to much simplified systems, eliminating any water recovery or gas humidification. After presenting the company activity, some specific results will

be presented describing the performance of these MEAs as well as their lifetime, in near ambient temperature and pressure applications.

2:30 **Remarkably Stable PEM Fuel Cell Catalysts through Polymer Stabilization and Using Conductive Nano-Ceramic Supports**

Shichun Mu, PhD, Professor, State Key Laboratory of Advanced Technology f or Materials Synthesis and Processing, Wuhan University of Technology, China

Novel and effective approaches to increase lifetime of PEM fuel cell catalysts are well developed in Wuhan University of Technology. The stability of conventional Pt/C catalysts is greatly improved through perfluorosulfonic acid (PFSA) polymer stabilization, where Pt nanoparticles or carbon supports are PFSA-stabilized. High catalytic activities of these catalysts are also observed by both CV (cyclic voltammetry) and ORR (oxygen reduction reaction) measurements. In addition, our research group has demonstrated the remarkable high stability of catalysts supported on conductive ceramic materials (e.g. TiB_2, ZrO_2 and SiC). For example, the stability of the Pt/TiB_2 catalyst is approximately 4 times better than that of Pt/C. Also, the catalyst shows a greatly improved stability by using nano SiC as supports and is almost identical in ORR activity compared with Pt/C. These results show that the PFSA-stabilized catalyst and the Pt/ceramic catalyst are promising for PEM fuel cell applications.

3:00 **Electrochemical Stability of Nanometer-Scale Pt Particles in Acidic Environments**

Byungchan Han, PhD, Researcher, Mechanical Engineering Department, Stanford University

The increased surface to volume ratio achieved by particle size reduction leads to lower materials cost and higher efficiency of fuel cell catalysts, but there are questions as to whether the intrinsic stability of materials also decreases with particle size. Using *ab initio* computations we investigate the electrochemical stability, passivation, and dissolution behavior of Pt as a function of particle size, potential and pH. Our results clearly show that smaller Pt particles dissolve well below the bulk dissolution potential, and through a different mechanism. Pt dissolution from a nanoparticle occurs by direct electro-oxidation of Pt to soluble Pt^{2+} cations, unlike bulk Pt, which dissolves from the oxide. These results have important implications for understanding the stability of Pt and Pt alloy catalysts in fuel cell architectures, and for the stability of nanoparticles in general.

3:30 **Selected Oral Poster Highlights and Open Discussion**

4:00 *Concluding Remarks, End of Conference*

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