FUEL CELLS DURABILITY & PERFORMANCE

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

November 15-16, 2007 • Miami, FL USA

PROGRAM AGENDA

Thursday, November 15, 2007

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

9:00 The President's Hydrogen Fuel Initiative: Improving Fuel Cell Durability & Performance

Nancy Garland, PhD, Acting Fuel Cell Team Leader, Office of Hydrogen, Fuel Cells and Infrastructure Technologies, The U.S. Department of Energy

The Department of Energy's Hydrogen Program recently initiated new research and development projects aimed at reducing component cost and increasing stack durability and performance of transportation and stationary fuel cells. Updated progress in the Program including highlights from the new projects from will be presented. There has been recent interest globally in the introduction of fuel cells to the marketplace because they can drastically reduce the time to recharge/refuel and because of their reliability. New market transformation activities in the Program such as forklifts for distribution centers will be discussed.

9:30 Technology Development Needs for Stationary and Transportation Fuel Cells

Tom Jarvi, PhD, Director, Technology Development, UTC Power, United Technologies

To enable broad commercial applicability, fuel cell technologies must be made significantly more affordable while maintaining or enhancing durability and performance. Previously, industry and academia have focused primarily on understanding and enhancing performance. In recent years, it has become apparent that the performance requirements of many applications can largely be met, and the focus has shifted to increasing durability and reducing cost. This talk will attempt to clarify the significant challenge that simultaneously meeting cost and durability requirements represents for fuel cell products.

10:00 An Automotive Perspective on Durability Protocol Challenges from Single Cells to Fuel Cell Vehicle Systems and Industry Needs

Jesse M. Schneider, Manager, Fuel Cell Vehicle Systems, Advanced Vehicle Engineering, DaimlerChrysler Corporation

Durability of PEM technology in dynamic ranges, though much progress has been made in recent years, are not yet up to the level of conventional vehicle powertrains. Public durability protocols (from the USFCC, US DOE, JARI, for example) are helpful for establishing a baseline for the state of the art of the technology in single cells. But these aren't yet commonized due to a number of reasons. Also, it is too early to standardize the protocols as the technology evolves, but guidelines or protocols are needed. There are many challenges involved in establishing such single cell protocols, due to different operating conditions. Also, there are potential degradation effects not only to the catalyst and membrane, but also due to hydrogen impurities. For automotive applications, fuel cell systems, durability protocols are considered intellectual property, making it difficult to establish a common guideline or standard. However there is a draft standard initiated at SAE (J2722) which is attempting to establish a drive durability cycle baseline.

10:30 Refreshment Break, Exhibit/Poster Viewing

11:00 MEA Development for Automotive Applications

Kev Adjemian, PhD, Manager, Fuel Cell Laboratory, and Akihiro Iiyama, PhD, Expert Leader, Nissan Motor Co., Ltd., Japan

Since the inception of the fuel cell program at Nissan Motor Company, great developmental strides have been made in both component and system optimization. This work has resulted in Nissan Motor Company providing the first fuel cell vehicle for commercial taxi service in Japan. Nevertheless, further improvements to the durability and performance of the MEA are required for mass-commercialization. This is being carried out by first understanding the underlying mechanisms followed by formulating effective counter-measures and new materials. Using this approach, major advancements towards fuel cell commercialization are being realized.

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11:30 On-Road Experiences with FC Degradation from FCV Learning Demonstration

Jennifer Kurtz, Senior Engineer, National Renewable Energy Laboratory

After the first two years of DOE's fuel cell vehicle Learning Demonstration project, NREL has amassed a significant amount of on-road fuel cell vehicle performance information. This data has been analyzed to determine fuel cell voltage degradation, and whether there are any detectable dominant factors affecting the degradation rates. NREL will present the latest public results on this topic from their analysis.

12:00 Fast Conditioning - Impacts on System Performance & Life Cycle Cost

Kevin Beverage, Lead Process Engineer, Electrochemical Technology Group, Nuvera Fuel Cells, Inc.

Conditioning of PEM fuel cells is a necessary, yet not well understood process that is required before a fresh PEM can reach 100% of its expected performance. When manufacturing commercial stacks, the time requirement becomes a critical consideration for the overall cost of the product since traditional conditioning procedures demand anywhere from 8-24 hours of operation, adding a significant premium due to overhead. An investigation into the current hypotheses regarding conditioning mechanisms is presented as well as results showing 1 hour conditioning of subscale stacks and 1.5 hour conditioning of full scale commercial stacks. Ongoing work toward reducing the necessary conditioning time to a target of 10 minutes will be discussed as well as the potential durability impacts of certain procedures used to accelerate conditioning.

12:30 Luncheon Sponsored by:
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Technology Commercialization Alliance

2:00 GDL Durability Testing at SGL Group - The Carbon Company

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

Fuel Cell components are subject to degradation and are changing their properties over time. Although there are operating conditions which can cause faster and slower degradation rates using identical cell components, the desire to have more chemically stable components is also present. This paper gives an overview of SGL's activities to assess and quantify GDL degradation under selected conditions. The emphasis is on ex situ tests which are conducted in designed experiments. Results allow for extrapolation and analysis of the main external effects on durability.

2:30 Low-Cost, Durable Kynar® Based Fuel Cell Membranes

James T. Goldbach, PhD, Research Scientist, Corporate and External Research Dept, Arkema Inc.

Arkema has developed a new approach to PEM design whereby the mechanical property requirements are decoupled from the other desired properties. This decoupling is accomplished by blending two very dissimilar polymers, a fluoropolymer such as Kynar® poly(vinylidene fluoride) with any one of a range of non-fluorinated polyelectrolytes. Using this blending process along with inexpensive starting materials, many different membrane compositions can be produced at significantly reduced cost over traditional methodologies. The newest membrane generation utilizing Arkema's polymer blending approach has shown a dramatic increase in durability. Continued testing of this membrane in standard fuel cell durability tests shows excellent performance compared to industry material benchmarks. The latest results of these tests will be reviewed along with future testing plans.

3:00 Strategies and Technologies to Improve the Durability of Membranes and MEAs for PEM Fuel Cells

Gonzalo Escobedo, PhD, Senior Engineer, DuPont Fuel Cells, E.I. du Pont de Nemours and Company, Inc.*

DuPont has been involved in the fuel cell industry from its infancy, starting with PEM membrane supply used to make the first fuel cells for NASA space program in the 1960's. Nafion® PFSA was the first membrane used and is still the leading membrane in PEM fuel cell systems today. DuPont continues to develop new and improved membranes that enable stack and system developers to design more effective and efficient fuel cell systems. This presentation will present an overview of the industry's past and what DuPont has done to meet the requirements for FC systems today and the durability and performance challenges for PEMs in the future. *In collaboration with: D.Curtin, R.Perry, K.Barton, and B.Choudhury

3:30 Refreshment Break, Exhibit/Poster Viewing

4:00 Experimental Validation of a Method of Oxygen Removal During a Shutdown of an Automotive PEM Fuel Cell

George S. Saloka, Research Engineer, Fuel Cell Research, Ford Motor Company*

Lifetime of a PEM fuel cell can be significantly shortened by an exposure to air from an idle to a start-up transition. Hydrogen fuel introduced into anode compartment, that contains air during a vehicle start-up simultaneously mixes with oxygen within the same catalyst layer (anode) that can lead to local potential gradients within the same electrode that can attack the catalyst, its catalyst support, and the membrane. Experiments utilizing the oxygen depleted gas from the cathode of the fuel cell to purge the anode during shut down were undertaken. Anode gas cycling experiments have demonstrated that cycling between air and hydrogen severely degrades cell performance due to reduction of the catalyst active area. However, nitrogen and 5% oxygen gas cycling have a minimal effect on cell performance. Hydrogen crossover tests indicate that the membrane remains unaffected as a result of the anode gas cycling. Polarization curves indicate that using an oxygen depleted gas (5% oxygen) to purge a fuel cell during shut-down is nearly as beneficial as using neat nitrogen to purge a fuel cell during fuel cell shut-down. *In collaboration with: J.Adams, and C.Paik

4:30 The Titanium Separator with Stable Durability and Low Electrical Resistance

Toshiki Sato, Senior Researcher, Materials Research Laboratory, Kobe Steel, Ltd., Japan*

The high corrosion resistant separator with low electrical resistance has been developed. It consisted of titanium substrate coated with gold alloy thin film by magnetron sputtering. The low and stable electrical resistance in corrosive atmosphere such as inside fuel cell has been achieved by the controlled heat treatment after the coating on passive TiO_2 layer. *In collaboration with: J. Suzuki, Y.Ito, S.Tanifuji, and J.Hisamoto

5:00 Solving Durability and Performance Issues of PEFC's by Eliminating Carbon Supports and Highly Dispersed Catalysts

Mark K. Debe, PhD, Senior Staff Scientist and Technical Manager, 3M Fuel Cell Components Program, 3M

Loss of surface area and catalyst activity as a result of high voltage/cycling induced carbon support corrosion, Pt dissolution and agglomeration, are now well documented, fundamental limitations of conventional electrocatalysts currently in use for automotive and other applications of PEM fuel cells. The inverse relationship of specific activity with dispersed Pt catalyst particle size also caps performance entitlements, while high levels of per-oxides limit membrane lifetimes. Robust operating systems will demand significantly better membrane electrode assemblies. For over ten years we have been developing NSTF (nanostructured thin film) catalysts as the next generation catalyst support and thin film coating system that has now been shown to eliminate or significantly reduce all of these issues while enabling high volume roll-good manufacturing. We will present an overview of the NSTFC technology and discuss different water management requirements for use of these ultra-thin electrode based MEA's.

5:30 Panel Discussion

6:15 End of Day One

Friday, November 16, 2007

8:15 Exhibit/Poster Viewing, Coffee and Pastries

9:00 Non-Fluorinated Proton-Conducting Materials for Fuel Cell Membrane and Electromagnetic Method of Conductivity Testing

Elena Shembel, DSc, President and CEO, Enerize Corporation*

The goal of this work is developing non-fluorinated low cost fuel cell polymer membrane with high conductivity, minimal dependence on humidity, and stability under high temperatures. The polymers for the membrane have been produced by a joint condensation method of aliphatic polyamides, aromatic sulfo-acids and aldehydes in organic solvent media with adding a catalytic quantity of sulfuric acid. They are spaced cross-linked polymers comprising graft aromatic sulfo-acid radicals. Synthesized materials are thermally stable up to 230°C and have high conductivity. The membrane conductivity was evaluated by nondestructive, non-contact electromagnetic method, which could also be used for automatic testing of polymer membranes during production. *In collaboration with: V.Redko, V.Khandetskyy, Enerize; O.Chervakov, Y.Kobelchuk, V.Ryabenko, K.Gerasimenko, I.Maksuta, A. Markevich, Ukrainian State Chem. Technol. University; D.Meshri, Advance Research Chemical

9:30 FlowCath™ Technology - A Route to Precious Metal-Free Cathodes for PEM-Type Fuel Cells

Andrew Creeth, PhD, Chief Technology Officer, ACAL Energy Ltd., United Kingdom

ACAL Energy Ltd is developing FlowCath™ technology for PEM fuel cell cathodes for standard proton ion exchange membranes which removes the need for precious metal catalysts. An indirect redox system is used with catalysts that offer significantly reduced cost and substantial performance improvement potential. It is a platform technology that can be used for multiple fuels and applications that span automotive, stationary and portable. A description of the technology with performance to date and prospects will be given.

10:00 Carbon Multi-Wall Nanotubes in Fuel Cells

Bhabendra Pradhan, PhD, Technical Director Carbon Initiatives, and Stewart McKenzie, Columbian Chemicals Company

The incorporation of carbon nanotubes into fuel cell materials and components offers step change improvements in performance and durability. Recent research and development efforts focused on fuel cell electrocatalysts have primarily involved molecular manipulation of the metal component. Carbon nanotechnology offers potential benefits beyond the perceived limits of the carbon supported catalyst. Manipulation of the carbon support to influence electrode structure, increase corrosion resistance, increase performance, and thereby lower costs is being strongly pursued by several companies. The interactive nature of fuel cell materials, components, requires a clear understanding of the optimization of the catalyst ink formulation, MEA fabrication, and especially the carbon-based materials characteristics. Initial cyclic voltammetry data show a clear indication of the increased performance and increased durability of this technical approach.

10:30 Refreshment Break, Exhibit/Poster Viewing

11:00 PEM Fuel Cell Durability Testing

John R. Davey, PhD, and Rod L. Borup, PhD, Institute for Hydrogen and Fuel Cell Research, Los Alamos National Laboratory

The durability of polymer electrolyte membrane (PEM) fuel cells is a major barrier to the commercialization of these systems for stationary and transportation power applications. Durability is difficult to quantify and improve, in part because of the quantity and duration (i.e., up to several thousand hours or more) of testing required. Ideally, a component developer would like to evaluate new materials and cell designs with a minimum of long-term PEMFC testing. This has led to the development of accelerated testing methods. These testing methods rely upon understanding the degradation mechanism for a specific fuel cell component. Many of the testing methods used for accelerated testing of individual components will be presented, including efforts to understand the degradation mechanism.

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11:30 Ballard's Approach to Concept Level Testing: The Mk1020 ACS Fuel Cell Stack

George Skinner, Senior Engineer, Test & Reliability Group, Ballard Power Systems, Inc., Canada

The Mk1020 ACS Fuel Cell Stack is a scalable, self-humidifying, air-cooled design intended for reliable & robust operation over a wide range of operating conditions. This presentation describes how Ballard's Test & Reliability group contributed to the development of the design, from exploring the operating envelope of the concept prototypes to developing a set of standardized characterization tests & defeatured load cycles used to verify the design for customer field tests.

12:00 Complex Approach to Design and Evaluation of Fuel Cell Systems and Components

Vesna Stanic, PhD, Chief Scientist, EnerFuel

EnerFuel has been developing a PEM fuel cell powered remote surveillance system (RSS) that will be commercially available in 2007. To be competitive with the currently available surveillance technologies, the system has low cost, portability and one year run time before it needs hydrogen storage to be recharged. Furthermore, the system provides reliable operation at various environmental conditions. Addressing specific durability and performance issues related to low power portable fuel cells through the use of a complex approach to design and evaluation of fuel cell system and components, EnerFuel overcame fuel cell commercialization barriers.

12:30 Lunch on Your Own

2:00 Atomic-Scale Characterization of Bimetallic Catalyst Particles for PEM Fuel Cell Cathodes

Karren L. More, PhD, Group Leader, Microscopy, Materials Science and Technology Division, Oak Ridge National Laboratory

High angle annular dark field (HAADF)-STEM imaging (Z-contrast imaging) with sub-Å resolution is being used to directly image bimetallic catalyst particles having crystallographic/atomic ordering, surface 'skin' or 'skeleton' structures, and core-shell morphologies. In this study, several Pt-based bimetallic catalysts, such as Pt-Co, Pt-Cr, Pt-Ti, and Pt-W, have been characterized by HAADF-STEM, standard high-resolution TEM (with EDS for compositional analysis), and X-ray diffraction, in order to identify the crystallographic structure and predominant particle shapes and to correlate these microstructural observations with cathode durability and performance.

2:30 Investigation of Durability Issues in Polymer Electrolyte Membrane (PEM) Electrolytic Cells

Sarb Giddey, PhD, Senior Research Scientist, Fuel Cell and Ionic Technologies Group, CSIRO Energy Technology, Australia*

Distributed hydrogen generation would remove the need for the costly up-front transportation / distribution infrastructure requirements and can assist with the early trials of the fuel cell technology and introduction of the hydrogen economy. Polymer electrolyte membrane based electrolytic cells offer high efficiencies, can operate at higher current densities leading to compact design, and produce high purity hydrogen at high pressures with electrochemical compression. However, the efficiency degrades with time and in some cases a catastrophic failure occurs that leads to a loss in the current efficiency. In this paper, the sources of performance degradation and efficiency loss with time have been discussed. *In collaboration with: S.P.S.Badwal and F.T.Ciacchi

3:00 Transient Multi-Scale Modeling Of Coupled Aging Mechanisms in PEFC - A Theoretical Tool for Experimental Interpretation and Advanced MEA Design

Alejandro A. Franco, PhD, Physicist, Laboratory of PEFC Components (LCPEM), DRT/LITEN/Department of Hydrogen Technologies (DTH), CEA-Grenoble, France*

In this talk we discuss a new dynamic mechanistic model of coupled electrochemical ageing processes in a PEFC MEA, on the basis of a recent modular multi-scale non-equilibrium thermodynamics approach developed by us. It couples cathodic Pt oxidation/dissolution/ripening, Pt^{z+} diffusion/migration/re-crystallization in ionomer and cathode carbon corrosion, with a novel description of the nano-scale ionomer/Pt interface dynamics and MEA micro-scale charge transfers. The model analyses MEA response sensitivity to operating conditions, initial Pt/C/Nafion® loadings and temporal evolution of the electro-catalytic activity. Impact of initial electrodes morphology on durability is studied and the time influence on EIS pattern is simulated. Predictions are validated in dedicated benches and by *ex-situ* experiments and characterization techniques. *In collaboration with: M.Gerard

3:30 Refreshment Break, Exhibit/Poster Viewing

4:00 Development of Advanced MEA's for PEM Water Electrolysis

Everett B. Anderson, PhD, Director of Electrochemical Technology, Distributed Energy Systems

On-site hydrogen generation using proton exchange membrane (PEM) technology is an attractive option today for many industrial applications and being looked at as a promising near-term solution for the role-out of the hydrogen economy. In order to compete in these emerging energy applications the cost of generation must be reduced. The membrane-electrode assembly (MEA) is at the center of these cost reduction efforts. Recent efforts to identify new membrane materials and catalysts that can reduce the cost of the MEA will be presented. *In collaboration with: J.Friedman, J.Manco, K.Ayers

4:30 An *In-Situ*, Real-time, Gas Humidity Sensor for Fuel Cells

Nathan Hurvitz, Director of Engineering & Operations, VIASPACE

Accurate measurement of fuel cell operating conditions is critical to the proper design and performance characterization of PEMFCs. In the past, inlet gas humidity measurements have been a particular problem because of the lack of a suitable sensor. Now, tunable diode laser spectroscopy (TDLAS) has been used to solve this problem. The VIASPACE HS-1000 VIASENSOR incorporates a patent pending miniature laser sensor technology to provide rapid, accurate, and reliable measurements of fuel cell gas humidity. This paper describes the technology and its application to the precise measurement of fuel cell gases.

5:00 Selected Oral Poster Highlights

5:30 Concluding Discussion, End of Conference