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WORKSHOP AGENDA

Pre-Conference Workshop

Lithium Batteries vs. Fuel Cells: Race to Dominate the World Marketplace

Wednesday, December 6, 2006

8:30 Registration, Exhibit/Poster Viewing, Coffee and Pastries

9:00 Future Directions in Electrochemical Energy Conversions: Critical Role of New Materials

9:30 Product Showcase Demonstration Session 1 *(sponsorship opportunity)*

10:00 Refreshment Break, Exhibit/Poster Viewing

10:30 Lithium Batteries and Fuel Cells in the Application Driven Market: Major Technological Challenges

11:00 Product Showcase Demonstration Session 2 *(sponsorship opportunity)*

11:30 PANEL DISCUSSION:

Lithium Batteries and Fuel Cells Technologies: Different Problems - Common Solutions

Facilitator:
M. Stanley Whittingham, PhD, Professor and Director, Institute for Materials Research, SUNY at Binghamton

12:15 Luncheon (sponsorship opportunity)

2:00 Fuel Cells R&D Long and Short Term Targets: From Materials Development to Stacks and System Integration

2:30 Product Showcase Demonstration Session 3 *(sponsorship opportunity)*

3:00 Refreshment Break, Exhibit/Poster Viewing

3:30 Hydrogen Fuel Infrastructure - the Key Issue in PEM Fuel Cell Development and Implementation

4:00 Product Showcase Demonstration Session 4 *(sponsorship opportunity)*

4:30 PANEL DISCUSSION:

What Fuel Cell Systems Will Ultimately Meet the Challenges of Sustainable Energy at Low Cost?

Facilitator:
James C. Cross III, Vice President of Technology, Nuvera Fuel Cells

5:30 Concluding Remarks, End of Workshop

5:30 Networking Wine & Cheese Reception (sponsorship opportunity)

MAIN CONFERENCE PROGRAM AGENDA

Thursday, December 7, 2006

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

FUNDAMENTAL FACTORS AFFECTING PEM FUEL CELLS DURABILITY AND PERFORMANCE

8:45 The President's Hydrogen Fuel Initiative: Improving Durability

Nancy Garland, PhD, Technology Development Manager, Office of Hydrogen, Fuel Cells and Infrastructure Technologies, U.S. Department of Energy

The DOE Hydrogen Program works to overcome technical barriers of fuel cell vehicle and hydrogen infrastructure technologies. Significant technical challenges in fuel cell technology include cost and durability. In 2006, the Hydrogen Program will initiate new RD&D efforts aimed at tackling DOE 2010 technical targets such as 5000 hours durability with cycling for 80-kWe (net) integrated transportation fuel cell power systems. These new efforts will be discussed.

9:15 Durability and Performance Issues of Fuel Cell Systems for Military Applications

Elizabeth Bostic, Fuel Cell Team Leader, U.S. Army Communications-Electronics, Research, Development, & Engineering Center

The benefits of fuel cell technology including high efficiency, low acoustic and thermal signatures, and low emissions provides the incentive for the U.S. Army to critically examine these technologies as one potential power solution. The U.S. Army Communications-Electronics, Research, Development, and Engineering Center (CERDEC) Fuel Cell Team focuses on the test and evaluation of prototype fuel cell systems and funds these efforts for military adaptation. Current efforts reach across the globe and through many areas of fuel cell technology. While significant progress has been seen in recent years, there continues to be a lack of reliability and durability for fuel cell technologies. CERDEC is working with commercial partners to address these challenges in order to provide the best possible power solution to the Warfighter.

9:45 Cost and Performance of PEM Fuel Cells: Key Challenges

Speaker to be confirmed

For PEM fuel cells technology to be successful in the market place, it must be competitive in several key metrics, including performance, life, durability, and cost. This presentation will address the key cost drivers of PEMFC stacks including material and process contributions and stack performance. As the cost of stacks decrease, balance-of-plant components will contribute a larger percentage to overall system cost. The interactions between stack materials, operating condition requirements, and balance-of-plant components will be discussed with regard to system cost and complexity.

10:15 Refreshment Break, Exhibit/Poster Viewing

MEAs & MEMBRANES - DEVELOPMENT, DEGRADATION AND TESTING

10:45 Durability Issues for Advanced, Low Precious Metal MEAs

Emory S. De Castro, PhD, Executive Vice President, E-TEK Division, PEMEAS Fuel Cell Technologies

Through support from the Department of Energy, E-TEK developed ion beam assisted deposition methods to create MEAs for the PEM market. We have achieved total precious metal loadings of under 0.2 mg/cm^2 platinum, and demonstrated moderate success toward achieving the 2010 automotive specific power goals (g Pt/kW). In developing materials with ultra-low platinum loading, several issues arise for durability. We will discuss the results and analysis of durability testing on these low loaded structures, as well as general results on developing MEA components to meet long term operation.

11:15 Realizing Automotive Stack Needs through MEA Development

Kev Adjemian, PhD, Manager, Fuel Cell Laboratory, Nissan Motor Co., Ltd., Japan

The most significant factor governing automotive fuel cell stack performance and durability is the MEA (Membrane Electrode Assembly). Nissan Motor Company's approach has been to attack each component of the MEA separately and then to further improve the assembly itself. This has been accomplished by understanding and mitigating the basic failure mechanisms of the membrane, the platinum catalyst, the carbon support and overall MEA design. Using this strategy, major steps towards FC commercialization are being realized.

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11:45 Automotive MEA Development

Deborah A. Moore, Associate, New Product Development, W. L. Gore & Associates, Inc.*

The conditions required by automotive applications are the most challenging for polymer electrolyte fuel cell MEA durability. By identifying single cell tests which accelerate different failure mechanisms, new membranes and electrodes were developed to enhance durability. By selecting and combining the most durable MEA components, over 9000 hours life in these harsh automotive cycling conditions was demonstrated. *In collaboration with: C.Baczkowski, T.Berta, S.Cleghorn, M.Crum, M.Edmundson, C.Gray, W.Liu, and N.Sisofo

12:15 Luncheon Sponsored by Wohlers&Tan Marketing Communications for the Sciences

1:30 Membrane Degradation Mechanisms in Polymer Electrolyte Membrane Fuel Cells

James M. Fenton, PhD, Director, Florida Solar Energy Center, University of Central Florida*

Membrane degradation mechanisms in PEMFCs were studied using an *in-situ* and nondestructive technique, which relies on the measurement of the membrane degradation rate in a fuel cell. Degradation of Nafion® membranes were studied and the fluoride emission rate (FER) as measured from the fuel cell effluent water analysis was used as a quantitative indicator of the membrane degradation rate. The degradation mechanisms as proposed in the literature and the ones hypothesized from the experimental findings will be discussed. *In collaboration with: V.Mittal and H.R.Kunz, University of Connecticut

2:00 Accelerated Evaluation of Membrane Degradation and Degradation Mechanisms

Florian Finsterwalder, PhD, Manager MEA Development, DaimlerChrysler AG, Germany*

The lifetime of PEM fuel cells is limited by chemical degradation of the membrane due to hydrogen peroxide induced radical attack [*A.B. LaConti, Handbook of Fuel Cells, V.3, 2003*]. A novel accelerated ex-situ test is presented to quickly asses the lifetime of a membrane. The set up mimics radical attack (O_2H, OH-radicals) under conditions which are relevant for automotive fuel cells. Based on results from different types of membranes degradation mechanisms are discussed as well as possibilities to avoid radical attack or formation. *In collaboration with: M.Quintus, DaimlerChrysler AG

2:30 Hyflon® Ion Membranes and MEAs: Durability Study

Luca Merlo, Ing, Fluoropolymer R&D, Solvay Solexis SpA, Italy*

Solvay Solexis is active in the development of the class of PFSA membranes known as 'short-side-chain' (trade name Hyflon® Ion). SSC ionomers are synthesised starting from the CF_2=CF-O-$CF_2CF_2SO_2F$ sulfonyl fluoride vinyl ether. Compared to Nafion®, SSC ionomers show a combination of properties, namely high cristallinity and high glass transition temperature, which makes them particularly well suited for high temperature/automotive operation. The aim of this work is the study of the degradation in time of membrane and MEA during FC operation. Different degradation mechanisms have been proposed and protocols have been developed to perform accelerated testing. In the present work, the durability of Hyflon® Ion membranes and MEAs is shown. Both ex-situ and fuel cell durability tests are carried out to provide a full picture of membrane and MEA stability characteristics. *In collaboration with: A.Ghielmi, M.Gebert, L.Cirillo, and V.Arcella, Solvay Solexis SpA

3:00 MEA Degradation Associated with Water Motion during Cycling at Sub Zero Temperatures

Michel Pinéri, PhD, DRT/LITEN-Laboratory for Innovation in New Energy Technologies & Nanomaterials, CEA-Atomic Energy Commission, France

Water plays a key role in membranes and active layers to get high proton conductivities. High water contents (up to 30% by volume) are currently obtained in RT water saturated MEA. DSC, NMR, Mechanical experiments show that desorption of water and crystallization may occur outside membranes in materials cooled below 0˚C. Preliminary µ X ray experiments support this explanation. Fast and permanent degradations result from such changes in water contents.

3:30 Refreshment Break, Exhibit/Poster Viewing

EXTREME CONDITIONS

4:00 Degradation Mechanisms in PEM Fuel Cells under Harsh Conditions

Christopher Hebling, PhD, Head of Department Energy Technology, Fraunhofer Institute for Solar Energy Systems ISE, Germany*

Under real operating conditions PEM fuel cells show a limited durability which is affected by a variety of degradation mechanisms. They could be caused for example by frequent start-up and shut-down of the fuel cell or by freezing of water within the fuel cell components during cold start-up. In our work the long term behaviour under harsh conditions was examined by means of structural degradation effects of the cathode, the anode and the membrane. Furthermore in-situ and ex-situ analyses were used in order to study the degradation of the cathode by catalyst agglomeration at elevated temperatures as well as during extreme cold-start scenarios. *In collaboration with: U.Wittstadt, T.Smolinka, M.Oszcipok, Fraunhofer ISE

4:30 Fuel Cells in Cold Climate

Joakim Nordlund, PhD, Co-Founder, Cellkraft AB, Sweden

The presentation will include data and results from Cellkraft's on-going work developing fuel cells for cold climate applications. Results will be shown from both field testing and laboratory results, including thermal cycling and cold start of fuel cells from - 30˚C.

5:00 Designing for Durability and Performance in Extreme Environments: Contaminated Feeds and Mechanical Vibrations

Bruce J. Tatarchuk, PhD, Professor, Dept of Chemical Engineering, Center for Microfibrous Materials Manufacturing, Auburn University

Environmental factors strongly affect the performance, power density, life cycle cost and overall efficacy of fuel cell integrated power systems. Two specific factors will be presented in this talk, (i) the influence of contaminated feeds and methodologies to mitigate these influences at both the anode as well as the cathode, and (ii) the influence of vibration and shock from the catastrophic event to the normally anticipated operating environment.

5:30 Accelerated Testing Methodology of Fuel Cell Stacks

Olga Polevaya, Manager of Applied Research, Nuvera North America*

Accelerated testing methodologies were developed to project fuel cell stack lifetime and detect early failure modes. While accelerated testing of fuel cell components is often conducted in the off-fuel cell operating conditions i.e. chemical solutions, humidity cycling or half-cell potential cycling, the stacks assembled with the same components may undergo different aging routines. Multiple cells of full active area 500cm^2 were assembled into Nuvera XDS900TM type short fuel cell stacks to accumulate statistical data. Different load cycles imitating real field scenarios were studied including but not limited to start-up and shutdown, potential reduction, OCV, hydrogen or air starvation etc. Cell voltage decays and cell voltage decay progress were derived from accelerated tests concluding accelerated factors and characteristic timing for stabilization of aging process. Decrease of the catalyst active area was found accelerated in the proposed methods comparing to the steady state operation. Membrane failures due to developing hydrogen crossover were detected earlier in the selected accelerated tests rather than in steady state operation and attributed to the lack of mechanical rather than chemical stability. *In collaboration with: A.Maggiore, Nuvera Europe; K.Beverage, Nuvera NA, Italy

6:00 Discussion, End of Day One

Friday, December 8, 2006

8:15 Exhibit/Poster Viewing, Coffee and Pastries

COMPONENTS, STACKS, SYSTEMS, AND TESTING

9:00 Durability and Degradation Mechanisms of PEM Fuel Cell Components

Rod Borup, PhD, Team Leader, Institute for Hydrogen and Fuel Cell Research, Los Alamos National Laboratory*

PEM fuel cell durability testing is performed with tests being conducted with steady-state conditions (both constant voltage and constant current), with dynamic conditions using power cycling to simulate a vehicle drive cycle and use of accelerated testing methods. The long-term performance characteristics of MEAs, Electrocatalysts and Gas Diffusion Layers (GDL) and their impact on PEMFC operating durability are evaluated in terms of their associated degradation mechanisms. *In collaboration with: F.Garzon, D.Wood, J.Davey, and P.Welch, LANL

9:30 PEM Fuel Cell Durability: Transportation Market Requirements, Gaps and Technologies

Sathya Motupally, PhD, Manager, PEM Fuel Cell Durability, UTC Fuel Cells, A United Technologies Company

Transportation fuel cells have to meet stringent operating requirements. These requirements will be reviewed and a gap analysis will be presented. Materials and system solutions capable of closing the identified gaps will be discussed.

10:00 Fuel Cell Durability Testing at the Argonne Fuel Cell Test Facility

Ira D. Bloom, PhD, Manager, Electrochemical Analysis & Diagnostics Laboratory, Chemical Engineering Division, Argonne National Laboratory*

The Fuel Cell Test Facility (FCTF) conducts standardized, independent performance evaluations of fuel cell hardware. Such testing can provide insights into the factors that limit fuel cell performance and durability. The FCTF is designed to run tests representative of the automotive application; the load profiles can emulate standardized driving schedules, as well as arbitrary power versus time tests. Sample results from such tests will be presented. This work was performed under the auspices of the US Department of Energy, Office of Hydrogen, Fuel Cells and Infrastructure, under Contract No. W-31-109-Eng-38. *In collaboration with: J.Basco, L.Walker and P.Prezas

10:30 Refreshment Break, Exhibit/Poster Viewing

11:00 Fundamental Issues of PEM Fuel Cell Durability and Performance

Zhigang Qi, PhD, Fellow, Plug Power, Inc.

When a proton-exchange membrane fuel cell fails, it is normally due to either the membrane breach or due to the catalyst activity loss. These failures are usually related in part to the membrane and the catalyst themselves; in part to the other components of the fuel cell system; and in part to the whole fuel cell system and to conditions of its operation. This presentation will discuss key challenges facing PEM fuel cells, the underlining reasons, and efforts towards overcoming these challenges. In addition, it will illustrate several specific methodologies that have been proven to be effective in enhancing fuel cell performance and durability.

11:30 Durability of Advanced Metallic Fuel Cell Stacks in Automotive Applications

Antonino Toro, Technology Development Manager, Nuvera Europe, Italy

Operating stability and long life are essential requirements to enable the commercialization of fuel cell technology, and are being pursued vigorously by component, stack, and system developers. The US DoE has set durability targets that are informed by the demands of the intended markets (both stationary and automotive), and which serve as an important reference for the industry - the expectation and need is that durability and all other requirements be met simultaneously in a single embodiment. This is extremely challenging, above all for automotive applications where continuous process parameter variation and extreme changes in environmental conditions both can have strong impacts on the integrity and operational stability of the FC materials. Disciplined material selection, detailed engineering of cell and stack designs, and enforcement of optimized operating protocols are all essential. This paper describes highlights of Nuvera's automotive stack qualification and durability testing campaign, including running in different process conditions, from extended steady state operation to partial and/or continuous load cycling, including on-off and cold start up, giving insight into the complete spectrum of scenarios expected in the actual vehicle life cycle.

12:00 Hydrogenics' Fuel Cell Stack Durability at Non-Humidified Conditions

Rami Abouatallah, PhD, PEng, Senior Research Engineer, Fuel Cell Technology, Hydrogenics Corporation, Canada

In an effort to simplify the fuel cell system for increased overall reliability and reduced system weight, elimination of stack humidification components (anode and cathode) was considered. Stack testing was performed using very low humidity gas feeds (20% anode RH, 2% cathode RH) and the effect on stack performance and durability was determined. Successful achievement exceeding 1000 hours of durability testing with zero voltage decay was obtained on multiple stacks.

12:30 Lunch on Your Own

ELECTROCATALYSTS

2:00 Fundamental Studies of Platinum Electrocatalyst Degradation

Deborah J. Myers, PhD, Group Leader, Hydrogen and Fuel Cell Materials, Chemical Engineering Division, Argonne National Laboratory*

One of the phenomena responsible for performance degradation of a polymer electrolyte fuel cell (PEFC) is the loss of electrochemically active surface area (ESA) of the platinum-based electrocatalysts. A contributing factor for ESA loss is the oxidation, dissolution, and re-deposition of the platinum during fuel cell operation. We are systematically investigating the dissolution behavior of Pt electrocatalysts in an aqueous, non-adsorbing electrolyte, mimicking the conditions encountered in the PEFC, as a function of potential, potential cycling, alloying, temperature, and other variables that are of interest in the automotive applications of PEFCs. *In collaboration with: X.Wang and R.Kumar, Argonne National Laboratory

2:30 Development of High-Performance Nanostructured Materials for Fuel Cells

Chikashi Nishimura, PhD, Director, Fuel Cell Materials Center; Group Leader, Hydrogen Purification Materials Group, National Institute for Materials Science (NIMS), Japan

At NIMS, so far, we have developed high-performance materials by controlling microstructures and nanostructures, including nanostructure controlled doped-CeO_2 solid electrolyte, V-based hydrogen separation membranes, Ni_3Al catalytic foils for fuel reforming and corrosion resistant high nitrogen stainless steels. Here, we will challenge to develop key materials for fuel cells, operated at intermediate temperatures, and for efficient and inexpensive hydrogen production, matching today's needs for fuel cells.

3:00 Durability of Advanced Electrocatalysts for PEM Fuel Cells

Paolina Atanassova, PhD, Manager of R&D, Fuel Cells, Cabot Corporation

The development and volume manufacture of durable, low-cost oxygen reduction electrocatalysts with high activity and utilization is one of the most critical remaining challenges for the successful introduction of fuel cells into mass markets. There are several related aspects to this problem: the high cost of platinum used in the current generation Membrane Electrode Assemblies (MEA) and lack of sufficient durability under load cycling conditions. In addition, the durability of commonly used carbon supports is a major challenge due to corrosion at high cell potentials and temperatures, and especially during start/stop cycles typical for transportation applications. The combination of highly active low-precious metal alloy catalysts and durable advanced carbon supports is recognized as the most viable approach to meet cost and durability targets for the first commercial generation of fuel cell vehicles. Cabot's Fuel Cell effort has applied the combined strengths of Cabot's long standing leadership in Carbon Black technologies to carbon support structure, surface modification and manufacturing, and the recognized strengths of Cabot Superior MicroPowders's spray based method to the rapid development and scaled manufacturing of low cost, highly active fuel cell electrocatalysts. Long-term durability testing data under load cycling and accelerated corrosion test protocols will be presented.

3:30 Refreshment Break, Exhibit/Poster Viewing

MODELING AND EXPERIMENTAL DATA

4:00 Modeling Pt Loss in PEM Fuel Cell Cathodes

Dane Morgan, PhD, Assistant Professor, University of Wisconsin - Madison*

The effective active surface area of Pt is reduced over time in PEM fuel cell cathodes, causing degradation of performance. We use electrochemical simulations to understand this process and how it might depend on such parameters as hydrogen crossover rates, voltage cycling, and particle size distribution. A key issue is the balance between coarsening of particles and dissolution of Pt into the ionomer. *In collaboration with: Yang Shao-Horn, Massachusetts Institute of Technology

4:30 Water and Heat Transport in Polymer-Electrolyte Fuel Cells

Chao-Yang Wang, PhD, Professor of Mechanical Engineering and Materials Science; and Director of the Electrochemical Engine Center, Pennsylvania State University

This talk will present the latest experimental (including X-ray microtomography) and multiscale modeling efforts towards developing a basic understanding of liquid water formation and transport in various components of a PEFC. The emphasis will be on important interactions between water and heat transport and their impact on PEFC performance and durability. Detailed mechanisms and development of a multiphase, nonisothermal model for PEFC startup from subzero temperatures will also be presented.

5:00 Elucidating PEM Fuel Cell Performance and Durability via Experiments and Modeling

Ken S. Chen, PhD, Principal Member of Technical Staff, Sandia National Laboratories*

In this presentation, we report our experimental and modeling efforts at Sandia National Laboratories aiming at elucidating the key phenomena that control performance and durability of polymer electrolyte membrane fuel cells. Specifically, we will discuss our findings via experimental diagnostics / characterization and computational modeling/analyses on liquid water transport and removal in PEM fuel cells, and MEA (membrane assembly electrode) component degradation under normal, hydration/dehydration, and load-cycling conditions. *In collaboration with: M.A.Hickner, Sandia Nat'l Labs

6:00 Concluding Discussion, Closing Remarks, End of Conference

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