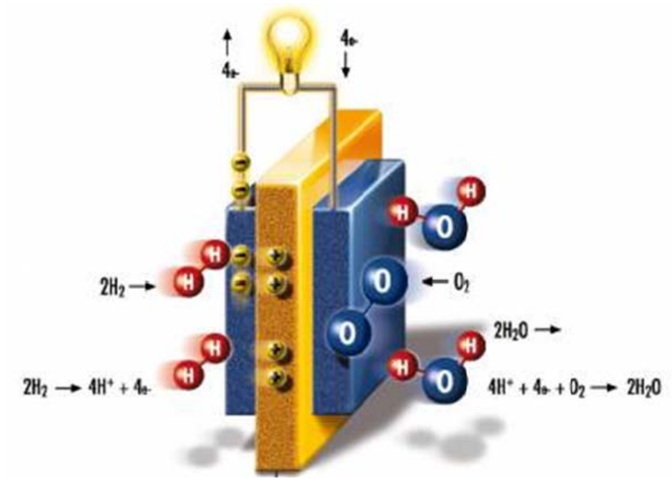
THE FIRST WORKSHOP ON THE RECENT ADVANCES IN FUEL CELLS



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RYERSON UNIVERSITY

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About MITACS Elevate

MITACS has played a leadership role in linking businesses, government and not-for-profits with over 50 of Canada's universities to develop cutting-edge tools to support the growth of their knowledge-based economy since 1999. Their cutting-edge programs focus on developing and attracting a new generation of Canadian researchers and entrepreneurs through skills training & entrepreneur workshops, technical training events, graduate and post-doctoral internships and outreach activities.

MITACS Elevate is a two-year pilot program for postdoctoral fellows (PDFs) in Ontario. This unique program provides support to both PDFs who are already working on a collaborative research project with an Ontario industry partner as well as to those PDFs who are not currently working with an industrial partner but would like to initiate a collaboration. Elevate PDFs take part in a customized training program to further develop their professional development skills including courses in project management, communication skills, and networking skills. They also have the opportunity to investigate other areas of interest such as commercialization or entrepreneurship. Elevate PDFs who don't currently have a research collaboration with an industrial partner are involved in developing an individualized program to engage industry with support from MITACS staff.

Workshop Chairs

Dincer, Ibrahim, University of Ontario Institute of Technology
Fung, Alan, Ryerson University

Organizing Committee Members

Colpan, C. Ozgur, Ryerson University
Farhad, Siamak, University of Waterloo
Huynh, Keith, Queen's University
Marzoughi, Reihane, University of Toronto
Nabovati, Aydin, University of Toronto
Younessi-Sinaki, Maryam, University of Waterloo
Zahibian, Farshid, Ryerson University
Zamel, Nada, University of Waterloo

A MESSAGE FROM THE ORGANIZING COMMITTEE

The research and development on fuel cell science and technology have increased significantly in the last decade. Different research groups all around the world have made significant progress on different types of fuel cells that could be used in a wide range of applications from portable to stationary energy systems. Both Federal and Provincial Governments have also emphasized on the role of fuel cells in the future of energy production in Canada, and have started incentive plans to promote their use. This workshop aims to bring together researchers, scientists, engineers, policy makers, and students from academia, industry, and government sectors to provide an opportunity for exchange the knowledge, share the experience, and foster relationships that will certainly strengthen the works done in these sectors.

We have invited 12 distinguished speakers from industry, academia, and national laboratories in North America. A wide range of topics will be covered in their talks, which includes modelling, experiments, materials, manufacturing, and future strategies for fuel cell science and technology. There will be also Q&A periods in which the attendees will have a chance to actively participate in the discussions.

We would like to thank to the main workshop sponsor, MITACS Elevate program, for their generous support. Particularly, we appreciate the efforts of Alison Ewart, Melinda Benn, and Susan Yu of MITACS in helping with the organization of this event. We also acknowledge the contributions of Ryerson University and University of Waterloo. Most importantly, we would like to thank all the speakers and session chairs for their contribution to this event.

We wish you all a fruitful meeting and a pleasant stay.

Organizing Committee

Program

08:30-09:00	Registration and Breakfast
09:00-09:30	Welcoming remarks Alison Ewart, Program Director, MITACS Elevate
Session-1: **Progress in Fuel Cell Science and Technology** Chair: Alan Fung	
09:30-10:00	1.1 "Fuel Processing for Fuel Cells: New Catalysts and Novel Reactor Designs", Brant A. Peppley
10:00-10:30	1.2 "Enhancing the Durability of PEM and SOFC Electrode Layers", Viola I. Birss
10:30-11:00	Networking/Coffee Break
Session-2: **High Temperature Fuel Cells** Chair: Murat Aydin	
11:00-11:30	2.1 "High Temperature Solid Oxide Fuel Cells: Status, Challenges and Opportunities", Subhash C. Singhal
11:30-12:00	2.2 "Integrated Fuel Cell Systems for Multi-Generation Purposes", Ibrahim Dincer
12:00-12:30	2.3 "Metal-Supported Solid Oxide Fuel Cell Research and Development", Olivera Kesler
12:30-13:30	Networking Lunch
Session-3: **Low Temperature Fuel Cells** Chair: Gregory Jerkiewicz	
13:30-14:00	3.1 "Overview of Recent Activities in Hydrogen and Fuel Cell Research in Chemical Engineering at the University of Waterloo", Michael Fowler
14:00-14:30	3.2 "Experimental Analysis of a Single Cell Flowing Electrolyte – Direct Methanol Fuel Cell (FE-DMFC)", Edgar Matida
14:30-15:00	3.3 "PEM Fuel Cells: Mass Transport Phenomena", Zhong Sheng (Simon) Liu
15:00-15:30	3.4 "Fundamental Understanding and Durability of Proton Exchange Membrane Fuel Cells", Biao Zhou
15:30-16:00	Networking/Coffee Break
Session-4: **Towards the Commercialization of Fuel Cells** Chair: Terry Kimmel	
16:00-16:25	4.1 "Fuel Cell Commercialization: Progress and Research Directions", Shanna D. Knights
16:25-16:50	4.2 "Next Generation Fuel Cell Power Systems: Advancements in Stack and Balance of Plant Architecture", Rami M. Abouatallah
16:50-17:15	4.3 "Advances in PEM Catalysts and their Supports: The H2&FC National Program", Alan Guest
17:15-18:00	Panel Discussion Session
18:00-18:05	Closing Remarks

1.1 Fuel Processing for Fuel Cells: New Catalysts and Novel Reactor Designs

Brant Peppley

Abstract

The hydrogen economy is evolving and fuel cells operating on pure hydrogen for forklifts, buses and power back up are all becoming more competitive and more widely used. However, the opportunities to utilize conventional fuels, biomethane, waste industrial solvents and solid organic waste to produce hydrogen or hydrogen-rich streams for fuel cells is still of great interest. This requires research and development into cost effective new ideas for catalysts and reactor designs. This talk will look at the research challenges and recent successes in this area.

Biographical Sketch

When it comes to fuel cell systems and research, Dr. Brant Peppley is at the top of his field. Dr. Peppley has been working in the field of fuel cell research since 1986 and his notable credentials include Canada Research Chair in Fuel Cells, Professor, Department of Chemical Engineering and Mechanical and Materials Engineering, Queen's University, and Director of the Queen's-RMC Fuel Cell Research Centre, which is a multidisciplinary research group consisting of 11 faculty members and numerous postdoctoral fellows and graduate students from Queen's University and the Royal Military College of Canada.
Dr. Peppley's current research activities include modeling of polymer electrolyte fuel cells and the development of new technologies for processing diesel fuel and bio-fuels for use in solid oxide fuel cells. Dr. Peppley is extremely dedicated to the fuel cell industry and his ongoing enthusiasm and hard work in fuel cell research is unparalleled.

1.2 Enhancing the Durability of PEM and SOFC Electrode Layers

Viola I. Birss

Abstract

Fuel cell research efforts in the Birss group are focussed on enhancing the lifetime of anode and cathode materials of relevance to both proton exchange membrane (PEM) and solid oxide (SOFC) fuel cell systems. In terms of our PEMFC work, a new class of mesoporous carbon support materials is being developed, with the main aim being the stabilization of the catalytic Pt nanoparticles on the carbon surface and increasing the carbon corrosion resistance. Using powerful TEM tomographic methods, we have been able to explain the superior performance of some of the Pt/meso-C materials under development. In relation to research in the SOFC area, while Ni-YSZ (yttria-stabilized zirconia) cermets have excellent properties for use as SOFC anodes, they are susceptible to performance loss in the presence of sulfur (S) in the fuel stream. Our work is therefore directed towards developing a better understanding of the S poisoning mechanism and then applying this knowledge to the *in situ* recovery of these anode materials from S poisoning.

Biographical Sketch

Viola Birss is a Professor of Chemistry and a Tier I Canada Research Chair in Materials for Fuel Cells and Related Energy Applications at the University of Calgary. Dr. Birss was one of the key founders of both the Western Canada Fuel Cell Initiative and the pan-Canadian Solid Oxide Fuel Cells Canada (SOFCC) organization, and is currently the Scientific Co-Director of the SOFCC NSERC Strategic Research Network. Dr. Birss has been the recipient of numerous prestigious scientific awards and honours, is a Fellow of the Canadian Society for Chemistry and the Electrochemical Society, and has served on many review panels and Boards. Her research has been focused on better understanding fuel cell reaction mechanisms, as well as on improving the performance and lifetime of both low temperature PEM fuel cells and high temperature SOFCs through the optimization of electrode properties. This work has included the development of sulphur and coke tolerant SOFC anodes, highly active anodes for the catalysis of methanol oxidation, and mesoporous carbon support materials for use in PEM fuel cell cathodes. Her research work also includes the electrochemical formation of protective oxide films for light metal alloys, and the development of wear resistant surface coatings, novel nanotemplates, and a stable and biocompatible glucose biosensor for the treatment of diabetes.

2.1 High Temperature Solid Oxide Fuel Cells: Status, Challenges and Opportunities

Subhash C. Singhal

Abstract

Solid oxide fuel cells (SOFCs), based on an oxide ion conducting electrolyte such as stabilized-zirconia, offer a clean, low-pollution technology to electrochemically generate electricity at high efficiencies. These cells operate between about 550 and 1000^{o}C, and some hydrocarbon fuels such as natural gas can be reformed within the cell stack eliminating the need for an expensive, external reformer. The most important need to commercialize SOFC technology is to significantly reduce the overall cost of SOFC-based power systems, while maintaining adequate performance and performance stability with time. Reduction of cell operation temperature enables use of low-cost metallic interconnects and a decrease in maintenance costs. However, at lower temperatures, greater ohmic loss due to reduced ionic conductivity of the electrolyte and reduced catalytic activity of the electrodes result in lower cell performance. To improve cell performance at lower temperatures, employing thin electrolyte and nanoscale materials in the electrodes has recently been considered. However, a crucial question that remains to be answered is whether the beneficial effect of employing nanoscale materials will persist even after long term cell operation at high temperatures, even though the initial performance may have indicated substantial enhancement.

This overview focuses on the materials, processing, and performance of solid oxide fuel cells, with relative advantages/disadvantages of tubular and planar geometries. Stacks and systems built with both tubular and planar geometries are described and their operating experience discussed. Applications of such cells in stationary, mobile and military market sectors are reviewed and challenges in reducing cell and system costs are summarized. Considerable recent progress has been made in employing solid oxide fuel cells for small/portable and residential power generation applications because of their fuel flexibility and advances in materials and processing techniques; SOFCs offer important advantages over PEMFCs and DMFCs, notably their ability to use CO or liquid hydrocarbons as fuel, which makes them ideally suited for residential, portable, and military applications.

Biographical Sketch

Dr. Singhal joined the Energy and Environment Directorate at PNNL in April 2000 after having worked at Siemens Power Generation (formerly Westinghouse Electric Corporation) for over 29 years. At PNNL, Dr. Singhal provides senior technical, managerial, and commercialization leadership to the Laboratory’s extensive fuel cell and clean energy programs. At Siemens/Westinghouse, he conducted and/or managed major research, development, and demonstration programs in the field of advanced materials for various energy conversion systems including steam and gas turbines, coal gasification, and fuel cells. From 1984 to 2000, he was manager of Fuel Cell Technology there, and was responsible for the development of high temperature solid oxide fuel cells (SOFCs) for stationary power generation. In this role, he led an internationally recognized group in the SOFC technology and brought this technology from a few-watt laboratory curiosity to fully-integrated 200 kW size power generation systems. He has authored over 85 scientific publications, edited 14 books, received 13 patents, and given almost 300 plenary, keynote and other invited presentations worldwide.

Dr. Singhal is also an Adjunct Professor in the Department of Materials Science and Engineering at the University of Utah, and a Visiting Professor at the China University of Mining and Technology-Beijing. He serves on the Advisory Boards of the Department of Materials Science and Engineering at the University of Florida, Florida Institute for Sustainable Energy, Division of Materials Science and Engineering at Boston University, and the Center on Nanostructuring for Efficient Energy Conversion at Stanford University.

Dr. Singhal is a member of the U.S. National Academy of Engineering and the Washington State Academy of Sciences; a Fellow of four professional societies (American Ceramic Society, The Electrochemical Society, ASM International, and American Association for the Advancement of Science); and a senior member of the Mineral, Metals & Materials Society (TMS). He served on the Electrochemical Society's Board of Directors during 1992-94, received its Outstanding Achievement Award in High Temperature Materials in 1994, and continues as the Chairman of its International Symposium on Solid Oxide Fuel Cells held biennially since 1989. He served as President of the International Society for Solid State Ionics during 2003-2005. He received the American Ceramic Society's Edward Orton Jr. Memorial Award in 2001; an Invited Professorship Award from the Japan Ministry of Science, Education and Culture in 2002; Christian Friedrich Schoenbein Gold Medal from the European Fuel Cell Forum in 2006; Fuel Cell Seminar Award for outstanding leadership and innovation in the promotion and advancement of fuel cell technology in 2007; and the prestigious Grove Medal in 2008 for sustained advances in fuel cell technology. He serves on the Editorial Board of the Elsevier's*Journal of Power Sources* and is an Associate Editor of ASME's *Journal of Fuel Cell Science and Technology.* He has also served on many national and international advisory panels including those of the National Materials Advisory Board of the National Research Council, National Science Foundation, Materials Properties Council, U.S. Department of Energy, NATO Advanced Study Institutes and NATO Science for Peace Programs, United Nations Development Program (UNDP), United Nations Industrial Development Organization (UNIDO), International Energy Agency (IEA), and the European Commission.

2.2 Integrated Fuel Cell Systems for Multi-Generation Purposes Ibrahim Dincer

Abstract

Interest has increased recently in fuel cell applications for both stationary and mobile power generation, motivated largely by their potential role in reducing emissions and increasing overall system efficiencies, even in small-scale installations. Furthermore, integrated fuel cell systems have received more attention in various sectors, ranging from industrial to residential applications, especially for co- and tri-generation purposes. There are essentially multiple issues as there is a strong need to address for practical applications, such as efficiency, cost, resources, environment and sustainability. This presentation focuses on various integrated fuel cell energy systems (including SOFC, MCFC and PEMFC) for multi generation purposes, including power, heat, cooling, hot water, hydrogen, desalination, etc. It also discusses various projects and applications under case studies. The research findings show that such systems address the crucial issues by providing better efficiency, better cost effectiveness, better resources use, better environment and better sustainability.

Biographical Sketch

Ibrahim Dincer is a full professor of Mechanical Engineering in the Faculty of Engineering and Applied Science at UOIT. He is Vice-President for World Society of Sustainable Energy Technologies (WSSET) and International Association for Hydrogen Energy (IAHE). Renowned for his pioneering works in the area of renewable/ sustainable energy technologies he has authored and co-authored numerous books and book chapters, more than 600 refereed journal and conference papers, and many technical reports. He has chaired many national and international conferences, symposia, workshops and technical meetings. He has delivered more than 200 keynote and invited lectures. He is an active member of various international scientific organizations and societies, and serves as editor-in-chief (for International Journal of Energy Research by Wiley, and International Journal of Exergy and International Journal of Global Warming by Inderscience), associate editor, regional editor, and editorial board member on various prestigious international journals. He is a recipient of several research, teaching and service awards, including a Premier's research excellence award in Ontario, Canada in 2004. He has made innovative contributions to the understanding and development of sustainable energy technologies (particularly renewables). He has actively been working in the areas of hydrogen and fuel cell technologies, and his group has developed various novel technologies/ methods/etc.

2.3 Metal-Supported Solid Oxide Fuel Cell Research and Development

Olivera Kesler

Abstract

Metal-supported solid oxide fuel cells (SOFCs) have the potential to substantially decrease the cost and increase the mechanical durability of SOFCs compared to cermet-supported or ceramic-supported fuel cell architectures. The use of metal supports for SOFCs also has the potential to allow the fuel cells to be more rapidly thermally cycled, due to the higher thermal shock resistance of the metals, thus potentially decreasing fuel cell start-up times, while the toughness of the metal supports can make the cells more suitable for vibration-intensive applications, such as transportation. In the SOFC Canada NSERC Strategic Network and in the Fuel Cell Materials and Manufacturing Laboratory at the University of Toronto, research activities are aimed at developing materials and fabrication techniques to produce metal-supported SOFCs that can be readily scaled to large-volume production. The talk will provide an overview of the R&D activities related to the development of metal-supported cells, including a discussion of the scientific and technical challenges facing their design and some strategies in use to overcome those challenges.

Biographical Sketch

Olivera Kesler is an associate professor at the University of Toronto, and the Canada Research Chair in Fuel Cell Materials and Manufacturing. Her research group is focused primarily on the fabrication of SOFCs, including designing new manufacturing methods for their fabrication, as well as the microstructural, architectural, and compositional design of SOFC components. Other research areas of interest include the design of diagnostic techniques to better understand the performance and degradation of fuel cells. Previous work includes studies of plasma sprayed thermal barrier coatings, design of metallic foam core sandwich beams, and the development of new oxidation-resistant materials and microstructures for PEMFC cathode catalyst supports.

3.1 Overview of Recent Activities in Hydrogen and Fuel Cell Research in Chemical Engineering at the University of Waterloo

Michael Fowler

Abstract

Dr. Fowler will cover an overview of current research activities in Chemical Engineering at the University of Waterloo. Dr. Fowler's primary research interests are in the area of fuel cell design and performance, specifically fuel cell system reliability, and research into potential failure modes and causes experienced in fuel cells stacks. Research activities into membrane degradation and diagnostics will be covered, as well as fundamental research into the mass transfer in PEM gas diffusion layers. Dr. Fowler will also introduce hydrogen economy modelling, which is focused on hydrogen energy hubs. An 'energy hub' by our definition is the interaction of energy loads and energy sources that will include different technologies for power generation, energy storage, and energy conversion. Dr. Fowler will also introduce the research of Dr. Chen which is focused on innovative catalyst and membrane development, as well as the research of Dr. Croiset in the field of Solid Oxide Fuel Cell materials development.

Biographical Sketch

Dr. Fowler is an Associate Professor in the Chemical Engineering Department at the University of Waterloo. His primary research interests are in the design and performance of hydrogen fuel cell stacks and systems, including the modeling of fuel cell system reliability, and research into potential failure modes and causes experienced in hydrogen power systems. In order to adequately model fuel cell performance and reliability, an interest in both fuel cell modeling, as well reliability analysis and simulation is pursued. Control systems and maintenance planning over the life of a fuel cells stack must account for degradation and changes in the performance characteristics. Dr. Fowler's research includes these adaptive control systems for fuel cell and fuel cell/battery hybrid systems. He has completed projects designs of hydrogen retail stations, and hydrogen based off grid community power systems. The design of distributed energy systems will include significant energy modeling in order to balance the various energy sources, and in such systems both electricity and hydrogen will become energy vectors to transfer and store the energy.

3.2 Experimental Analysis of a Single Cell Flowing Electrolyte – Direct Methanol Fuel Cell (FE-DMFC)

Edgar Matida, Nasim Sabet, and Cynthia Cruickshank

Abstract

In direct methanol fuel cells (DMFCs), unwanted methanol crossover from the anode to the cathode through the polymer electrolyte membrane (PEM) reduces the overall fuel cell performance. In order to mitigate this crossover, Kordesch et al. [1] proposed the introduction of a flowing electrolyte (FE, for example, diluted sulfuric acid) between the anode and cathode. The introduction of the flowing electrolyte will carry away the methanol crossover by means of convection mechanisms. This procedure requires the management of three working fluids (i.e., diluted methanol, the flowing electrolyte, and air) in addition to the inclusion of two membrane electrode assemblies (MEAs) at the anode and cathode sides.

A flowing electrolyte – direct methanol fuel cell was built and tested experimentally. The fuel cell has parallel serpentine channels for the methanol and air passages. The flowing electrolyte channel is formed by a polyethylene porous material (porous size from 50 to 110 microns). The active area of the fuel cell is approximately 25 cm^2. Nafion® NR-212 is used in the MEAs. Effects of the flowing electrolyte channel thickness (namely, 2.0, 1.5, and 0.6 mm) and sulfuric acid concentration on the performance of the cell were studied. It was observed that a thicker flowing electrolyte channel results in lower power density, due to an increase in internal resistance, as expected. Finally, sulfuric acid having a concentration bigger than 2 molar (18%) was found to be the adequate for usage as flowing electrolyte when FE-DMFC performance is concerned. Other developments in the research group will also be described.

Reference

[1] K. Kordesch, V. Hacker, U. Bachhiesl, “Direct methanol-air fuel cell with membranes plus circulating electrolyte,” Journal of Power Sources, vol. 96, no. 1, pp 200-203, June 2001.

Biographical Sketch

Dr. Matida received his Ph.D. in Mechanical Engineering from the Yokohama National University in Japan and is specialized in the area of Thermofluids. He has also industrial experience working with gas turbines at Hitachi Works, also in Japan. Currently, Dr. Matida is an Associate Professor in the Department of Mechanical and Aerospace Engineering at Carleton University in Ottawa. He has been working with both numerical (Computational Fluid Dynamics, CFD, applied to turbulent particle-laden gas flows) and fluid flow measurement techniques using Phase Doppler Anemometry. Past work in the particle-laden flow field includes two patent applications, one report of invention, and one award sponsored by the AHTI (Association of Health Technologies Industry). He has secured funding from NSERC (Natural Sciences and Engineering Research Council of Canada), CFI (Canada Foundation for Innovation), and OCE (Ontario Centres of Excellence, five industrial projects). Recently, Dr. Matida has expanded his interest towards comprehensive experimental and numerical studies of flowing electrolyte - direct methanol fuel cells (FE-DMFCs) in a project involving five graduate students. Dr. Matida has published more than 35 refereed research publications.

3.3 PEM Fuel Cells: Mass Transport Phenomena

Zhong Sheng (Simon) Liu

Abstract

A better understanding of mass transport phenomena in PEM fuel cells is critical for further reducing cost, improving performance and durability. This presentation will try to outline the important mass transport phenomena and heat transfer as well, and show how they affect fuel cell performance. Modeling and numerical simulation of mass transport phenomena is discussed with a focus on the challenges regarding how to build up mathematical models for better representing the nature of complex and coupled physical and chemical phenomena. In the end, it lists future research needs and research directions.

Biographical Sketch

Dr. Liu is a senior research officer and group leader (modeling and simulation group) at NRC Institute for Fuel Cell Innovation. He is an adjunct professor of University of Waterloo and University of Victoria. He was the Institute's acting director of science and technology from June 2006 to June 2007. His university degrees (Bachelor, Master and PhD) were granted by Jilin University in China. He was a full professor/Ph.D supervisor of Jilin University. He spent six years conducting research in computational mechanics at Peking University, University of California at Berkeley, Technical University of Munich, University of Wales Swansea and University of Toronto. Since 1998 when he joined NRC, he has been leading the modeling and simulation group which performs computational modeling at different length-scales (atomic-scale, molecular-scale and continuum-scale) for different applications such as fuel cell catalysts, catalyst-layers, behaviors of thin-films made of nano particles, mass/heat transport phenomena, fluid flow, stress-strain analysis, vibration and acoustics. Now he and his team are collaborating with automakers on generating key knowledge of PEM fuel cells for automotive application.

3.4 Fundamental Understanding and Durability of Proton Exchange Membrane Fuel Cells

Biao Zhou

Abstract

This presentation will introduce the state of the art of optimization tools for Proton Exchange Membrane Fuel Cells (PEMFC). These optimization tools developed by Dr. Zhou's team can be used to deal with fluid dynamics, liquid water dynamics, electron dynamics, and thermodynamics. The talk will explain the fundamental mechanisms behind the failures of PEM fuel cells through a multi-disciplinary point of view.

Biographical Sketch

Biao Zhou is an Associate Professor in the Department of Mechanical, Automotive and Materials Engineering at the University of Windsor. Dr. Zhou graduated from Tsinghua University, and worked at the Chinese Academy of Sciences, Princeton University, University of Taxes at Austin, Royal Military College of Canada, and Ballard Power Systems, Inc. Dr. Zhou is internationally recognized for his research in the areas of Proton Exchange Membrane Fuel Cell (PEMFC) mathematical modeling, innovative design, and optimization.

His current research includes:

- Water and thermal management in PEMFC
- Large Eddy Simulation (LES) of turbulent combustion with detailed chemistry for bio-diesel combustion and Homogeneous Charge Compression Ignition (HCCI) engine.
- Nano-structure design of Membrane-Electrode-Assembly (MEA)
- Lithium-ion battery management system
- Motor control
- Electric vehicle
- Fuel cell-battery hybrid vehicle

4.1 Fuel Cell Commercialization: Progress and Research Directions

Shanna Knights

Abstract

An overview of recent fuel cell commercialization progress at Ballard Power Systems will be presented, with a brief description of the current key fuel cell application markets of back-up power, materials handling, bus, and distributed generation. Market growth will be further accelerated by key technology advances to enhance durability and reduce cost. Whereas catalyst performance targets in terms of mass activity have been demonstrated, the associated durability generally is partially sacrificed in high performing catalysts. Although there is an increased understanding of “real world” requirements for fuel cells, further work is required to ensure durability is achieved over a wide range of operating conditions. The impact of key operating conditions parameters on MEA component degradation will be discussed. Finally, a brief description of research collaboration activities and research targets at Ballard will be provided.

Biographical Sketch

Ms. Shanna Knights is Manager of Research at Ballard Power Systems. Her fuel cell research areas during fifteen years at Ballard include durability, reliability, performance, and operational behaviour. Her group at Ballard conducts R&D for the fuel cell components of membrane, anode and cathode catalyst layers, gas diffusion layers, and for the integration of the MEA components, with the objective of developing next generation products with reduced cost, and increased performance and durability. Activities include the elucidation of failure mechanisms, accelerated stress test development, understanding structural and operational failure relationships, component characterization, development of design concepts and relationships for performance and durability, modeling for performance and degradation, and trade-off analysis for the optimum materials and design for a given product application. Ballard Power Systems fuel cell stacks are designed for a range of applications, including bus, materials handling, back-up power, cogeneration, and distributed generation. Ballard is actively engaged in a number of research collaborations with universities, research institutions and industry.

4.2 Next Generation Fuel Cell Power Systems: Advancements in Stack and Balance of Plant Architecture

Rami Abouatallah

Abstract

Advancements in Hydrogenics' fuel cell stack technology have provided significant performance and durability improvements; however, success with stack technology is only a portion of the advancements required to enable the entry of fuel cells into commercial markets. System durability and reliability, combined with stack and balance-of-plant cost reductions, are equally important and are key barriers to entry for successful commercialization.

Hydrogenics' HyPM® fuel cell power modules are built upon the proprietary non-humidified system architecture that was introduced across the entire HyPM® series of power products in 2009. Leveraging advancements in fundamental fuel cell stack technology, combined with the latest advancements in overall system design, the next generation HyPM® power module family builds on Hydrogenics' combined stack and system design expertise. This presentation will show the latest performance and durability results which showcase long life, non-humidified operation in excess of 13,000 hours of operation with minimal system performance loss. Furthermore development steps towards a highly simplified and integrated stack and balance-of-plant system will be shown.

Biographical Sketch

Rami Abouatallah received his Ph.D. degree in chemical engineering at the University of Toronto, Ontario, Canada. His doctoral thesis focused on the catalytic activity of nickel in the presence of vanadium species during alkaline water electrolysis. Dr. Abouatallah joined Hydrogenics Corporation in 2002 where he has been leading the MEA and GDM material evaluation and stack durability programs for PEM fuel cell and PEM electrolysis stack development. In addition, he has been leading the development of stack diagnostic tools and procedures. Dr. Abouatallah has participated in multiple customer and government-funded projects. Dr. Abouatallah now manages the Advanced Stack Technology team at Hydrogenics. He is a licensed professional engineer and Adjunct with the University of Waterloo, Waterloo, Ontario, Canada.

4.3 Advances in PEM Catalysts and their Supports: The H2&FC National Program

Alan Guest

Abstract

The presentation will focus on the organization of and the most recent outcomes from a three year $10 M project involving 60 scientists across Canada aimed at reducing the cost and increasing the durability of PEM fuel cells by lowering the amount of Platinum used for ORR catalysis and replacing Carbon as a support for the catalyst. The project is aimed at achieving DOE 2015 targets for activity, durability and cost and is one of the largest thrusts of government research for fuel cell technology.

Biographical Sketch

Alan Guest is currently the Coordinator of the National Research Councils' H2&FC National Program. Working from the Institute for Fuel Cell Innovation he manages the Technology Development Project entitled "Advanced PEMFC for Near Term Commercialization Products". The project involves 60 scientists at 4 NRC institutes, 2 major fuel cell manufacturers, 4 universities, and 3 government departments. Alan has more than 25 years of experience in high technology business and product development and was originally trained as a physicist at the UoT.

LIST OF PARTICIPANTS

Last Name	First Name	Organization
Abouatallah	Rami	Hydrogenics Corporation
Aghahosseini	Seyedali	UOIT
Ahmadi	Pouria	UOIT
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Aydin	Murat	UOIT
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Bateni	Reza	University of Toronto
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Fazeli	Amir	University of Waterloo
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Fung	Alan	Ryerson University
Goerzen	John	University of Waterloo
Goledzinowski	Matt	ACS Corp.
Groves	Michael	Royal Military College of Canada
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Knights	Shanna	Ballard Power Systems
Ladak	Ally	CADDAC
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Li	Hongqiang	Atomic Energy of Canada Ltd.
Liu	Zhong-Sheng (Simon)	NRC-IFCI
Lohi	Ali	Ryerson University
Maffei	Nicola	Natural Resources Canada
Maheandiran	Joseph	University of Waterloo
Marzoughi	Rei	University of Toronto
Matida	Edgar	Carleton University
McAlary	Gordon	Canadian Shield Energy Systems
Mertes	Andreas	University of Waterloo
Monder	Misha	Queen's University
Mundhwa	Mayur	Royal Military College of Canada
Nabovati	Aydin	University of Toronto
Orhan	Mehmet	UOIT
Ouellette	David	Carleton University
Paul	Devproshad	Queen's University
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