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STUDIES ON NOVEL DESIGNS OF PROTON EXCHANGE MEMBRANE (PEM) FUEL CELLS

Yanyan Zhang
Ph.D. Candidate
Advanced Materials and Technologies Laboratory
Department of Mechanical Engineering
University of Connecticut

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Proton exchange membrane (PEM) fuel cells are promising sources of clean power in many applications ranging from portable electronics to automotive and land-based power generation. However, widespread commercialization of PEM fuel cells is primarily challenged by their low reliability in service. This dissertation addresses two issues concerning fuel cell reliability, one pertaining to mitigating the factors promoting membrane electrode assembly (MEA) degradation and failure, and the other aimed at reducing the system complexity.

During the operation of a PEM fuel cell, significant variation of the local current density could exist along the cell, causing sharp temperature and stress gradients in certain points, affecting the water management, and creating local hot spots and "pin-holes," all of which severely impact membrane reliability. The first goal of the dissertation is to minimize the local current density variation and potentially improve membrane reliability by determining the optimal operating parameters of PEM fuel cells with the objective of constraining the current density variation, which usually causes the local hot spots and degrades the membrane reliability. Computational studies are presented to determine the optimal operating conditions. Novel materials designs are also explored computationally and experimentally toward the goal of achieving uniformity in local current density distribution. Toward reducing the system complexity, a second focus of the dissertation is to explore a new air-breathing fuel cell design, in which the air is drawn at the cathode surface by natural convection from the ambient, and arrays of air-breathing cell units could be designed to meet required power and voltage needs. By eliminating the balance of plant associated with the air feed at the cathode, the system complexity is reduced, contributing to improve the entire system reliability. Numerical studies are conducted to investigate the performance of a single as well as array of air-breathing fuel cell units. Overall, the studies in this dissertation deliver new approaches and fundamental insights to addressing some of the current limitations in fuel cell technology.

Biographical sketch of the candidate: Yanyan Zhang received the B.S. and M.S. degrees in Mechanical Engineering from Shanghai Jiao Tong University in 1999 and 2002, respectively, and worked for the Daimler Chrysler Corporation in China prior to starting her doctoral work in the *Advanced Materials and Technologies Laboratory* in Fall 2003. Ms Zhang's doctoral dissertation has led to 5 journal publications and 1 conference presentation. Preview her research at http://www.engr.uconn.edu/amtl/p-yzhang.html

Advisory Committee: Professor Ranga Pitchumani (Major Advisor)
Professors Ted Bergman, Wilson Chiu, Ugur Pasaogullari, and Lei Zhu
(Associate Advisors)

University of Connecticut