SAND2009-0320P
SAND Number: #### #### #

Quarterly Progress Report

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

Project Title: Hydrogen PEMFC Water Transport, B&R # EB4209, EEW112798.

Project Period: October1, 2008 to December 31, 2008
Date of Report: January 6, 2009

Principle Investigator: Ken S. Chen, 505-844-5783, kschen@sandia.gov
Other Key National Lab Researchers:

Sub-Contractors Funded through AOP Task: Chao-Yang Wang, Penn State Univ.

Industrial Partners: none

DOE Managers: Nancy Garland

Project Objective: To develop analytical and multi-dimensional numerical models for simulating (1) water transport and removal in a PEM (proton exchange membrane or polymer electrolyte membrane) fuel cell under normal operation conditions, and (2) ice formation and thawing during the start-up of a PEM fuel cell under subzero temperatures or freezing conditions.

Background: Particularly during peak power conditions, water generated in the oxygen reduction reaction and transported from anode to cathode via electro-osmotic drag must be removed efficiently in order to achieve and maintain high PEM fuel cell performance. Under freezing conditions, water within a PEM fuel cell can freeze. The formation of ice within the MEA (membrane electrode assembly), in particular in the cathode catalyst layer, can hinder reactant transport and degrade cell voltage so as to limit the cold-start performance of a PEM fuel cell.

In this sub-project, we propose to develop analytical and multi-dimensional models for simulating 1) water transport and removal under normal operation conditions; and 2) ice formation and thawing during the start-up of a PEM fuel cell under subzero temperatures or freezing conditions. Specifically, we propose to develop sub-models for liquid water removal via droplet detachment and evaporation. Furthermore, we propose to develop multi-dimensional models for simulating water transport and removal under normal operating conditions, ice formation and thawing during start-up under subzero temperatures or freezing conditions.

Status: The work on elucidating the phase-change (water vapor condensation and liquid water evaporation) effects inside the cathode gas diffusion layer (GDL) of a PEM fuel cell was completed using a 3-D numerical model. Parametric studies were carried out to examine the

effects of operating conditions (such as the relative humidity of inlet gases) and materials properties (such as the thermal conductivity of GDL on phase change. This work was documented in a manuscript that was submitted on December 29, 2008 to the Journal of the Electrochemical Society for consideration of publication.

Plans for Next Quarter and Key Issues: Start working on elucidating rapid self-start of a PEM fuel cell from subzero temperatures or freezing conditions.

Patents: none.

Publications:

1. S. Basu, C.-Y. Wang, and K. S. Chen, "Phase change in a polymer electrolyte fuel cell", a manuscript submitted to the *Journal of the Electrochemical Society*, December 29, 2008.