the ENERGY lab

PROJECT FACTS

Fuel Cells

Improved Flow-field Structures for Direct Methanol Fuel Cells—NuVant Systems, Inc.

Background

In this congressionally directed project, NuVant Systems, Inc. (NuVant) will improve the performance of direct methanol fuel cells (DMFCs) by designing anode flow-fields specifically for the delivery of liquid methanol. The goal is to deliver concentrated methanol to the DMFC anode in an even and controllable manner such that the phenomenon known as crossover is avoided. Crossover occurs in a DMFC when unutilized methanol passes from the anode to the cathode through the permeable Nafion electrolyte. Traditionally, crossover has been avoided by pre-diluting methanol (with water) to decrease the methanol concentration gradient across the Nafion electrolyte. This operating strategy is undesirable for portable power applications because it reduces the specific energy content (watt-hours per kilogram) of the fuel (diluted methanol) that must be carried. NuVant's technology to deliver concentrated methanol to the DMFC anode could increase the specific energy content of DMFC fuel, potentially pushing the performance beyond the current state-of-the-art in portable power (lithium-ion batteries).

The project is managed by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL), whose mission is to advance energy options to fuel our economy, strengthen our security, and improve our environment. With the Solid State Energy Conversion Alliance, NETL is leading the research, development, and demonstration of solid oxide fuel cells (SOFCs) for coal-fueled central generation power systems that will enable low cost, high efficiency, near-zero emissions and water usage, and capture carbon dioxide (CO_2).

Project Description

NuVant will contend with the problem of methanol crossover by employing highly porous structures at the DMFC anode which will allow for controlled delivery of highly concentrated or “neat” methanol to the anode side. The methanol delivery to the anode side will be adjusted in concert with the back-diffusion of water from the cathode side such that diluted methanol will be created in-situ at the anode. In this way crossover will be minimized and high gross fuel energy density will be achieved. The basis for success is the tightly controlled structure of the porous material and the fuel delivery mode. The pore diameter and total porosity play a very important role in how (and how much) the highly concentrated methanol arrives at the anode. Various hydrophilic and/or hydrophobic treatments of the porous substrate impact the way methanol distributes over the entire geometric area of the electrode. These treatments also impact the way reaction products are being exhausted.

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PARTNERS

None

PROJECT DURATION

Start Date	End Date
08/01/2009	12/31/2011

COST

Total Project Value
$ 1,142,481

DOE/Non-DOE Share
$913,985 / $228,496

U.S. DEPARTMENT OF ENERGY

In order to best build these porous structures, a thorough understanding of flow and diffusion through porous media is required. A computer model will be developed that utilizes the relevant physical and chemical properties of methanol to model the flow of liquid fuel through the porous graphite plates that compose the anode flow-fields. The modeling effort will begin with a literature review to identify the physical and chemical properties necessary to accurately model the flow of methanol through porous graphite media. These parameters will enable the development of a mathematical model to predict how various flow-fields affect fuel distribution across the DMFC anode. A down-selection will identify flow-fields exhibiting the best-demonstrated performance according to the mathematical model. Physical prototypes of the down-selected flow-fields will be created. The prototypes will be evaluated for hundreds of hours in a bench scale DMFC stack test. This test will serve as validation that improved DMFC performance can be achieved via improved flow-fields.

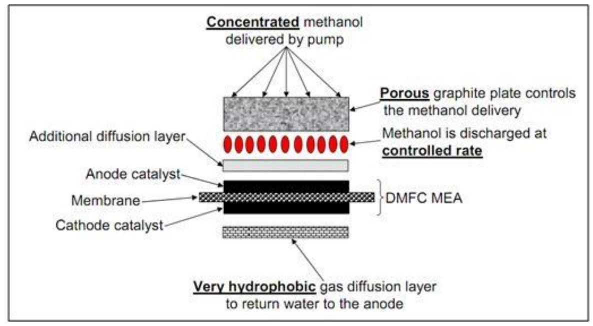

Diagram of a demonstration short stack

Goals and Objectives

The primary goal of this project is to develop improved flow-fields for DMFCs. This will be achieved by modeling the transport of methanol through anode flow-fields (porous graphite structures), creating prototypes of the best demonstrated flow-fields, and validating the down-selected flow-fields in a DMFC stack.

The primary project objectives are:

- Produce computational fluid dynamic models of various flow-field geometries and material porosities using FLUENT software package (Ansys, Inc.).
- Fabricate porous plates according to modeling results.
- Maximize fuel energy density by optimizing membrane electrode assembly (MEA) structure and operating scheme.
- Perform extended life tests of optimized MEAs.
- Construct one or more short stacks consisting of three to four cells.
- Optimize the short stack(s) in terms of operating parameters.

Accomplishments

- FLUENT modeling of the porous plate structure was performed and determined that a square-grid flow-field on both sides of the porous plate would provide the most uniform flow distribution.
- Flow-field plates were successfully fabricated from porous graphite using a table-top end mill machine.
- DMFC single cells were evaluated using the porous graphite flow-field plates and resulted in gross fuel energy densities of over 781 watt-hours per liter with fuel utilizations of over 79.4 percent.
- Single cells have been operated using the porous flow-field plate configuration for over 80 hours with no significant decrease in power output.
- A short stack has been constructed consisting of two cells; initial performance testing has begun.

Benefits

The principal benefit of this project is the improved performance of DMFC direct methanol fuel cells due to the design and validation of porous graphite plates specifically for the delivery of liquid methanol.