SOLID OXIDE FUEL CELL DEVELOPMENT AT PNNL

J.W. Stevenson, P. Singh, and G.L. McVay

Pacific Northwest National Laboratory
P.O. Box 999, Richland, WA 99352

INTRODUCTION

Pacific Northwest National Laboratory (PNNL), in collaboration with government agencies and private industries, is developing advanced solid oxide fuel cell (SOFC) power generation systems for a wide variety of applications ranging from stationary power production to automotive auxiliary power applications. The technology development at PNNL, which consists of both experimental and computational activities, covers many R&D areas, including optimized materials for cell/stack components, cost-effective fabrication procedures, and advanced stack designs offering high performance and reliability.

Much of the effort at PNNL is directed towards the development of inexpensive, high power density SOFC stacks operating at intermediate temperatures, e.g. 650-800ºC. Advantages of operation in the intermediate temperature range include the possibility of using inexpensive alloys as interconnect components, reduced thermal stability demands on other "hot box" components (manifolds, pipes, etc.), thermal compatibility with fuel reformers, and simplified system thermal management (i.e., smaller ΔT from room temperature to operating temperature reduces cathode air preheating and thermal cycling challenges). However, reducing the stack operating temperature to the intermediate temperature range presents challenges in regard to obtaining high power density from the cells, as both electrode polarizations and ohmic resistances within the cells increase with decreasing temperature. Specific efforts related to intermediate temperature stacks include optimization of compositions, microstructures, and fabrication techniques for anode-supported cells, improved electrode materials, inexpensive alloy-based interconnect materials, and thermally cyclable seals.

In addition to its in-house research activities, PNNL acts as a co-leader (along with the National Energy Technology Laboratory (NETL)) of the Department of Energy's Solid-State Energy Conversion Alliance (SECA) initiative. The goal of the SECA initiative is to accelerate the development of modular 3 to 10 kW SOFC power systems offering fuel flexibility and low system cost (~$400/kW).

SOFC DEVELOPMENT PROGRAMS AT PNNL

SECA Core Technology Program (DOE-FE)

The SECA Core Technology Program (CTP) funds work at universities, national laboratories, and industries intended to support the SECA industry teams in their efforts to develop commercially successful SOFC power systems. SECA-CTP development activities at PNNL are focused on advanced cell/stack component materials (e.g., intermediate temperature cathodes, redox and sulfur tolerant anodes, metallic interconnects, and seals), and the development of computational models that assist in optimization of cell and stack designs by simulating cell and stack behavior in both transient and steady-state modes.

SOFC APU Development (Delphi Corporation / BMI / DOE-FE)

A SECA industry team, comprised of Delphi Corporation and Battelle Memorial Institute, is jointly developing an SOFC-based on-board auxiliary power unit (APU) for the automotive industry. Research and development activities at PNNL are focused on SOFC stack development, and include development of optimized materials and fabrication techniques for high-performance anode-supported cells, optimization of SOFC stack interconnects and seals, modeling to optimize stack design parameters, and stack testing to validate improvements.

Advanced SOFC Component Materials Development (Cummins Power Generation / McDermott Technology / DOE-FE)

PNNL is working with another SECA industry team, Cummins Power Generation and McDermott Technology, to develop improved cell component materials that enhance the cell performance and performance stability. Advanced electrochemical and analytical techniques are used to characterize and understand anodic and cathodic electrode processes. This study is targeted at developing electrode materials formulations and processing conditions that lead to electrical performance enhancement and bulk and interfacial stability during cell fabrication and operation.

Palm Power Cathode Development (DARPA)

Under a DARPA sponsored "Palm Power" program, PNNL is developing advanced cathode electrode materials and electrode architectures to optimize the activation and mass transport limitations in the cathode.

High Temperature Electrochemistry Center (DOE-FE)

Recently, PNNL has teamed with the Department of Energy's Fossil Energy Office and Montana State University to form the High Temperature Electrochemistry Center. The purpose of this center is to further the understanding of the fundamental electrochemical and microstructural processes occurring in high temperature electrochemical systems such as fuel cells, electrolyzers, thermoelectric devices, and sensors.

Summary

PNNL is developing advanced cell/stack component materials, fabrication processes, and computational modeling tools to assist the efforts of SECA industrial teams and other industries in meeting the required cost and performance targets for SOFC power systems to enter the commercial marketplace.