Fuel Cell Catalyst

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Fuel Cells for Stationary Power and a Report from SECA's 4th Annual Program Review:
This issue, *The Catalyst* reports on fuel cells for stationary power applications and takes a look at some results from the Solid-State Energy Conversion Alliance's industry teams.

features:

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SOFCo and Cummins have teamed up to develop a 4-kW fuel cell for the SECA program. This photo shows SOFCo's 60-cell solid oxide fuel cell unit.

SECA Program Status

The SECA (Solid-State Energy Conversion Alliance) Program is dedicated to developing innovative, cost effective ways to commercialize solid oxide fuel cells (SOFCs). SECA was initiated in the fall of 1999 and consists of an alliance between industry teams, research and development institutions, and government organizations. It is our vision to realize the cost and performance potential of the fuel cell technology and deepen and widen its market penetration. SECA is our way to this future. The overarching goal is to break out of the fuel cell niche market into widespread market acceptance by producing fuel cells at a cost of $400 per kilowatt or less through mass customization of common modules.

The low-cost potential of SECA fuel cells is very important as it would give fuel cells the potential of wide and deep market penetration. The fact that SECA fuel cells can achieve low cost at small sizes is also important. At small sizes, the technology has a chance of reaching more and bigger markets. At the 3-10kW size it is suitable for stationary, transportation, military, residential, APU, telecommunication, and UPS/battery replacement applications and markets. These markets are vast. These markets include the automotive markets and no industry knows how to reduce costs like the automotive industry.

Fuel cells are an attractive power generation option because they use an electrochemical process instead of combustion. The absence of combustion eliminates the formation of pollutants including nitrogen oxides, sulfur oxides, hydrocarbons, and particulate matter. Because of their efficiency and environmental performance, SECA fuel cells are an integral part of several U.S. Department of Energy Office of Fossil Energy initiatives including Vision 21 and FutureGen. SECA fuel cells should ultimately be able to be used in large coal-based, central station power plants and in plants configured to produce hydrogen, power and sequester carbon dioxide.

Because all fuel cells utilize hydrogen, all fuel cells will benefit from the emergence of a hydrogen economy. However, since SECA fuel cells are able to easily reform hydrogen carrier fuels such as natural gas, the SECA fuel cell can also operate on conventional fuels. In this sense, they are a bridge to the hydrogen economy. In addition, SECA fuel cells may be able to produce separate carbon dioxide streams during power generation from natural gas. Such streams could be collected and the carbon processed.

SECA's Industry Teams are working hard to reduce these costs, making fuel cells an affordable generation option. SECA currently has four industry teams that include Delphi, General Electric, Cummins, and Siemens Westinghouse, working on a SOFC design for a target market that will contribute to a high-power-density SOFC that can be mass-produced at costs that are ten-fold less than current costs. Industry teams will incorporate feedback from end users and manufacturers regarding necessary modifications to their designs as they are being developed. The industry teams will also help define the more basic and fundamental advanced research to be performed under the SECA Core Technology Program (CTP). Through the CTP, science and technology gaps will be addressed, thereby allowing the industry teams to pursue their development process in parallel with the much-needed scientific knowledge advancements and technology breakthroughs as they emerge.

Detailed results from the industry teams include:

- Delphi, in partnership with Battelle, is developing a 5-kW (kilowatt), planar, 700-800°C, anode-supported SOFC compact unit for the distributed generation (DG) and auxiliary power unit (APU) markets. Delphi is an expert at system integration, high-volume manufacturing and cost reduction. The team is focused on making a very compact and light-weight system

MTU HotModule Series Production Plans

MTU CFC Solutions GmbH, part of the DaimlerChrysler Group and German partner of FuelCell Energy, reports that it is "on schedule for series production" of its 250-kW "HotModule" molten carbonate fuel cell power plants. MTU has delivered ten field test systems in Europe and the United States, eight of which are still undergoing tests.

The HotModule power plants achieve "electrical grid power of 230 kW" and produce about 180 kW of thermal energy, for an overall energy efficiency potential of more than 90 percent. The most recent installation of a HotModule fuel cell was at the Michelin tire plant in Karlsruhe, Germany (photo below).

Cost is still a big factor for making fuel cells competitive with other generation technologies, but MTU believes it can cut the HotModule's per-kilowatt cost in half within a few years. MTU CFC Solutions' manager, Michael Bode, says the price will need to fall much further since the standard for current generation technologies is EUR 1,000 per kilowatt, even though those technologies are "considerably less efficient than our HotModule." In the medium-term, to make the HotModule commercially attractive, MTU intends to aim for a cost between EUR 1,200 and EUR 1,500 per kilowatt of installed output.

MTU CFC Solutions has set its preliminary target for series production start-up in 2006.

BERNADETTE GEYER, EDITOR

Waste heat from MTU's HotModule fuel cell installed at the Michelin tire plant is used to produce process steam for vulcanizing tires. The tire plant operates on a three-shift system, and is therefore in continual need of steam.

(from pg. 1) suitable for transportation applications. Delphi's cost goals are actually more aggressive than those of the SECA Program ($250/kW versus $400/kW). The team has already achieved a power density of 1.0 W/cm^2 at 800°C with a 34 cm^2 active area in a single cell with metal interconnects. In December 2002, it achieved 0.288 W/cm^2 at 750°C with a 106 cm^2 active area in a 1-kW stack consisting of two 15-cell planar anode-supported stacks in a series.

- General Electric is initially developing a natural gas, 5-kW, planar, 700-800°C, anode-supported SOFC compact unit for residential power markets. GE is evaluating several stack designs and is especially interested in extending planar SOFCs to large hybrid systems. They also have a radial design that can simplify packaging by minimizing the need for seals. GE has made good progress in achieving high fuel utilization with improved anode performance using standard materials by optimizing microstructure. In button cells, GE has achieved an amazing power density of 1.8 W/cm^2 at 850°C and 0.9W/cm^2 at 650°C. GE has achieved 0.25 W/cm^2 in three to five cell, six-inch radial stacks at 800°C with 80 percent fuel utilization. In order to achieve SECA cost goals of $400/kW and an efficiency of 40 percent with autothermal reforming of 5-kW natural gas stacks, GE must achieve 0.30-0.35 W/cm^2 at 0.75 volts and 80 percent fuel utilization in the final system that will consist of many more cells stacked together than has currently been operated.

- Cummins and SOFCo (formerly McDermott) are developing a 4-kW product initially for recreational vehicles (RVs) that would run on propane using a catalytic partial oxidation (CPOX) reformer. The team has produced a conceptual design for a multilayer SOFC stack. The basic cell is fabricated by tape casting. Anode ink is screen-printed onto one side of the electrolyte tape, and cathode ink onto the other. The printed cell is sandwiched between layers of dense ceramic that will accommodate reactant gas flow and electrical conduction. The assembly is then co-fired to form a single repeat unit. The use of electrolyte support and a unique cell design, using materials that are thermally matched, permits co-sintering of the entire stack in one step. The conceptual design will be validated using two 1.0- to 1.5-kW, 850°C, sixty-cell stack tests, planned for 2003.

- Siemens Westinghouse Power Corporation (SWPC) is developing 5- to 10-kW products to satisfy multiple markets. SWPC has developed a new tube design for their 5-kW units that uses flat, high power density (HPD) tubes. This allows for a shorter tube length and twice the power output compared to their current cylindrical tube. It also results in more efficient manufacturing, assembly, and better volumetric power density. SWPC has already achieved 0.35 W/cm^2 from the redesigned HPD tubular design. SWPC, with partner Fuel Cell Technologies (FCT), has learned that a stack with shorter cells performs differently from a larger cell stack. This has necessitated several design changes within the stack and the control system. A notable change involves how the fuel flow is managed to attain proper flow distribution and safe temperature profiles throughout the stack. SWPC and FCT have achieved over 3,000 hours of operation at 950°C. Within the next year, these insights will be applied to the high-power density cells being developed under the SECA program.

Through its Industry Team program, SECA is leading the way in developing breakthrough fuel cell technologies that will provide clean, efficient, and affordable energy solutions.

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CFCL's First Commercial SOFC Technology

Ceramic Fuel Cells Limited's latest modular SOFC stack design, together with the company's skills and expertise in fuel cell system design, form the basis of its collaboration with application partners to integrate this technology into a wide range of products.

This commercial SOFC stack design comprises an all-ceramic stack optimized for internal reforming of methane with an operating temperature of 850°C and a capacity of 1-2 kW. The modular stack design leads to significant advantages in stack reliability and adaptability to a wide range of applications.

The current state of CFCL's technology is the culmination of extensive development efforts since 1992 when the company was formed. In the beginning, the company focused on metal-ceramic stacks with both electrolyte and anode-supported cell technology. However, not being satisfied with the thermal cycling ability of these concepts, CFCL decided to develop a revolutionary all-ceramic stack technology at the end of 2000. This resulted in the present stack design, which is made up of 4 components, collectively referred to as a "layer set":

i. Alumina strengthened solid oxide cell
ii. Alumina strengthened solid oxide interconnector/separator
iii. Glass-ceramic fuel side seal
iv. Glass-ceramic air seal

CFCL uses tapecasting, screen printing and sintering for the fabrication of cells and interconnects. Decal printing is used to fabricate seal gaskets. With these well-proven processes, the company has achieved high stack manufacturing yields in its pilot fabrication facility with a capacity of up to 1,000 layer sets per week.

Over the years, CFCL has also developed significant skills and expertise in SOFC systems. The company has designed and constructed over 50 test stations for both hydrogen and methane operation in sizes from single cell test stations to multi-kW stations. A 1.5-kW complete system was tested in 1998, a 25-kW system in 2000 and a 40-kW system has been designed and most components verified in 2002. A fuel processor for LPG to methane rich fuel was developed in 2000. This expertise in SOFC systems enables CFCL to effectively support its application partners in the integration of its SOFC stacks into various systems.

EDWIN FOONG, MARKETING MANAGER
CERAMIC FUEL CELLS LIMITED

Status of Fuel Cells at Siemens Westinghouse

At the recent review of the Solid-State Energy Conversion Alliance, held April 15-16, 2003, Shailesh Vora presented an update of Siemens Westinghouse's fuel cell demonstration and commercialization activities. Vora noted that the Stationary Fuel Cells group of the company's Power Generation Unit has about 150 employees at its Pittsburgh, Pennsylvania, office.

Through its participation in the SECA program, Siemens Westinghouse must meet Phase I cost goals of $800/kW by 2004. Researchers at the company are exploring new cell geometries to increase power density and are working to eliminate the internal reformer in Siemens Westinghouse's solid oxide fuel cell system. The company is moving from a tubular to a planar cell design (see photo above), and is now using what it calls the HPD10 design (high power density, 10-channel). The ten smaller channels in the new design have resulted in a lower probability of failure, as well as enhanced cell performance at a lower temperature.

Siemens Westinghouse's current 60,000-square-foot facility is located in Churchill, Pennsylvania, and has a capacity of 1-2 MW of SOFC systems per year. The company is currently demonstrating its CHP250 proof-of-concept fuel cell system in Toronto, Canada.

BERNADETTE GEYER, EDITOR

The Direct FuelCell® Commercialization Update

FuelCell Energy Inc. (FCE) products, like all fuel cells, utilize hydrogen to produce electricity, and, in so doing, provide the clean, efficient power generation necessary to meet the environmental and energy needs of the United States. FCE has addressed the hydrogen infrastructure dilemma by generating hydrogen internally to the fuel cell power plant. FCE is exploring the net generation of hydrogen on future designs, to fuel cars or other hydrogen-based applications.

FuelCell Energy has recently completed a successful Field Trial Program at Los Angeles Department of Water and Power and embarked on a Field Follow Program for the first commercial product, the DFC300A (see photo above), which produces 250 kW. This product is now operating in a variety of applications worldwide – including heavy industry, telecommunications, institutions, beverage processing, manufacturing, hospitals and a military base – using both natural gas and renewable fuels.

FCE will also be delivering the first DFC1500 (1000 kW) system later this year. This particular installation will operate on anaerobic digester gas from a wastewater treatment plant in Seattle, Washington. FCE has recently completed the initial testing and operation of the DFC1500 fuel cell module at its facility in Danbury and will incorporate the module into the balance of plant in Torrington, Connecticut. Together with the DFC3000 (2000 kW), these plants are the largest fuel cell power plants commercially available today and offer the quickest path to economic generation of power by fuel cells in the target markets.

FCE is on an aggressive compliance program to certify its powerplants to national and state programs. The electrical balance of plant on the DFC300 was recently certified to UL1741; the DFC1500 and DFC3000 certifications are in process. FCE is currently engaged in certifying all products to CSA FC1, Stationary Fuel Cell Power Systems.

FCE has also received certification for the DFC300 under the California Rule 21 program, an interconnection standard, and expects to be certified to the California Air Resources Board Distributed Generation Program requirements, an emissions and permitting program, during the 2nd quarter 2003.

RICHARD C. SHAW, PE, FUELCELL ENERGY, INC.

Calendar

8th Grove Fuel Cell Symposium

ExCeL, London, UK - 24-26 September 2003.
Visit http://www.grovefuelcell.com/ for information.

1st International Conference on Polymer Batteries & Fuel Cells, PBFC-1

Jeju Island, KOREA - 1-6 June 2003.
Visit http://pbfc.kaist.ac.kr/ for information.

Hydrogen and Fuel Cells 2003

Vancouver, British Columbia, CANADA - 8-11 June 2003.
Visit http://www.hydrogenfuelcells2003.com/ for information.

Fuel Cell Technology Institute: Short Course on Fuel Cells

Irvine, California, USA - 23-26 June 2003.
Visit http://www.nrcrc.uci.edu/FCTI/ for information.

2nd European Polymer Electrolyte Fuel Cell Forum

Luzern, SWITZERLAND - 30 June-4 July 2003.
Visit http://www.efcf.com/ for information.

industry notes

DOE's Solid-State Energy Conversion Alliance announced plans to add two new projects to its program. Two new teams, headed by FuelCell Energy and Acumentrics, will join four other industry development teams already in SECA.

The United States will lead a $1 billion public-private effort to construct FutureGen, the world's first fossil-fuel, pollution-free power plant, which will serve as a "living prototype" of new carbon sequestration technologies while producing both electricity and hydrogen. The hydrogen would be extracted for multiple uses, including as fuel for a fuel cell.

FuelCell Energy's DFC300A Direct FuelCell Power Plants have been certified to meet the American National Standards Institute (ANSI) products safety standards for stationary fuel cell systems, ANSI Z21.83, making it the largest fuel cell power plant to be certified under this standard.

The California Public Utilities Commission has exempted many types of small, renewable, and clean self-generation – including fuel cells smaller than 1 MW that are net metered – from utility surcharges. The exemptions are available to customers of Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas and Electric Company.

The Univeristy of Hawaii-Manoa's Hawaii Natural Energy Institute has joined with UTC Fuel Cells, the Office of Naval Research and Hawaiian Electric Company to open the 4,000-square-foot Hawaii Fuel Cell Test Facility. Initial funding for the facility was secured with the assistance of Senator Daniel Inouye through a $1.5 million U.S. Department of Defense appropriation for research collaboration between HNEI and the Naval Research Laboratory under the Hawaii Energy and Environmental Technology Initiative.

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