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Progress in Carbonate Fuel Cells

Authors:

Kevin M. Myles
Michael Krumpelt
Michael F. Roche
Ira D. Bloom
Howard K. Geyer
J. Ernesto Indacochea
Stanley A. Johnson
Michael T. Lanagan
Sheldon H.D. Lee

Contractor:

Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60439

Contract Number:

W-31-109-Eng-38

Conference Title:

Fuel Cells '95 Review Meeting

Conference Location:

Morgantown, West Virginia

Conference Dates:

August 9-10, 1995

Conference Sponsor:

U.S. Department of Energy, Morgantown Energy Technology Center (METC)

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CONTRACT INFORMATION

Contract Numbers	49946/49943
Contractor	Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
Contractor Project Manager	Kevin M. Myles
Principal Investigators	Michael Krumpelt and Michael F. Roche
Co-Investigators	Ira D. Bloom, Howard K. Geyer, J. Ernesto Indacochea, Stanley A. Johnson, Michael T. Lanagan, and Sheldon H. D. Lee
METC Project Manager	William C. Smith
Period of Performance	October 1, 1982 to Open

OBJECTIVE

Our objective is to increase both the life and power of the molten carbonate fuel cell (MCFC) by developing improved components and designs. Current activities are as follows:

- Development of lithium ferrate ($LiFeO_2$) and lithium cobaltate ($LiCoO_2$) cathodes for extended MCFC life, particularly in pressurized operation, where the present cathode, NiO, provides insufficient life
- Development of distributed-manifold MCFC designs for increased volumetric power density and decreased temperature gradients (and, therefore, increased life)
- Development of components and designs appropriate for high-power-density operation (>2 kW/m^2 and >100 kW/m^3 in an integrated MCFC system)
- Studies of pitting corrosion of the stainless-steel interconnects and aluminized seals now being employed in the MCFC (alternative components will also be studied)

Each of these activities has the potential to reduce the MCFC system cost significantly. Progress in each activity will be presented during the poster session.

BACKGROUND INFORMATION

Background information was given in four proceedings papers (1-4) that were presented during the previous Contractors Review Meeting. Briefly, we developed a doubly doped $LiFeO_2$ cathode having an acceptable performance; the relative lives of the $LiFeO_2$, $LiCoO_2$, and NiO cathodes are now being measured.

In the studies of distributed-manifold MCFCs, many of the concepts in the original patent (5) were demonstrated. Currently, we are testing 625 cm^2 MCFCs that employ distributed manifolding.

In the high-power-density studies, operation for 1200 h at a specific power >2 kW/m^2 was demonstrated in an MCFC employing a doubly doped $LiFeO_2$ cathode. Current efforts are focussed on design optimization; the goal is a volumetric power density in excess of 100 kW/m^3 for an integrated MCFC system.

The pitting-corrosion studies were initiated in late FY 1994; no data on pitting corrosion were reported at the last Contractors Review Meeting. During this fiscal year, we have observed pitting corrosion on stainless steel and on a nickel-clad stainless steel.

PROJECT DESCRIPTION

In this project, we are investigating ways to increase both the performance and life of the MCFC while reducing its cost.

Studies of cathode materials include basic measurements such as resistivities, Seebeck coefficients, dopant solubilities, and microstructures. MCFC tests to establish cathode performance and life are also conducted.

The distributed-manifold studies include modeling, development of novel methods of dimpling cathodes and anodes (to form gas flow channels), and tests of MCFCs (up to 625 cm^2) to establish their performance and life.

The high-power density studies include modeling, cell design, and measurements of performance and life for MCFCs operated at a current density of 3200 A/m^2 (double the current density usually employed).

The pitting-corrosion studies include potentiostatic and static immersion tests of interconnect and seal materials. The interconnect materials consist of two types (310 and 316) of stainless steel and a nickel-clad stainless steel. The seal material is an aluminized stainless steel. Coupons of these materials are partially immersed in a molten salt (Li_2CO_3-K_2CO_3 or Li_2CO_3-Na_2CO_3) through which either exhaust anode gas or cathode gas is bubbled. The gas stirs the melt and blankets the sample and salt.

Materials from the above studies are generally characterized by scanning electron microscopy and X-ray diffraction.

RESULTS

Cathode Life

Accelerated life tests of MCFCs having $LiFeO_2$ (doubly doped), $LiCoO_2$, and NiO cathodes were conducted for up to 2000 h at high partial pressures of oxygen and carbon dioxide and at a current density of 1600 A/m^2. These tests indicated the potential for long life from both the $LiFeO_2$ and $LiCoO_2$ cathodes. In addition, both cathodes have yielded a voltage of 0.92 V at 1600 A/m^2. This voltage is close to that of the nickel-oxide cathode (0.95 V) under the same test conditions.

Distributed Manifolding

MCFCs (100 cm^2) having distributed manifolding, flat current collectors, and dimpled nickel-chrome anodes and nickel-oxide cathodes (dimpled to form thin gas flow channels) were operated for up to 2000 h with a standard cathode oxidant (air plus 27% CO_2) at one atm. The best had a volumetric power density of 250 kW/m^3 at 1600 A/m^2, which is about twice that of conventional designs under the same test conditions. The volumetric power density of the distributed manifold design under pressurized test conditions is expected to exceed 400 kW/m^3 at 2500 A/m^2 and 2000 W/m^2.

High Power Density

MCFCs having $LiFeO_2$ or $LiCoO_2$ cathodes were operated at a high current density (3200 A/m^2) and at a high specific power (over 2000 W/m^2) for up to 1200 h. These tests demonstrated the high power capabilities of the $LiFeO_2$ and $LiCoO_2$ cathodes.

We also designed a novel MCFC that is expected to have a low cost, a high volumetric power density, and a long life. Due to patent restrictions, details of the new design will not be disclosed during the poster session.

Pitting Corrosion

Pitting corrosion was found on both the nickel-clad anode side and the unclad cathode side of stainless-steel interconnect materials in both the potentiostated and static corrosion tests. On the cathode side of the interconnect, the pitting was found beneath the duplex corrosion layer that usually forms on the cathode side. Pitting-corrosion studies are now being conducted on the aluminized seal material (acceptable samples of it were prepared recently). In addition, other experiments are in progress to aid in understanding the underlying causes of the pitting corrosion.

FUTURE WORK

During FY 1996, the cathode life tests will be extended under a subcontract with M-C Power. The distributed-manifold and high-power-density studies are being merged because they have similar objectives. The pitting-corrosion studies are being expanded, and will address both the interconnect and seal materials in FY 1996. A new activity in FY 1996 will be development of a non-segregating electrolyte.

ACKNOWLEDGMENTS

These studies are being conducted under the auspices of the U.S. Department of Energy, Contract Number W-31-109-Eng-38. This research was sponsored by the DOE Morgantown Energy Technology Center (METC) and by the Electric Power Research Institute (EPRI).

Joseph R. Stapay and Kevin T. Byrne provided technical assistance in the laboratory.

REFERENCES

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5. G. B. Kirby Meacham, "Multiple Manifold Fuel Cell," U.S. Patent No. 5,268,241, issued December 7, 1993.

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