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Advances in Research for Solid Oxide Fuel Cells*

by

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DISCLAIMER

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CONTRACT INFORMATION

Contract Number	49638
Contractor	Argonne National Laboratory 9700 South Cass Avenue Argonne, Illinois 60439 (708) 252-4329
Contractor Project Manager	Kevin M. Myles
Principal Investigator	Michael Krumpelt
Co-Investigator	Timothy Kueper and Rajiv Doshi
METC Project Manager	William C. Smith
Period of Performance	October 1, 1993 to July 1, 1994

OBJECTIVE

Solid oxide fuel cells are attracting considerable interest among industrial organizations wanting to position themselves in a potentially important technology of the future. More than a dozen new organizations worldwide have begun SOFC development in the last few years.

BACKGROUND INFORMATION

Most of this R&D activity is in the planar technology, because it represents a good compromise between the proven but IR-limited tubular configuration and the high-performance but difficult-to-fabricate monolithic structure. Table 1 lists many but not all the organizations engaged in research on the three types of SOFCs, and Fig. 1 summarizes the status of this technology.

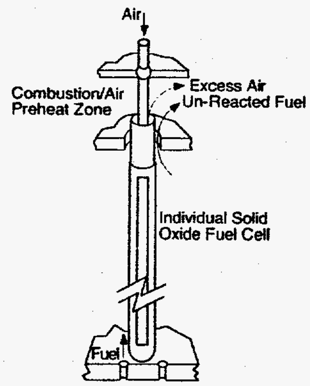
Table 1. R&D Activity on SOFCs

Tubular	Monolithic	Planar
Westinghouse	Allied Signal	Cerametec
Russia	MHI	Z-Tek
		TMI
		Siemens
		Dornier
		Sanyo
		Murata
		Tonen
		Tepco
		Fuji
		MHI

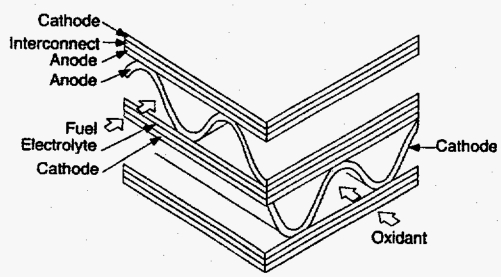
The planar configuration, in addition to being more easily fabricated, can also be adapted to metallic bipolar plates. However, to limit the effects of oxygen on the metal, the fuel cell operating temperature needs to be lowered from the typical

Several Types of SOFCs are Being Developed

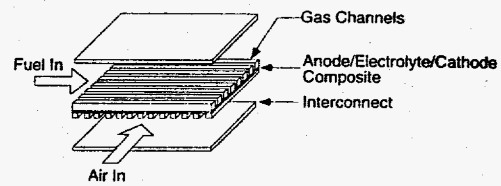
Tubular



Monolithic



Planar



	Tubular	Monolithic	Planar
Stack Size	25 kW	50 W	1 kW
Cell – active area	200 cm^2	25 cm^2	100 cm^2
– potential at 500 mA/cm^2	0.55 v	0.8 v	0.65 v

1000°C to about 800°C; and to compensate for the lower conductivity of the electrolyte at 800°C, the thickness of the electrolyte needs to be reduced.

PROJECT DESCRIPTION

Challenges

The challenges of developing the planar cell configurations are finding high-temperature edge and manifold seal materials that will make very flat ceramic trilayers of sufficiently large area, and minimize contact resistances in stacks of cells. Also, decreasing the operating temperature requires development of reliable thin-film fabrication methods for the electrolyte, and finding a metal with good oxidation resistance and a thermal expansion coefficient well matched with the different cell components. Finally, toughness and a thermal stress tolerance of stacks need to be improved.

RESULTS

Advances

Several industrial developers in Japan, Europe, and the U.S. are operating SOFC stacks of about one-half of a kilowatt power output. Typically, these stacks have an active area of 100-150 cm^2, and 10-20 cells running at 300-600 mA/cm^2 current density [1]. The cell potentials are still not stable enough but decline by about 10% in the first 1000 h of operation.

Several types of cell degradation mechanisms have been identified: coarsening of nickel-based anodes, migration of chromium from the interconnect material into the cathode, increasing contact resistance between the air electrode and metallic interconnect plates, and failure of seals.

Most of the planar stacks are made by tape casting and sintering the electrolyte, and then screen printing electrodes on both sides. The trilayers are then stacked with lanthanum chromite or metallic bipolar plates by using proprietary contact cements. Alternative fabrication methods are to calender anode/electrolyte bi-layers or deposit thin electrolyte films onto sintered anodes.

Argonne National Laboratory has been exploring new sealant and bipolar plate materials. Advances in these specific areas are discussed elsewhere in this report.

References

1. S. C. Singhal, and H. Iwahara, eds., Proceedings of the Third International Symposium on Solid Oxide Fuel Cells, Vol. 93-4, The Electrochemical Society.