

STATUS OF SOFCo'S PLANAR SOFC DEVELOPMENT

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ABSTRACT

Significant advances are being made at SOFCo in all aspects of planar SOFC development, including stack endurance and system design and development. A fully integrated, thermally sustaining multi-kW system demonstration is underway. The system integrates in one thermal enclosure the planar SOFC stacks with an advanced heat exchanger, a steam generator, a sulfur remover, a fuel processor, and a start-up burner. The initial system will deliver a 2-kWe output operating on pipeline natural gas. Further development of larger systems will be based upon scale-up of this unit in the 10-50 kW range.

INTRODUCTION

SOFCo, through its partners Ceramtec and McDermott Technology, has been developing Solid Oxide Fuel Cell (SOFC) technology since 1986. Current programs focus on integration of stacks and the balance of plant into a multi-kw unit. A simultaneous verification stack and system component performance is underway. The initial prototype will deliver a 2-kWe output operating on pipeline natural gas. Further development of larger systems will be based upon scale-up of this unit in the 10-50 kW range.

STACK DEVELOPMENT

SOFCo's primary focus is to develop the necessary SOFC technology to allow McDermott (Babcock & Wilcox company's parent) to commercialize SOFC products within the stationary power generation market. To incorporate SOFCo fuel cell stacks into commercially viable products, prime consideration has been given to both the performance and cost of SOFC stacks being developed at SOFCo. Operating temperature reduction, driven by system endurance, cost considerations, and manufacturability of cells and stacks, has been emphasized at SOFCo. Target commercial degradation rates of 0.5% per 1000 hours have been demonstrated in both single cells and stacks operating at

between 800° - 1000°C. Among the approaches taken to reduce operating temperature is the use of conventional thick film zirconia cells (180 microns) with modified electrode characteristics. The advanced electrodes have enabled significant reduction in operating temperature (at similar electrolyte thicknesses) while maintaining the single cell area-specific resistance (ASR). For example, the ASR with conventional electrodes was 1 ohm.cm² at 1000°C, while the cells incorporating the advanced electrodes exhibited an ASR of 1.1 ohm cm² at an operating temperature of 850°C (Figure 1). This approach has enabled SOFCo to successfully conduct multi-stack integrated systems test. In addition, thin film zirconia and lanthanum gallate based cells using alternate high-conductivity electrodes are being evaluated in short stacks.

Stack endurance characteristics have also been improved, with several stacks being operated at 850° - 900°C for more than 10,000 hours at a < 0.5% per 1000 hour voltage degradation rate (Figure 2). Long an issue among SOFC developers, the performance difference between single cells and stacks has been reduced considerably, as seen in Figure 3, where a close comparison in performance is depicted. Similar results are also seen with lanthanum gallate cells. Figure 4 compares the performance of a gallate single cell (0.5 ohm.cm²) and a 5-cell gallate stack (0.6 ohm.cm²). Long term endurance of gallate single cells was also demonstrated (Figure 5).

Multi-stack modules operating on both hydrogen and pipeline natural gas are being tested. Figure 6 shows the performance of two 2-stack modules. These tests are operated under a thermally self-sustaining mode where no additional electric heating was provided during stack operation. During a recent utility power interruption, the Unit 3 stack operated in an electrically self sustaining mode for more than 5 hours where the auxiliary equipment such as the air blower, data acquisition and the computer were operated by the stack power output.

SYSTEM DEVELOPMENT

SOFCo's approach has been to incorporate the cell and stack technology into systems that are configured for use in distributed power applications, including remote residential and small commercial. These experimental prototypes ranging in power from 5 – 20-kW, will lead to market entry products, eventually leading to larger (50 - 200-kW) systems. Central to developing the necessary technology to allow for the commercialization of SOFCs is the development of systems that:

- operate on natural gas
- are fully integrated
- are thermally self-sustaining
- can be remotely monitored

To this end, SOFCo has constructed a 2-kWe technology demonstration unit (TDU) that integrates in one thermal enclosure the SOFC stacks with an advanced heat ex-changer, a steam generator, a desulfurizer, a fuel processor, and a start-up burner.

The initial system (Figure 7) constructed at McDermott Technology Inc.'s (MTI) Alliance, Ohio, research facility incorporates simulated SOFC stacks as a means of isolating balance-of-plant subsystems to test the functional performance and reliability of those systems prior to incorporating actual SOFC stacks. Robust design and development of the TDU's balance of plant has resulted in advances in the non-stack elements of the system. Currently, efforts are aimed at integrating actual stacks into the existing TDU to produce a fully integrated, thermally self-sustaining SOFC power generator. System modifications also include developing a battery back-up and peaking subsystem as well as cogeneration heating elements that will allow for optional space or water heating. Finally, a fully integrated control system that will enable remote sensing to be used as a means of monitoring the system in an unmanned control environment will be developed on future TDUs.

Commercialization of the SOFC systems include developing a series of SOFCo/MTI partners that will serve as manufacturing, distribution, and service associates. Talks with associates are underway. The formation of a separate company to commercialize the SOFCo-developed technology is anticipated. This will allow for rapid response to market demand by assembling a core group of partners all aimed toward commercializing the technology.

SUMMARY

SOFCo and its partners are developing planar SOFC power generators, which are fully integrated, thermally self-sustaining power systems. Cell and stack technology performance has shown that commercial targets can be achieved. Experimental 2-kW prototype technology demonstration units are being constructed which will lead to market entry products, eventually leading to larger (5 - 200-kW) systems.

ACKNOWLEDGEMENT

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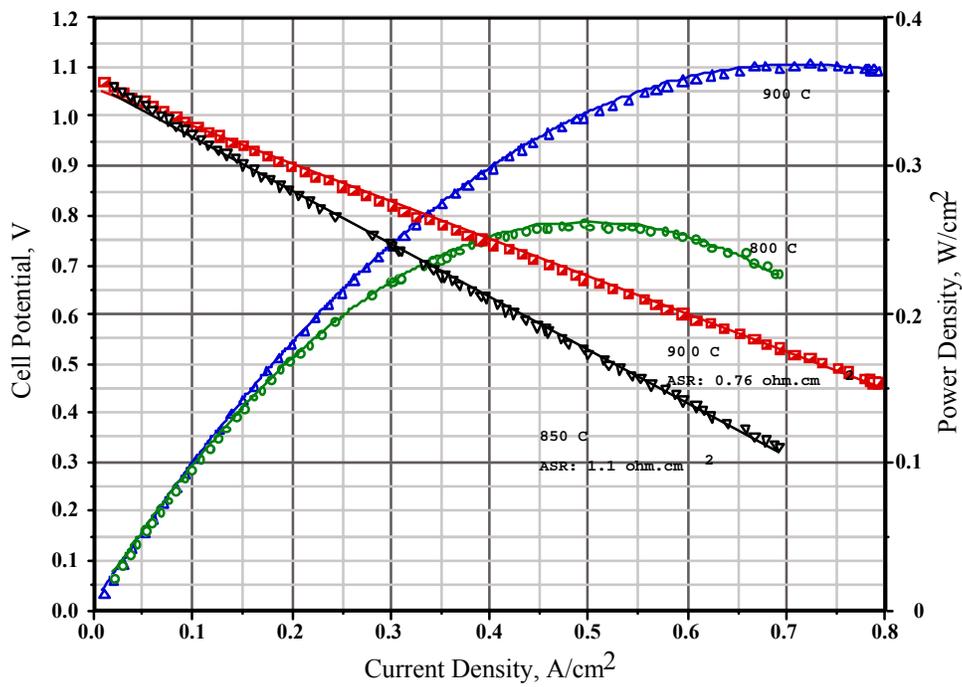


Figure 1. Single Cell (180 micron electrolyte) Performance Using Advanced Electrodes

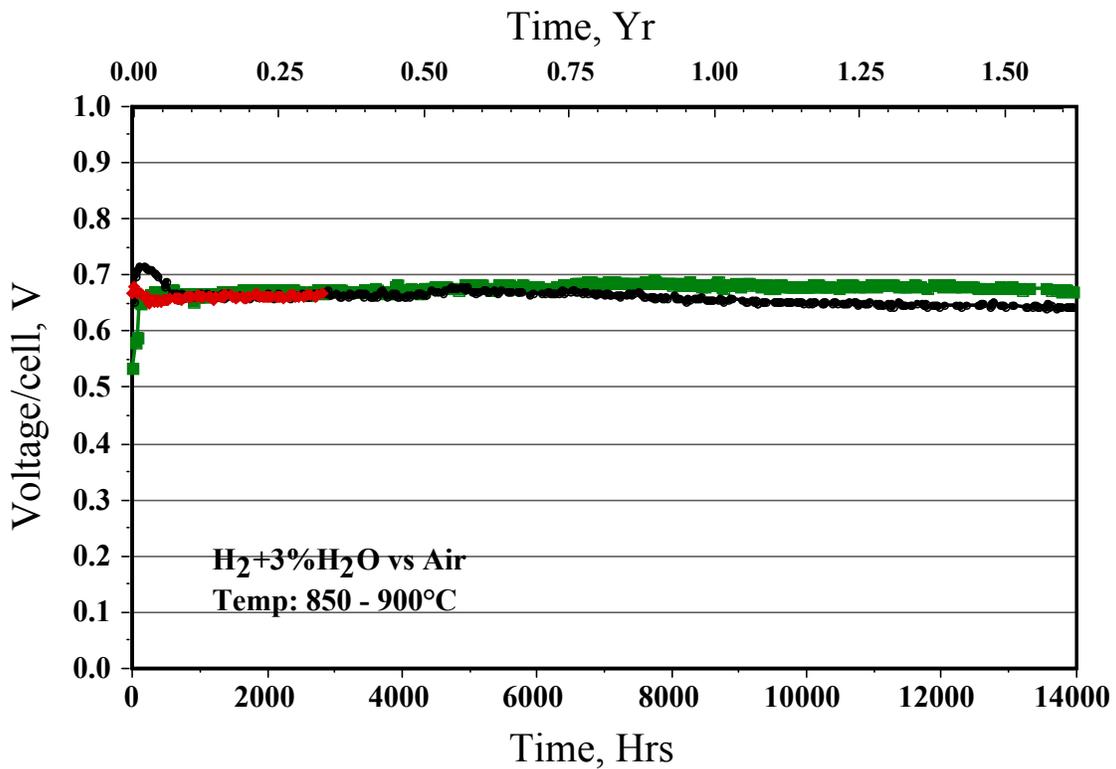


Figure 2. Long Term Performance of Short Stacks

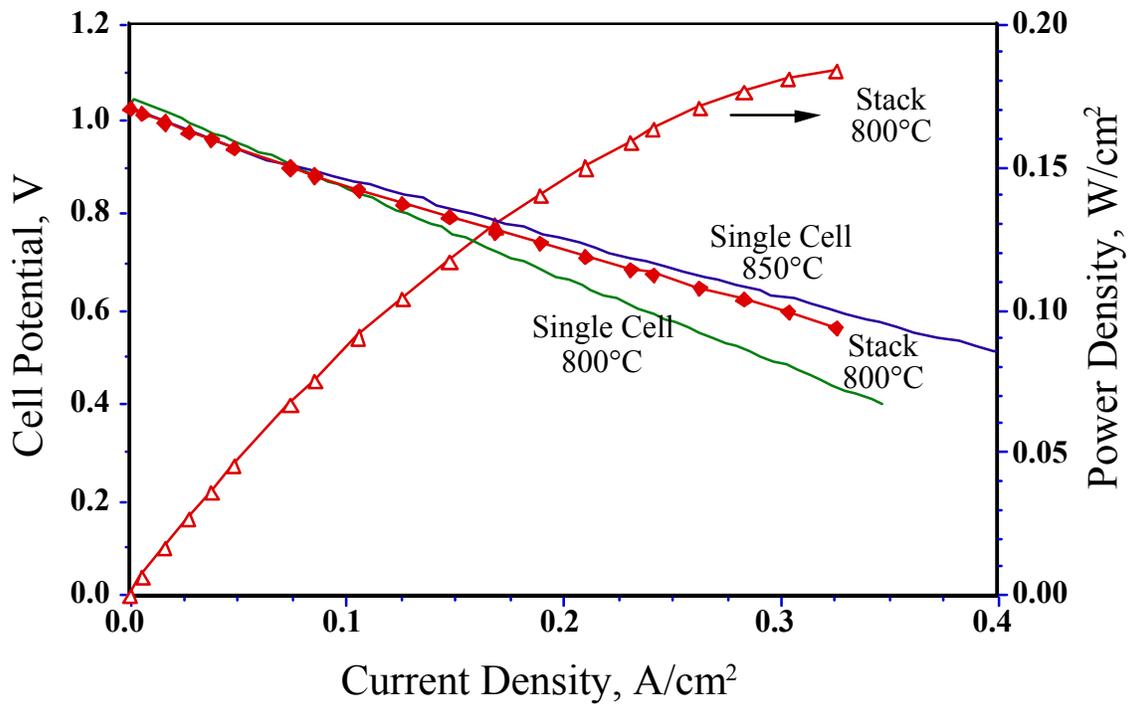


Figure 3. Comparison of Single Cell and Stack Performance (Zirconia Electrolyte)

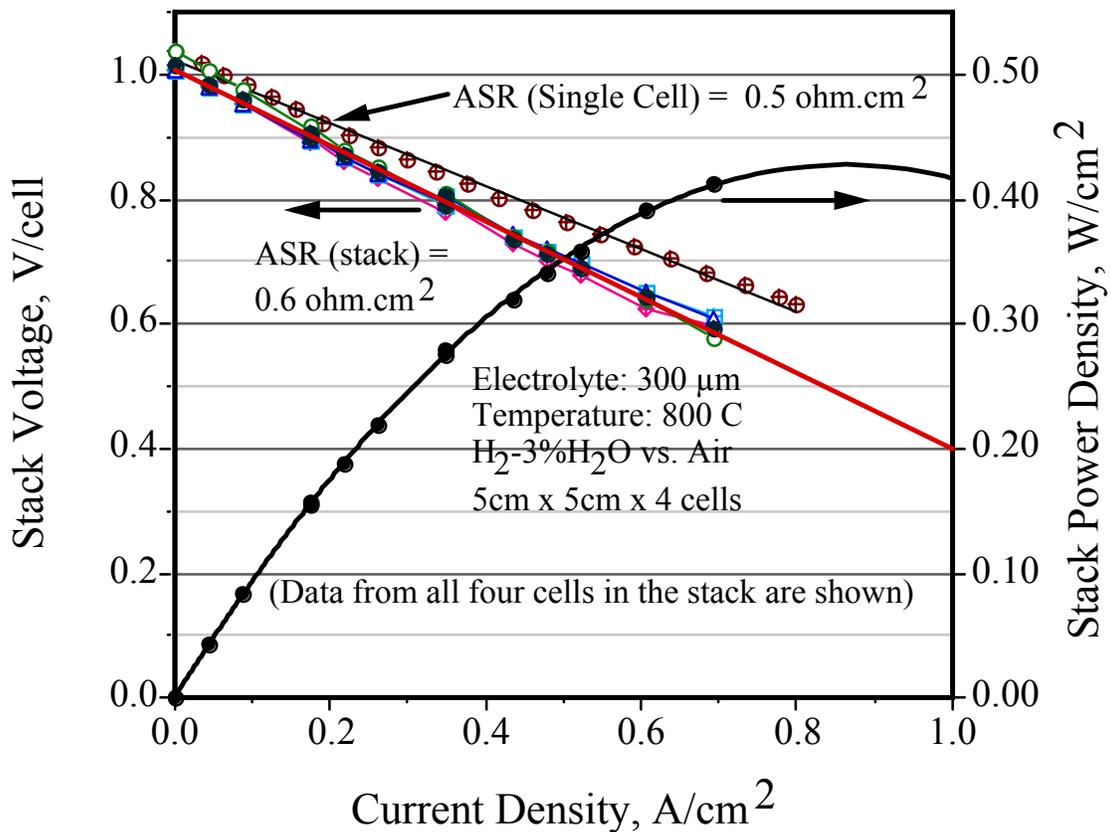


Figure 4. Comparison of Single Cell and Stack Performance (Gallate Electrolyte)

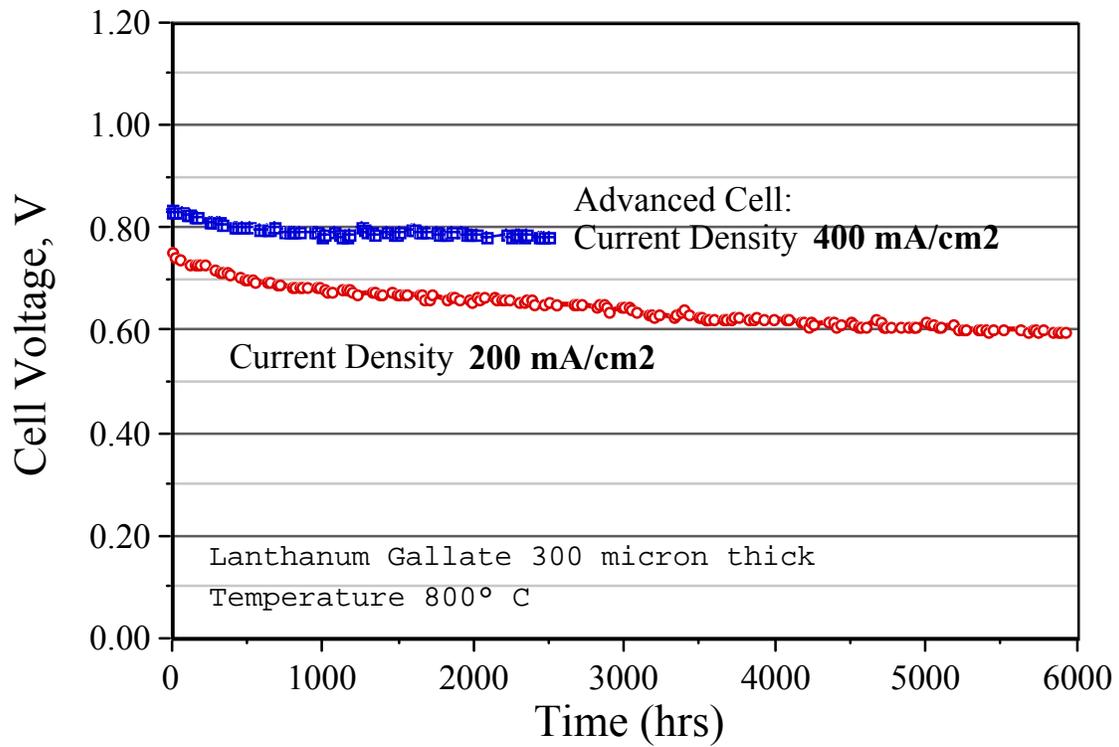


Figure 5. Long Term Endurance of Gallate Single Cells

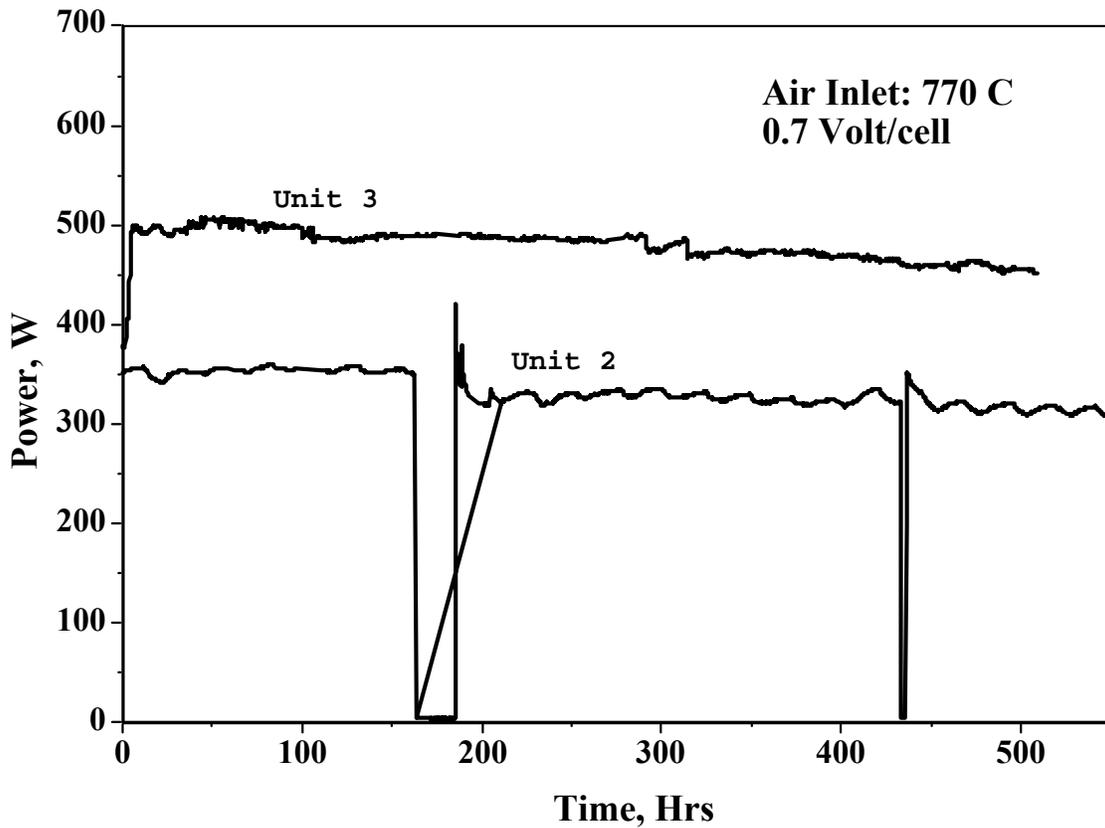


Figure 6. Thermally Self Sustaining Multi-Stack Module Performance

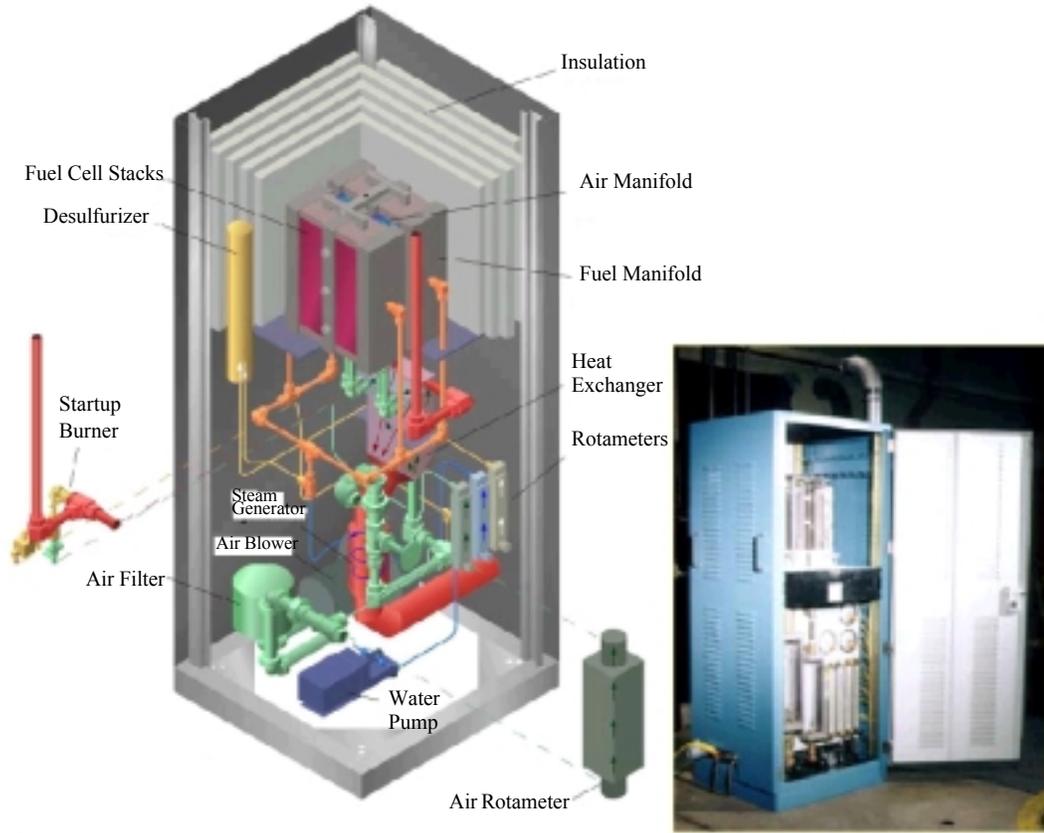


Figure 7. 2-kWe Technology Demonstration Unit System