IV.A.6 Intermediate Temperature Solid Oxide Fuel Cell Development

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Objectives

- Fabricate and test a thin, supported lanthanum gallate electrolyte-based solid oxide fuel cell (SOFC) stack.
- Determine operating characteristics of the stack in the intermediate temperature range.

Approach

- Develop fabrication process for thin, supported lanthanum gallate electrolyte.
- Verify performance of thin cells in button cell configuration.
- Evaluate low temperature cathode materials using symmetric cells.
- Test the new cathode material in short stacks.

Accomplishments

- Button cells were fabricated using the tape lamination technique.
- Preliminary cathode half-cell evaluation was conducted using new cathode compositions.
- Process for infiltration of electrode material has been developed.

Future Directions

- Select promising cathode compositions and develop cathode application process.
- Fabricate and test short stacks.

Introduction

Reducing the operating temperature of SOFCs offers several benefits: improvement in long-term stability by slowing physical and chemical changes in the cell materials; lower cost systems by the use of less expensive balance of plant components; compatibility with hydrocarbon reformation allowing partial internal reformation which in turn reduces the heat exchanger duty; and finally, the potential to improve thermal cycle capability. In addition, the use of stainless steel interconnects is also facilitated by lower operating temperatures. A temperature range of 600 to 700°C is ideally suited to derive the performance stability, system integration and cost benefits.

In order to derive the advantages of the lower operating temperature, two factors that limit the cell performance, namely the electrolyte resistance and electrode polarization, must be addressed. Lanthanum gallate compositions have shown high oxygen ion conductivity when doped with Sr and Mg. Unlike other oxygen ion conductors such as ceria and bismuth oxide that are potential candidates for lowering cell operating temperature, the Sr and Mg doped lanthanum gallate (LSGM) compositions are stable over the oxygen partial pressure range of interest. The combination of stability in a fuel gas environment and the high oxygen ion conductivity makes the LSGM material a potential choice for intermediate temperature SOFCs. However, challenges in the development of electrode materials and thin cell fabrication processes need to be overcome to make use of the potential of the LSGM electrolyte.

Approach

Tape cast process development was performed to cast LSGM tape of various thicknesses to provide sintered electrolyte thicknesses ranging from 50 to 200 microns. The process variables included: powder surface area, organic content in the tape slip, and sintering temperature. The primary objectives of the activity were to achieve sintered electrolyte density and flatness required for stacking. Single cells and symmetric cells with 2.5 cm^2 active area were tested for performance characteristics.

While a lanthanum cobaltite cathode has good intermediate temperature catalytic activity, the primary issues related to the use of cobaltite cathodes are excessive diffusion of Co into LSGM causing phase destabilization of the electrolyte, and the high coefficient of thermal expansion (CTE) of cobaltite compositions.

Two alternative cathode compositions were evaluated in half-cell tests at the two universities.

Results

Thin electrolyte single cells were fabricated using the tape lamination technique. Both anode and cathode porous structures were evaluated as the support for the electrolyte. At least one electrode material was infiltrated into the porous structure. The performance of a cathode-supported cell is shown in Figure 1. The thin, 75 micron LSGM electrolyte cells showed an area specific resistance of 0.5 ohm-cm^2 at an operating temperature of 700°C. The long-term performance of selected cells is shown in Figure 2. Similar performance and stability results were also obtained using cells with the anode-support configurations. A modified infiltration technique was developed in order to achieve a more uniform distribution of electrode material into the porous structure. Micrographs of the cathode infiltrated structure are shown in Figure 3. Button cell tests using the new infiltration technique showed (Figure 4) an improvement in cell performance.

Cathode symmetric cells using cobalt-ferrite compositions were tested at the two universities. The cathode polarization losses were measured to be 0.06 ohm-cm^2 at 650°C.

Sintering process development for fabricating 10 x 10 cm electrolyte was conducted. Initial trials with thick electrolyte defined the sintering process to achieve flat, dense electrolyte. Fabrication development of a thin 10 x 10 cm cell structure has been initiated.

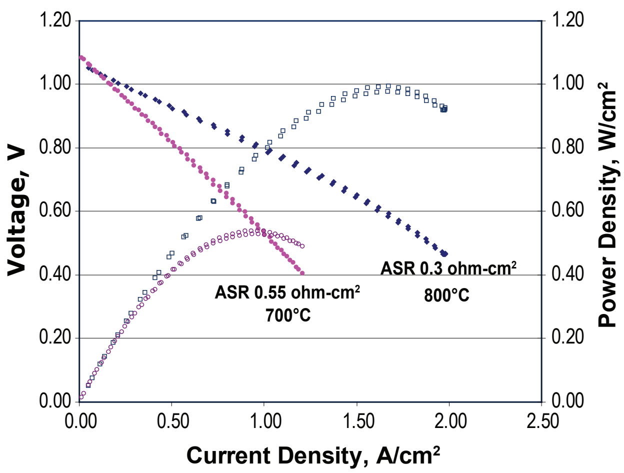

FIGURE 1. Performance of a Cathode Supported LSGM Cell; Electrolyte Thickness of 75 Microns Was Used

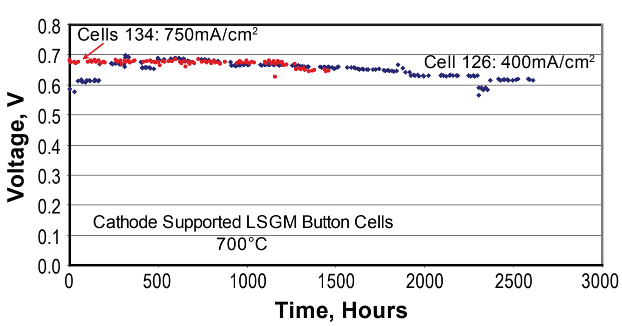

FIGURE 2. Long-Term Stability of Cathode Supported Cells at an Operating Temperature of 700°C

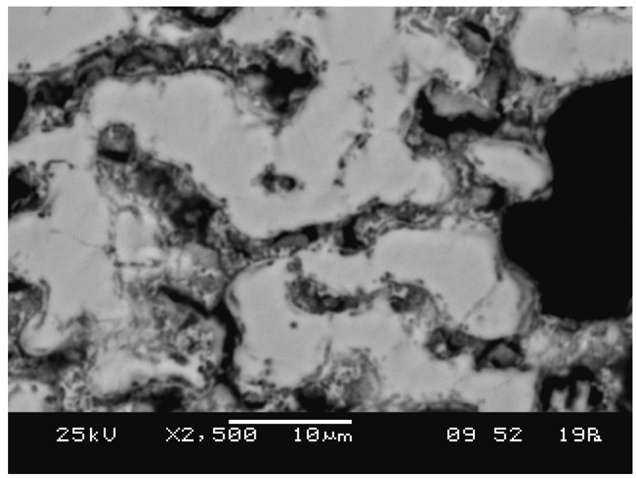

FIGURE 3. Micrograph of Infiltrated Cathode

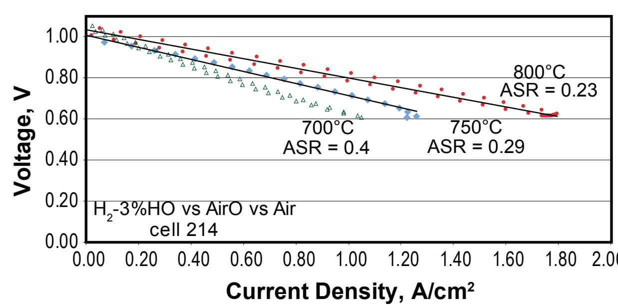

FIGURE 4. Button Cell Performance with Infiltrated Cathode

Conclusions

- Thin, supported cells meet the performance target of 0.5 ohm-cm^2 resistance at 700°C.
- Long-term tests of single cells show stable performance.
- Alternative cathode materials show low cathode polarization at temperatures <700°C.