PATTERNED SERIES-CONNECTED SOFCs

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High power densities been reported by many groups for single planar anode-supported SOFCs. However, stacking, sealing, and interconnecting of planar SOFCs remain as major challenges. Typically, stack performance is considerably worse than single-cell performance. New cell/stack geometries that can alleviate these difficulties are thus desirable.

This paper describes the design and fabrication of a new type of patterned series-connected SOFC. As illustrated in Figure 1, a cross sectional schematic view of several cells, this stacking configuration is similar to the well known "banded tubular" design (1,2,3) and a similar planar version (4). However, the current design has some unique features. First, the electrolytes are thin (≈ 10 μm), such that the cells can potentially achieve high power densities at relatively low temperatures, like typical anode-supported SOFCs. The low operating temperature is important for the usual reasons (5), and also because it reduces the shunting of the cell current by slightly-conducting supports such as fully or partially stabilized zirconia. Second, the cell widths are ≈ 1mm, versus ≥ 1 cm in prior work. This allows one to achieve relatively high voltages in small devices, important for portable device applications of SOFCs. It also minimizes resistance losses across the electrodes, even when they are relatively thin. However, this cell width is still large enough that conventional low-cost processing techniques such as screen printing can be used for fabrication. We term the current design "Integrated Solid Oxide Fuel Cell" (ISOFC).

The ISOFC design has a number of advantages compared to planar SOFC stacks:

1. The interconnect is in intimate contact with the electrodes, yielding reduced resistance losses compared to interconnect-electrode pressure contacts (6).
2. Since there is no need to make pressure contacts over large areas, the manufacturing flatness requirements are substantially less than for planar stacks.
3. Interconnect conductivity requirements are reduced compared to planar stacks, even though the small interconnect area (≈ 10% of the cell area) results in a high current density, because the interconnect is much thinner.
4. Since the support does not have an electrical function, it can be chosen to maximize mechanical strength and/or minimize cost.
5. Since the current is collected at the ends of the series-connected cells, rather than flowing through separate PEN's and interconnects, the ISOFC design is ideally suited for a closed-end flattened tube geometry that simplifies sealing while providing high volumetric power density and allowing use of planar processing methods such as screen printing.

In this paper, we describe basic design considerations of the ISOFC and discuss experimental results obtained to date. The development of the support material, which focused on achieving the necessary substrate porosity and mechanical strength, is described. The deposition of the anode, electrolyte, interconnect, and cathode layers, along with their electrical and microstructural characterization, are described. Early results on ISOFC stack performance are discussed, and compared with a simple electrical model of ISOFC operation.

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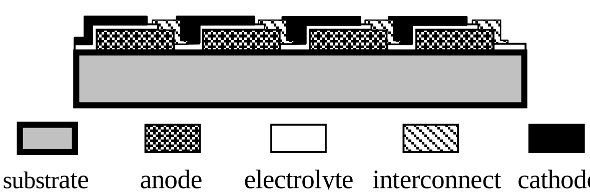

Figure 1. Cross-section schematic of ISOFC.