DEVELOPMENT OF ANODE-SUPPORTED SOFC WITH METALLIC INTERCONNECTOR

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INTRODUCTION

In 1989, Tokyo Gas started research and development of a planar SOFC that is expected to give low manufacturing costs and a high power density. The important milestone was recorded in 1993 and 1998 by the successful power generation of 1331 W using hydrogen as a fuel and 1679 W with direct internal reforming of methane at 1273 K. Since then our efforts have been concentrated on reduction in operating temperature to establish mechanical and thermal reliability of planar SOFCs.
Low-cost manufacturing process for anode-supported SOFCs suitable for reduced temperature operation has been developed. We have successfully developed anode-supported SOFCs with high electric conversion efficiency as high as more than 50%HHV.

STACK STRUCTURE

Figure 1 shows the schematic illustration of basic stack structure with alloy interconnects and manifolds developed for mitigating thermal stresses. The alloy manifold was bonded indirectly with the single-cell through thin and flexible metallic foil. The single-cell with the alloy manifold is sandwiched by metallic interconnects having an embossed structure. All components other than the single-cell are made of metallic alloy based on a ferric stainless steel which has sufficient oxidation resistance under the cathode condition and a thermal expansion coefficient close to that of the single-cell.

RESULTS AND DISCUSSION

The tests of the thermal-cycles between room-temperature and 1023 K have been conducted for single- and three-cell stacks with cells of 5 cm x 5 cm dimensions and a single-cell stack with a cell of 11 cm x 11 cm dimensions at a heating rate of 200 K / h. Mean degradation rate of the stacks were found to be less than 1 % / cycle, and no severe degradation was observed.

These results indicate that the stack structure shown in Figure 1 has a function for mitigating thermal stress as expected, and electric contact between the cathode and interconnects remains enough even after the thermal-cycle. Therefore we manufactured and tested a 10-cell stack with 5 cm x 5 cm single-cells. Figure 2 shows a picture of the 10-cell stack installed into an electric heating furnace. As a result, the open circuit voltage of the stack kept constant during four thermal-cycles. It was also found that the cells after thermal-cycle tests had no cracks.

To prove these experimental results, we ran numerical simulations about residual stress of a co-sintered cell and a cell in a cell-stack. The model calculation for the thermal stress in the electrolyte and the anode were carried out using the finite element program “ABAQUS” (Hibbit, Karlsson and Sorensen, Inc). Figure 3 shows the results of the calculation for residual stresses at room temperature: (a) is a co-sintered cell and (b) is a cell in a cell-stack. By installing a single-cell into the stack, the compressive stress in the electrolyte increased from 670 MPa to 800 MPa. However, the strength of 8YSZ is more than 1 GPa and thus these residual stresses are not so large as to induce a failure of the electrolyte. Tensile stress in the anode decreased from 37 MPa to 26 MPa. This indicates the anode is not subject to damage from thermal stresses. It can be concluded that the anode-supported cell has high durability against thermal cycling.

ACKNOWLEDGEMENT

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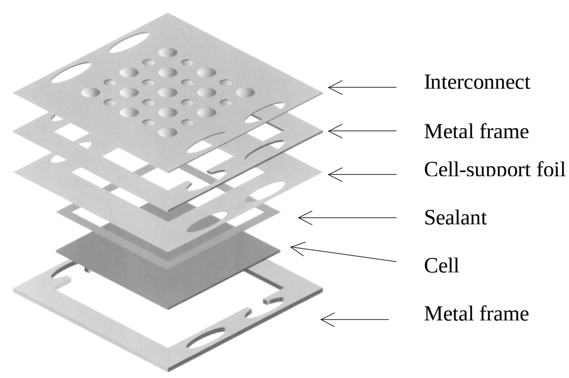


Figure 1. Schematic illustration of basic stack structure with alloy interconnects and manifolds developed for mitigating thermal stresses.

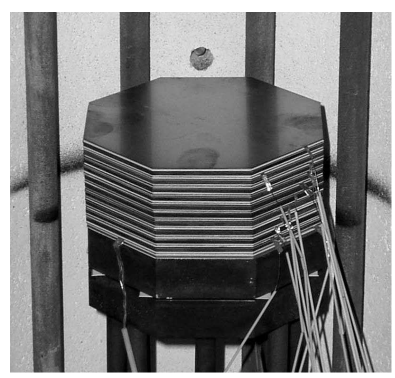
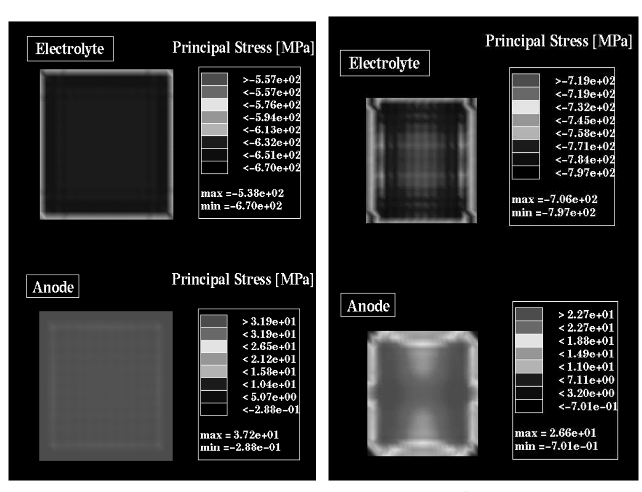


Figure 2. External view of a 10-cell stack with 5 cm x 5 cm single-cells Steady-state polarization of the electrode at 1073 K.



(a) (b)

Figure 3. Calculation results of residual stresses for a co-sintered cell (a) and a cell in a cell-stack (b) at room-temperature.