

## Anode Supported Interconnect for Electrolyte Membrane SOFC

Kenji Yasumoto, Hibiki Itoh, and Tohru Yamamoto  
Smart Materials Science Department,  
Central Research Institute of Electric Power Industry,  
2-6-1 Nagasaka, Yokosuka, Kanagawa 240-0196, Japan

To commercialize solid oxide fuel cells (SOFCs), both the reduction of fabrication costs (1) and the achievement to a higher and more stable performance are necessary. The contact between electrodes (anode and cathode) and interconnect becomes important when stacks are considered. Although the most part of the voltage drop comes from the contact resistance on anode side (1), the anode supported interconnect cell has not yet been successfully fabricated, because alkaline earth doped lanthanum chromite interconnect material did not densified when it was co-fired with yttria stabilized zirconia (YSZ) (2). Furthermore, alkaline earth doped lanthanum chromite was known to be poorly sinterable in air because of the high vapor pressure of Cr (VI) containing species (3). Recently, however, Sakai et al. (4) reported that Ca doped lanthanum chromite,  $(La,Ca)CrO_3$ , can be desized in air when an slightly excess amount of Ca was doped. As for co-firing, Kawada et al. (2) reported that migration of Ca from  $(La,Ca)CrO_3$  to YSZ was one of the biggest problems in the co-firing process because it prohibits the sintering of the interconnect. In this paper, in order to fabricate anode supported interconnect for electrolyte membrane SOFCs using YSZ-based anodes, a material with sufficient electrical conductivity was introduced between the anode and the interconnect to protect them from solid reactions and/or chemical diffusion. The performance of the obtained cell was examined.

The powders of interconnect materials,  $(La,Ca)-(Cr,Co)O_3$  (coded as LCCC), were supplied by a chemical corporation in Japan. An interlayer material was introduced between the anode and interconnect. The details of the interlayer will be reported in near future. Particular Ni and YSZ powders were used in the cermets anode, the ratio of coarse YSZ : NiO : fine YSZ was 4:6:1. Details of this cermet have been described elsewhere (5). The powder was mixed, pressed and sintered in air at 1673 K into pellets of about 20 mm in diameter and about 2 mm in thickness for an anode/interconnect cell (cell-A). A block sintered at 1673 K in air was cut into supporters of about 30 mm  $\times$  30 mm  $\times$  10 mm size for a cathode/electrolyte/anode/interconnect cell (cell-B). An interlayer material was slurry-coated on one side of the anode bases (cell-A and B) and fired at 1673-1723 K. The interconnect material was slurry-coated on cell-A and B, and fired at 1673-1723 K. The process was repeated for several times to make the interconnect thick enough. For cell-B, YSZ was slurry-coated on the opposite sides and fired at 1673-1723 K. Then, Sr doped lanthanum manganite cathode of 4 cm<sup>2</sup> in square shape was printed by tape cast on the YSZ film of cell-B, and fired at 1423 K for 1 h. Finally, Pt mesh was attached to the cathode and interconnect of cell-B using Pt past, and fired at 1273 K for 1 h. The structure of cell-A was investigated with a scanning electron microscopy, SEM, and an electron probe micro analyzer, EPMA, (JEOL Ltd., JXA-8900R). The electrochemical performance was examined by DC polarization and AC impedance measurements at 1273 K. In the electrochemical measurements, gaseous H<sub>2</sub> humidified by water at 293 K (350 ml/min) as a fuel and dry air (1000ml/min) as an oxidant were supplied to the anode and cathode, respectively.

In order to investigate the anode/interlayer/interconnect structure more closely, a cross section of cell-A was observed by SEM. Figure 1 shows the SEM image. It indicates that the interconnect/interlayer membrane was

dense. The thickness of the obtained interconnect/interlayer membrane was about 10  $\mu$ m, with the interlayer being about 2  $\mu$ m and the interconnect being 8  $\mu$ m, respectively. However, the interface between interconnect and interlayer was not observed in this SEM image. So we decided to investigate the distribution of chemical elements by EPMA for cell-A. From results of EPMA, we did not observe a diffusion of LCCC and Ni-YSZ, showing that solid reactions and/or chemical diffusions on the anode/interconnect interface were prohibited by the interlayer.

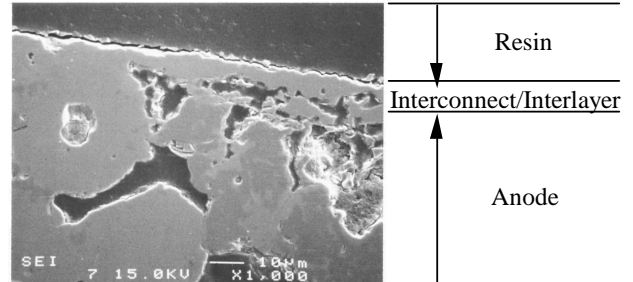


Figure 1. Cross-sectional SEM image of the anode/interconnect interface.

We succeeded in fabricating the dense interconnect on anode. In order to exam its effects, cell-B, with the anode supported interconnect and an YSZ electrolyte membrane, was examined with humidified hydrogen as fuel and air as oxidant at 1273 K. Figure 2 shows the relationships between current density and cell voltage and those between current and power densities measured on cell-B at 1273 K. Because the open circuit voltage (OCV) is about 1.0 V, we think both the interconnect and the electrolyte of cell-B were dense. Cell-B showed the maximum power density of about 0.4 W/cm<sup>2</sup> at about 0.8 A/cm<sup>2</sup>. This result is smaller than that of a similar cell without interconnect reported in our previous work (6, 7). From the complex impedance plots, interconnect resistance (ca. 0.12  $\Omega$ ·cm<sup>2</sup>) was found smaller than that of electrolyte (ca. 0.22  $\Omega$ ·cm<sup>2</sup>) and electrode reactions (ca. 0.50  $\Omega$ ·cm<sup>2</sup>). Although the electrolyte film of Cell-B was fabricated thick, it is not a big problem, for we can fabricate thin electrolyte films as reported in our previous work (6, 7). On the other hand, the electrodes must be improved in the future.

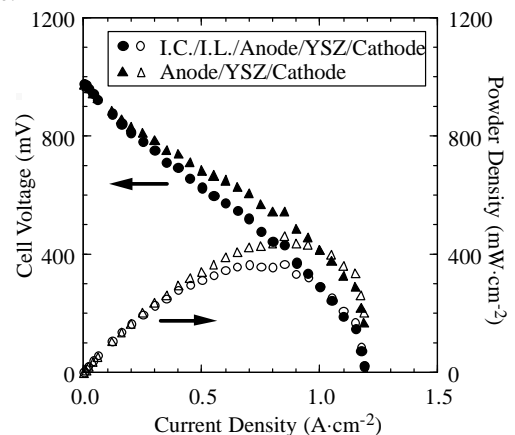


Figure 2. Relationships between current density and cell voltage (the closed symbols), and between current and power densities (the open symbols) measured with (●○) or without (▲△) interconnect / interlayer membranes for cell-B at 1273 K.

- (1) T. Yamamoto et al., *J. Power Sources*, **61**, 219 (1996)
- (2) T. Kawada et al, *Solid State Ionics*, **50**,189 (1992)
- (3) H. U. Anderson, in *Proc. Crystalline Ceramics*, H. Paulmour III, R. F. Davis, and T. M. Hare, Editors, p. 469, Plenum, New York (1978)
- (4) N. Sakai et al, *J. Mater. Sci.*, **25**, 4531 (1990)
- (5) H. Itoh et al., *J. Electrochem. Soc.*, **144**, 641 (1997)
- (6) H. Itoh, in *meet. abst. of the 2001Joint Intl. Meet.*, V. 2001-2, p. 385, The ECS Proc. Series, Pennington, NJ (2001)
- (7) A. Nakamura et al, in *Solid Oxide Fuel Cells VIII*, The ECS Proc. Series, Pennington, NJ (2003) in press