

IMPROVEMENT OF LSM CATHODE FOR HIGH POWER DENSITY SOFC

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Optimisation of processing $(La_{1-x}Sr_x)_yMnO_{3\pm\delta}$ /yttria-stabilised zirconia (LSM/YSZ) composite cathodes has lead to high performance solid oxide fuel cells. Symmetric cells for cathode optimisation were produced by spraying two identical LSM/YSZ cathodes on each side of the approximately 190 μm thick YSZ foil and then sintering. The cathodes were characterised by impedance spectroscopy using a Solartron 1260 impedance analyser in a frequency range of 0.1 Hz-2.5 MHz. The area specific polarisation resistance (R_p) and the area specific series resistance (R_s) were extracted from the impedance spectra by using EQUIVCRT. The microstructures of the symmetric and full cells were investigated using a low vacuum scanning electron microscope (Jeol LV5310).

Figure 1 shows the microstructure of a symmetric cell. Homogenous microstructure with sub-micron pores was obtained, which has resulted in an R_p of 0.09 Ωcm^2 at 850 $^\circ\text{C}$ and 0.31 Ωcm^2 at 750 $^\circ\text{C}$, while R_s was 0.29 Ωcm^2 at 850 $^\circ\text{C}$ and 0.61 Ωcm^2 at 750 $^\circ\text{C}$ in a symmetric sample with a YSZ tape of 185 μm . The lowest R_p values that have been achieved were 0.02 Ωcm^2 at 950 $^\circ\text{C}$, 0.06 Ωcm^2 at 850 $^\circ\text{C}$, 0.24 Ωcm^2 at 750 $^\circ\text{C}$, and 1.1 Ωcm^2 at 650 $^\circ\text{C}$. Such low R_p and R_s are attributed to a long triple phase boundary and very good adhesion between cathode and electrolyte. An interfacial resistance (ΔR) can be drawn from a comparison of R_s and the ideal electrolyte resistance. Calculation from the impedance measurements shows that the activation energy for the cathode polarisation was approximately 1.26 eV.

Anode supported cells were produced by tape casting the anode support, spraying the NiO-YSZ active anode and YSZ electrolyte layer, followed by co-sintering. Then the cathode was sprayed and sintered. The cells with an active electrode area of $4 \times 4 \text{ cm}^2$ were tested in a set-up designed by Risø. Figure 2 shows I-V curves for an anode supported cell produced using the optimised cathode processing technique. The cell with an active area of $4 \times 4 \text{ cm}^2$ was tested using humidified hydrogen with 3 % H_2O as fuel and air as oxidant. The hydrogen flow was 30 l/h and airflow was 140 or 170 l/h. Figure 2 demonstrates the high power density achieved in the anode supported cell with optimised cathode. The single anode supported cell with an active area of $4 \times 4 \text{ cm}^2$ showed a high power density of 1.44 W/cm^2 at 850 $^\circ\text{C}$, 1.17 W/cm^2 at 800 $^\circ\text{C}$, 0.8 W/cm^2 at 750 $^\circ\text{C}$, 0.51 W/cm^2 at 700 $^\circ\text{C}$, and 0.29 W/cm^2 at 650 $^\circ\text{C}$ at a cell voltage of 0.7 V.

Figure 3 shows the microstructure of the anode supported cell. The electrolyte with a thickness of 8-10 μm is dense and in good contact with the anode. Series resistance contribution from the anode/electrolyte interface could be very small due to the co-sintering process at temperature of 1300-1400 $^\circ\text{C}$. The calculation for the symmetric cell has demonstrated that the resistive contribution at cathode/electrolyte interface would be significant to the total loss of a cell. One can see from Figure 3 that the LSM/YSZ cathode is very homogenous and has a good contact with the YSZ electrolyte. Thus, the microstructure of the cathode in the symmetric cells shown in Figure 1 is reproduced in the anode supported cell shown in Figure 3.

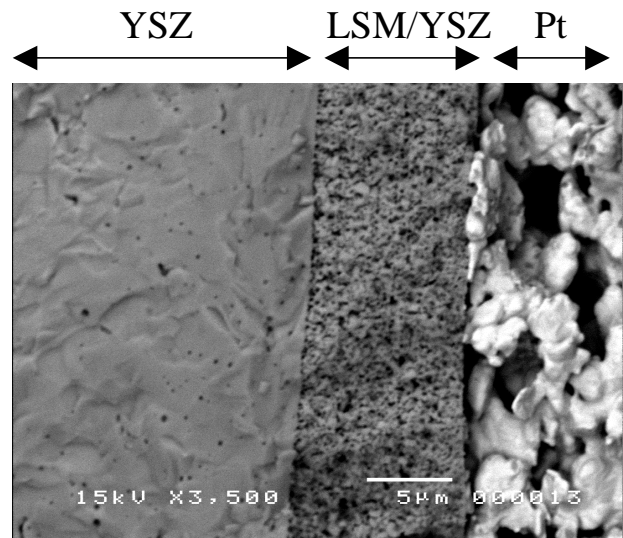


Figure 1. SEM picture of the cross section of a symmetric cell with the YSZ electrolyte thickness of 185 μm . The R_s and R_p are 0.29 and 0.09 Ωcm^2 at 850 $^\circ\text{C}$, 0.61 and 0.31 Ωcm^2 at 750 $^\circ\text{C}$, respectively.

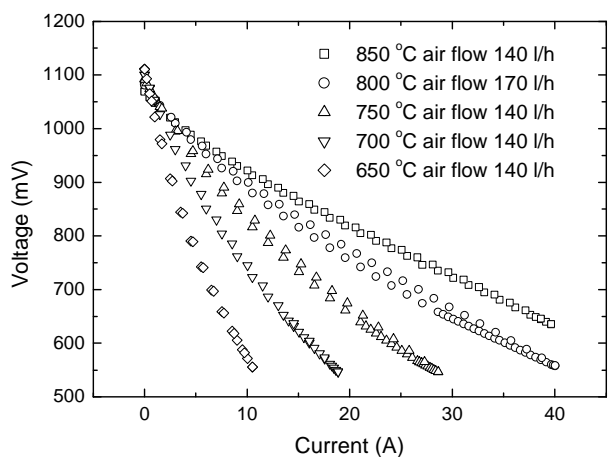


Figure 2. I-V curves obtained under the condition of hydrogen flow of 30 l/h. The cell temperatures were measured right underneath the cell.

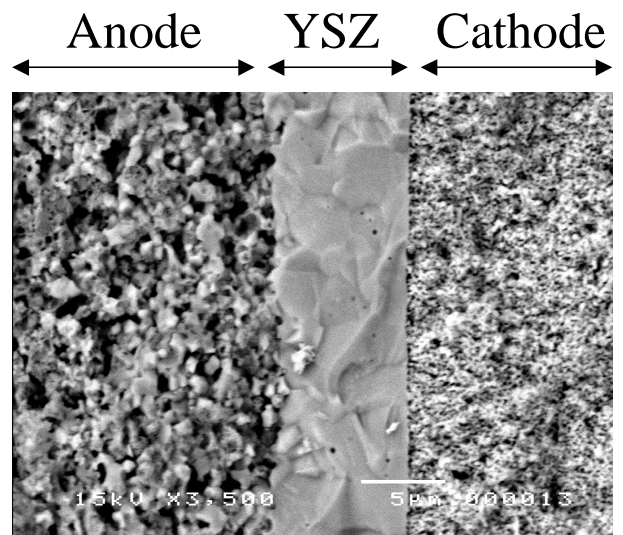


Figure 3. SEM picture showing the microstructure of the anode/electrolyte/cathode layers in the anode supported cell.