ELECTROCHEMICAL BEHAVIOUR OF ANODE SUPPORTED SOLID OXIDE FUEL CELLS DEVELOPED BY DIFFERENT TECHNIQUES

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Introduction

Solid Oxide Fuel Cells (SOFCs) are promising highly efficient and environmentally compatible energy conversion devices, that produce electricity from oxygen and hydrogen fuel working in high temperature [1],[2].

In order to improve the long-term stability of the electrodes and electrolyte of the SOFC stacks, is recently recognized that the operation temperature should be lowered to 600-900°C. Moreover, lower operating temperature allows the use of cheaper materials for interconnects and external high temperature components and promises reduced degradation processes and a longer lifetime of the stacks [3].

Anode-supported SOFC is one of the methods to reduce the service temperature because it allows the reduction of the thickness of 8 mol% yttria-stabilized zirconia (YSZ) electrolyte [4].

The development of porous anode materials with high stability, such as high mechanical strength, high thermal shock resistance, appropriate gas permeability and high electrical conductivity are hence needed.

This paper describes the physical characterisation and electrochemical behaviour of planar anode supported SOFCs with electrolyte produced by different techniques: tape casting and screen printing.

Experimental procedure

Flat cells (20x20 mm), investigated in the present work were developed with similar anode supported configuration: on a porous 50 vol.% Ni/YSZ cermet anode (800 µm thickness) was deposited a dense thin YSZ electrolyte (5 µm thickness), then another porous $(La_{0.85}Sr_{0.15})_{0.9}MnO_3$ (LSM) cathode (80 µm thickness) was deposited.

Cell A and cell B differ by production method: for both cells the anode support is produced by tape casting, and cathode is produced by screen printing; the electrolyte is obtained through screen printing for cell A and through tape casting for cell B.

SEM, XRD and microanalyses were used to investigate the microstructure and the elemental composition of the electrodes and electrolyte before and after services.

The electrochemical behaviour of every single cell (anode-electrolyte-cathode) was studied by Open Circuit Voltage (OCV) measurements and Polarisation Analysis (I-V) in the temperature range between 750 and 900°C using a specific apparatus developed in our laboratory (Fig 1). Pt mesh and Pt past was used for collecting the current on cathode and anode side. During the cell heating, the tube (anode side) was purged with Argon. When testing temperature was reached, the argon flow was progressively changed to the reduction gas H_2.

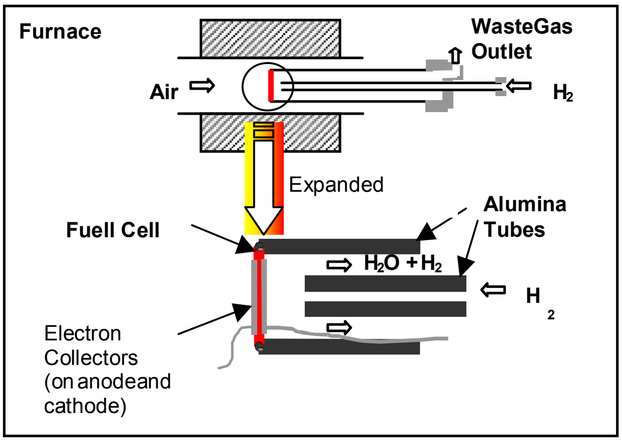

Fig. 1: *schematic description of the apparatus used for electrochemical characterisations*

Experimental Results

Fig. 2 shows current density/voltage and current density/power density characterization of the two different produced cells operating at 900°C. An OCV of 1030 mV was obtained for the A cells whereas a value of 1080 mV was obtained for the B cell.

Moreover, for high current density, power density and current show strong different results. The same behaviour was obtained also at different tested temperature (750°-800°-850°-900°C).

Fig. 3 shows a SEM micrograph of a cross section of A cell and the same microstructure in term of grain size, porosity and thickness was observed in B cell.

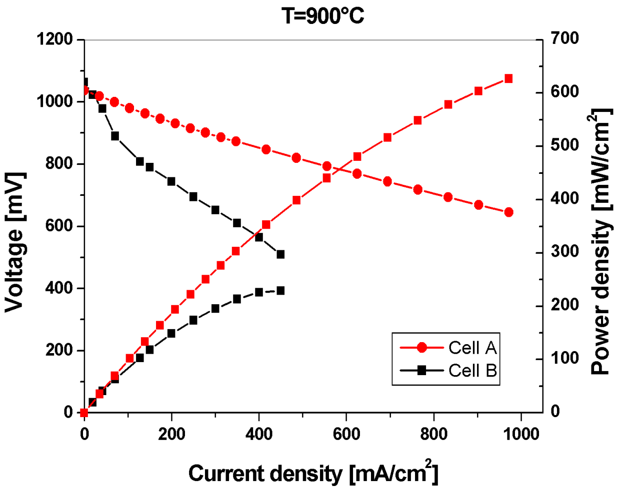

Fig. 2: *Performances of cell A and cell B with H_2/air as operating gases at 900°C*

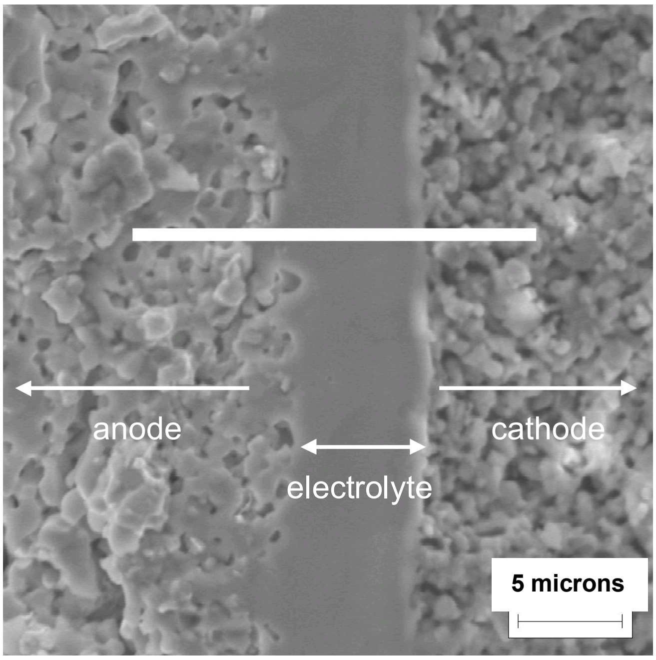

Fig. 3: *SEM micrograph of the anode, electrolyte and cathode fracture surface of cell A (3000x)*

Discussion and Conclusions

To reduce the SOFC operating temperature from 1000° to 800°C and maintain good performance, it has been necessary minimize ohmic and polarization losses.

Towards this goal, the use of thin film processes, like screen printing and tape casting for preparing the components, has been highly developed. Thin film processes are very promising techniques indeed to reduce component thickness and to optimize ternary interfaces where ionic and electronic transfer occurs.

In our study we decide to prepare thin film electrodes on anode substrate suitable for SOFCs operating at reduced temperature. Complete cells have been tested at a temperature range from 750° to 900°C, under air at cathode side and pure hydrogen at the anode side.

The electrochemical performance of cells produced in different way, tape casting and screen printing, shows strong electrochemical difference even if the SEM analyses show the same microstructures.

These experimental results, or the different electrochemical behaviour, could only be attributed at poor interface bonding between anode-electrolyte and cathode-electrolyte that reduces the presence of the triple phase (LSM/YSZ/gas) boundary.

Hence, the tape casting technique to develop electrolyte components tends to produce a reduction of reactive interfaces that strongly influences the performance of the SOFCs.

Future work will be addressed to improve the tape casting technique, changing production parameters, to develop films with different reactive surface able to increase reactive triple phase boundary.

References

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