Development of YSZ Films for Solid Oxide Fuel Cells : Comparison between Electrophoretic and Screen-Printing Depositions

D. Rotureau*, A. Simone°, C. Pijolat*,
L. Montanaro°, J-P. Viricelle*

* Centre SPIN, Ecole Nationale Supérieure des Mines, 158, Cours Fauriel, 42 023 St.Etienne (France)

° Dpt of Mat. Sci. and Chem. Eng., Politecnico of Torino, Corso Duca degli Abruzzi, 24, 10 129 Torino (Italy)

The aim of this study is to investigate the potentialities of both electrophoretic deposition (EPD) (1) and screen-printing (SP) (2) technologies to manufacture planar SOFC device. A first part of the work deals with the elaboration of YSZ (8 mol% Y_2O_3) layers by both technologies, onto α-alumina planar substrates, and with the comparison of their electrical performances in relation with their microstructure. A thin platinum layer was deposited onto the substrates to act as an electrode for the EPD process and for further electrical characterizations. EPD mono-layers could be obtained by adjusting the deposition parameters (tension, time). With a tension set at 50 Volts, a thickness of 18 µm was reached for deposition time of 3 minutes. Longer deposition time resulted in crack formation in the obtained films. To overcome this problem, EPD double layers were also prepared but delamination between overlapped films occurred. For SP process, two types of ink were developed : a traditional formulation including the YSZ powder and some organic binders, and a non conventional ink into which binders are replaced by a gel precursor of YSZ. The aim of the gel ink process is to improve the sintering and the adhesion to the substrate of the resulting layer compared to the conventional process for which no inorganic binder (glass) could be added in reason of final electrical properties requirements. For each type of ink, double layers were deposited and the resulting thickness after annealing were around 60µm for the conventional ink and around 40µm for the gel ink. In both cases, EPD and SP, the annealing was performed at 1200°C during 1 hour. As shown in SEM images in figure 1, a progressive decrease of the porosity was observed from conventional screen-printing to the non-conventional one, finally to EPD films. In addition, it can be underlined that the EPD layers presented in all cases a very low surface roughness compared to the screen-printed deposits.

Conductivity measurements were performed in the range 250-550°C (figure 2) and values were extrapolated at 1000°C using Arrhenius law. Dense EPD monolayers have suitable conductivity value, close to 0.1 S/cm at 1000°C (3). For double EPD layers, low values (around 0.01 S/cm) are explained by layer delamination. Although SP process leads to more porous thick films, the conductivity is 0.07 S/cm at 1000°C for layers issued from traditional ink. Substitution of binders by a YSZ precursor gel in SP inks allowed to decrease the porosity but not to increase the conductivity (0.04 S/cm at 1000°C) due to some cracks formation in the layers.

From these preliminary results, EPD appears more suitable for YSZ elaboration for SOFC electrolyte application. Further characterizations such as gas tightness are under progress. SP can be used to produce porous layers : LSM electrodes but also intermediate electrode/electrolyte layers consisting of LSM-YSZ mixtures are under investigations (4).

REFERENCES

1. J. Will, A. Mitterdorfer, C. Kleinlogel, D. Perednis, L.J. Gauckler, Solid State Ionics, **131**, 79 (2000).

2. N.Q. Minh, T. Takahashi, Science and Technology of Ceramic Fuel Cells, Elsevier Science, Amsterdam (1995).

3. N.Q. Minh, J. Am. Ceram. Soc., **76 [3]**, 563 (1993).

4. E.I. Tiffée, A. Weber, D. Herbstritt, J. Eur. Ceram. Soc., **21**, 1805 (2001).

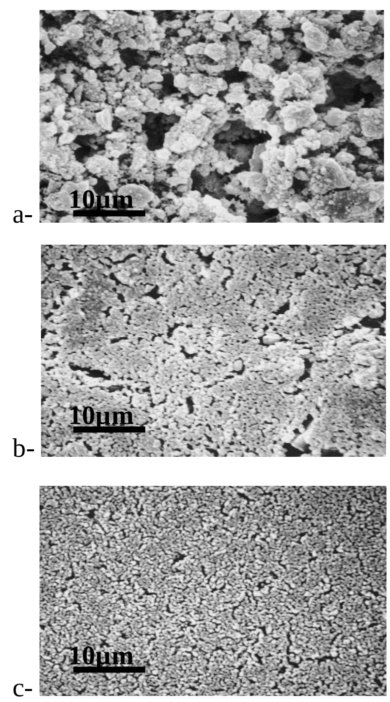

Fig. 1. SEM micrographs of surfaces of layers obtained from a) SP conventional ink, b) SP gel ink, c) EPD (50V, 1 min).

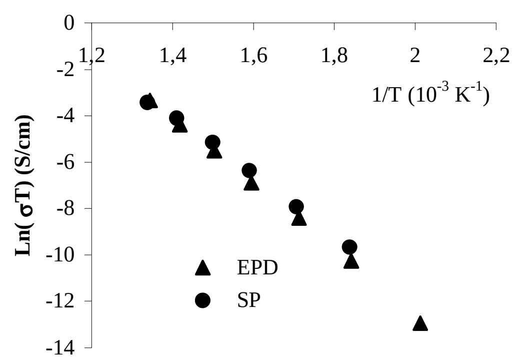

Fig. 2 : Arrhenius plot of total electrical conductivity (S/cm) of conventional SP and EPD (50V, 2min) layers.