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Innovative microstructures of MIEC cathode for IT-SOFCs

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Abstract – This work describes a systematic study of the effect that several electrostatic spray deposition (ESD) parameters such as nozzle-to-substrate distance, solution flow rate and substrate temperature have on the microstructure of the obtained $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) films on dense $Ce_{0.9}Gd_{0.1}O_{2-\delta}$ substrates. A wide variety of original microstructures of these cathodes ranging from dense to porous, with particular features such as reticulation and micro-porosity were successfully obtained. The influence of the LSCF microstructure has been investigated on the electrochemical performance of LSCF cathodes using AC impedance spectroscopy.

Since the operation of solid oxide fuel cells at intermediate temperatures (IT-SOFCs) causes an increase of the interfacial polarization losses as well as ohmic loss in the electrolyte, the cell performance has to be improved. To compensate for the efficiency reduction, alternative electrolyte and cathode materials are being evaluated as potential candidates for IT-SOFCs. However, the performance of the cell is not only dependent on the properties of the materials that comprise it, but also on their microstructures, mainly that of the cathode. It is known that porosity allows permeation of gaseous species to and from reactive sites, while its geometry controls the surface area available for such reactions to occur. A comprehensive analysis of this correlation is therefore desirable in that it isolates the contribution of the architecture of the cathode film from that of its intrinsic properties.

The deposition of $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) films was investigated using electrostatic spray deposition (ESD) technique starting from a precursor solution which was atomized into charged droplets by electrohydrodynamic forces and sprayed onto a heated home-made $Ce_{0.9}Gd_{0.1}O_{2-\delta}$ substrate. It operates at relative low temperatures while allowing excellent degree of control over the stoichiometry and microstructure of the films, which makes it most adequate in this study. In our investigation, we have systematically mapped microstructures obtained using different operation conditions [1], using nozzle-to-substrate distances of 15, 30, 45, 48 and 53 mm, solution flow rates of 0.34, 0.67 and 1.5 mL/h, and substrate temperatures of 250, 275, 300, 350, 400 and 450 ºC. SEM/EDS analyses have shown that large arrays of different LSCF film microstructures were obtained, ranging from dense to reticulated (Fig. 1) to porous (Fig. 2), with thicknesses ranging from 1 to 30 μm. Single phased LSCF with typical perovskite structure were successfully deposited for the first time by ESD on CGO substrates. The correlation between deposition parameters and resulting morphology are discussed in detail. Electrical characterization of samples selected according to these criteria was performed using AC impedance spectroscopy measurements in order to investigate the influence of the LSCF microstructure on the electrochemical performance.

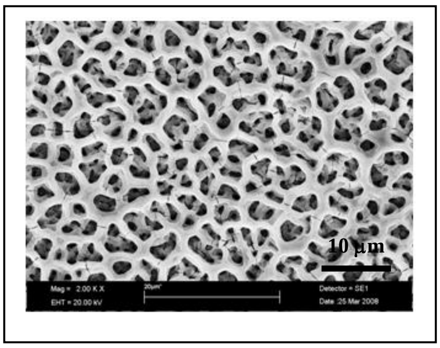

Figure 1: Reticulated LSCF films deposited by ESD.

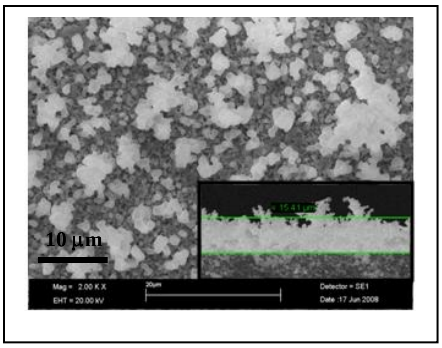

Figure 2: Porous LSCF films deposited by ESD (inset: cross section view).

References

[1] D. Marinha, E. Djurado. Journal of Solid State Chemistry, in press (2009).