Thin Films of $La_{1-x}Sr_xCo_yFe_{1-y}O_{3-\delta}$ for Micro-Solid Oxide Fuel Cell Cathodes made by Spray Pyrolysis

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Mixed ionic / electronic conducting LSCF thin films were prepared and investigated for possible use as a cathode in a Micro-Solid Oxide Fuel Cell.

Spray pyrolysis[1,2,3] was used in order to deposit $La_{1-x}Sr_xCo_yFe_{1-y}O_{3-\delta}$ films from a precursor consisting of a mixture of 3:2:1:4 $La(NO_3)_3{\cdot}6H_2O$: $SrCl_2{\cdot}6H_2O$: $Co(NO_3)_2{\cdot}6H_2O$: $Fe(NO_3)_3{\cdot}9H_2O$ (LSCF) dissolved in an ethanol and diethylene glycol monobutyl ether solution. This precursor is then sprayed onto a heated substrate. The volume distribution of the solvent droplets produced by the air pressurized nozzle was determined with varying flowrate and air pressure.

LSCF was deposited on substrates suitable for micromachining, such as silicon and photostructurable glass (Foturan®), as well as on sapphire. The type of nozzle, nozzle substrate distance, the kind of metal salts and the solvent was kept constant throughout the deposition experiments. Whereas substrate temperature, total salt concentration in the precursor solution, solution flowrate, air pressure and deposition time was varied. The influence of annealing temperature and time on the film morphology was also investigated.

The flowrate does not significantly change the droplet volume distribution; whereas the air pressure does effect the droplet volume distribution in a way that higher pressure leads to a more uniform distribution. The substrate temperature during film deposition was found to have a strong influence on the film morphology, in case the temperature is too low, the as deposited film is too wet, thus cracks are formed, see Figure 1. The same is valid in case the flow rate is too high. Choosing an intermediate substrate temperature (250 °C – 300 °C) results in a continuous film, even after annealing, see Figure 2. If the temperature is too high, no film is formed but powder which does not cover the complete substrate, see Figure 3. Within the investigated air pressure range (0.5 to 1.5 bar) no significant effect of the air pressure on the film morphology is observed. By raising the annealing temperature or extending the annealing time nano sized pores are formed in the film, see Figure 4 and Figure 5.

To measure the in plane conductivity, four point conductivity measurements were carried out on the actual thin films at different temperatures in air. The conductivity is found to be lower than that of dense bulk samples.

[1] Bohac, P. and L. Gauckler, *Chemical spray deposition of YSZ and GCO solid electrolyte films.* Solid State Ionics, 1999. **119**(1-4): p. 317-321.

[2] Perednis, D., *Thin Film Deposition Using Spray Pyrolysis*. 2003, PhD Thesis, Swiss Federal Institute of Technology: Zürich.

[3] Perednis, D., K. Honegger, and L. Gauckler. *Deposition of Thin YSZ Films by Spray Pyrolysis*. in *Fourth European Solid Oxide Fuel Cell Forum*. 2000. Lucerne / Switzerland.

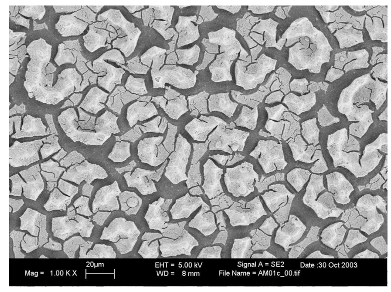

Figure 1: LSCF on Foturan® after annealing at 650 °C, substrate temperature 190 °C.

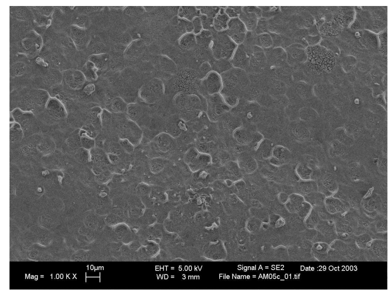

Figure 2: LSCF on Foturan® after annealing at 650 °C, substrate temperature 260 °C.

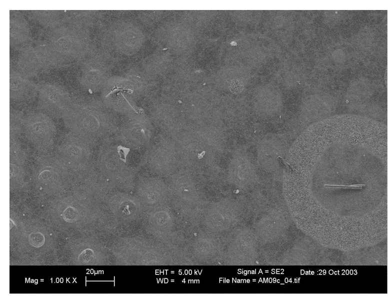

Figure 3: LSCF on Foturan® after annealing at 650 °C, substrate temperature 320 °C.

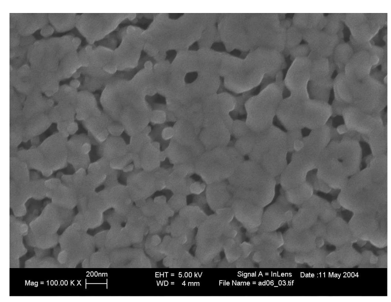

Figure 4: LSCF on sapphire after annealing at 800 °C, substrate temperature 280 °C.

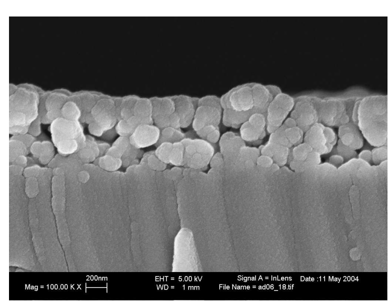

Figure 5: Cross section of Figure 4.