

CATHODE SUPPORTED THIN FILM SOFCs

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Introduction

Many solid oxide fuel cell developers have focused on cost reduction as the key strategy for successful commercialization of SOFC technology. One approach to reducing the stack and system cost is to reduce the operating temperature of the cells to 600-800°C where low cost alloys may be employed in the stack and the balance of plant. Inexpensive materials and manufacturing are required for low cost cells but the cell performance should not be compromised.

Prior work in our group demonstrated a co-fired LSM supported device designed for oxygen separation. Cell performance was quite good (η_{cell} 0.5 V at 1.55 A/cm²) at 800°C [1] when the LSM-YSZ was sintered at 1400°C. In the present study we have focused on reducing the firing temperature to 1200-1300°C to allow the use of more reactive electrodes as well as introduce the possibility of co-firing La_{0.7}Sr_{0.3}CrO₃ interconnects with the cathode/electrolyte/anode structure to enable single step fabrication of planar and tubular SOFCs. In addition, here we attempt to co-fire LSM/SSZ or LSM/LSGM bi-layers in order to demonstrate the use of higher conductivity electrolytes for cathode-supported cells. The techniques described can be used for co-firing cathode supported cells or anode supported cells for fuel cells or oxygen separation.

Experimental

La_{0.65}Sr_{0.30}MnO₃ (LSM) powder (d_{50} =1.3 μm , surface area ~4.71 m²/g) was obtained from Praxair Specialty Ceramics (USA) and Timrex KS6 graphite pore former from Timcal Ltd (Switzerland). 50 g of LSM was attritor milled with Menhaden fish oil (3 wt%) using zirconia milling balls in IPA for 1 hr at 550 rpm. 17.5 g of the graphite pore former 3 wt% of polyvinyl butyral and dibutyl phthalate were added after milling was complete. The mixture was dried, ground with mortar and pestle, then sieved <150 μm . The resulting powders were then uniaxially pressed at 15 ksi in a stainless steel die. The resulting green disks were either used as is or pre-fired to 950°C for 4 hrs to remove the binder/graphite before thin film deposition.

8YSZ powders were obtained from Tosoh Corporation (Japan). 9 mol% Scandia stabilized zirconia powders were synthesized using Pechini [2] and La_{0.9}Sr_{0.1}Ga_{0.9}Mg_{0.1}O₃ powders by the glycine-nitrate (GN) [3] method. In the GN method, glycine was added to the solution in glycine/nitrate (G/N) ratios of 0.5. The powders synthesized were calcined at 1000°C or 1100°C for 4 h and then attritor milled in isopropyl alcohol (IPA) using YSZ balls at the rotation speed of 550 rpm for 3-6 hrs. NiO-YSZ anode powder was also prepared by attritor milling for 1 hr at 550 rpm.

Colloidal deposition of ceramic films and electrodes by aerosol spray has been previously described [4]. The

ceramic powder is simply dispersed in IPA with a dispersant and applied to the porous support. Sintering of the bi-layer or tri-layer structures was carried out at 1250°C for 4 hrs in air.

Results

LSGM films were co-fired with LSM at 1250°C; however, as shown in Figure 1, through-porosity remained. Dense films of YSZ and SSZ shown in Figure 2 were successfully co-fired with an LSM support at 1250°C. Co-fired tri-layers consisting of porous LSM, dense YSZ, and porous NiO-YSZ are shown in Figure 3. For LSM supported electrolytic oxygen separation cells tested no gas diffusion limitation was observed even beyond 2 A/cm². Fuel cell testing of the co-fired tri-layer cells is ongoing.

Acknowledgements.

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Reference

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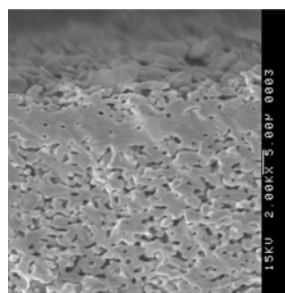


Figure 1. LSGM thin film on porous LSM support.

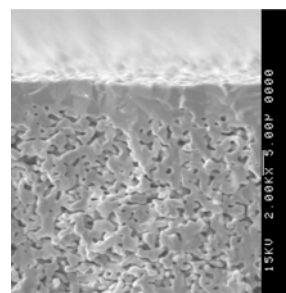


Figure 2. SSZ thin film on porous LSM support.

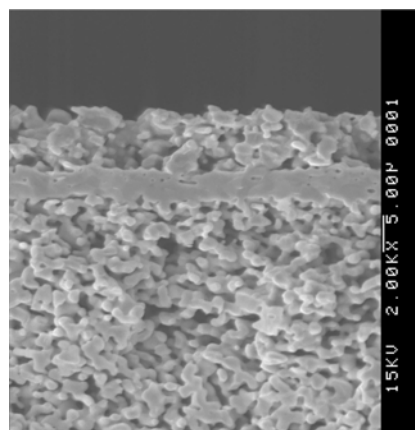


Figure 3. Co-fired tri-layer (porous LSM, bottom; YSZ dense film in center; porous NiO-YSZ, top layer).