$Pr_xSr_{1-x}MnO_{3-\delta}$ (PSM) and $La_{0.8}Sr_{0.2}Mn_{0.8}Co_{0.2}O_{3-\delta}$(LSMC) Infiltrated LSCF Cathodes for SOFCs

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Introduction

- The cathode is an important area of SOFC development since cathode polarization still makes considerable contribution to energy loss in SOFC operation, more so at lower operating temperatures
- $La_{1-x}Sr_xMnO_{3\pm\delta}$(LSM) (>800°C) and $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) (<750°C) still remain the most widely used for SOFC, due primarily to the limitations of alternative cathode materials: unproven long-term stability and inadequate compatibility with electrolyte/other cell components especially at high temperatures required for fabrication.
- One reliable approach is to modify the surface of the-state-of-the-art cathode by a thin-film coating of a catalyst with higher stability and catalytic activity toward oxygen reduction reaction (ORR)
- The activity and stability are both enhanced through infiltration during operation (Fig.1c)
- In-depth investigation for LSM infiltration and development of new infiltration species for further performance improvement are needed.

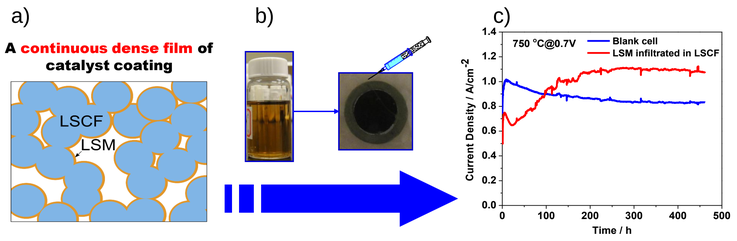

Figure 1. a) Schematic of an LSM infiltrated LSCF cathode; b) a typical infiltration process; and c) the performance of the full cells without infiltration (blank) and LSM infiltration

Experimental

- Symmetrical cells were fabricated with two-electrode or three-electrode configuration for interfacial polarization resistance (Rp) measurement under open circuit conditions (OCV) and overpotential under steady state polarization, respectively.
- Testing of homemade full cells with baseline and infiltrated LSCF cathode were performed at 750°C with a constant voltage of 0.7 V.
- Microstructure was characterized with a 300 kV HF3300 TEM/STEM/EDS.
- Modeling and simulation were conducted for performance prediction and observed performance improvement of LSM infiltrated LSCF.

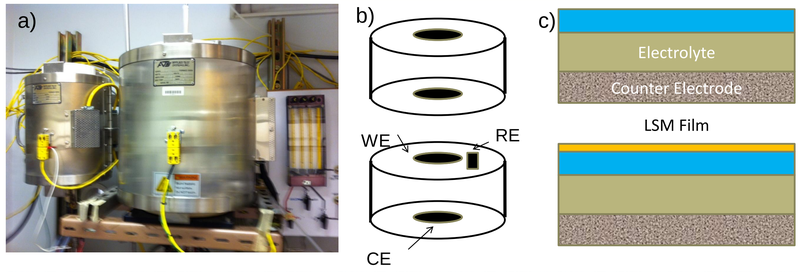

Figure 2. a) GT SOFC testing system station; b) schematic of symmetrical cells with 2 electrode and 3 electrode configuration, and c) schematic of a thin-film test cell with blank LSCF (top) and LSM-coated LSCF (bottom) for fundamental study

Results and Discussion

1. Development of PSM as an infiltration material

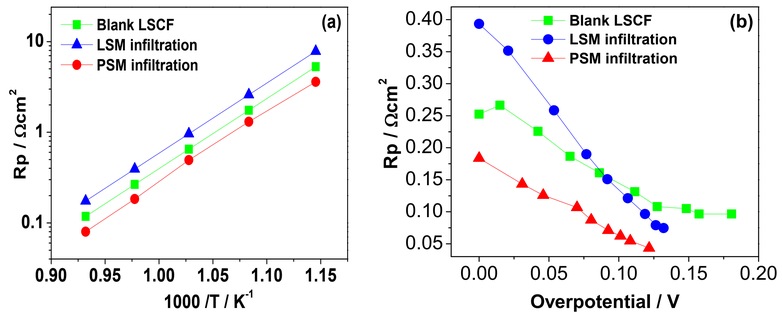

Figure 4. a) Temperature dependence of interfacial polarization resistance of LSCF with PSM and LSM infiltration at OCV; b) Rp versus overpotential for LSCF cathodes without/with PSM and LSM infiltration measured at 750°C

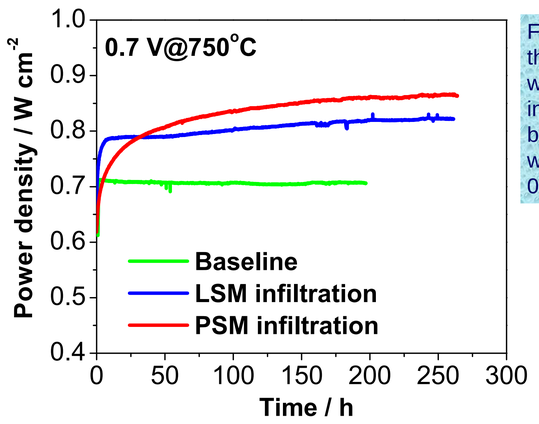

Figure 5. Typical lifetime of the homemade button cells with PSM and LSM infiltrated LSCF as well as baseline LSCF cathode with a constant voltage of 0.7 V at 750°C

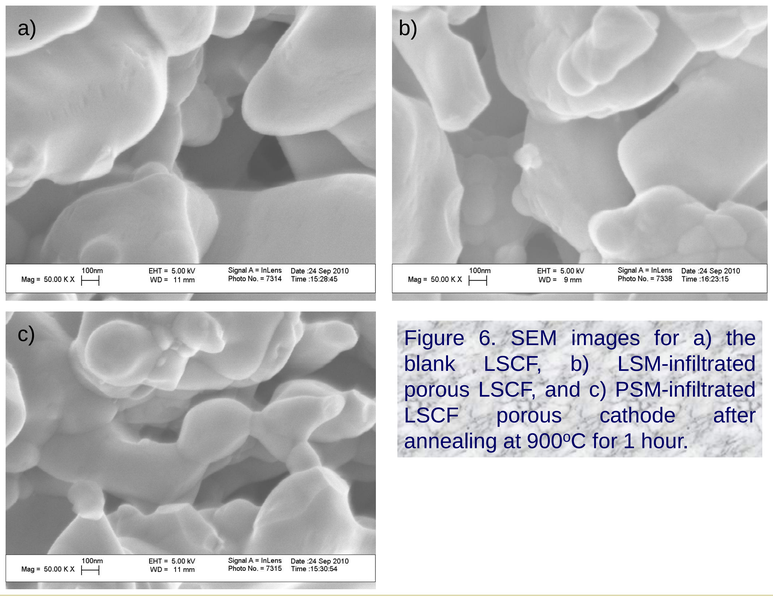

Figure 6. SEM images for a) the blank LSCF, b) LSM-infiltrated porous LSCF, and c) PSM-infiltrated LSCF porous cathode after annealing at 900°C for 1 hour.

Compared with conventional infiltration via particle deposition, the image of LSM and PSM infiltration suggests that the film assumes an epitaxial relationship with respect to the LSCF backbone due to the structural similarity.

2. Modeling and simulation

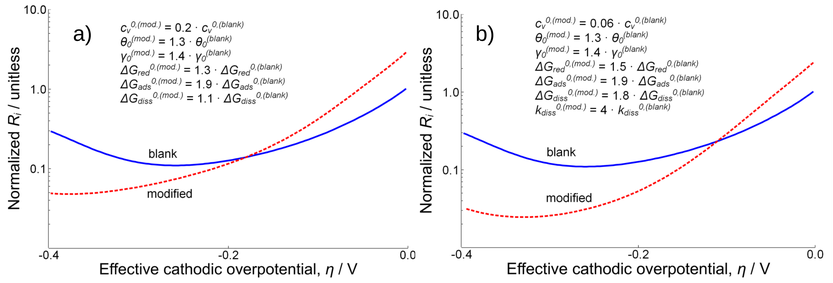

Figure 7. Simulated normalized Rp vs effective cathodic overpotential for blank LSCF and LSCF with modified surface properties under different conditions

3. Microanalysis of surface & interface

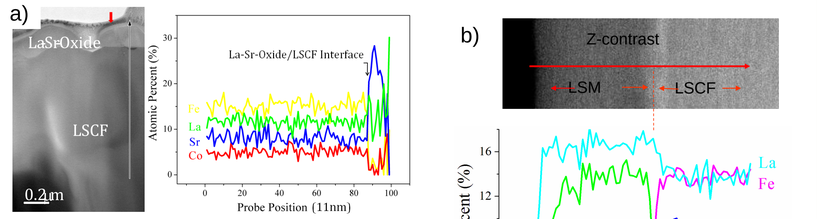

Figure 8. STEM images and atomic percent profile for: a) blank LSCF and b) LSM coated LSCF pellets annealed at 850°C for 900 hrs

There is Sr/La oxide layer presented in blank LSCF, which is possibly related to the limited electrochemical activities. In contrast, there is no such oxide layer on the LSM-coated LSCF samples under similar annealing conditions in which Co diffuse into LSM layer.

4. Development of LSMCo cathode

Based on our microanalysis, the time-dependent activation over a few hundreds of hours and durability of LSCF are likely associated with the formation of a favorable hybrid surface phase intermediate (LSMCo) between coating species and substrate LSCF.

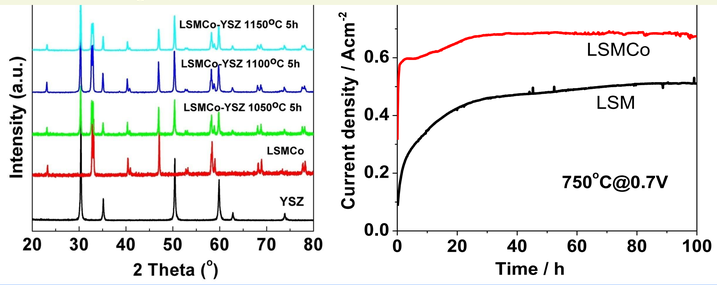

Figure 9. a) XRD patterns of LSMCo-YSZ composites fired at various temperatures, and b) long-term stability of full cells with LSM and LSMCo cathodes at 750°C under 0.7 V

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