Modified LSM-YSZ Cathodes for Reduced Temperature Solid Oxide Fuel Cells (SOFC)

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Introduction

Most state-of-art solid oxide fuel cells (SOFC) use 8mol% yttria stabilized zirconia (YSZ) as the electrolyte, Ni-YSZ as the anode, and $La_{1-x}Sr_xMnO_{3-\delta}$ (LSM)-YSZ as the cathode (1). Due to the insufficient performance of the electrolyte and electrodes at low temperatures (<700°C), cells have been operated at high temperatures (800°C-1000°C). Lowering cell-operation temperatures will expand the materials selection, suppress the degradation of SOFC components, and consequently extend cell lifetime. Therefore, a thin-film electrolytes as well as alternative electrolytes with higher oxide-ion conductivity than that of YSZ have been extensively explored to reduce cell ohmic loss at reduced temperatures (2-6). However, at low temperatures cathode polarizations lead to a significant cell-performance loss because the electrochemical reaction rates decrease dramatically (7). To enhance the reactions, alternative cathode materials including $Sm_{0.6}Sr_{0.4}CoO_{3-\delta}$ (SSC) have been developed (8). Unfortunately, due to the thermal expansion mismatch with YSZ and deleterious reaction with YSZ at high-temperature processing steps, SSC can not be directly used in the YSZ-based SOFCs.

To take advantage of SSC in reduced-temperature cathodes in YSZ-based cells, in this study SSC is infiltrated into the porous LSM-YSZ cathodes at 800°C using a precipitation method. The effect of SSC addition on the cathode polarizations and cell performance at low temperatures (600°C-700°C) is reported.

Experimental

20g YSZ powder (Tosoh-Zirconia; TZ-8Y) was ball milled with 2 wt% Menhaden fish oil, in isopropanol alcohol (IPA), for 24 hours. 2 wt% polyvinylbutyral (PVB) and dibutylphthalate (DBT) binders were added to the solution that was additionally milled for 1 hr. The solution was dried under a heat lamp, and the dried powder was then ground and sieved down to 150 microns. 3g of the sieved powder was pressed in a metal die with a diameter of 1.5 inch, at 10kpsi. The resultant discs were sintered at 1400°C for 4 hrs to obtain dense YSZ discs with a diameter of ~1.19 inch.

Symmetric cells were prepared using an aerosol spray method (6). 1g YSZ and 1g $La_{0.7}Sr_{0.3}MnO_{3-\delta}$ (Praxair Specialty Ceramics) were attritor-milled in IPA, for 1 hr, with the addition of 0.1g fish oil and 1 drop of DBT. The solution was then sonicated for 5 mins, and sprayed on both sides of YSZ discs to form symmetric cells having $1cm^2$ electrodes. The electrodes were then sintered at 1150°C for 4 hrs, and absorbed aqueous solution containing urea and Sm, Sr, Co nitrates in the ratio of 0.6:0.4:1. The electrodes were heated at 90°C for 2 hrs. Pt current collectors were placed on the electrodes and fired at 800°C for 2hrs. Single cells in this work were fabricated using the techniques detailed elsewhere (6). The SSC was incorporated into the LSM-YSZ cathodes using the precipitation method as mentioned above.

The cell I-V (current density-voltage) curves were collected with lab-coded software, and its performance was also characterized using a Solartron 1260 frequency response analyzer connected with a Solartron 1286 electrochemical interface. The cell microstructures were observed with a scanning electron microscopy. The formation of SSC perovskite phase was analyzed using XRD examination.

Results

Fig. 1 shows the XRD pattern of the prepared powder sintered at 800°C for 2hrs. The majority of the pattern corresponds to $Sm_{0.6}Sr_{0.4}CoO_{3-\delta}$ with the perovskite phase, although there are some peaks from impurities. This allows us to incorporate SSC into LSM-YSZ cathodes and avoid the adverse reactions between SSC and YSZ.

Acknowledgements

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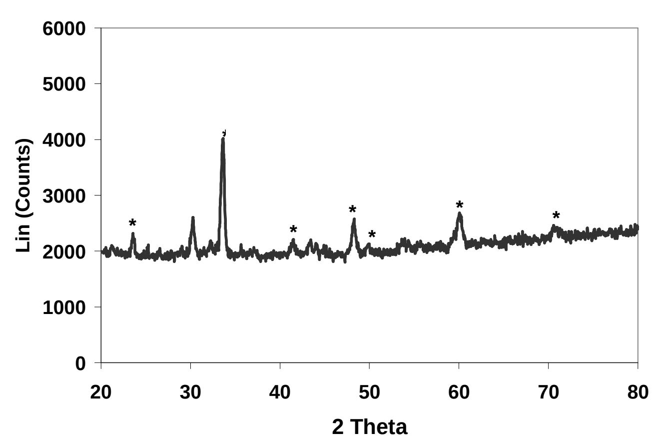

Fig. 1 XRD pattern of the prepared SSC powder sintered at 800°C for 2hrs. (*) perovskite phase