Oxygen Reduction Activity of Lanthanum Strontium Nickel Ferrite

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It is well recognized that lower operating temperatures (≤650 °C) would allow the use of high temperature steels as interconnect materials and significantly reduce the cost of fabrication and increase the reliability of solid oxide fuel cell (SOFC) stacks. The major drawback is the greatly reduced performance of other cell components especially the cathode.

Current SOFC cathode development has focused on Lanthanum Strontium Ferrite (LSF) which shows substantial improvement over Lanthanum Strontium Manganite in the 700 °C to 900 °C range. LSF is however not sufficiently electrochemically active for practical applications in the low end of this temperature range. Thus LSF cannot be used in new SOFC stack designs which would make use of steel interconnects.

Towards this low temperature SOFC goal, we have investigated a wide range of LSF materials doped on the perovskite B site with elements that may facile redox activity. Here we report on the doping of LSF with nickel (LSNF) of composition $La_{0.7}Sr_{0.3}Ni_xFe_{1-x}O_3$ were prepared with "x" ranging from zero to 0.4 fraction. The materials were prepared by glycine nitrate combustion, calcined at 1200 °C, attrition milled, and sieved to 325 mesh. A ink comprising 50 wt % oxide powder, and 50% screen print binder (Ferro), was mixed in a 3 roll mill until uniform. The ink was screened onto yitria stabilized zirconia and sintered at 1150 to 1225 °C for 2 hrs. The sintering temperature depended on the composition in an attempt to maintain similar microstructures. The resulting electrodes were 20 microns thick with 50% porosity. Electrodes were prepared with an intervening samarium (20%) doped ceria (SDC) interlayer. Electron microscopy revealed some variation in microstructure across the series of compositions.

The electrodes were characterized using current interrupt cyclic voltammetry (CI-CV) and AC impedance. A lugin probe Pt/Ag/AgO reference wire was placed within 1.0 mm of the working electrode surface with a platinum paint counter electrode. The CI-CV data provide direct information on the single electrode faradaic resistance of the material without the complications arising from two electrode measures. The cathodic measurements were taken over a temperature range of 650°C to 850°C and fitted to a hyperbolic sine function to obtain the relevant Butler-Volmer parameters – the charge transfer coefficient, α,and the zero over-voltage exchange current density, I_o. The I_o values were analyzed by Arrhenius reaction kinetics to obtain the activation energy for the rate limiting step.

Figure 1 shows the current interrupt curves for LSNF with x=0.4 compared to the undoped LSF30 material. The results a typical of all the nickel doped materials in that performance is degraded with the introduction of nickel. Analysis of the Butler-Volmer parameters does not show a consistent variation with nickel doping level and that the influence of nickel on sintering of the films accounts for the majority of performance variation.