$La_{0.8}Sr_{0.2}MnO_3$-$La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_3$ Composite Cathodes for Anode Supported Solid Oxide Fuel Cells

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Introduction

Anode supported solid oxide fuel cells with thin film electrolytes have been reported to exhibit high performance at temperatures as low as 800 °C (1). The ohmic contribution of the thin film electrolyte on electrode supported cells is small when compared to electrolyte supported cells. Furthermore, low overpotentials at the anode can be achieved using cermet composite NiO/YSZ anodes (2). The high overpotential at the cathode is the limiting factor in the performance of anode supported thin film electrolyte cells at intermediate temperatures (3). Composite cathodes of YSZ + LSM have been reported to lower overpotentials at the cathode by spreading out the reaction zone (4,5). An alternative to YSZ is Sr and Mg doped $LaGaO_3$ (LSGM) which has been found to be an excellent oxide-ion conductor at 800 °C (6). Electrolyte supported cells with LSGM electrolytes are reported to perform better than similar YSZ cells, with power densities of 0.5 W/cm^2 at 800 °C (7). Thus, composites consisting of LSGM and LSM are potential candidates for cathodes for anode supported, thin-film electrolyte solid oxide fuel cells.

Experimental

In this study, NiO/YSZ anode substrates with a thickness of about 0.8mm were fabricated by tape casting and cut into 1 inch diameter cells. An electrolyte film of YSZ with a thickness of 10µm was deposited on the substrates by a spray technique and fired at 1400 °C. A cathode interlayer consisting of the composite $La_{0.8}Sr_{0.2}MnO_3$ and $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_3$ was applied in paste form with a thickness of 10 to 15µm and fired at temperatures between 1000 °C and 1200 °C. A final $La_{0.8}Sr_{0.2}MnO_3$ cathode layer was subsequently applied with a thickness of approximately 50µm and fired at 1000 °C. Single cells were tested at 800 °C with flowing humidified H_2 as fuel and with air as oxidant.

Results and Disscusstion

The relative ratio of LSM and LSGM in the composite cathode interlayer was varied between 40 and 60 wt% LSM. The cell with a cathode interlayer consisting of 50 wt% LSM and 50 wt% LSGM fired at a temperature of 1150 °C exhibited the best performance with a maximum power density of 1.4 W/cm^2 at 800 °C. The performance of the cells was highly dependent on the firing temperature of the LSM + LSGM composite cathode interlayer. For the 50 wt% LSM cell, the maximum power density measured at 800 °C increased from 1.05 W/cm^2 for the cathode interlayer fired at 1000 °C to 1.4 W/cm^2 for the interlayer fired at 1150 °C. At firing temperatures above 1150 °C, the power density decreases dramatically. The ohmic resistance and anode overpotential varied only slightly from cell to cell. The changes in the power density are the result of large changes in the cathode overpotential. Depending on firing temperature and composition, the cathode overpotential varied from 0.075 to 0.275V at a current density of 2 A/cm^2. For the best performing cell with 50 wt% LSM cell fired at 1150 °C, the total overpotential measured at 800 °C was 0.58V at 3 A/cm^2, of which 0.3V was due to ohmic resistance (100 Ωcm^2). The overpotential at the cathode was as low as that for the anode, both being equal to 0.14V at 3 A/cm^2.

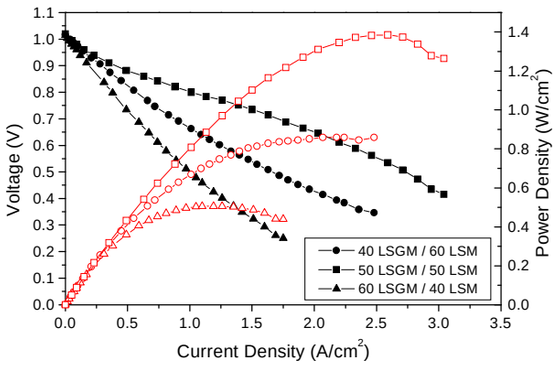

Figure 1. Voltage and power density curves as a function of current density for cells with various weight percents of LSM and LSGM in the composite cathode interlayer. Cells measured at 800 °C and the cathode interlayer fired at 1150 °C.

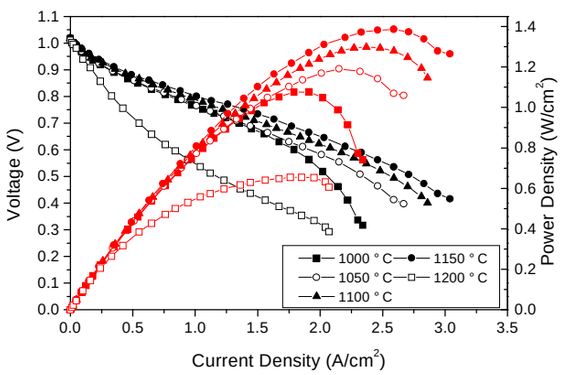

Figure 2. Voltage and power density curves as a function of current density for cells with 50 wt% LSM + 50 wt% LSGM composite cathode interlayers fired at various temperatures. Measurements conducted at 800 °C.

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