Electrochemical properties of composite cathodes using Sm doped layered perovskite for intermediate temperature–operating solid oxide fuel cell

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A B S T R A C T
SmBaCo 3 O 5+δ (SBCO) showed the lowest observed Area Specific Resistance (ASR) value in the LnBaCo 3 O 5+δ (Ln: Pr, Nd, Sm, and Gd) oxide system for the overall temperature ranges tested. The ASR of a composite cathode (mixture of SBCO and Co 0.85 Gd 0.15 O 2-δ ) on a Co 0.85 Gd 0.15 O 2-δ (CGO91) electrolyte decreased with respect to the CGO91 content; the percolation limit was also achieved for a 50 wt% SBCO and 50 wt% CGO91 (SBCO50) composite cathode.
The ASRs of SBCO50 on the dense CGO91 electrolyte in the overall temperature range of 500–750 °C were relatively lower than those of SBCO50 on the CGO91 coated dense 8 mol% yttria-stabilized zirconia (8YSZ) electrolyte for the same temperature range. From 750 °C and for all higher temperatures tested, however, the ASRs of SBCO50 on the CGO91 coated dense 8YSZ electrolyte were lower than those of the CGO91 electrolyte.
The maximum power densities of SBCO50 on the Ni-8YSZ/8YSZ/CGO91 buffer layer were 1.034 W cm⁻² and 0.611 W cm⁻² at 800 °C and 700 °C.

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1. Introduction

Recently, Intermediate Temperature-operating Solid Oxide Fuel Cells (IT-SOFCs) have been focused on because Solid Oxide Fuel Cells (SOFCs) operated at high operating temperature ranges over 800 °C have problems of thermal degradation, thermal expansion mismatch and high fabrication cost. However, cathode overpotential has dramatically increased at the intermediate operating temperature ranges and has typically been the major source of voltage loss in IT-SOFC operation. Therefore, most research on IT-SOFCs has been devoted to cathode materials [1–3].

One candidate cathode material using ionic and electronic conductors (MIECs), a layered perovskite with the general formula LnBaCo 2 O 5+δ (Ln: lanthanides 0 < δ < 1), has recently been a subject of interest for cathode materials for IT-SOFCs because of its high oxygen transport properties, excellent oxygen surface exchange coefficients and superior oxide ionic diffusivity [4, 5].

Our group has shown that layered perovskite materials are promising cathode materials for application to IT-SOFCs at temperatures between 500 °C and 700 °C [6–9]. For example, the maximum electrical conductivity value of SBCO was 570 $\text{S cm}^{-1}$ at 200 °C; this material also showed a metal–insulator transition (MIT) phenomenon at about 200 °C. The Area Specific Resistance (ASR) results for single phase SBCO and for a composite cathode comprised of 50 wt% SBCO and 50 wt% CGO91 were 0.13 and 0.05 $\Omega\cdot\text{cm}^{-2}$ at 700 °C. The coefficients of thermal expansion (CTE) of the SBCO of 19.7 x 10⁻⁶ K⁻¹ and 20.0 x 10⁻⁶ K⁻¹ at 600 and 700 °C dropped to 12.5 x 10⁻⁶ K⁻¹ and 12.7 x 10⁻⁶ K⁻¹ at 600 and 700 °C, which values are similar to the value of the CGO91 electrolyte [7].

In this work, the electrochemical properties of a composite cathode prepared using SBCO with various weight percentages of CGO91 (from 0 wt% to 70 wt%) were investigated for direct applica-