Journal of Power Sources 192 (2009) 120–125

Contents lists available at ScienceDirect

Journal of Power Sources

journal homepage: www.elsevier.com/locate/jpowsour

Fabrication, electrochemical characterization and thermal cycling of anode supported microtubular solid oxide fuel cells

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ARTICLE INFO

Article history:
Received 30 September 2008
Received in revised form
22 December 2008
Accepted 23 December 2008
Available online 31 December 2008

Keywords:
Micro-SOFC
EIS
I–V
Thermal cycles

ABSTRACT

This work describes the manufacture and electrochemical characterization of anode supported microtubular SOFC's (solid oxide fuel cells). The cells consist of a Ni–YSZ anode tube of 400 μm wall-thickness and 2.4 mm inner diameter, a YSZ electrolyte of 15–20 μm thickness and a LSM–YSZ cathode. The microtubular anode supporting tubes were prepared by cold isostatic pressing. The deposition of thin layers of electrolyte and cathode are made by spray coating and dip coating respectively. The cells were electrochemically characterized with polarization curves and complex impedance measurements using 5% H_2/95% Ar and 100% of H_2, humidified at 3% as reactant gas in the anodic compartment and air in the cathodic one at temperatures between 750 and 900 °C. The complex impedance measurements show an overall resistance from 1 to 0.42 Ω cm^2 at temperatures between 750 and 900 °C with polarization of 200 mA cm^{-2}. The *I–V* measurements show maximum power densities of 0.3–0.7 W cm^{-2} in the same temperature interval, using pure H_2 humidified at 3%. Deterioration in the cathode performance for thin cathodes and high sintering temperatures was observed. They were associated to manganese losses. The cell performance did not present considerable degradation at least after 20 fast shut-down and heating thermal cycles.

1. Introduction

Solid oxide fuel cells, SOFC's, have a great potential being the cleanest, more versatile and most efficient systems for chemical to electrical energy conversion [1]. Up to now yttria-stabilized zirconia, YSZ, is the most used electrolyte material due to its good O^{2-} conductivity, excellent mechanical properties and chemical compatibility [2]. In recent years, increasing interest in microtubular SOFC's [3,4] has developed due to their higher mechanical and thermal stability, simpler seal requirements, higher power densities per unit volume and shorter times to start-up and shut-down when compared with planar and tubular conventional designs.

The cell configuration used in this study consists of a nickel and yttria-stabilized zirconia (Ni–YSZ) cermet anode supporting tube with a thin YSZ electrolyte layer and a thin lanthanum strontium manganite and yttria-stabilized zirconia (LSM–YSZ) composite cathode. The purpose of this study was to optimize the fabrication processes for these microtubular cells, focusing on the effect of cathode thickness and sintering temperature in the electrochemical performance of the cells.

Usually, in the microtubular SOFC's designs the supports are fabricated using extrusion techniques [5–7]. In our case the cells are anode supported on Ni–YSZ tubes fabricated by cold isostatic pressing. In addition the anode support geometry allows placing a thin-coated electrolyte, which reduces the electrolytic resistance losses and yields better conductance at lower temperatures than for electrolyte support set-ups [8–10].

In anode supported cells gas transport through the thick anode may contribute to polarization losses. Consequently, the tubular anode supported cell geometry requires a good permeability, low tortuousity factor for easy gas transport as well as a high number of triple-phase boundaries (TPB's), and a high mechanical and thermal stability which also implies a good adhesion with the electrolyte. In a previous work the Ni–YSZ cermet tubes were physically and electrically characterized and their microstructure optimized using half cells and platinum paste as cathode [11].

We present a complete electrochemical study of cells with different configurations measuring *I–V* curves and using EIS analysis to separate the contribution of each component to the cell. Finally, we performed degradation experiments by measuring the cell's performance, under thermal cycles, which are one of the major limitations for these systems [12].

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doi:10.1016/j.jpowsour.2008.12.107