Evaluation of Metallic Interconnects for use in Intermediate Temperature SOFC

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Introduction

The use of metallic interconnects in planar solid oxide fuel cells (SOFC) operating at intermediate temperatures (< 800 °C) is attractive for a number of reasons including good mechanical strength, ease of fabrication, and potential low cost. The metallic interconnect should exhibit good oxidation resistance as well as high electronic conductivity in both anodic and cathodic atmospheres in the temperature range 600 to 800 °C. Potential alloys for interconnect use include Ni-Cr based superalloys, such as Haynes 230, or stainless steels such as ferritic SS 430. However, in both oxidant (air) and fuel (humidified hydrogen) atmospheres the Cr containing alloys form a highly resistive oxide layer of Cr_2O_3. One approach to improving the electrical conductivity of interconnects is to suppress the formation of Cr_2O_3 and promote the formation of more conductive oxide phases. This can be accomplished by depositing thin films of certain metals onto the interconnect surface before oxidation. Upon heating, the metal coating oxidizes, reacts with the Cr from the base alloy, and subsequently forms an oxide layer other than Cr_2O_3. For example, oxidation of Mn-coated Cr containing alloys results in the formation of the $(Mn, Cr)_3O_4$ spinel phase, while La coating promotes the formation of the perovskite phase $LaCrO_3$.

Experimental

Sample coupons and interconnects for a planar SOFC stack were fabricated from foils of Haynes 230 and SS 430. Thin layers of either Mn or La metal were deposited onto the surface of the interconnect foils by electron beam deposition. The Mn and La coatings were approximately 2000 angstroms thick after deposition. Coated and uncoated foils were oxidized in both air and humidified hydrogen atmospheres for various periods of time at 800 °C. The resulting oxide layers formed on the interconnect were characterized for phase content and electrical conductivity. The area specific resistance of the oxide layer was measured in both air and hydrogen atmospheres as a function of temperature. In addition, coated and uncoated interconnect foils were tested in 4-cell planar SOFC stacks at 800 °C and their performance was evaluated with time.

Results

The oxide layer formed on Mn-coated Haynes 230 samples consisted of the spinel phase $(Mn, Cr)_3O_4$ while the layer on the uncoated samples was primarily Cr_2O_3. The area specific resistance (ASR) of the oxide layer formed on the Mn-coated Haynes was significantly lower than that formed on the uncoated sample in the temperature range 300 < T 800 °C, as shown in Figure 1. However, the oxide layer formed on uncoated SS 430 contained the spinel phase $(Fe, Cr)_3O_4$ and exhibited a low ASR without Mn-coating (Figure 1). In addition, the oxide layer formed on La-coated Haynes 230 consisted of the perovskite phase $LaCrO_3$ and exhibited an ASR one order of magnitude lower than that of uncoated Haynes 230. The performance characteristics of uncoated and coated interconnects operated in planar SOFC stacks are compared in Figure 2. The net stack resistance of stacks operated with coated interconnects was half that of stacks operated with uncoated Haynes 230 interconnects. This translated into a doubling of the maximum power from ~ 22.5 W to > 47 W at 800 °C.

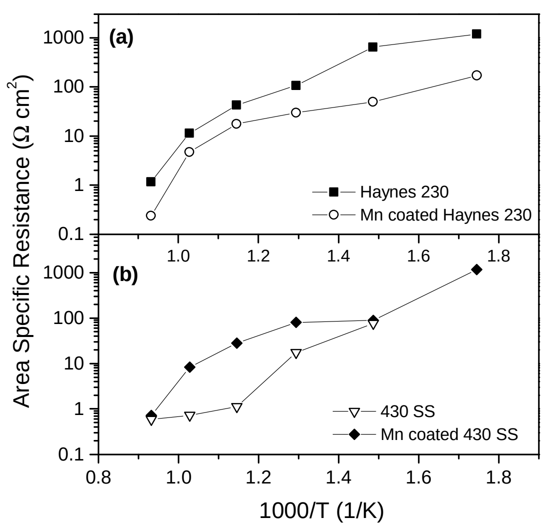

Figure 1. Area specific resistance of the oxide on the metallic interconnect as a function of temperature after four days of oxidation in humidified hydrogen at 800 °C for (a) uncoated and Mn coated Haynes 230 and (b) uncoated and Mn coated 430 stainless steel. Measurements conducted in air.

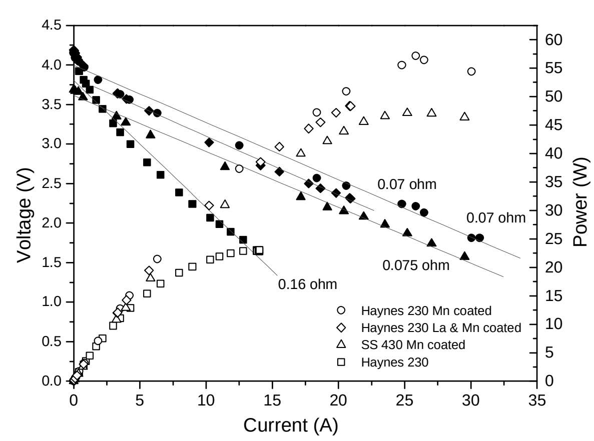

Figure 2. A comparison of the voltage-current and power-current characteristics of 4-cell planar SOFC stacks operating at 800 °C with uncoated Haynes 230, Mn-coated Haynes 230, Mn-coated SS 430, and La & Mn coated Haynes 230 interconnects.