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Synthesis of $La_{0.7}Sr_{0.3}MnO_3$ thin films supported on Fe–Cr alloy by sol–gel/dip-coating process: Evaluation of deposition parameters

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LSM (lanthanum strontium manganite) thin films were deposited by sol–gel/dip coating on metallic substrate (SS439 — Cr 16.6%) aiming the application in solid oxide fuel cells. The gels were prepared with different ratios of organic/metal salt concentration and viscosities. LSM films were deposited on alloy substrate with varying number of layers (1, 2 and 3) and annealed at temperatures of 600–1000 °C. The films were characterized by X-ray diffraction and scanning electron microscopy to study the influence of the deposition parameters on the structure and morphology of the films. The LSM films deposited with lower viscosity exhibited better adhesion to the substrate with good homogeneity. The sample prepared with gel viscosity of 50 mPa·s and one deposited layer presented pure crystalline phase, crack-free surface and a more homogeneous coating.

1. Introduction

Solid oxide fuel cells (SOFCs) are efficient, energy-saving, and environment-friendly energy conversion devices that generate electricity and heat [1,2]. The reduction of the operation temperature of SOFC from 1000 °C to below 800 °C allows the use of metallic interconnect in planar-type SOFCs [2]. Metallic interconnects have many advantages including higher thermal and electronic conductivities, good mechanical strength and cost effectiveness. Ferritic stainless steels are promising materials for interconnect applications because they are quite inexpensive, have similar thermal expansion coefficients with other cell components, produce a thin, continuous, and conductive chromia scale, and have a very long lifetime at the SOFC operating temperature [3–5].

Several coating systems have been proposed for stainless steel interconnects to reduce chromium volatilization while maintaining low electrical resistance. These coatings consist mainly of perovskite layers based on lanthanum strontium manganite (LSM) or cobaltite, and manganese containing spinels, which are chemically and thermally compatible with other cell components [6,7]. The LSM perovskite has been applied as a protection layer material, because it has high electrical conductivity, low Cr diffusion, and the same structure and electrochemical behavior of the SOFC cathode.

The performance of SOFCs can be improved by better control of the morphology and electrochemical properties of the components. The methods used for coating metallic interconnects include chemical vapor deposition, pulsed laser deposition, plasma spraying, screen printing, slurry coating, radio frequency magnetron sputtering, electrodeposition and sol–gel process [7]. Among these methods, the sol–gel process provides several advantages: the microstructure and composition of electrode materials can be easily controlled, low-temperature processing is possible and the adhesion on the substrate is strong [8,9]. Despite these advantages, the sol–gel method is not largely used for perovskite coating on metallic interconnects and deposition parameters should be investigated to optimize the properties of the protective coating.

The aim of this work is to study the relation between the synthesis parameters (i.e., precursor concentration, gel viscosity, number of layers, and annealing temperature) and the structural and morphological characteristics of LSM films deposited on Fe–Cr alloy by sol–gel/dip coating process. From this analysis, the optimum parameters to obtain single-phase, continuous, homogeneous and crack-free LSM films were determined.

2. Experimental details

2.1. Alloy substrate

Commercial ferritic stainless steel (SS439 from ArcelorMittal, Brazil) was used as substrate (10 mm × 10 mm × 1 mm). The chemical composition measured by X-ray fluorescence is shown in Table 1. The substrate surface was sanded (SiC sandpapers: 400, 600, 1200 and 2400) and polished with diamond abrasives. The polished substrates were ultrasonically washed in several steps with deionized water, isopropyl alcohol and acetone during 10 min and then dried at 100 °C in a furnace.

2.2. Sol–gel solution

LSM ($La_{0.7}Sr_{0.3}MnO_3$) film precursors were prepared by the sol–gel process. The solution of metal salts (concentration Cs) was prepared

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