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Synthesis of highly ordered three-dimensional nanostructures and the influence of the temperature on their application as solid oxide fuel cells cathodes

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ABSTRACT

The creation of nanostructured materials with three-dimensional periodicity has been identified as a potential interesting field for increasing the overall performance of solid oxide fuel cells (SOFCs). In this work, we have investigated the formation of $Pr_{0.6}Sr_{0.4}Fe_{0.8}Co_{0.2}O_3$ nanotubes with different diameter sizes employing polymeric membranes as templates. The samples were characterized by X-ray diffraction and field emission scanning electron microscopy. The polarization resistance of the materials was measured by electrochemical impedance spectroscopy (EIS). A study of the influence of the temperature on the nanostructure has also been carried out, demonstrating that the sintering process affects to the electrochemical performance of the cathode. The study shows that the nanotubes with higher diameter size present a better performance at high temperatures than those with diameter sizes smaller than 100 nm. The ASR (area specific resistance) value of the sample synthesized with a pore diameter size of 0.8 μm is as good as 0.12 Ω cm^2, allowing it use as cathode in solid oxide fuel cells (SOFCs).

1. Introduction

Environmental problems are one of the most important challenges for the human future societies. One of the aspects with more influence on this problem is the field of the energy. Several energy devices have appeared and developed in the past decades, fuel cells being one of them. Due to their high efficiency, flexibility with respect to the fuel and low environmental impact, the solid oxide fuel cells (SOFCs) are considered one of the most promising energy conversion devices [1,2]. However, their high operating temperature (800–1000 °C), creates problems associated with the cost of the equipment. This fact has intensified the need of reducing the temperature of the cell to the intermediate range (500–700 °C). Lowering the operation temperature of SOFCs affects not only to the cost, but also to the range of material selection and improves the stability and reliability for the SOFC system [3]. The development of the intermediate temperature solid oxide fuel cells (IT-SOFCs) would promote the introduction of these devices onto the market by reducing manufacturing costs and increasing their durability.

These IT-SOFCs allows the use of new materials such as the nanostructured materials. These new materials are temperature dependent, because the increase of temperature promotes the sintering of the particles changing therefore the structure of the material. The use of nanostructured materials as SOFC electrodes could provide some advantages as the increase of the specific area. This fact is closely related to the creation of double and triple phase boundary (DPB and TPB) which has a great influence in the catalytic activity of the electrodes. Several techniques are being employed in order to obtain new nanostructured materials [4,5]. One of them is the use of polymeric templates as polymethilmetacrilate (PMMA), polystyrene and polycarboxylate. These templates act as pore formers and allow the formation of nanoporous materials [6,7]. Other types of nanostructured materials are the nanotubes, which are commonly obtained employing either polymeric or inorganic membranes.

This paper describes the initial steps in the development of a high performance nanostructured $Pr_{0.6}Sr_{0.4}Fe_{0.8}Co_{0.2}O_3$ material for its application as cathode for SOFCs. The nanostructure includes perovskite-type nanotubes synthesized with polycarbonate porous membranes, with a porous diameter of 0.1 and 0.8 μm.

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