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Abstract Title: $La_{0.8}Sr_{0.2}MnO_{3-\delta}$-based nanocomposite functional layers for improved cathode efficiency in SOFCs.

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Abstract Text:

The ongoing energy transition towards the substitution of fossil fuels for renewable and environmentally friendly energy sources, leads to the search for alternative energy conversion systems. In this context, Solid Oxide Fuel Cells (SOFC) are efficient electrochemical devices that are able to convert chemical energy in the form of fuels into electricity [1]. The efficiency of SOFCs at low operating temperatures is mainly limited by the high polarization resistance of the cathode [2], reason why several strategies are being proposed to enhance the electrochemical activity of such electrodes. Among them, optimizing the electrode microstructure by different preparation methods, such as infiltration and spray-pyrolysis deposition, have rendered excellent and durable electrochemical performance [3]. In addition, the tailoring of the electrode/electrolyte interface by incorporating functional layers have proven to be particularly useful to improve electrode properties [4].

The present work proposes an alternative approach by the incorporation of several nanocomposite functional layers at the interface between the traditional $La_{0.8}Sr_{0.2}MnO_{3-\delta}$ (LSM) cathode and the $Zr_{0.84}Y_{0.16}O_{2-\delta}$ (YSZ) electrolyte. Different compositions that combined LSM with different ionic conductors, i.e. LSM-$Ce_{0.9}Gd_{0.1}O_{1.95}$ (CGO) and LSM-$Bi_{1.5}Y_{0.5}O_3$ (BYO), were directly deposited by spray-pyrolysis on the YSZ electrolyte in a single step by a co-synthesis method. The nanocomposite functional layers were studied by different structural and microstructural techniques, such as XRD and SEM-EDX. They exhibited lower grain size compared to that of the homologous single phase; specially the LSM-CGO nanocomposite showed improved adherence to the electrolyte without the presence of any crack or delamination, with the lowest grain sizes of 12.54 and 8.56 nm for LSM and CGO, respectively, after annealing at 1000 ºC. SEM images revealed a dense functional layer with a thickness of about 750 nm. Overall, all functional layers showed a dense structure with excellent adherence to the electrolyte and no chemical reaction could be detected between the cell components.

The electrochemical properties of functional layers were also investigated by impedance spectroscopy, distribution of relaxation time, dc-bias and I-V curves. The incorporation of any functional layer reduced the Area Specific Resistance (ASR) values of the cathode, which was associated with a reduced charge transfer resistance and a fast oxide ion transport at the electrode/electrolyte interface as consequence of the good ionic/electronic conductivity of the functional layer. The polarization resistance at 700 ºC was of 1.71 and 0.46 Ω cm^2 for the LSM cathode without and with LSM-CGO active layer, respectively. The performance of thesingle cell with LSM-CGO as functional layer, Ni-YSZ|YSZ|LSM-CGO/LSM, revealed maximum power densities of 1.20 and 0.85 W cm^{-2} at 800 and 700 ºC, respectively, values that were considerably higher than those obtained for the cell without any functional layer, i.e. 0.79 and 0.46 W cm^{-2}.

The obtained results confirm the improved performance of SOFCs when tailoring the cathode/electrolyte interface by incorporating a functional layer with nanostructured features and mixed ionic-electronic conducting properties. With that in mind, this research may serve to improve the electrochemical performance of solid oxide cells at intermediate/low operating temperatures without compromising the cell's integrity.

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