



## Effect of DC current polarization on the electrochemical behaviour of $\text{La}_2\text{NiO}_{4+\delta}$ and $\text{La}_3\text{Ni}_2\text{O}_{7+\delta}$ -based systems<sup>☆</sup>

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### ABSTRACT

The electrode performance of  $\text{La}_2\text{NiO}_4$  and  $\text{La}_3\text{Ni}_2\text{O}_7$  as cathode materials for solid oxide fuel cells (SOFC) was analyzed. The study was focused on the electrode polarization resistance of the interfaces formed by the cathodes with  $\text{Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta} + 2\%\text{Co}$  electrolyte. The study was extended to cathodes based on  $\text{La}_2\text{NiO}_4\text{-Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta}$  composite and Pt to analyze the effect of changing the electronic and/or ionic transport properties on the electrode interface resistance. The electrode performance was studied in open circuit conditions and with DC current polarization. Important differences in the performance of the pure cathode materials were obtained as function of DC current flux. However, in  $\text{La}_2\text{NiO}_4\text{-Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta}$  composite the DC current flux produces minor changes in the electrode polarization resistance. The aging process also affects the OCV electrode performance of cathodes based on Pt and pure ceramics, whereas the effect is practically invaluable in  $\text{La}_2\text{NiO}_4\text{-Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta}$  composite. The electrode performance is higher for the composite cathode compared to pure ceramic electrodes for OCV or for low values of DC polarization. However, the important decrease in the interface resistance obtained for high values of DC current flux for  $\text{La}_2\text{NiO}_4$  and  $\text{La}_3\text{Ni}_2\text{O}_7$  cathodes increases their electrode performances to values close to those obtained in  $\text{La}_2\text{NiO}_4\text{-Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta}$  composite. This retains the cathode overpotential with values as low as 140 mV at 750 °C for values of current load of 530 mA cm<sup>-2</sup> for both pure and composite  $\text{La}_2\text{NiO}_4$ -based cathodes. The low cathode overpotential allows to estimate values of power density between 300 and 350 mW cm<sup>-2</sup> at 750 °C for  $\text{La}_2\text{NiO}_4$ ,  $\text{La}_3\text{Ni}_2\text{O}_7$  and  $\text{La}_2\text{NiO}_4\text{-Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta}$  composite, operating with  $\text{Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta} + 2\%\text{Co}$  electrolyte, with 300 μm in thickness, and a Ni- $\text{Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta}$  cermet anode with H<sub>2</sub> as fuel.

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### 1. Introduction

Reducing the operating temperature in SOFC from the traditional high temperatures (~1000 °C) to intermediate temperatures (<800 °C) is one of the more interesting features to make viable the SOFC technology [1–2]. The main advantages coming from the decrease in the operating temperature are the possible use of inexpensive materials and the suppression of reactions between the cell components [3]. However this low/intermediate temperature produces an important decrease in the performance of the cell, mainly due to the relatively high internal resistances coming from the electrolyte and the interface cathode/electrolyte [4,5]. The decrease in these internal resistances is essential to make SOFCs economically competitive. Diminishing the electrolyte thickness is the way

to reduce the internal loss of the electrolyte, whereas the cathode/electrolyte interface should be improved by the use of mixed conducting cathodes or the addition of an ionically conducting second phase to the electronically conducting cathode [6,7]. However some difficulties to develop better SOFC components arise from the complexity of the electrochemical processes involved. In particular the oxygen reduction reaction at the cathode is usually considered the main limiting factor in SOFC systems but its mechanistic understanding is still unsatisfactory [8]. This makes difficult to get consistent set of values for cathode losses from the literature [9,10] and important discrepancies can be obtained from results coming from different authors [11,12]. The main reason for most discrepancies could be related to microstructural differences associated to the use of porous electrodes. These porous systems give realistic information of materials in SOFC conditions but it is very difficult to separate microstructural/morphological properties from intrinsic properties [8]. On the other hand, the electrode polarization resistance is usually measured under OCV conditions, which is difficult to relate to electrode overpotential under working conditions.

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