Development of composite steam electrodes for BCZY based high temperature protonic conducting electrolyzers

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The use of high temperature electrolyzers (HTE) of steam offers high efficiency of conversion of renewable and peak electricity to H_2 by utilising available sources of heat and steam from solar or geothermal plants. Solid oxide electrolyzer cells (SOECs), that use oxide ion conducting electrolytes and operate at around 800 °C, the hydrogen is produced on the steam feed side. However, in proton conducting electrolyzer cells (PCECs) a high temperature proton conducting electrolyte is used instead and protons are pumped and form dry H_2, leaving O_2 on the steam side. These PCECs can produce pressurized dry H_2 directly and they will be able to operate at lower temperatures (600 °C). The present contribution is part of the developments from the FP7 Electra project.
$BaCe_{0.2}Zr_{0.7}Y_{0.1}O_{3-\delta}$ (BCZY27) was selected as electrolyte material for the high temperature protonic electrolyzer, thus this study is focused on the study of suitable anodes for this electrolyte.
The compatibility and stability of different proposed phases with the BCZY27 was tested by carrying out a heat treatment together with the electrolyte at high temperature (1100 ºC) and, then, at high steam pressure conditions (700 ºC, 1.5 bars of steam in air and 2 bars of total pressure) and finally analyzed by means of XRD. First selected candidates were $La_{0.8}Sr_{0.2}MnO_3$ (LSM), $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_3$ (BSCF) and $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_3$ (LSCF). Afterwards, the anodes were prepared as composites by mixing one of these phases with the BCZY27 electrolyte.
The first screening was prepared by mixing 50-50 vol.% of each phase. The electrochemical properties of the composite anodes tested by impedance spectroscopy on BCZY27 electrolytes as symmetrical cells as a function of the temperature (800-500 ºC) under air with 1.5 bar of steam, with a total pressure of 2 bar. The LSCF/BCZY27 electrode showed the best performing electrode, with a Rp more than 1 order of magnitude lower than the other two electrodes. Then the performance of the LSCF/BCZY27 composite was improved by (1) changing the ratio of the different phases and (2) improving its microstructure.
Then the measurement conditions (mainly steam, pO_2 and pH_2O) were changed to analyze and understand the different processes that take place in the anode under realistic operation conditions.