Development of a new perovskite electrocatalyst for solid oxide cells with a novel symmetrical geometry

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Significance and Relevance

In this work, new electrocatalytic material has been developed for reversible solid oxide cells in order to not only increase their performance and chemical stability, particularly against seawater vapour environment and oxygen atmosphere, but also use safe raw materials for both humans and the environment (Co and Ni free electrode). The important obtained result is that this kind of reversible solid oxide is capable of having very low resistance during H_2 production. Moreover, to optimize the structure of the global cell having a symmetrical geometry, an isotropic morphology has been designed capable of increasing the gas diffusion within the electrodes and ensuring mechanical stability in case of high partial pressures in the electrolysis mode of operation.

Introduction and Motivations

According to the objectives of numerous countries globally, the urgent need to decarbonize economies and provide energy security is what is driving the global energy transition. A prominent factor of this endeavour is the hydrogen economy, which serves as a versatile and sustainable energy source for use in transportation, manufacturing, and other fields. Water electrolysis is one of the most environmentally friendly ways to produce hydrogen, especially when it is coupled with renewable energy[1]. Traditional electrolysis depends on freshwater, which is poor in many areas. On the other hand, the vast quantities of seawater (or other non-potable water sources) would provide a nearly unlimited water supply if saline water could be used directly as a clean energy source. In this frame of usage of direct seawater, the design and optimization of the electrodes, which are usually different for fuel oxidation and oxygen reduction processes, is a crucial problem in SOC technology. In order to simplify the cell manufacture, lower the costs, and improve the cell durability, the idea of symmetrical electrodes—where the same material is used for both the anode and the cathode—has attracted plenty of attention recently[2]. By removing the need for several materials with distinct thermal and chemical compatibility criteria, symmetrical electrodes solve problems like interfacial deterioration and thermal expansion mismatches. In addition to optimizing production procedures, this strategy opens the door for reliable and effective SOC technologies that may fulfil the needs of the emerging energy scenario.

Materials and Methods

The perovskite-based electrode materials $Ba_{0.5}Sr_{0.5}Fe_{0.9}Mo_{0.1}O_{3-\delta}$ were synthesized through the sol-gel method. The resulting powders were characterized by Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD), which are reported in Fig. 1. Electrochemical impedance spectroscopy (EIS) measurements were conducted in electrolyte-supported and complete button cells to test their performance in electrolysis and fuel cell operating mode[3]. The current-voltage characteristics were extracted to show competitive performance with the state-of-the-art materials in both operating modes (electrolytic and fuel cell mode) and in both environments (H_2/H_2O and O_2)[4].

Results and Discussion

The data analysis showed $Ba_{0.5}Sr_{0.5}Fe_{0.9}Mo_{0.1}O_{3-\delta}$can provide high electrochemical performance in terms of polarization resistance if compared to other Co-free materials. The distribution of relaxation times analysis performed on the impedance results subsequently demonstrated the impact of O_2 and H_2/H_2O partial pressure and temperature. Moreover, under a cyclic process, it was found that the mentioned electrode takes back its structure in an oxidizing environment after it is subjected to a reducing atmosphere. In the oxygen environment, the performance of the electrode appeared

promising while its performance in the reducing environment is currently being carried out. In the end, materials were deposited on two different solid oxide electrolytes (Gd-doped ceria and $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.8}O_{3-\delta}$) and found compatible with them at the operating temperature.

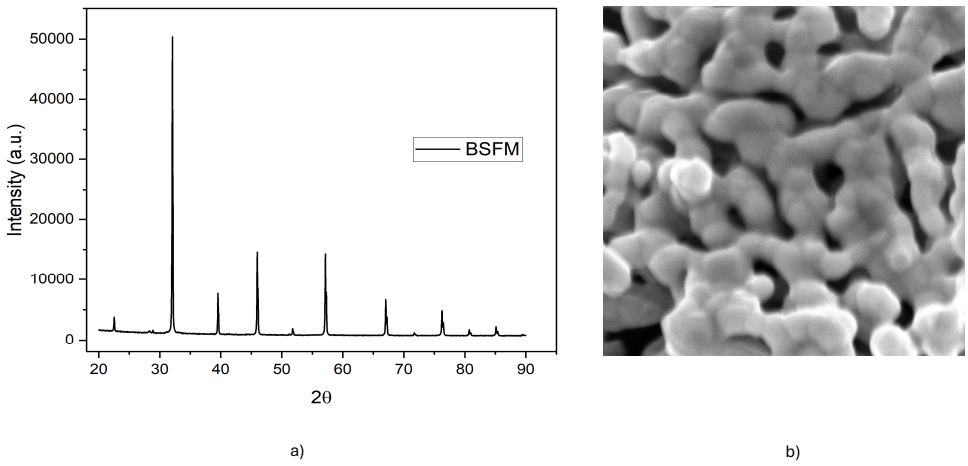

Figure 1: a) the structural characterisation b) the morphological characterization, of the BSFM electrocatalyst

References

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