MASTER INTERNSHIP M2 CDM (5 months, Feb. - June)

2024-2025

Title of the project: Scale-up of reversible cells for high-temperature fuel cell and electrolyser applications.

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Laboratory / Department / Team : ICB / PMDM

Collaborations: Femto-St / MN2S

Summary:

Research into fuel cells and electrolyzers has so far focused on two areas: low temperature (25 < T < 180°C), dominated by the polymer electrolyte membrane, and high temperature (600 < T < 1000°C) for SOFCs (Solid Oxide Fuel Cells) and SOECs (Solid Oxide Electrolyser Cells). Since the 2000s, there has been growing interest in Proton Ceramic Fuel Cells (PCFCs), a system that combines the advantages of PEMFCs and SOFCs. The operation of a PCFC is based on proton conduction in a ceramic electrolyte. This allows operation in a temperature range of 400 to 600°C. The lower operating temperature limits material ageing compared to SOFCs, while maintaining equivalent power output. In addition, the use of a PCFC in reversible mode allows hydrogen to be produced by electrolysis of water. These systems are known as PCECs (Protonic Ceramic Electrochemical Cells).

AMO_3-type compounds (A = Ba, Sr; M = Ce, Zr, perovskite structure) are currently the most widely studied materials in the field of PCFC and PCEC electrolytes. In these compounds, the substitution of the metal cation M by a trivalent cation (Y, Gd, In, Sc, etc.) improves the hydrogen diffusion properties within the crystal lattice of the material. To date, $BaCe_{0.9}Y_{0.1}O_{3-\delta}$ (BCY10) has one of the highest proton conductivities at 600°C among perovskite structural oxides, but exhibits poor stability in a reducing atmosphere. Substitution with Zr increases the chemical stability without significantly reducing the proton conductivity.

As part of the PILOT-HY project, button cells (D = 22 mm) based on $BaZr_{0.2}Ce_{0.7}Y_{0.1}O_{3-\delta}$ have been successfully produced. This study aims to achieve 3 new objectives:

- The fabrication of large diameter PCEC cells (D = 50 mm). This stage, which is essential for the rest of the project, will be achieved through a series of processes. First, the anode support is cast in strips. Next, the dense electrolyte is deposited on the substrate by magnetron sputtering under reactive conditions. Finally, the cathode is formed by screen printing;
- electrochemical characterization of the previously produced assemblies using the Fiaxell Technologies test bench. The results obtained in this section will allow us to understand the mechanisms involved in the operation of a cell in electrolysis mode (PCEC) and to clarify the key stages that modify the performance of cells in fuel cell mode (PCFC);
- the integration of cells to form a three-cell stack. Testing under real operating conditions will provide information on the compatibility, stability and durability of the materials that form the core of a PCEC.

Type of project (theory / experiment): Experiment

Required skills: Knowledge of ceramic materials and inorganic materials characterisation techniques (XRD, SEM, BET, …).

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