

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

2025-2026

Title of the project: Implementation of a test bench for protonic ceramic electrolysis cells**Supervisor(s):** Dr. Lionel Combemale / Pr. Gilles Caboche**Laboratory / Department / Team :** ICB / PMDM**Collaborations:****Summary:**

Research on fuel cells and electrolyzers has primarily focused on two temperature domains: low temperature ($25 < T < 180$ °C), dominated by polymer electrolyte membranes, and high temperature ($600 < T < 1000$ °C), characteristic of solid oxide fuel cells (SOFCs). Since the early 2000s, increasing attention has been directed toward protonic ceramic fuel cells (PCFCs), which combine the advantages of PEMFCs and SOFCs. PCFCs operate through proton conduction in a ceramic electrolyte, enabling functionality within the intermediate temperature range of 400–600 °C. Operating at these lower temperatures mitigates material degradation compared with SOFCs, while maintaining comparable power densities. Furthermore, when operated reversibly, PCFCs can electrolyze water to produce hydrogen. Such systems are referred to as protonic ceramic electrochemical cells (PCECs).

Among candidate electrolytes, AMO₃-type perovskites ($A = \text{Ba, Sr}$; $M = \text{Ce, Zr}$) are the most extensively studied for PCFCs and PCECs. In these compounds, substitution of the tetravalent cation M by trivalent dopants (Y, Gd, In, Sc, etc.) enhances hydrogen diffusion within the crystal lattice. To date, BaCe_{0.9}Y_{0.1}O_{3-δ} (BCY10) exhibits one of the highest proton conductivities at 600 °C among perovskite oxides, but suffers from poor stability under reducing conditions. Partial substitution with Zr improves chemical stability while only modestly reducing proton conductivity.

As part of the PROTEC project, button cells ($\varnothing \approx 25$ mm) based on BaCe_{0.7}Zr_{0.1}Y_{0.1}Yb_{0.1}O_{3-δ} (BCZYYb7111) have been successfully fabricated. The present study pursues two new objectives:

- The construction of a new test bench for evaluating cells produced at ICB under electrolysis conditions. This setup must allow the controlled introduction of water vapor into the air stream and enable the collection of the hydrogen generated during operation;

- The testing of button cells fabricated at ICB Laboratory. These cells, consisting of three ceramic layers (NiO–BCZYYb7111 as the anode, BCZYYb7111 as the electrolyte, and BCZYYb–LNF as the cathode), will be supplied throughout the training period and subjected to aging under realistic conditions using the previously developed device. Characterization before and after testing will be carried out to assess possible degradation phenomena, such as fracture or delamination.

Type of project (theory / experiment): Experiment**Required skills:** Knowledge of ceramic materials and inorganic materials characterisation techniques (XRD, SEM, BET, ...).