

## Thesis topic for 2024

**Location:** Institut des Matériaux de Nantes Jean Rouxel (IMN), Nantes Université

**Type of funding:** ED 3MG

**Thesis title:** Synthesis, structure and conductivity of ceramic proton conducting electrolyte materials.

**Thesis director:** Eric QUAREZ (70%) and co dir. Olivier JOUBERT (30%)

### Context

For over 20 years, ST2E's Hydrogen-Fuel Cells theme has been developing exploratory research into proton-conducting ceramic materials. This activity has led to its inclusion in ANR and European projects, most recently PEPR H2. This research is currently led by Eric Quarez, who has just passed his HDR and is co-directing the Lozane Hamze thesis with O. Joubert (dir). This thesis (PEPR H2) focuses on the characterization of the state-of-the-art material in proton conductors:  $\text{Ba}(\text{Zr}_x\text{Ce}_{0.8-x}\text{Y}_{0.1}\text{Yb}_{0.1})\text{O}_{2.9}$  ( $0 \leq x \leq 0.8$ ); the exploratory character is not developed. The aim here is to continue our recognized activity in this field, and to synthesize and study new materials with novel compositions, taking into account the current problem of the criticality of certain elements in the periodic table. The aim is to perpetuate the laboratory's DNA of discovering new ceramic materials.

### Scientific presentation of the subject

The main aim of this research is to explore new perovskite-like materials close to  $\text{Ba}(\text{Zr}_x\text{Ce}_{0.8-x}\text{Y}_{0.1}\text{Yb}_{0.1})\text{O}_{2.9}$  that can be applied in battery devices or solid oxide electrolyzers, and to replace yttrium with a less critical rare earth. The thesis is divided into three parts: one dedicated to synthesis, another to structural determination, and one devoted to the measurement of conductivity levels. Since perovskite compounds can exhibit slight distortions in the oxygen lattice (octahedral tilt), as well as temperature-dependent phase transitions, the use of neutron diffraction in addition to X-ray diffraction is often necessary for accurate structure determination. Phase protonation will be studied as a function of temperature using X-ray diffraction and thermogravimetry. Conductivity levels will be measured in dry and humid air. The aim is to establish the links between the structure of the materials studied and the conductivity levels observed, in order to rationalize the results obtained and formulate new, optimized compositions.

## **Working context**

The project will take place at the Institut des Matériaux de Nantes Jean Rouxel (IMN), a laboratory of around 200 people (<https://www.cnrs-imn.fr/>), one of the leading materials research centers in France, in the Equipe Stockage et transformations électrochimiques de l'énergie (ST2E). At IMN, researchers in the ST2E team have extensive experience in the field of ceramic materials for high-temperature battery and electrolysis applications (SOFC and SOEC). Thanks to their expertise in synthesis and solid-state chemistry in general, they have developed new electrodes and electrolytes while improving existing materials. The doctoral school is ED 3MG, which covers chemistry and physics in the broadest sense. Further information: <https://ed-3mg.doctorat-paysdelaloire.fr>.

## **Candidate profile**

The candidate should be motivated, dynamic and hold a M2 or equivalent in materials science. He/she should have a solid and varied background in materials synthesis (low-temperature, soft chemistry), characterization (X-ray diffraction, spectroscopy and/or microscopy) and electrochemical analysis (electrochemical impedance, etc.). He/she will participate in the activities of the ST2E team, and will be expected to present his/her work at national and international conferences. A good level of English is desirable.

## **Funding**

Nantes Université doctoral contract (approx. €2050 gross/month) starting 01/10/2024.

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Candidates should send a detailed CV, transcripts and rankings of their Master's degree (1 and 2) or equivalent, a letter of motivation, a letter of appreciation from one of the M2 research internship supervisors, and any other document attesting to their suitability for this position (e.g. letter of recommendation).