



## Master thesis proposal



Laboratoire PMC  
Ecole Polytechnique  
91128 Palaiseau  
Director: Jacques PERETTI

**Title:** Electrochemical synthesis and characterizations of doped oxide catalysts for water splitting

**Keywords:** transition metal oxides, oxygen evolution, electrodeposition, X ray diffraction, Atomic force microscopy, Raman spectroscopy

### Scientific description:

The electrochemical decomposition of water into oxygen and hydrogen is an efficient way to convert and store renewable energies. Doped cobalt oxides present interesting catalytic properties with respect to the oxidation of water to oxygen (OER) in an alkaline environment, and are among the best candidates for large-scale deployment of this energy conversion strategy. In our team, we study the structure and oxidation state of thin films of cobalt oxides and cobalt iron oxides in the form of a model catalyst. For this, we grow ultra-thin films of these oxides by electrodeposition on gold crystals. Our X ray diffraction and X ray absorption results show that, in the case of  $\text{Co}_3\text{O}_4$ , an amorphous layer with an oxidation state of +3 and a thickness of less than a nanometer forms on the surface before water decomposition begins.

In the framework of this internship, we are interested in synthesizing Mn and V doped cobalt oxides. For this purpose, we will study different electrochemical routes for producing ultra-thin films of these oxides with different dopant concentrations. We will characterize the morphology of these films by atomic force microscopy and their structure by X ray diffraction. We will determine their composition by X ray fluorescence and energy dispersive spectroscopy. We will also characterize the local environment of the metal atoms using Raman spectroscopy. These characteristics will be correlated with the OER activity (overpotential and Tafel slope). We are also interested in studying the effect of film annealing on the structure and the OER activity. For this purpose, we will use a dedicated oven allowing simultaneous X ray diffraction in a controlled atmosphere.

This work is inter-disciplinary and relies on experimental competencies from the fields of electrochemistry (sample preparation and electrochemical characterizations), analytical chemistry (Raman spectroscopy, X ray fluorescence) and surface and structural characterizations (atomic force microscopy, X ray diffraction). It will benefit from the availability of all these techniques at PMC laboratory and the rich scientific environment and interactions present among the physics and the chemistry groups of the laboratory.

**Techniques/methods in use:** electrodeposition, X ray diffraction, atomic force microscopy, Raman spectroscopy, electrochemical measurements

**Applicant skills:** background in thin film preparation, surface characterizations

**Industrial partnership:** N

**Internship supervisor(s):** Fouad Maroun, [fouad.maroun@polytechnique.edu](mailto:fouad.maroun@polytechnique.edu), 01 69 33 46 57

**Internship location:** Laboratoire PMC, Ecole Polytechnique, 91120 Palaiseau

**Possibility for a Doctoral thesis:** Y (application for a doctoral fellowship)