

## Electrode Surface Optimization for Plasma-Based Ammonia Production (ESOPAP)

Ammonia ( $\text{NH}_3$ ) is a critical compound for both agriculture and emerging energy applications, traditionally produced via energy-intensive Haber-Bosch. In the context of global decarbonisation and the energy transition, there is a pressing need to develop sustainable, low-carbon alternatives for ammonia synthesis. Plasma-based processes have emerged as a promising solution, enabling ammonia production under ambient conditions using renewable electricity. However, the efficiency and yield of plasma-based ammonia synthesis are significantly influenced by the state/material characteristics of the electrode surface involved in the reaction. Surface modification during the plasma exposition such as oxidation, nitridation, carbon deposition, and ion sputtering can dramatically alter catalytic activity and reaction pathways. Understanding these influences is essential for optimising electrodes composition, plasma reactors and advancing scalable, sustainable ammonia production. The objective of this project is to systematically investigate the role of electrode surface states and identify optimal electrode materials and surface conditions for maximising ammonia yield.

To investigate surface modification, a well define initial state is required. Electrodes are synthesised by liquid phase layer-by-layer deposition, with possible annealing in different atmosphere, to achieve various surface chemical composition, oxide to nitride form of transitional metals. This deposition method promotes strong chemical bonding with electrode substrate leading to adhesive and compact thin films with a controlled thickness<sup>1,2</sup>. These criteria are of importance to perform the following plasma exposition without layer pill-off or delamination. Then, the electrodes will be assessed for ammonia production rates and efficiency with a glow discharge reactor equipped with an exchangeable electrode system, primarily focusing on the cathode. Prior and post-plasma exposition characterisations are performed to elucidate the possible impact of oxidation, nitridation, carbon deposition, and ion sputtering on the surface material. After a first round of testing, correlation between surface modification with plasma reactor performance will enable to identify optimal surface, leading to a new batch of electrodes synthesis and plasma expositions.

This postdoc project covers the entire research workflow:

- **Thin films preparation and characterisation:** the candidate will be involved in the electrode characterization after deposition and post plasma exposition using the following techniques: SEM+EDS, XRD and XPS analysis. If interested, the candidate can also be part of the electrode synthesis.
- **Catalytic properties assessment:** electrodes will be assessed for ammonia production rates and efficiency with a glow discharge reactor equipped with an exchangeable electrode system, primarily focusing on the cathode, at LPP.

**The aim is to understand the relationship between the electrode surface state characteristics (e. g. chemical composition, crystallinity, morphology) and the catalytic properties for ammonia plasma production.** The project benefits from the combination of plasma chemistry from Laboratoire de Physique des Plasmas (LPP) and thin film deposition from Laboratoire de Physique de la Matière Condensée (PMC).

**Profile:** we are seeking a **highly motivated post-doctoral candidate in Plasma-Surface or Materials Science, or a related field** to join for a **comprehensive, hands-on research**. Experience in plasma and/or in thin film characterisation is highly appreciated. The candidate is expected to be curious, proactive, and motivated to learn new techniques, along with strong analytical and problem-solving skills in teamwork.

**Location:** Laboratoire de Physique de la Matière Condensée (PMC), and Laboratoire de Physique des Plasmas (LPP) , Ecole Polytechnique, in Palaiseau.

**Duration:** 12 months

**Supervisors:** Clémence Badie (tenure-track assistant prof.) and (CNRS)

**Application:** CV + cover letter + one or more reference contacts from former advisor/professor.

**Contacts:** Clémence Badie ([clemence.badie@polytechnique.edu](mailto:clemence.badie@polytechnique.edu)) and Olivier Guaitella ([olivier.guaitella@lpp.polytechnique.fr](mailto:olivier.guaitella@lpp.polytechnique.fr)) and Maik Budde ([maik.budde@lpp.polytechnique.fr](mailto:maik.budde@lpp.polytechnique.fr))