Proposition de CDD Assistant Ingénieur en physico-chimie des matériaux

Development of conformal coatings of piezoelectric polymers for stimuli responsive water management in fuel cell gas diffusion layers

In the context of renewable energies transition, fuel cells arise as essential technologies owning to their properties to generate a 100% clean energy with a power generation efficiency as high as 40-60%[1]. In proton exchange membrane fuel cells (PEMFCs), hydrogen and oxygen gases are used as fuel and oxidizer, and only water is produced as "waste". Intensive research is conducted to further improve fuel cells performances, by maximising their power generation and lifetime. Indeed, the premature ageing of fuel cells, and consequently their performance loss due to factors such as catalysts debonding or water flooding, is currently limiting their implementation at the bigger scale.

It is in this context that we propose to enhance the water management in PEMFCs to help mitigate flooding issues, critical to the performance and longevity of PEMFCs as excess water obstructs the flow of reactants[2,3]. The disruptive approach of this project consists in functionalizing a gas diffusion layer (GDL) with a hydrophobic piezoelectric actuator polymer in the form of conformal coating, such as the polyvinylidene fluoride (PVDF) to promote a stimuli responsive water evacuation.

This research is a collaborative effort between the Institut Européen des Membranes (IEM, Dr. Stéphanie Roualdès) in Montpellier and the Luxembourg Institute of Science and Technology (LIST, Dr. Vincent Rogé), leveraging their complementary expertise to achieve the project's objectives. The missions of the Assistant Ingénieur to be recruited at IEM will be the development of PVDF-like films by using Plasma-Enhanced Chemical Vapor Deposition (PECVD). PVDF layers have been recently recognized as competitive piezoelectric polymers[4]. Moreover, polymer-like films can be deposited with high conformity and stability by PECVD. Thus, the primary focus of the IEM partner will be on optimizing the PECVD process parameters to produce high-quality PVDF-like films that exhibit piezoelectric properties. This involves relevant choice of precursor (C_4F_8 being prioritized) and fine-tuning of various PECVD conditions such as precursor vapor flow rate, plasma power, substrate temperature, polarization, deposition time and post process treatment like annealing to achieve the desired film characteristics. The optimization process is crucial to ensure that the PVDF-like films not only possess piezoelectric responses but are also conformally and robustly deposited onto the GDL (Gas Diffusion Layer) substrates. Ellipsometry-porosimetry analysis will be performed to assess the growth and porosity of the thin films. Also, electrical characterization will be done to attest the actuator behavior of grown films. In parallel, the LIST partner will be responsible for the comprehensive physical characterization of the synthesized PVDF-like films. This characterization will include detailed analysis of the films' morphology, which involves studying the hydrophobicity and the surface structure and composition to ensure uniformity and proper adhesion to the GDL. Additionally, LIST will evaluate the crystallinity of the PVDF-like films, as this property significantly influences their piezoelectric performance. High crystallinity is associated with better piezoelectric properties, which are essential for effective water management in PEMFCs. LIST will also assess the piezoelectric response of the films, ensuring that they exhibit the necessary piezoelectric actuator properties to actively manage water transport within the fuel cell.

Financement : Institut Carnot Chimie Balard Cirimat (Soutien à projet International Carnot – AAP 2024)
Période : septembre 2025 - aout 2026 (1 an)
Laboratoire : Institut Européen des Membranes (IEM), Université de Montpellier
Encadrant du stage à l'IEM : Stéphanie Roualdès (stephanie.roualdes@umontpellier.fr)
Partenaires au LIST : Vincent Rogé, Marc Michel

Toute candidature se fera par envoi par mail à l'encadrant du stage. Elle devra être accompagnée d'une lettre de motivation, d'un CV détaillé, et des notes obtenues au niveau universitaire (le niveau L3 ou BUT étant le niveau minimal requis pour ce poste).

[1] Alaswad A, Palumbo A, Dassisti M, Olabi AG. Fuel Cell Technologies, Applications, and State of the Art. A Reference Guide. Reference Module in Materials Science and Materials Engineering: Elsevier; 2016

[2] Sun-Joon Byun D-KK. Removal of Flooding in a PEM Fuel Cell at Cathode by flexural wave. J Electrochem Sci Technol. 2019;10(2):104-14

[3] Li H, Tang Y, Wang Z, Shi Z, Wu S, Song D, et al. A review of water flooding issues in the proton exchange membrane fuel cell. Journal of Power Sources. 2008;178(1):103-17

[4] Mariello M, Guido F, Mastronardi VM, Giannuzzi R, Algieri L, Qualteri A, et al. Reliability of Protective Coatings for Flexible Piezoelectric Transducers in Aqueous Environments. Micromachines (Basel). 2019;10(11)