School of Engineering
Department of Chemical Engineering
NCE – Nanomaterials, Catalysis, Electrochemistry
Professor Nathalie Job

PhD offer: Optimized carbon supports for PEMFC electrodes

Context and goal

In the framework of the Energy Transition Funds collaborative project Be-Hyfe, the Department of Chemical Engineering of ULiège recruits a PhD student in Engineering. The research will be conducted in collaboration with IMEC/KUL (Interuniversity microelectronics centre/Katholiek Universiteit Leuven).

The goal of the project is to **develop optimized carbon structures to be used as catalyst supports for Proton-Exchange Membrane (PEM) fuel cells and their corresponding catalytic layers in Membrane-Electrode Assembly (MEA) configuration** in order (i) to enhance at best mass transport at high current in the catalytic layer, (ii) to improve contacts leading to carbon/catalytic phase/ionomer triple point, (iii) to ensure optimal ionic and electron conductivity and (iv) to decrease the MEA degradation upon operation while using the most up-to-date active phase (as, for instance, metal/alloy nanoparticles or nanostructures of complex shape).

Researches conducted during the last 15 years at the NCE lab were focused on the **mastering of the pore texture and composition of synthetic carbonaceous materials** that can be further used to **enhance the efficiency of (electro)chemical processes**. In parallel, **efficient synthesis routes to prepare carbon-supported (electro)catalysts (Pt and PtM)** were developed, along with the necessary infrastructure to assemble and characterise fuel cell elements in a very reproducible way. However, optimizing together the mass transport, charge transport and catalytic properties of such elements while improving their stability remains a challenge. The PhD will be focused on the development of new carbon nanostructures as efficient and stable supports for PEM fuel cells based on metals and alloys as catalytic phase. It aims at tackling several issues:

(1) *Mass transport limitations in the catalytic layers* through the synthesis and processing (as MEAs) of nanostructured carbon materials with appropriate pore texture and particle size.

(2) *Carbon corrosion upon use* through the post-treatment of the carbon supports to deposit a well-graphitized layer on top of the primary carbon nanostructure without altering the pore architecture necessary to mass transport.

(3) *Electrical/ionic conductivity of the electrodes* through the study of the MEAs formulation (optimization of the catalyst particle size, connection with the ionomer, use of additives). Indeed, it has been shown previously that changing the carbon support from classical carbon black to large particles of nanostructured carbons may lead to limitations in electrical conductivity; in parallel, the ionic conductivity strongly depends on the ionomer distribution within the layer, which itself depends on the carbon chosen.

(4) *Metal/alloy deposition* on these optimized carbon nanostructures using first classical Pt nanoparticles (as reference), then PtM alloy nanoparticles and hollow structures (which are extremely active and more stable) in order to decrease at best the necessary Pt quantity without decreasing the catalytic layer activity.

Role of the PhD student

The main role of the PhD student will be to design and build the electrodes, then to perform the complete physico-chemical and electrochemical characterization of the components (carbon supports and catalysts) as well as the final MEAs (on fuel cell test bench). The student will be in charge of the material/MEA preparation at every step, and will perform all analysis required to

understand the impact of carbon modification on the mass transport, electron/ion transport, global performance and durability of the catalytic layer of the fuel cell.

Within the Be-Hyfe project, the PhD student will also be involved in several activities aiming at developing a strong network between the project partners in Belgium and the other PhD students involved. This will include laboratories/company visits, workshops and technical/scientific discussions between partners.

Information

- *General:* The recruit will be registered as PhD student in Engineering at ULiège (Belgium). The work will mainly take place in Liège (Department of Chemical Engineering – Nanomaterials, Catalysis, Electrochemistry), with regular visits to IMEC (Leuven, ~100km from ULiège).
- *Promotor:* Prof. Nathalie Job - Department of Chemical Engineering – Nanomaterials, Catalysis, Electrochemistry
- *Co-promotor:* Prof. Philippe Vereecken (IMEC/KUL)
- *Be-Hyfe project:* This PhD position is part of the Energy Transition Fund project BE-HyFE which aims to establish a core group of 16 broadly trained and highly networked early-stage researchers who can support the Belgian industry in finding both technological and societal solutions to essential hydrogen challenges. The project offers you, next to an inspiring group dynamic with fellow researchers, a chance to establish specific hard and soft skills by means of a specialised training program (workshops, Hydrogen weeks, etc.), site visits to industry and (inter)national academic-industrial networking events. To encourage knowledge exchange and building the network, part of your PhD research will be performed in the Belgian knowledge institute of your co-promoter.
- *Student profile:* Master in Engineering or in Sciences (preferably with a strong formation in (electro)chemistry, materials and physics)
- *Language:* fluent English (mandatory)
- *Duration:* 4 years
- *Start:* between October 2021 and March 2022
- *Application:* please send a detailed CV and a motivation letter to Nathalie.Job@uliege.be
- *Application deadline:* September 30th 2021