POLITECNICO DI MILANO

PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 40th cycle

THEMATIC Research Field: COMPREHENSION OF APPLICATION-RELEVANT ELECTROCATALYST AGING PHENOMENA IN PEM FUEL CELLS AND DEVELOPMENT OF MITIGATION STRATEGIES VIA TAILORED CATALYST-LAYERS STUDIES

Monthly net income of PhDscholarship (max 36 months)
€ 1600.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Hydrogen represents a great opportunity in the hard-to-abate sectors in which competitive technologies for decarbonization are lacking, as in the transportation field. Proton Exchange Membrane Fuel Cell (PEMFC) is a commercially available technology that is stepping up for heavy-duty, facing the challenge of durability requirements (25’000 h). One of the main barriers to the widespread adoption of hydrogen technologies is durability, particularly the instability of noble metal catalysts, which are both expensive and scarce. In this context, the stabilization of the catalyst layer (CL), which is the core component where the electrochemical reactions are taking place, is considered strategically important. The CL has a complex architecture, including catalyst nanoparticles covered by an ionomer thin-film. Despite extensive aging studies in the literature, there is still a significant gap in understanding real-world degradation mechanisms and translating results into innovative but practical solutions. Most of the fundamental knowledge is indeed restricted to unrealistic environments and to configurations which limit the practical relevance.This project aims to advance the understanding of PEMFC electrocatalyst degradation while ensuring that findings are applicable to real-world scenarios by proposing effective mitigation strategies. Various catalyst-

	layer configurations with tailored properties will be compared. The following activities are identified: a) experimental analysis of single-cell performance and electrochemical parameters to assess electrocatalyst degradation under different operating conditions; b) fundamental experimental insights regarding electrocatalyst dissolution; c) post-mortem analysis of aged samples to track morphological/compositional changes; c) development of theoretical and modeling tools to physically interpret electrocatalyst instability and to predict single-cell performance.
Methods and techniques that will be developed and used to carry out the research	The main experimental analysis will be conducted using the facilities at the MRT Fuel Cell &Battery Lab (https://www.mrtfuelcell.polimi.it/) and the Pro-e-Storage interdepartmental laboratory, where the manufacturing of tailored components is also possible. The single-cell experimental analysis will include: (i) degradation testing, primarily through accelerated stress tests; (ii) in-situ electrochemical characterizations, such as polarization curves, electrochemical impedance spectroscopy, cyclic and linear sweep voltammetry, limiting current measurements, and oxide growth/reduction quantification; (iii) the use of harmonized zero-gradient cell hardware to ensure standardized and reproducible results. Collaborations with other research groups will permit to conduct catalyst dissolution analysis and post-mortem characterization.A physics-based modeling approach will be employed to analyse degradation phenomena and single-cell performance. This will build upon codes developed in Matlab® and Simulink®.
Educational objectives	The research topic bridges materials science and the engineering of electrochemical devices. The student will gain in-depth theoretical knowledge in thermodynamics as well as heat and mass transport phenomena. Additionally, they will develop advanced expertise in electrochemical measurement techniques and physics-based modeling. The role will also involve mentoring and coordinating graduating students.

Job opportunities	The acquired expertise will open opportunities for placements in companies operating in the automotive and transport sector, electrochemistry, advanced materials manufacturing and energy systems modeling. Additionally, the experience gained will provide the basis for pursuing a research career in academia and at international research centers.
Composition of the research group	1 Full Professors 3 Associated Professors 3 Assistant Professors 7 PhD Students
Name of the research directors	Prof. Andrea Casalegno, Prof. Andrea Baricci

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	800.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Increase in the scholarship for stays abroad: euro 800 per month, for up to 6 months.Educational activities:Financial aid per PhD student is available for purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences, instrumentations and computer, etc. This amount is equal to 10% of the annual gross amount, for 3 years. Teaching assistantship:Availability of funding in recognition of supporting teaching activities by the PhD student. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations. Computer availability: individual use.Desk availability: individual use.