ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

MUR DM 118 - Development of large-scale electrodes for energetic and sensing applications

Funded By	Dipartimento Scienza Applicata e Tecnologia [P.iva/CF:00518460019] MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584]

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Context of the research activity	Although at present avoiding the use of carbon is nearly impossible for energy-intensive industries, the conversion of the CO_2 into valuable molecules is the best solution for decarbonization, accompanied by the production of green H_2 to be used as energy carrier. In this framework, the electrochemical H_2 production and reduction of CO_2 demonstrated to be very promising. However, in order to push forward their application and trying to fill the gap between the lab-scale research and the industrial world, there is the urgent need to develop large-scale electrodes, able to guarantee high performance, similar to small scale ones. Progetto finanziato nell'ambito del PNRR – DM 118/2023 - CUP E14D23001730006

	In order to limit the accumulation of anthropic carbon dioxide in the atmosphere, electrochemical H_2 production and CO_2 conversion into high-value chemicals have attracted strong interest in last decades. The proposed activity will focus on the development of large-scale innovative electrolyzers. The central part of a these electrolyzers is the membrane electrode assembly (MEA). It comprises a solid-state ion-conductive polymer membranes sandwiched between two microporous catalytically active electrodes, responsible for the production of hydrogen or valuable chemicals, e.g. syngas, methane, ethylene. The research will primarily focus on optimizing the three-phase-interactions occurring at the interfaces formed within the MEA. Nanotechnology techniques, such as spray coating, 3D printing or screen printing, will be employed to enhance the electrolyte/catalyst interaction and scale up the laboratory prototype (5/25

Objectives	cm2) to a pre- industrial electrolyzer (0.5 m2). Furthermore, innovative solutions are necessary to address challenges related to the stability of the solid electrolyte and salt precipitation in the microfluidic component of the electrolyzer. The objectives of this PhD are: • Assessment of protocols for lab-scale MEA testing. • Investigation of solution to address the challenges of stability and salt precipitation. • Study on the catalyst deposition and electrode manufacturing techniques for industrial-scale MEA. • Assessment of protocols for industrial-scale MEA testing. • Investigation of new problematics emerging in industrial-scale MEA. • Design of innovative H2 and CO2 electrolyzer stacks. The conductive inks used for the preparation of large scale MEA, will be also implemented to fabricate electrodes for flexible wearable sensors based on hydrogel, highly sensitive to external deformations. Spray coating, 3D printing or screen printing techniques will be employed to guarantee a perfect adhesion and interaction between the deposited electrode and the underneath sensing materials. Ionic conductive hydrogels can be treated as solid electrolyte and thus the electrode/hydrogel interaction will be studied with a methodology analog to the one implemented for MEA.

Skills and competencies for the development of the activity	Expertise in material preparation and characterization, nanotechnologies, electronics, advanced processes and electrochemistry, as well as problem solving ability and practical experience in laboratory would be additional values. Candidates should have a strong motivation to learn through advanced research.