Scale-up studies on the optimization of catalyst loading and the porous transport layer for regenerative electrolyser applications

Abstract topic 1

MEAs composed of IrO_2 mixed with Pt Black in different ratio were prepared and characterized as OER/ORR for PEM-URFC application. The catalysts were characterized by XRD analysis and tested in a single cell with an active area of 8 cm_2. A study on the PTL influence on electrochemical performance was also carried out to understand the influence of the structure on MEAs performance. Constant Gas (CG)configuration was adopted to characterize the MEAs prepared.

MEA composed with IrO2 /Pt Black in a ratio of 0.69:1 showed the better performance for PEM URFC application. The best PTL was the titanium felt which permitted to obtain a current density of 2.4 A cm_2 at 1.86 V in electrolysis mode and 1 A cm_2 at 0.39 V in fuel cell mode. The results showed that both ratio and loading catalysts should be considered for an optimization study. Impedance spectroscopy analysis evidenced as an excessive catalyst loading increase the series resistance and influence negatively the MEA performance.

The catalysts that demonstrated the best overall performance in both fuel cell and electrolyzer modes was prepared for deposition on an active area of 25 cm^2. The fabricated MEAs was subsequently tested in a cell made by Baltic, equipped with specially designed titanium plates of 25 cm^2.

Following this, the focus will shift to the detailed design and manufacturing of manifolds, flow-fields, end-plates, gaskets, and the H2O supply system. The cell stack, which will be the core of the regenerative electrolyzer, will be designed to minimize the use of expensive materials. Consequently, thin bipolar plates and internal diffusers made from metal foams (eliminating flow-fields) will be employed. Component selection and design will be guided by mechanical modeling with advanced software (e.g., Solid Edge). The stack will comprise 3 cells, each with an active area of at least 25 cm^2, connected in series by bipolar plates, while the gas diffusers will be in parallel (gas manifolds). Constructing a short stack will provide insights into how a multicell device impacts prototype performance. Consistent with the Mission Innovation project's objectives, these findings will aid in the future automated development of the regenerative electrolyzer design process.

Curriculum Vitae - Stefania Siracusano

Stefania Siracusano was born in Messina (Italy), September 5, 1975, Present address: Via Porto Salvo 6, 98121 Messina. Phone:+39-090-624233; email: stefania.siracusano@itae.cnr.it

Position: senior researcher at the CNR Institute for Advanced Energy Technologies “Nicola Giordano” (CNR-ITAE) of Messina.

Degree in Chemistry at the University of Messina (2000).

Ph. D. in "Materials for Environment and Energy" at the University of Tor Vergata-Roma (2009).

Expertises: Energy and transport with reference to hydrogen production systems, fuel cells, electrochemistry, ceramic materials, chemical-physical characterization.

Author of about 50 articles on International Journals, 2 international patents and 2 chapter books. She has participated at different international and national conferences and workshops. She has been a referee for several international journals.

National Project responsibility: Currently responsible in the national Project IEMAP, – Materiali Avanzati per l'Energia. accordo di programma enea-cnr (dsctm) per la regolamentazione dei rapporti in relazione allo svolgimento di attivita' di ricerca nell'ambito del "programma mission innovation" (cup b82c21001820001) WP3, of several activities: LA3.4: Catalizzatori innovativi a basso contenuto di Critical Raw Materials (CRM) e/o CRM-free per le reazioni di evoluzione di ossigeno e di idrogeno in elettrolizzatori a membrana polimerica (PEM); LA3.5: Sviluppo di assemblati membrana-elettrodi (MEA) e loro caratterizzazione preliminare in elettrolizzatori PEM; WP3 – LA3.6: Valutazione delle prestazioni e della durata dell'elettrolizzatore PEM (2021-2024); in the "accordo di programma mite – enea per la regolamentazione dei rapporti in relazione allo svolgimento di attivita' di ricerca nell'ambito del piano nazionale di ripresa e resilienza (pnrr) – missione 2 "rivoluzione verde e transizione ecologica" – componente 2 "energia rinnovabile, idrogeno, rete e mobilità sostenibile" – investimento 3.5 "ricerca e sviluppo sull'idrogeno", finanziato dall'unione europea – next generation eu- CUP B93C22000630006", of the activity: LA1.1.7 Sviluppo di materiali e componenti con ridotto contenuto di metalli preziosi per elettrolizzatori protonici (PEM) basati su membrane innovative operanti anche ad elevata pressione differenziale (2022-2025).

Current European Community Project responsibility: for CNR of **"**Redox-mediated economic, critical raw material free, low capex and highly efficient green hydrogen production technology (**REDHY**) (HE, GA n. 101137893).

Current European Community project: She is involved in different projects financed by European Community called: "Advanced High Pressure and Cost-Effective PEM Water Electrolysis Technology" – **ADVANCEPEM** (HE Grant Agreement No 101101318); "New manufacturing approaches for Hydrogen Electrolysers to provide Reliable AEM technology based solutions while achieving Quality, Circularity, Low LCOH, high Efficiency and Scalability" – **HERAQCLES** (HE GA n. 101111784); "Economic green hydrogen production at scale via a novel, critical raw material free, highly efficient and low-capex advanced alkaline membrane water electrolysis technology" **HYSCALE** (HE G.A. n. 101112055).

European Community project: She was participated to different projects financed by European Community called: "Cost-effective PROton Exchange MEmbrane WaTer Electrolyser for Efficient and Sustainable Power-to-H2 Technology" – **PROMET H2** project (Grant Agreement No 862253) ; "Next Generation PEM Electrolyser under New Extremes" - **NEPTUNE** project (Grant Agreement No 779540); High performance PEM Electrolyzer for Cost-Effective Grid Balancing Applications" (**HPEM2GAS**) - Project funded by the European Community within the H2020 – JTI – FCH – 2015 – 1. No. 700008; "Enhanced performance and cost-effective materials for long-term operation of PEM water electrolysers coupled to renewable power sources" (**ELECTROHYPEM**), FP7 Project No. 300081. "Quasi-anhydrous and dry membranes for next generation fuel cells (**Quasidry**) FP7 Project No. 256821; "Improved Durability and Cost-effective Components for

New Generation Solid Polymer Electrolyte Direct Methanol Fuel Cells" (**DURAMET**), FP7 Collaborative Project No. 278054, Call FCH-JU-2010-1;
She was the coordinator of 2 bilateral project, the first between CNR and ASRT (Egypt), for the duration of 4 years (2 of the project and 2 of the renewal), which had as its objectives the optimization of the energy conversion and storage system consisting of a regenerative cell (SPE). The second between CNR and DIGST (Korea) for the duration of 2 years, which aims to develop and optimization of catalytic electrodes for PEM water electrolysers.
She took part in several national projects such as FISR, FIRB PON, POR and MSE, and few private contracts of partnership such as Pirelli Labs, Ansaldo Fuel Cell S.p.A, De Nora Tecnologie Elettrochimiche and Tozzi Renewable Energy S.p.A

Bibliometric indicators related to publications and citations:
Scopus : Documents 59; Citations 2790; h-index 30.
Pubblications of the last 5 years:

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- S. Siracusano, F. Giacobello, A. S. Aricò. Ag/Ti-suboxides as non-PGM anode electrocatalyst for PEM water electrolysis. Journal of Power Sources 565 (2023) 232903. https://doi.org/10.1016/j.jpowsour.2023.232903
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- N. Briguglio, F. Pantò, S. Siracusano, A.S. Aricò. Enhanced performance of a PtCo recombination catalyst for reducing the H2 concentration in the O2 stream of a PEM electrolysis cell in the presence of a thin membrane and a high differential pressure. Electrochimica Acta 344 (2020) 136153
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Patents:
1. S. A. Aricò, L.R. Gullo, D. La Rosa, S. Siracusano, A.B. Lopes Corriera Tavares, A. Sin Xicola. Ceramic Anode Solid Oxide Fuell Cell.
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