Publishable summary

SMAllinOne

Smart Membrane for hydrogen energy conversion:
All fuel cell functionalities in One material

Context and project objectives

A breakthrough of Proton Exchange Membrane Fuel Cells (PEMFC) requires a radical performances improvement of the key fuel cell material components (catalysts and protonic membrane) as well as highly innovative solutions to overcome the membrane assembly and integration limitations. The SmallinOne project addresses an architecture that strongly differs from the classical approach. The catalysts and the membrane are deposited step by step on a porous substrate using vacuum techniques. This architecture can be compared to the “top down integration” approach that is common in microelectronic. With respect to classical PEM fuel cell, this modifies drastically the morphology of the fuel cell materials. This innovative architecture is associated with the development of the basic PEM fuel cell materials (catalyst and ionic membrane) using vacuum technologies.

Work performed / Results achieved, intentions for use and impact

Volatile precursors suitable for the deposition of proton conductive membranes with vacuum techniques were synthesized. Proton conductive membranes were successfully deposited via PECVD, iCVD and ASPD. Conductivities as high as 150-200mS/cm were reached. For the realization of a composite catalyst via vacuum techniques two approaches were developed, direct synthesis of the composite material in vacuum and injection of catalyst nano-particles. In this frame, composite materials were successfully developed via photodeposition of platinum cluster on various conductive supports such as ATO nanoparticles. For these last composite catalysts systems, a quite innovative UV photo deposition method using covalently attached benzophenone (BPh) moieties onto the surface of inorganic conductive (WO_3, WC, & ATO NPs) was developed. This method was compared to a chemical reductive process. Promising electrochemical outputs were measured (ATO support most promising results). The use of benzophenone modification in the photochemical synthesis was shown to decrease the size of the deposited Pt particles.

These vacuum deposited catalysts have been associated with the plasma processes for the synthesis of an ion conductive catalyst composite. These materials have been assembled to build fuel cells. For a complete evaluation of the material potential, two fuel cell configurations were used: planar breathing fuel cells, without hot pressing the materials between bipolar plates: the various layers are deposited onto a porous substrate and tested in a self-breathing configuration. We also have deposited materials on commercial gas diffusion layers hot pressed between bipolar plates. In the planar breathing configuration, open circuit voltage of 900mV could be measured provided membranes thicknesses superior to 6µm are used. Coupling the vacuum catalysts with a Nafion® membrane power density of 120mW/cm^2 could be measured (platinum load 100µg/cm^2). When the MEA is sandwiched between bipolar plates, the result is quite close with a commercial Nafion® membrane as separator but when a vacuum deposited membrane is used as separator, no open circuit voltage could be measured. On the whole, one can see that the soft conditions of the planar breathing configuration are favorable to reach correct open circuit voltages: the thin vacuum membranes might be damaged by pressurization. Additionally, the deposition on rough gas

diffusion layer is favorable to the formation a crossing defects. On the whole, the mechanical stability of these vacuum deposited membrane are below the one of Nafion® like membrane.

Consortium

Coordinator

Dr. Jessica THERY, jessica.thery@cea.fr, www.smallinone.eu
Commissariat à l'Energie Atomique et aux Energies Alternatives – France

Partners

- Universita degli Studi di Bari – Italy
- Surface Innovations Ltd – United Kingdom
- Bar-Ilan University – Israel
- Federal Mogul Systems Protection – France
- IRD Fuel Cells A/S – Denmark
- ALMA Consulting Group SAS – France

The research leading to these results has received funding from the European Union Seventh Framework Programme (*FP7/2007-2013*) under *grant agreement* n° NMP3-SL-2009-227177 SMAllinOne.