Newsletter #4 - July 2022

Disruptive pemfc stack with nOvel materiaLs, Processes, arcHitecture and optimized INterfaces

Co-funded by the European Union

DOLPHIN

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Recent Progress

WP2 "Electrical and Fluidic Core" focuses on the manufacturing and characterization of thin Bipolar Plates (BP) and Gas Diffusion Media (GDM).

Innovative techniques for bipolar plates production have been optimized in order to obtain samples for tests in 100-cm² cells. Several iterations have allowed to reach optimal process parameters, enabling the delivery of laser-milled channels with a specified shape, realized in graphite sheets. Some samples dedicated to Tests Platform 2 have been manufactured (**Figure 1**), with different channel-rib designs for the anode and for the cathode. Unlike for the other techniques developed in Dolphin project, the channel and rib widths are kept at a very low value.

In parallel, tests at small scale have continued with the most challenging techniques. For instance, samples have been realized with thin printed ribs onto thin carbon sheet supports. The samples delivered (**Figure 1**) are going to be tested in small single cells, and compared to other the manufacturing options investigated in the project.

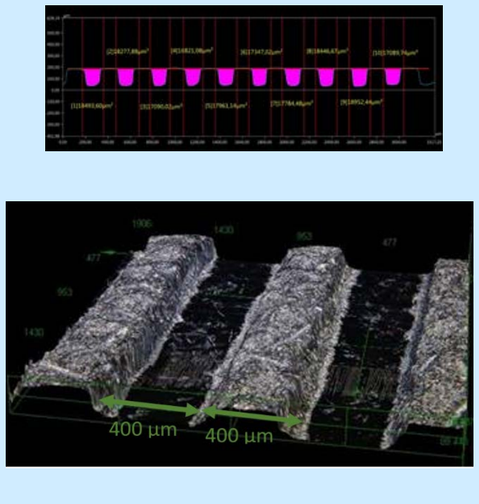

***Figure 1**:* Metrology of channels obtained by laser-milling technique (top) and observation of printed ribs on carbon thin sheets (bottom).

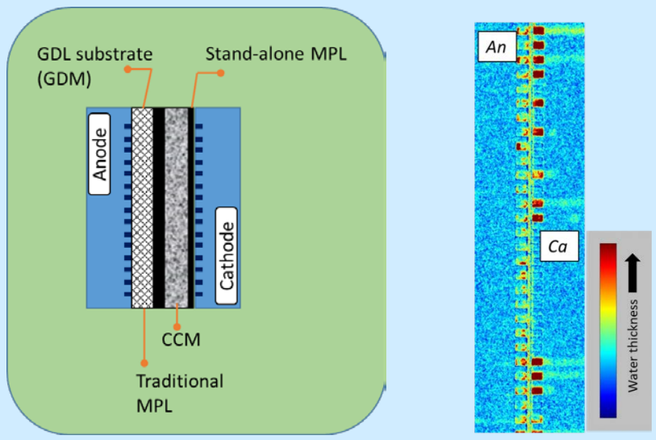

***Figure 2**:* Example for a combination of advanced components in the cells (schematic) employed for the neutron radiography investigations at ILL (left) and for the resulting information on water thickness (cf. also text) (right).

WP3 "Electrochemical Core"

Successful upscaling of the relevant manufacturing processes from the 1.8 cm² small active area design (TP1) to the 100 cm² active area design (TP2) could be reached for all components except the single layer of Graphene (SLG). Specifically regarding the electrode coating processes developed at CEA, this could be combined with a significant improvement in homogeneity of the electrode layers coated on both the commercial reference membrane and advanced membrane material provided by Chemours. Thus, superior CCM material combining DOLPHIN components could be provided for testing in WP4 on realistic cell sizes.

Concerning research on SLG coated onto the membrane, focus was rather put on two alternative pathways to mitigate the still high proton transport resistance of SLG coated membranes: exploring SLG variations featuring deliberate defects within the graphene molecular structure and optimizing the transfer process to the membrane for non-defective SLG. For both alternatives, samples of appreciable size (5 x 5 cm²) could be prepared by UoM for evaluation.

Fortunate circumstances allowed CEA and ZSW to participate in 2021 in two measurement campaigns performed at the NeXT (Neutron and X-ray Tomography) Facility of The Institut Laue-Langevin (ILL) in Grenoble. This provided a very precious additional opportunity to investigate material developed within DOLPHIN on its characteristics regarding liquid water management during cell operation by neutron radiography. As a result, the so-called water thickness is obtained as measure for the water content of the different layers within the cell. Several material combinations were investigated including the ZSW MPL with GDM and stand-alone, in comparison to alternative and reference GDL material. A publication on these results in a scientific journal is currently being prepared.

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Clean Hydrogen Partnership

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WP4 "Single Cell Tests" objectives are to characterize the different types of Electrochemical Cores (EC) and Electric and Fluidic Cores (EFC) developed within the DOLPHIN project.

After the preliminary selection at 2 cm² (TP1, Test Platform 1) of innovative concepts for Electrochemical Cores (EC) and Electric and Fluidic Cores (EFC) developed in DOLPHIN, the main objective of WP4 is to validate their performance at representative cell scale.

The first tests on the second Test Platform (TP2, 100 cm² active area, designed in WP2 by ZSW) started a few months ago at both CEA and ZSW. In order to compare the results obtained by both partners, the commercial reference MEA have been characterized under similar operating conditions, inspired by other European projects.

Test protocols were defined commonly according to EU PEMFC recommendation for testing (Stack test Project[1], JRC recommandations[2]). The performances obtained with the reference EFC and EC designs are shown (**Figure 3**). The results obtained in both labs are close from each other despite using different test benches. The TP2 reference setup exhibits good performances (with an active area of 100 cm²) under AutoStackCore (ASC) conditions (*ca* 0.9-1 W/cm² @ 0.6 V). Further tests will be performed in the forthcoming months using the optimized DOLPHIN components to select finally the two best concepts for EC and EFC for the upscale at short-stack level.

[1] http://stacktest.zsw-bw.de/media-centre.html
[2] Tsotridis G. et al.;EU Harmonised Test Protocols for PEMFC MEA Testing In Single Cell Configuration For Automotive Applications, Publications Office of the European Union, http://dx.doi.org/10.2790/342959, https://publications.jrc.ec.europa.eu/repository/handle/JRC99115

WP5 "Stack Tests" focuses on the design and manufacturing of composites terminal plates (ITP) in order to replace aluminum and reduce weight & volume and cost of the terminal plate.

The objectives of WP5 are performance and durability assessment at stack level, involving both short stacks for verification and final selection of designs and material and the final 5 kW stack design dedicated to demonstrate the project targets. Furthermore, the work package aims at the development of an innovative, light-weight, robust and cost effective integrated terminal plate (ITP) also comprising some BOP functionality contributing to improve the specific system power density. Additionally, issues regarding upscaling, production worthiness and life cycle costs are investigated employing in-deep analysis of production processes and economical modelling.

Nevertheless, good progress could be obtained regarding the joint manufacturing cost analysis effort. It is based on the inputs of all partners on the costs of materials and processes and a cost model developed and provided by CEA. This model facilitates assessment of cost reduction potentials achieved by the technical progress of the project as e.g. raw material savings, improved processes and higher power density, combined with economies of scale expected for envisaged mass production of the stack design. Raw material savings could e.g. be obtained by replacing the GDL substrate on one side of the cell by the MPL-only solution developed and already demonstrated within the project. Combining all cost reduction potentials, it could be demonstrated that more than 80% of the cost saving targeted for the complete project duration could already be achieved for the mid-term review, which fulfilled a major milestone for the project.

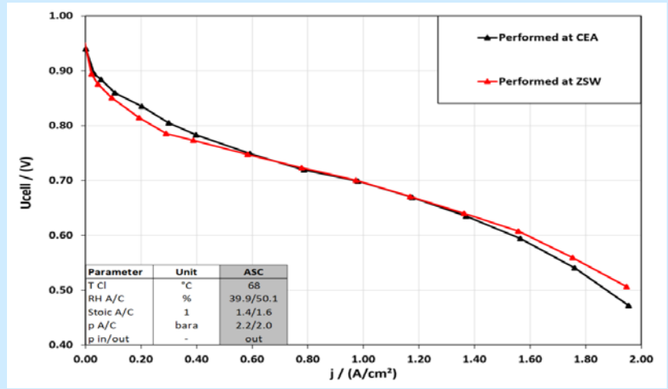

***Figure 3**:* Performances of the Commercial MEA with reference flowfield obtained at CEA (Black) and ZSW (Red) under AutoStackCore (ASC) operating conditions in TP2 single cell (100cm²).
100cm²).

WP6 "Dissemination, Communication & Exploitation" focuses on external communication measures, dissemination activities and coordinated exploitation of results and innovations.

A main highlight to mention is the online workshop which took place on June 18th, 2021, from 8:30 to 12:30. About 200 people from industries, technological organizations and academia were invited and 72 participants took part, which is a quite pleasing number from our point of view, demonstrating high interest in the topic, also especially also from industry.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No **826204**. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

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