DOLPHIN

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

Newsletter #3
April 2021

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Disruptive pemfc stack with n**O**vel materia**L**s, **P**rocesses, arc**H**itecture and optimized **IN**terfaces

The overall aim of the project is to validate **disruptive technologies for 100 kW light-weight & compact fuel cell stack designs,** reaching outstanding (specific & volumetric) power density while simultaneously featuring enhanced durability (under automotive application conditions) compared to state-of-the-art, and compatible with large scale/mass production of full power-stacks.

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Main Achievements To Date

WP1 "Stack Architecture, design" leads the activities of stack architecture development and modelling at the DOLPHIN Project. This work package aims to achieve i. an increase in power density (W/cm^2), ii. reduce the mass (kg) of the stack, iii. reduce the interface resistances of components and iv. reduce the volume (m3) of the stack.
WP1 is directly fed by the combined work done on WP2 (Electrical & Fluidics Core) and WP3 (Electrochemical Core), which have performed evaluations on different designs and materials solutions. Figure 1 shows an example of how the rib/channel pitch may have a consequent effect on the performances of the electrochemical core. Though, other challenges arise as pressure drop limitations, which will need further assessment at larger scale testing. To do so, at M24 of the project, test platform 2 (Figure 2) has been delivered by ZSW and has been shared with CEA to allow the progress of further testing during the project.

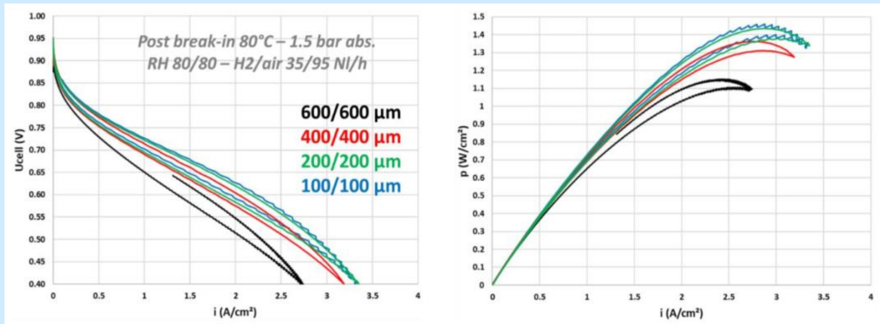

Figure 1 - Influence of the rib/channel pitch on reference MEA.

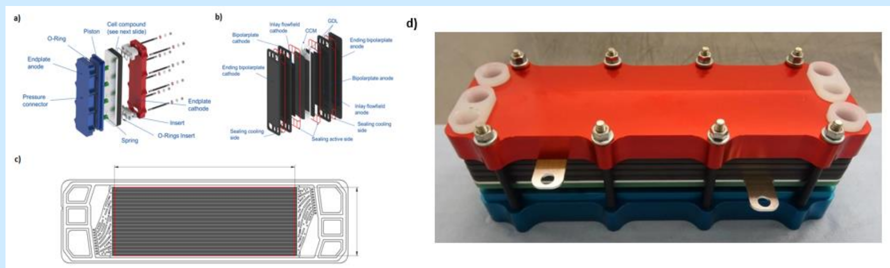

Figure 2 - Test platform 2 design provided by ZSW to Dolphin consortium.

WP2 "Electrical and Fluidic Core" focuses on the manufacturing and characterization of thin Bipolar Plates (BP) and Gas Diffusion Media (GDM).
Based on the previous feasibility tests, some plates have been produced successfully for the 100 cm^2 single cell of the project, with a flow field design with thin rib/channel dimensions, by printing techniques (CEA) and additive manufacturing (DMG-MORI). These plates (Figure 3) will be assembled in the cell and their performance tested. In parallel, the electrical conductivity of the carbon laminates has been improved by Hexcel (reaching values close to the targets), as an alternative candidate to metallic plates for BP.

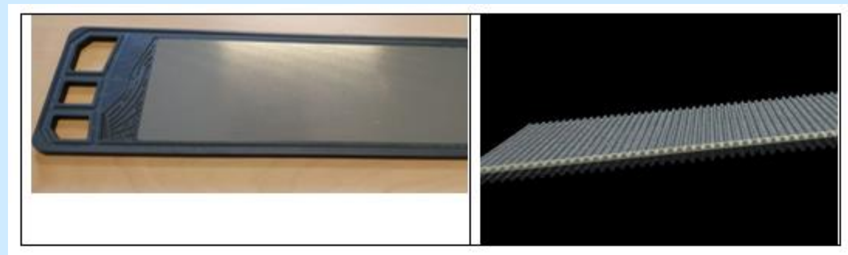

Figure 3: Channels obtained by printing techniques (left) and additive manufacturing (right)

Upcoming event:

DOLPHIN 1st Public Workshop

Focused on cell and production technologies

June 18th, 2021

08:30-12:30 (CEST)

Online, free of charge

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Main Achievements (Cont'd)

WP3 "Electrochemical Core" is dedicated to the development of a pioneering concept for the electrochemical core (EC) of the cell by integrating additional protective and functional layers with the functionality of the traditional catalyst coated membrane (CCM). Furthermore, innovative approaches to improve the CCM components are pursued.

To start with the innermost component, a new generation of membrane has been developed by Chemours combining better performance and improved tolerance to elevated temperature conditions. Work on coating small-area pieces of membrane by a single layer of Graphene (SLG) performed in the laboratory of the University of Manchester could be successfully supplemented by CEA resulting in a SLG-equipped CCM of appropriate size for testing in the small-area (1.8 cm² active area) single cell test platform (TP1) of the project. However, first measurements employing this new material demonstrated still limited proton conductivity of this CCM. Thus, work to tune the structure of the SLG by deliberately introducing lattice defects has been started. It is expected that this approach could result in an improvement of proton conductivity by orders of magnitude while still largely mitigating hydrogen cross-over losses.

Furthermore, CEA delivered first samples of CCM for testing in the 100 cm² test platform (TP2) of the project. This homogeneous reference material will be modified by e.g. gradients on the basis of modelling and test results to further optimize performance and durability.

Significant progress was achieved regarding the development of a protective MPL layer to be applied either on a thin fibre structure to obtain a traditional, though very thin GDL or to be coated stand-alone for integration into the EC. On one hand, ZSW was able to deliver standalone MPL samples for both the small (TP1) and 100 cm² (P2) test platforms employing a well-proven doctor blade technique. On the other hand, a precisely controllable spraying process has been introduced resulting in thinner material with better permeability.

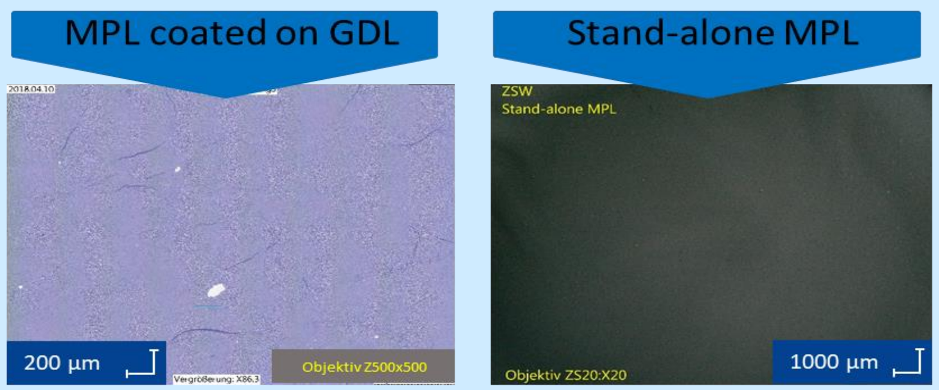

Figure 4 : MPL surface obtained by coating on a fibre substrate (left) and stand-alone (right).

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.

ZSW has synthetized a stand-alone Micro Porous Layer (MPL) and CEA has performed cell performance tests to compare the commercial reference GDL of the project (labelled H14C7) to the one (labelled H14 + MPL) associating this stand-alone MPL to the H14 GDL substrate with no MPL. Both materials are used on the anode and cathode sides and the tests have been done on a 1.8 cm² differential single cell allowing homogeneous operating conditions.

The first results (Figure 5) show that the "H14 + MPL" assembly reaches similar performance than the reference GDL under low and medium current densities. At higher current densities (> 3 A/cm²) the "H14 + MPL" cell exhibits higher performance most probably due to better gas transport properties.

This stand-alone MPL appears thus to be an interesting alternative to the commercial MPL and "MPL only" configurations (without GDL substrate) will be tested. This latter solution would lead to a reduced cell thickness while preserving, or even improving, the electrochemical performance by reducing the mass transport limitations.

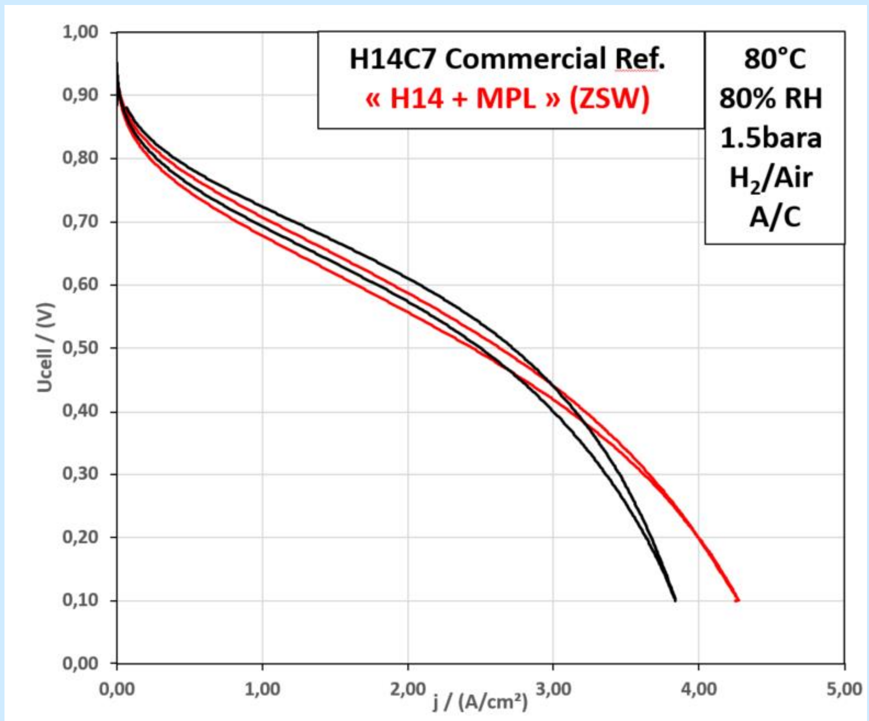

Figure 5: Example of performance of the DOLPHIN stand-alone Micro Porous Layer in differential cell (1.8cm²)

WP5 "Stack Tests" focus on 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.

Building upon the progress achieved during the previous year, the FEM model of the ITP has been refined and applied by Hexcel to assess stability and weight of two alternative base materials for the ITP, one based on carbon and one on glass fibres. Both admit designs featuring significantly improved properties in comparison to the reference material aluminium.

Furthermore, a common effort led by CEA has been started by the consortium to collect the information needed as input for life cycle cost modelling. Issues arising in terms of confidentiality of economically relevant information will be dealt with by generalizing input data and sharing only results relevant for the project as necessary.