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

Newsletter #5 - December 2022

Clean Hydrogen Partnership

Co-funded by the European Union

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

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The DOLPHIN Project – Towards Next-Generation Fuel Cell Stacks Featuring Outstanding Performance

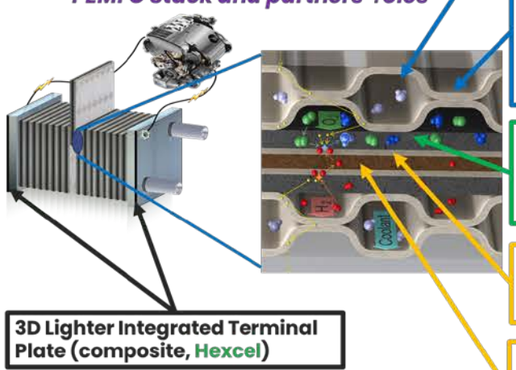
Context and objectives

Validate disruptive technologies for 100 kW light-weight & compact fuel cell stack designs with **high power density** for **automotive application** and **compatible with large scale production**

- Develop and test innovative materials and manufacturing technologies to produce advanced Bipolar and Terminal Plates
- Optimize the manufacturing parameters of MEA with new components
- Improve the Interfaces between layers to reduce mass-transport limitations and increase performances

Main KPIs	Int. SoA 2017 (AutoStackCore)	DOLPHIN (~ FCH-JU 2024 targets)
Weight-specific power density (kW/kg) at nominal power	3.4	≥ 4.0 (≥ +18%)
Volumetric power density (kW/l) at nominal power	4.1	≥ 5.0 (≥ +25%)
Area-specific power density (W/cm²) at 0.66 V (nominal conditions)	0.975	2.0 (+105%)
Cost (€/kW) at 100 000 units/year	36.8	< 20 (-45%)
Durability (hours)	3,500	6,000 (+70%)
Stack max operating temperature (°C)	95	105 (+10°C)

Main DOLPHIN technical items for the development of next-generation PEMFC Stack and partners' roles



3D Lighter Integrated Terminal Plate (composite, Hexcel)

Thinner carbon-based plates (HEXCEL)
Thinner metallic plates (Symbio)

New Flow Field design with downsized rib/channel pitch by printing (CEA), molding (Hexcel), stamping (Symbio), additive manufacturing (DMG-MORI), laser milling (ZSW), GDL machining (CEA)

Thin GDL substrate (Hexcel) with MPL and treatments (CEA)
Or only MPL without GDM fibre substrate (ZSW)

Advanced electrodes (CEA) with improved ionomers (Chemours) and possibly 2D/3D texturing

Thinner (<10 µm) or beyond PFSA membrane (Chemours) with Single Layer of Graphene coating (Univ. Manchester)

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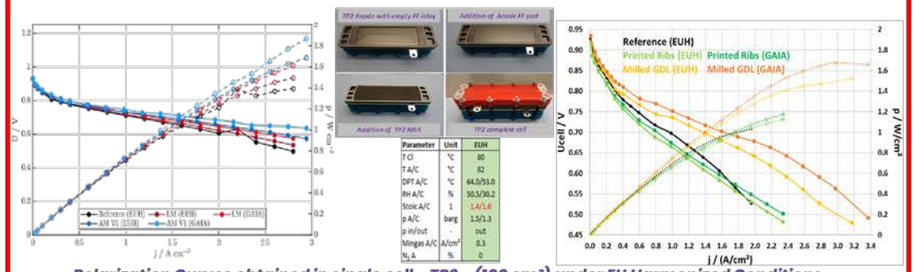
Development and Qualification of Thin Flow-Field Designs

- **Investigation into new and innovative manufacturing processes** to reach downsized rib/channel patterns to increase cell performances
- **Evaluation in large single cell « TP2 » (100 cm²)** of the different materials and processses in terms of performances, fluidic behavior and integration into stacks

Laser-Milling *Carbon-based pad*	***Additive Manufacturing*** *Stainless steel + gold coating*	***Reference Flowfield*** *Carbon-based (Machined)*	***Carbon printed ribs*** *Stainless steel + gold coating*	***Milled GDL*** *Machnied channel into GDM*
				
Channel/rib/depth (µm) ***Anode : ~200 / 100 / 150*** ***Cathode : ~200 / 100 / 300***	***Channel/rib/depth (µm)*** ***Anode: ~400 / 200 / 300*** ***Cathode: ~400 / 200 / 300***	**Channel/rib/depth (µm)** **Anode: 600 / 400 / 200** **Cathode: 500 / 500 / 300**	***Channel/rib/depth (µm)*** ***Anode: 500 / 300 / 200*** ***Cathode: 500 / 300 / 200***	***Channel/rib/depth (µm)*** ***Anode: 400 / 400 / 200*** ***Cathode: 400 / 400 / 200***



Parameter	Unit	EUH
T Cl	°C	80
T A/C	°C	82
DPT A/C	°C	64.0/53.0
RH A/C	%	50.5/30.2
Stoic A/C		1.4/1.6
p A/c	barg	1.5/1.3
p in/out		out
Mingas A/C	A/cm²	0.3
N_2 A	%	0

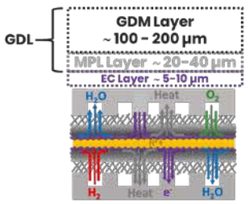
Polarization Curves obtained in single cell « TP2 » (100 cm²) under EU Harmonized Conditions for Automotive Applications and EU Project (GAIA) using reference commercial CCM and GDL

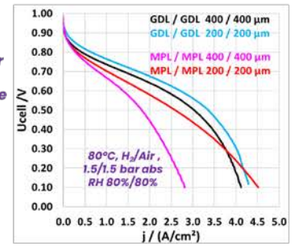
- **Huge improvement of performances with DOLPHIN Flowfields *vs.* Reference set-up : ~ 1.1-1.2 *vs.* ~ 0.9 W/cm² under EUH @ 0.66 V and ~ 1.6-1.8 *vs.* ~ 1.2 W/cm² under GAIA conditions @ 0.60 V**
- **Selection of the two best concepts** for the up-scaling at short-stack level : **Additive Manufacturing and GDL Milling**
- **Combination with the DOLPHIN MEA** integrating advanced components with optimized manufacturing/assembly processes for the short stacks

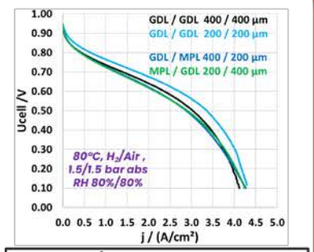
Optimisation of Components and Innovative Cell Architecture

- **Further insights into disruptive cell architectures** by coupling refined flowfield designs with **single or dual GDM removal**: preliminary evaluation at small scale
- **Development of stand-alone MPL** (to be coated onto GDM or CCM)

Polarization curves obtained in differential cell « TP1 » (2 cm²) for different « GDL or MPL » configurations at Anode/cathode according to Channel/Rib sizes







« MPL/MPL » Configurations
- Very poor performance without GDM with 400/400 µm design
- Higher performances with 200/200 µm but still lower than reference GDL/GDL

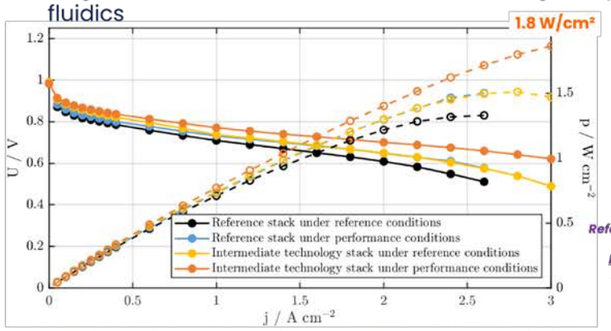
« GDL/MPL » Configurations
- Suppressing one GDM enables to reach satisfying performances under model operating conditions
- Preliminary validation of these innovative types of cell configuration

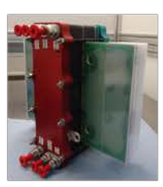
- **Evaluation at full-size cell scale** (TP2, 100 cm²) of **single-sided GDL** under representative operating conditions

- **GDL/MPL : Interesting Architecture regarding materials & cost saving**
- **Tests of 2 configurations using**
  - **Additive Manufacturing Flow-field**
  - *Single MPL Anode & GDL Cathode (not shown)*
  - **Anode GDL and MPL Cathode : best performances** (as expected from preliminary results in 2 cm² cell)
    - **1.8 A/cm² @ 0.66 V : 1.2 W/cm²**
    - **3 A/cm² @ 0.58 V : 1.75 W/cm²**

Validation into short-stacks

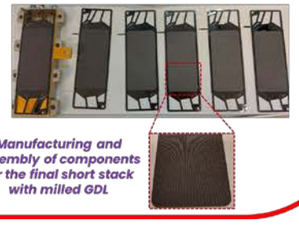
- **Assembly of short-stacks with prototype plates « TP3 »** (based on large single cell hardwares) to evaluate the homogeneity of performances and fluidics





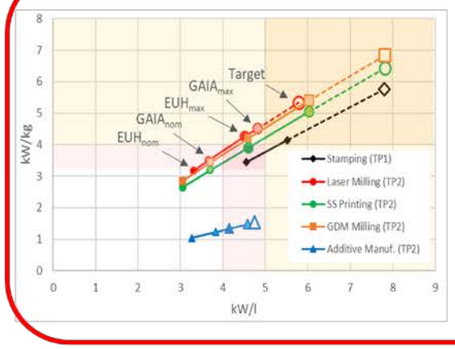
Reference stack: *Bipolar Plate with Reference Flowfield Design and Commercial MEA*
Intermediate Stack: *Bipolar Plate with Additive Manufactured Flowfield and DOLPHIN MEA*

- **Confirmation of very high performance levels in intermediate stacks :** similar to those obtained previously in large single cell
- **Preparation and production of components is on going** to assemble and then to test **two final short stacks** based on AM Bipolar plates and milled-GDL technologies with optimized DOLPHIN CCM



Manufacturing and assembly of components for the final short stack with milled GDL

KPI Evaluation



- **Evaluation of each concept** for cell and stack components within the project in regards to **Stack KPI using experimental results**
- **Additive Manufacturing**: outstanding max cell performance (~ 2 W/cm²) but weight and volume are not optimized
- **GDL-milling:** cell performance not yet optimized (~ 1.5 W/cm²) but low weight and volume are great advantages

Acknowledgements

This work has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No. 826204 (Project DOLPHIN).

This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

FCH — Fuel Cells and Hydrogen Joint Undertaking

Clean Hydrogen Partnership