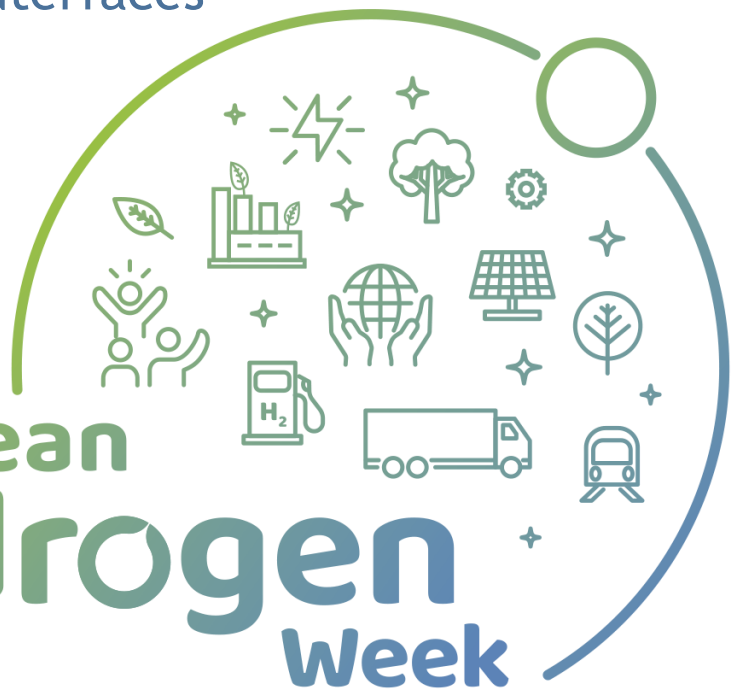
DOLPHIN

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

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



Joël PAUCHET

CEA (French Alternative Energies and Atomic Energy Commission)

http://www.dolphin-fc.eu/.

Joel.pauchet@cea.fr

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#CleanHydrogen

FCH

European Commission

Project Overview

Call year: 2018

Call topic:
FCH-01-6

Game changer fuel cell stack for automotive applications

Project dates:
[01/01/2019- 31/12/2022]

Total project budget:
[3 181 431 €]

DOLPHIN

% stage of implementation 23/11/2020: 35 %]

FCH JU max. contribution: [2 962 681 €]
Other financial contribution: [218 750 €]

European Hydrogen Week

Consortium

7 partners: 4 industries + 3 RTO
7 countries: 6 in Europe + USA

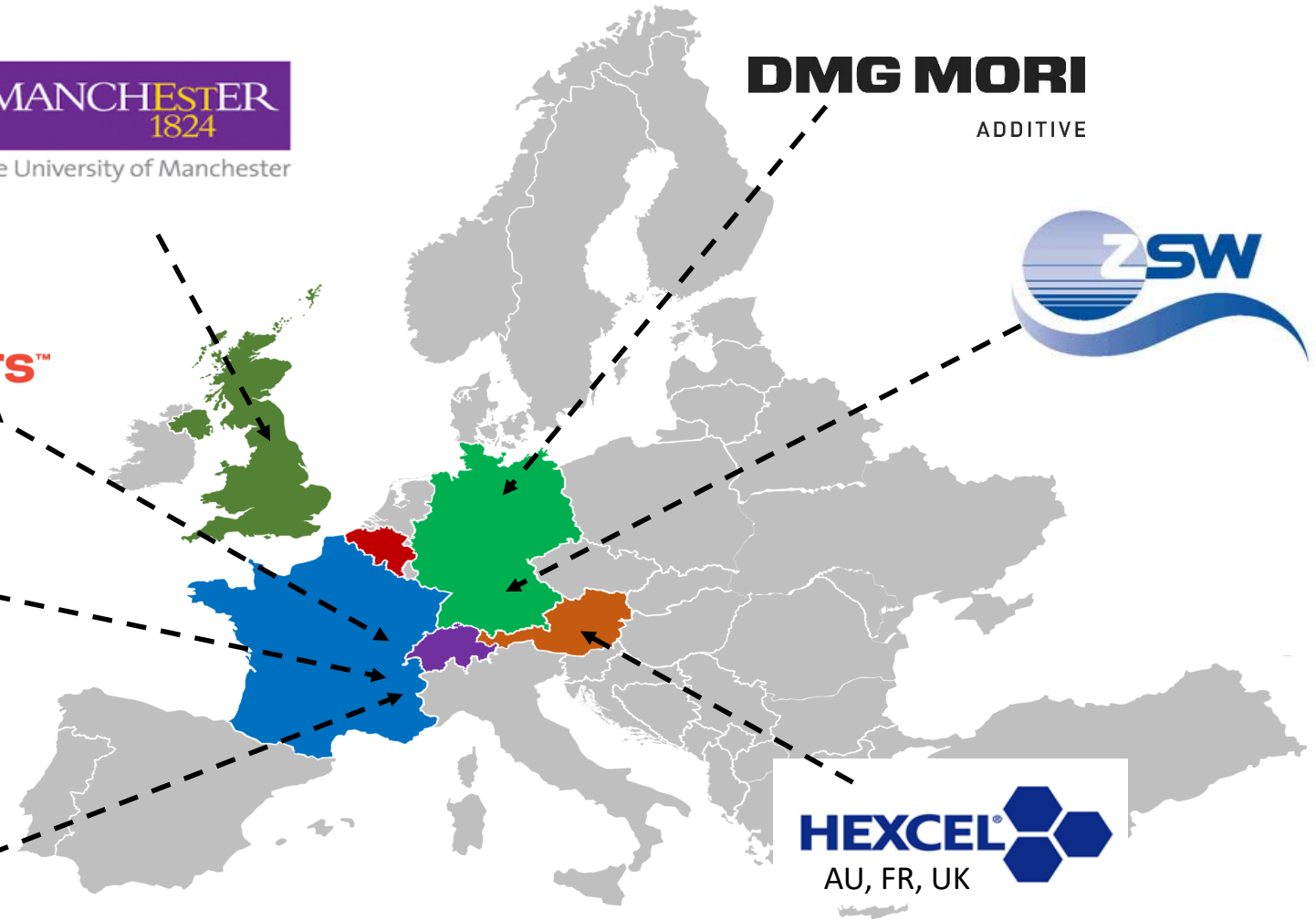
MANCHESTER 1824
The University of Manchester

DMG MORI
ADDITIVE

ZSW

Chemours™
FR, CH, BE, USA

SYMBIO
A FAURECIA MICHELIN HYDROGEN COMPANY

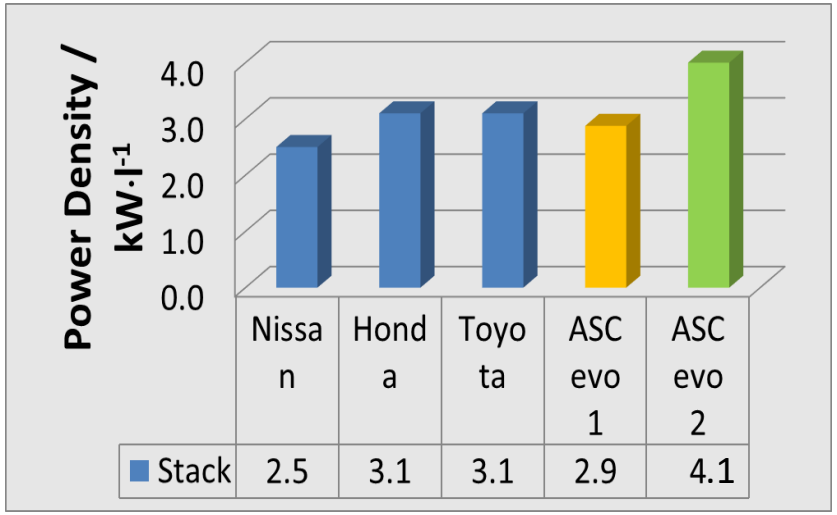


liten
cea tech

HEXCEL
AU, FR, UK

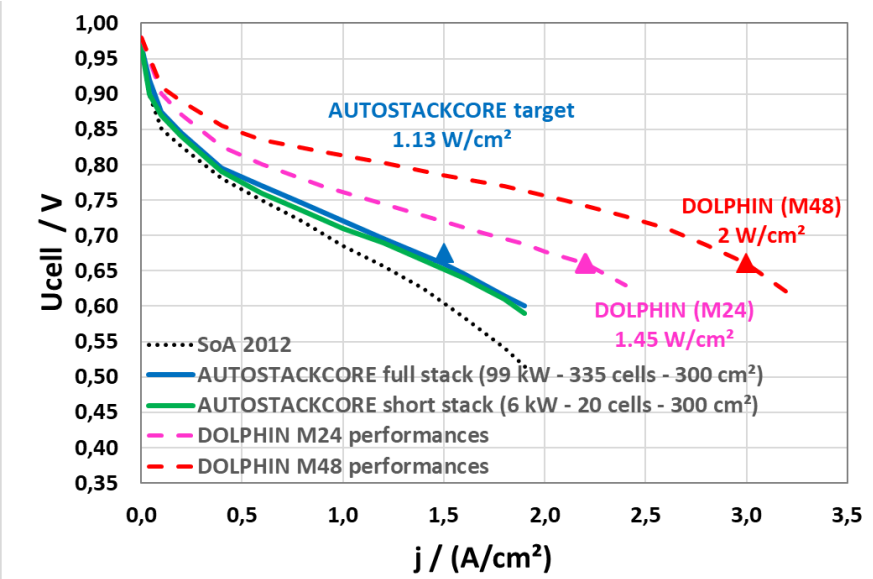
Main Objectives

Validate **disruptive technologies for 100 kW light-weight & compact fuel cell stack designs,** with high power density and enhanced durability (under automotive application conditions), and **compatible with large scale/mass production** of full power-stacks.



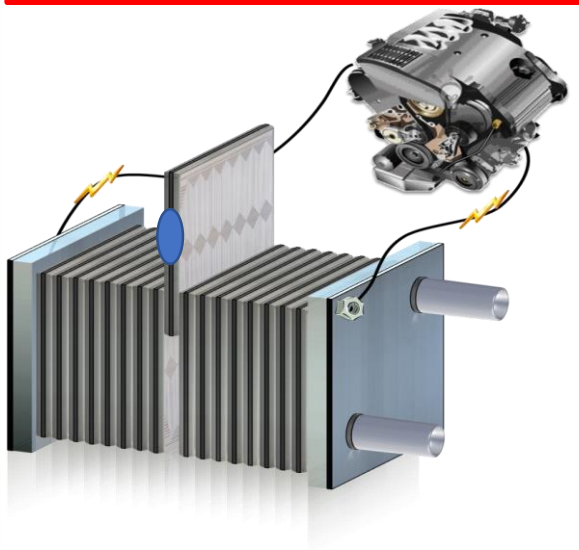
Public information (2017)

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	1.13	2.0 (+75%)
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)



Technical developments

5 kW demonstrator (CEA, ZSW) with improved materials/processes



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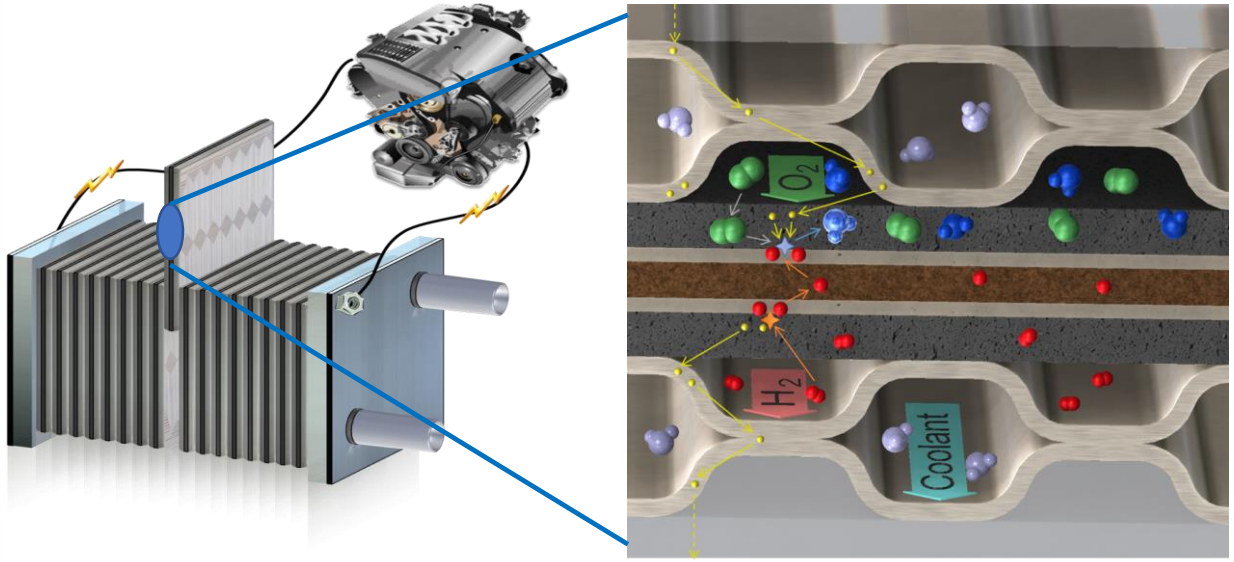

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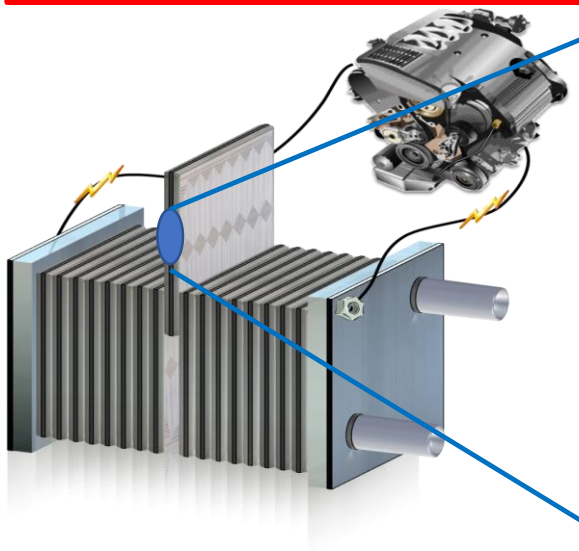
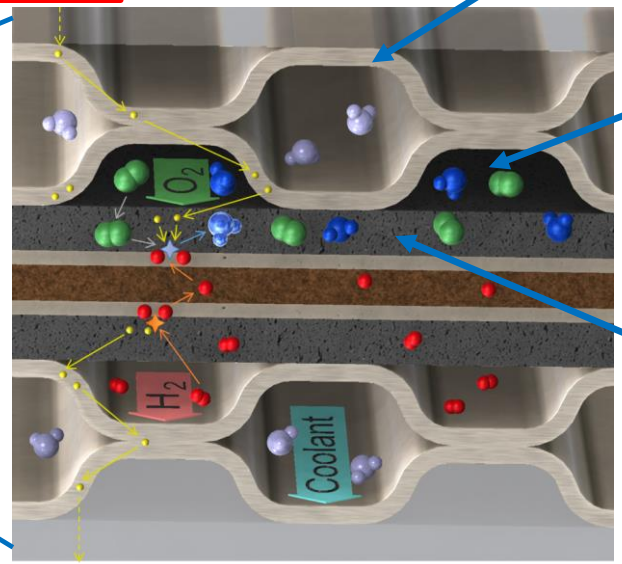




Thinner carbon-based plates (HEXCEL)
Thinner metallic plates (SYM)
Treatments of plates (SYM, CEA)

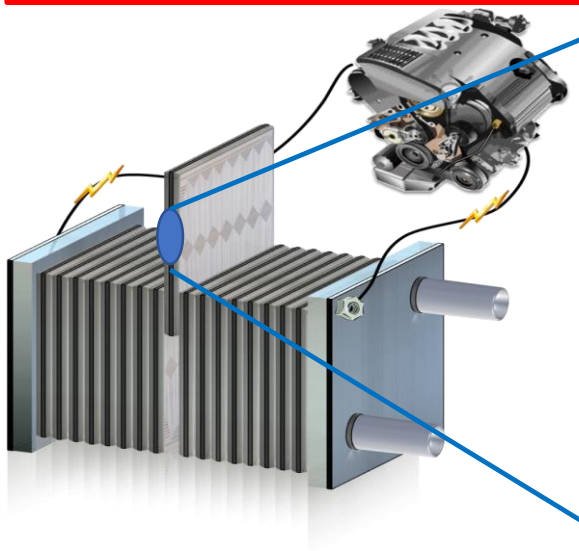
New (ZSW, CEA, SYM) Flow Field design with downsized rib/channel pitch by printing (CEA), molding (HEXCEL), stamping (SYM), additive manufacturing (DMG-MORI), laser milling (ZSW)

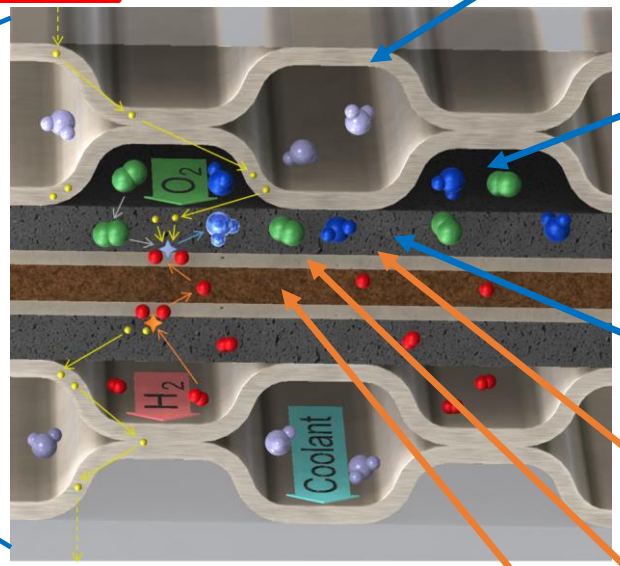
Thin GDL substrate (HEXCEL), with MPL and treatments (CEA)

Electrical and Fluidics Core

Technical developments

5 kW demonstrator (CEA, ZSW) with improved materials/processes





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Electrical and Fluidics Core

Thin GDL substrate (HEXCEL), with MPL and treatments (CEA)

Or MPL onto AL (ZSW)

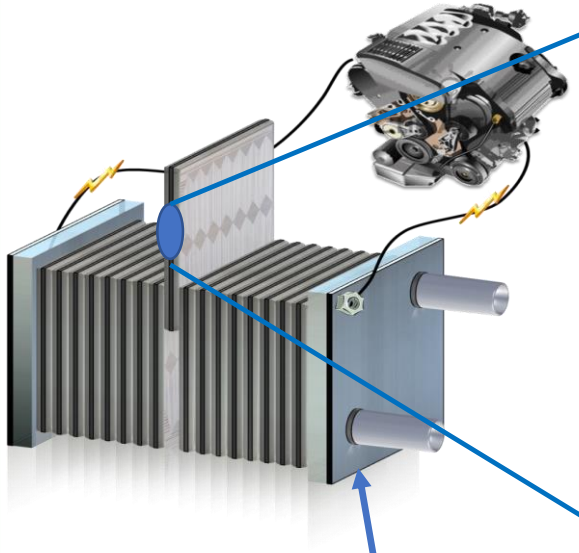
3D textured cathode AL (CEA) with improved ionomers (CHEM)

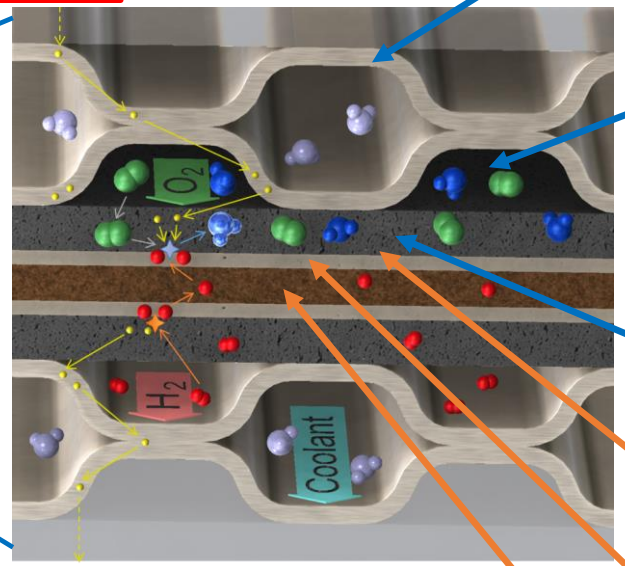
Thinner (<10 µm) or beyond PFSA membrane (CHEM) with SLG coating (UoM)

Electrochemical Core

Technical developments

5 kW demonstrator (CEA, ZSW) with improved materials/processes





3D Lighter Integrated Terminal Plate (composite, HEXCEL) with BoS functions

Thinner carbon-based plates (HEXCEL)
Thinner metallic plates (SYM)
Treatments of plates (SYM, CEA)

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

Electrical and Fluidics Core

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Or MPL onto AL (ZSW)

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Thinner (<10 µm) or beyond PFSA membrane (CHEM) with SLG coating (UoM)

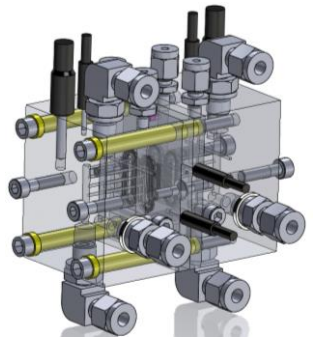
Electrochemical Core

Increase of performance

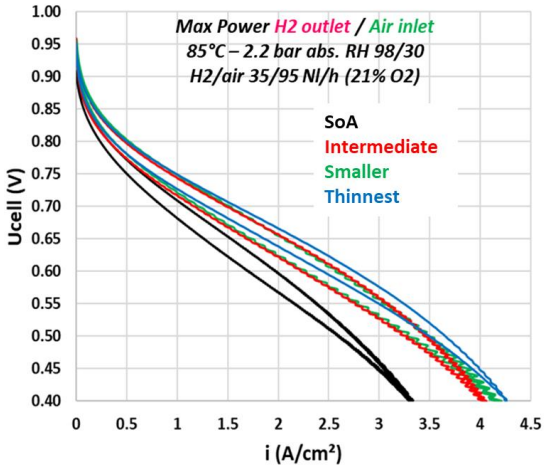
Achievement to-date 1.13 W/cm²

25% 50% 75%

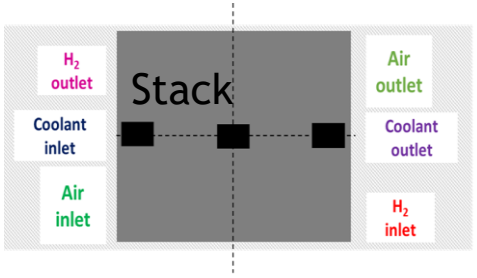
2W/cm²

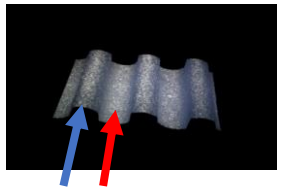


Differential cell (1.8 cm²) to mimic local conditions in the stack (CEA)



Increase of performance by reducing rib/channel pitch (CEA)





Rib/channel pitch

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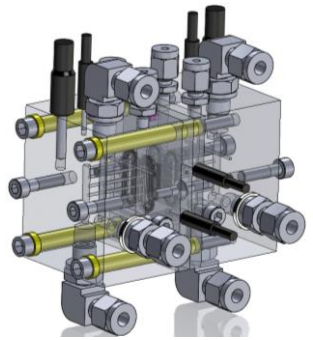
Increase of performance

Achievement to-date 1.13 W/cm² → 2W/cm²



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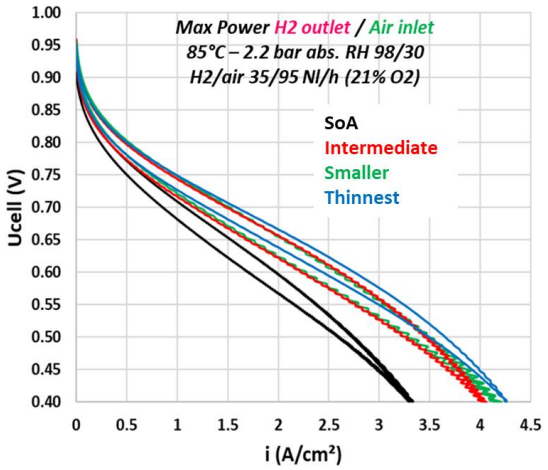

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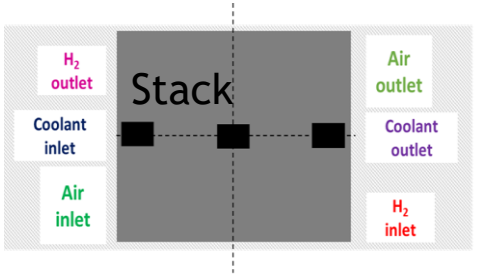
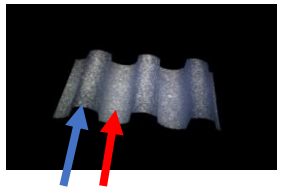
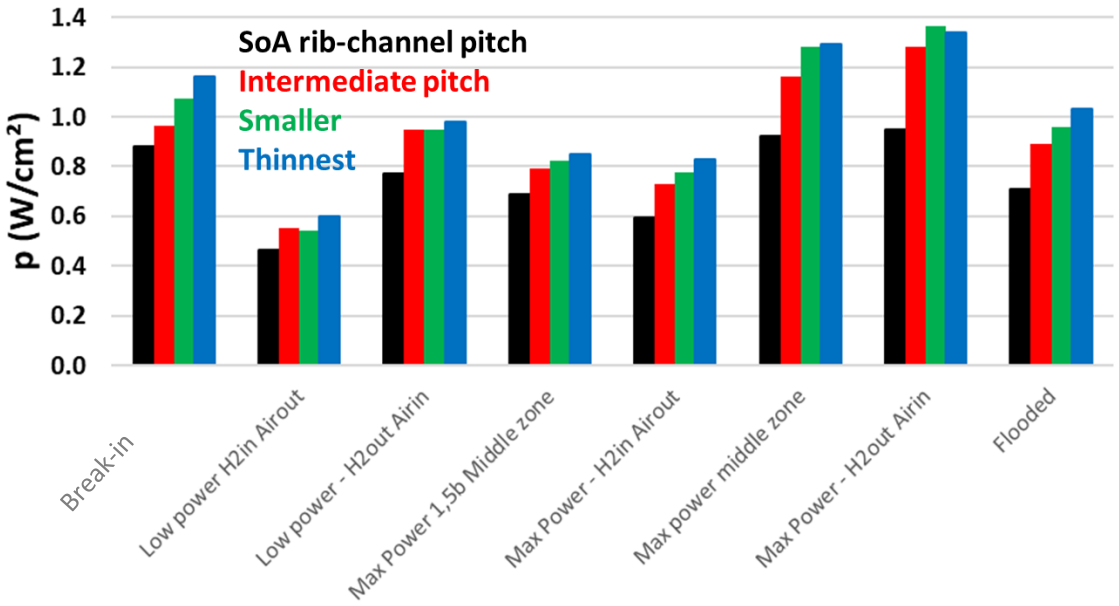




Rib/channel pitch

25% 50% 75%



Performance for different local conditions expected in the stack: machined flow-fields with different dimensions, commercial CCM (CEA)

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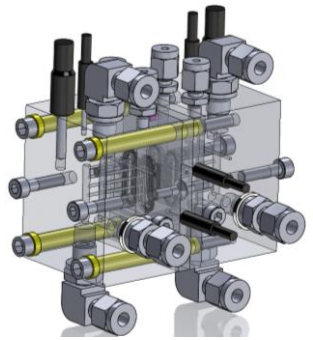
Increase of performance

Achievement to-date 1.13 W/cm² → 2W/cm²



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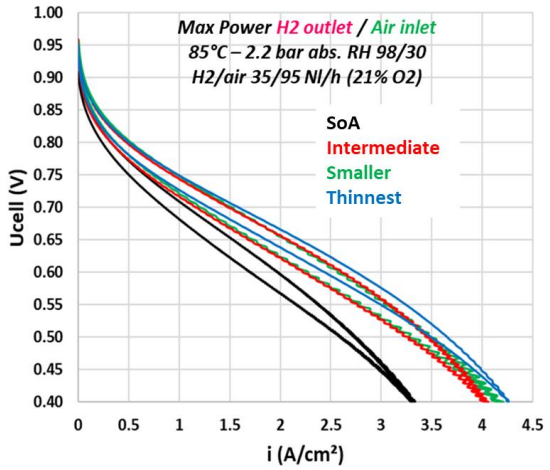

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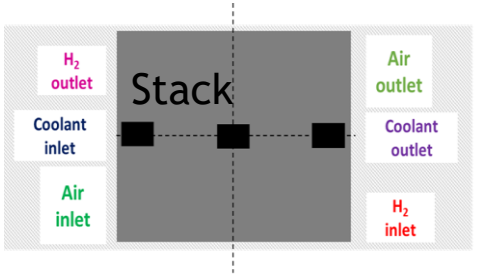
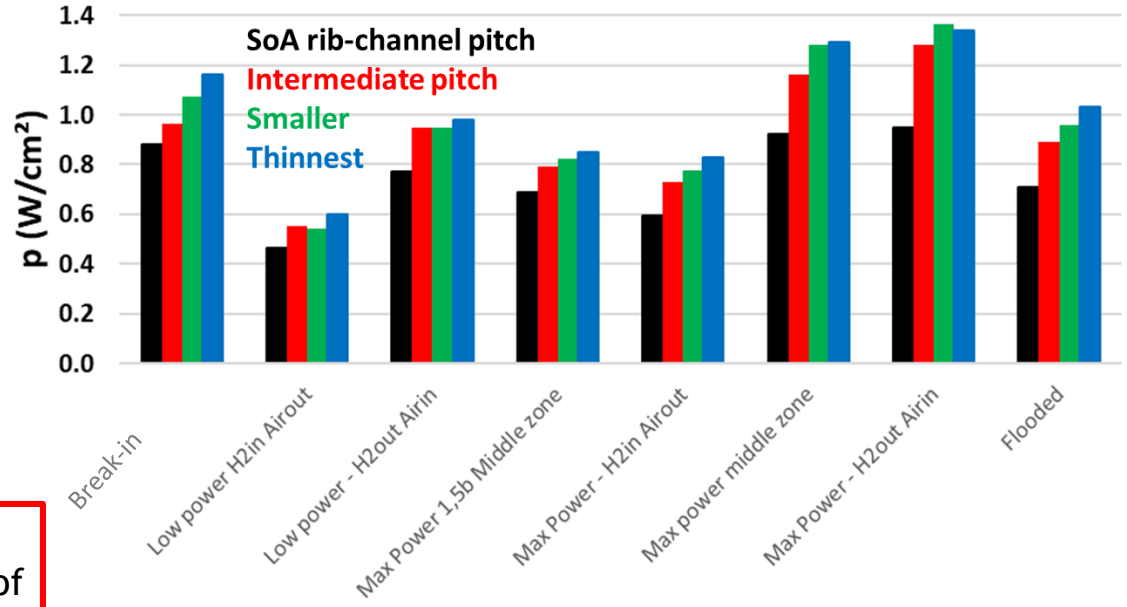


Next:
- Trade-off between increase of performance and increase of pressure drop
- Larger cell tests

25% 50% 75%



Performance for different local conditions expected in the stack: machined flow-fields with different dimensions, commercial CCM (CEA)

EFC: manufacturing of thin Flow-Fields

European Hydrogen Week

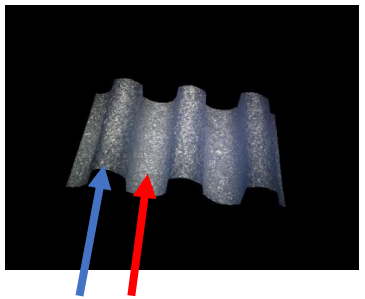
Achievement to-date

Stamped metallic
Rib-channel pitch
1.2 mm

Alternative process
Alternative material
< 1.2 mm

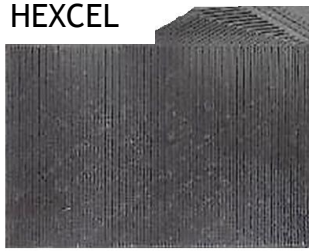
25% 50% 75%

- Printing
- Additive maufacturing
- Laser milling
- Thin metallic sheets
- Stamping
- Thin carbon sheets
- Molding

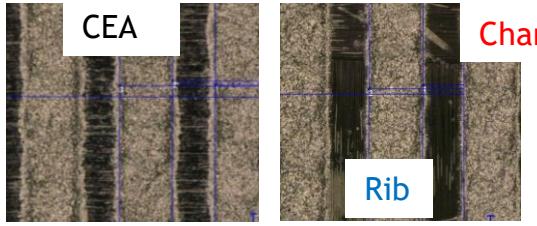


Rib/channel pitch

Additive manufacturing (intermediate pitch)



3D carbon-based molding (intermediate pitch)



On metallic sheet On carbon sheet

Printing (thin pitch)

Next:
- Increase of electrical conductivity
- Single cell performance test
- Select most promising solutions for larger scale tests

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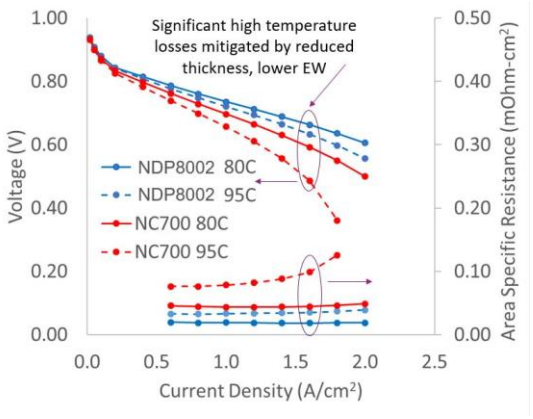
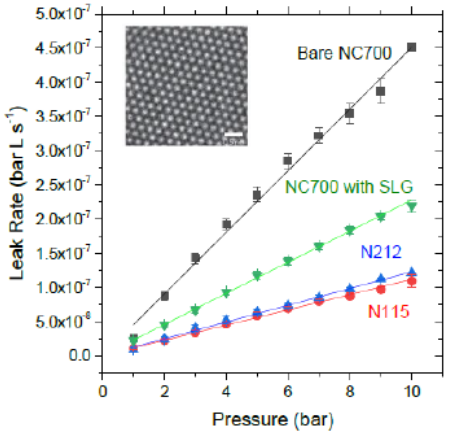
Electrochemical Core and Terminal Plate

Achievement to-date



Improved 10µm thick membrane (Chem)



Single Layer Graphene coating to reduce H_2 permeation (UoM)

Characteristics	Aluminum	Glass fiber composite, design A	Carbon fiber composite, design B
Mass	100%	-11%	-47%
Thickness	100%	-10%	-10%
Volume	100%	+25%	-9%

Integrated Lighter Composite Terminal Plate (Hexcel)

No SLG coating
ITP

SLG coating
Increased durability
ITP reduced weight

25% 50% 75%

- Improved membrane
- Improved ionomer
- S. Layer Graphene
- Stand Alone MPL
- Integrated Terminal Plate
- Textured CL

Next:
- improve MPL and SLG coating
- manufacture/test ITP

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Exploitation Plan/Expected Impact

Partner (Type)	Exploitable results	Impact/ commercial application
CEA (RTO)	• Alternative materials (graphene, carbon…) • Improved modelling and understanding of stack key components • Compact game changer fuel cell design	• Further research/collaborative projects • Patents, licensing/technology transfer
SYMBIO (IND)	• Optimised fuel cell components • Compact game changer fuel cell design	• Commercialisation of automotive FC stack • Further research and collaborative projects
ZSW (RTO)	• Improved modelling know-how and cell, component, stack design • Increased know-how in media distribution and component systems • Game changing measurement data	• Further research/collaborative projects • Patents, licensing/technology transfer • Education of students
HEXCEL (IND)	• Knowledge and know-how on the use of composite materials in the fuel cell market • Access potential new markets	• Commercialisation of composite technology in the fuel cell market • Synergies with other energy market
UoM (UNI)	• Graphene deposit on membranes • Thinner membrane with improved tightness	• Further research/collaborative projects • Patents, licensing/technology transfer
CHEMOURS (IND)	• Optimised thinner membranes and coating technologies	• Further research and collaborative projects • Commercialisation of membranes
DMG MORI ADDITIVE (IND)	• Improved manufacturing processes, new raw material developed, experience with fuel cell technology	• Further research/collaborative projects • Commercialisation of machines

Risks, Challenges and Lessons Learned

Description of the issue	Risk level	Contingency plan
Technological		
Materials for 1.8cm² and 100cm² single cell tests	L	Different manufacturing strategies are pursued
Novel membrane <10 µm	M	Use as-thin-as-possible commercial membranes to minimize transport losses
Scaling up of graphene coating	L	If the graphene area coverage is too low, two layers of graphene will be coated
Density of 2W/cm² at the end of the project	H	2 W/cm² is a very ambitious target; a go / no go milestone has been included to state on the progress on the different KPIs
Economical / market		
Cost of 20€/kW for the 5kW production	M	Different strategies are pursued; the most promising ones will be selected
Organizational		
Political Risk: « hard brexit » on May 2019	M	In case UK is no longer eligible to receive funding, UoM will find alternative funding
Pandemic Risk (new risk added)	M	Teleworking when possible; project extension as necessary

Thank you for your attention

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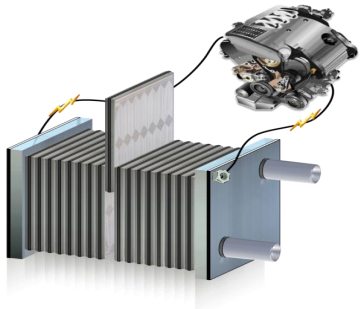
Disruptive pemfc stack with nOvel materiaLs, Processes, arcHitecture and optimized INterfaces



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