CAMELOT presentation

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FURTHER-FC Workshop

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camelot

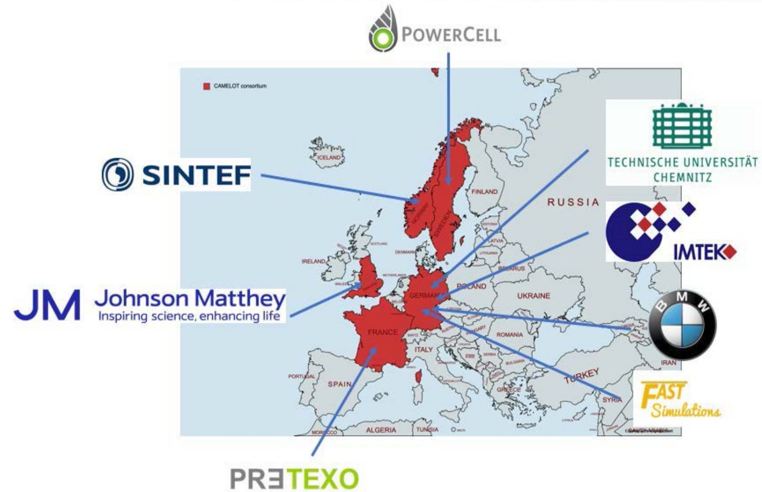
Understanding Charge, Mass and Heat Transfer In Fuel Cells for Transport Applications

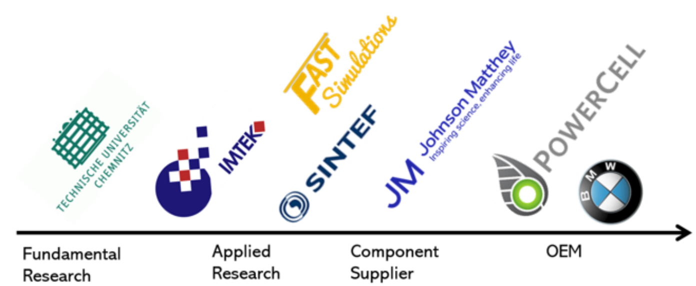
Clean Hydrogen Partnership

Co-funded by the European Union

About CAMELOT

- **GA #875155 — UNDERSTANDING CHARGE, MASS AND HEAT TRANSFER IN FUEL CELLS FOR TRANSPORT APPLICATIONS (CAMELOT)**
- FCH-01-4-2019 Towards a better understanding of charge, mass and heat transports in new generation PEMFC MEA for automotive applications
- 2020-2023 (10-month hiatus)
- Amendment 2022
  - Exit FCP
  - Enter PowerCell, FAST Simulations
- 2.5 M€ budget





Project objectives

Overall objectives

Improve the power density of fuel cells by understanding the limitations on the performance of MEA.

Objective 1: Identify the fundamental transport properties that limit performance in SoA and prototype beyond-SoA MEAs and materials.

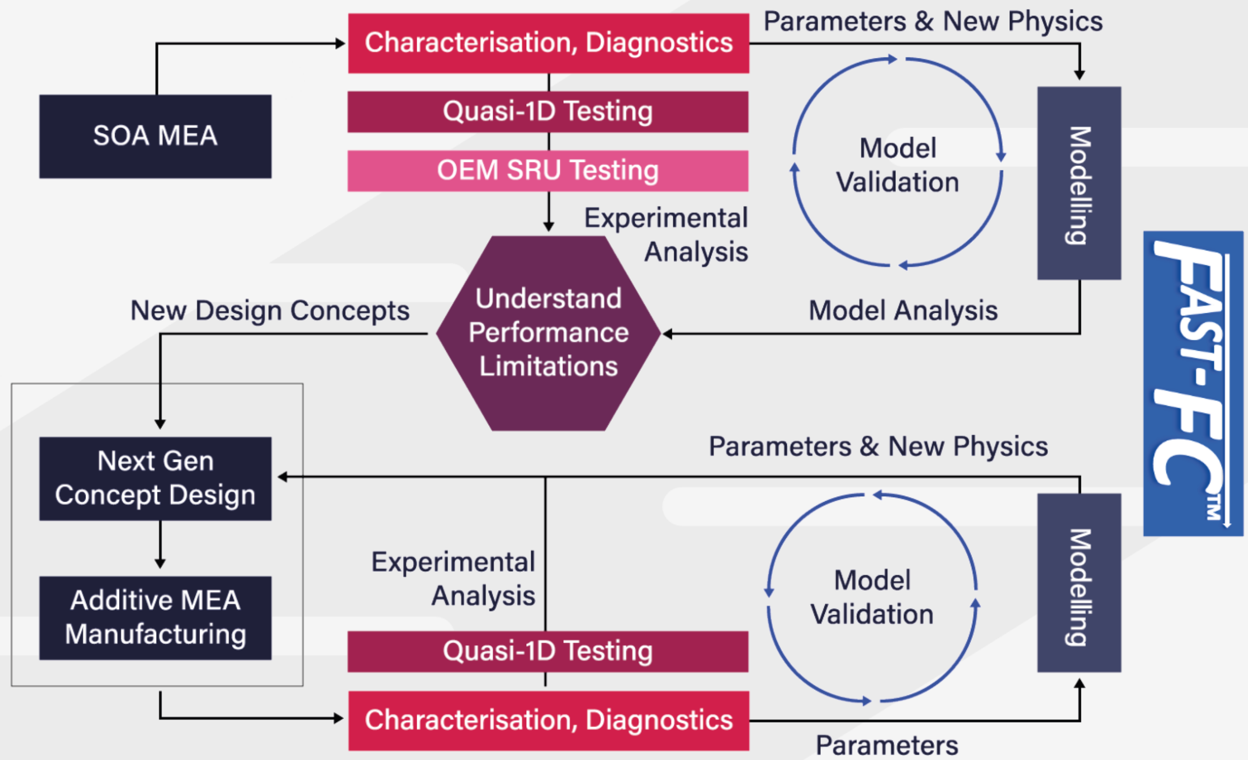
Objective 2: Extend a leading open source model to enable the accurate simulation of SoA MEAs using automotive SRU Hardware.

Objective 3: Produce MEAs with features that have the potential to enable disruptive performance increases and to validate the open source model for beyond-SoA MEAs.

Objective 4: Propose new beyond-SoA MEA designs in automotive SRU geometries that address SoA performance limitations and provide simulation tools that guide rational development of new MEA concepts.

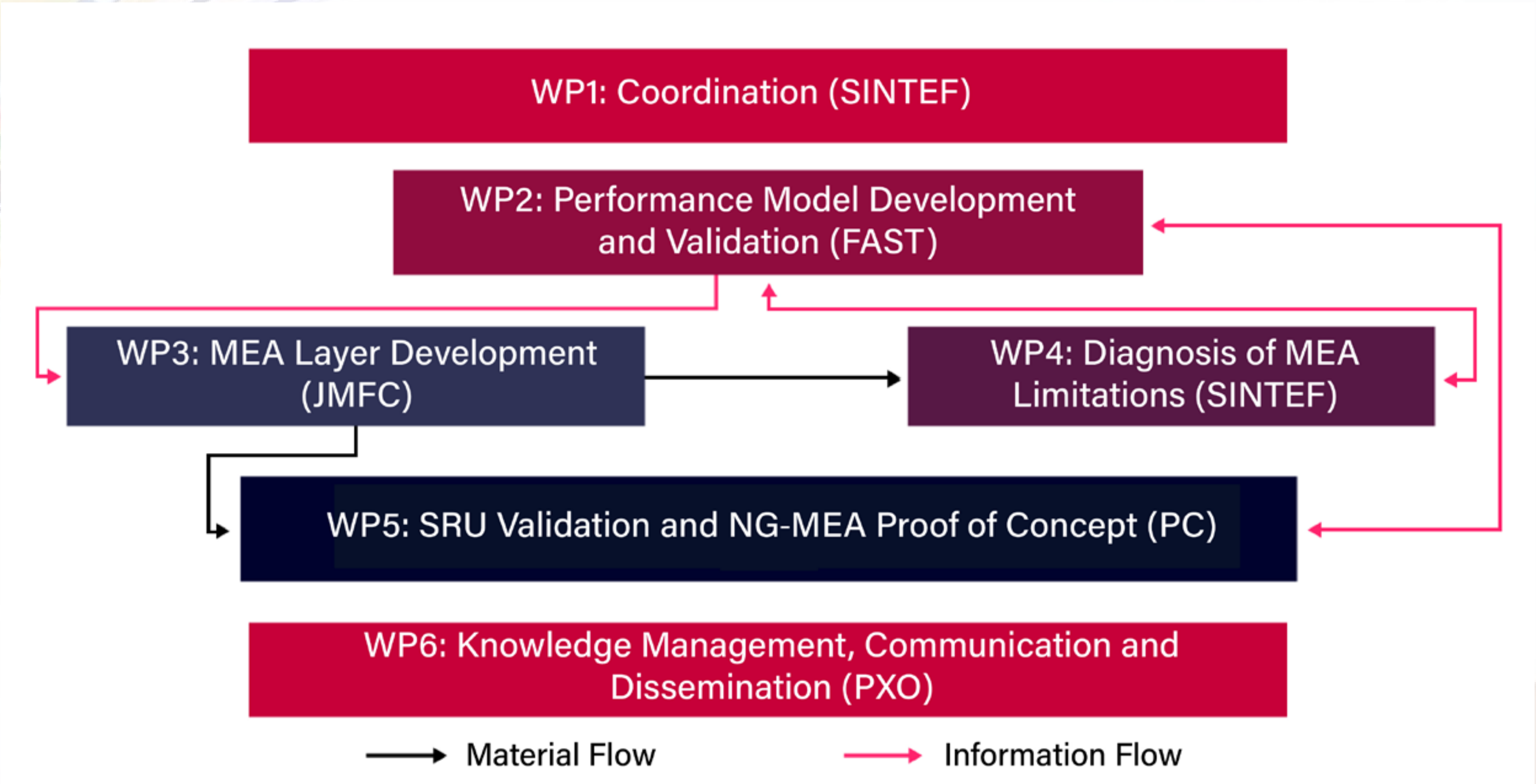
Concept

CAMELOT will use a combination of numerical modelling and advanced in situ characterisation techniques to build a scientific understanding of the limitations on SoA MEAs. The overall Concept of CAMELOT is illustrated in the scheme below.



__MEA__: Membrane Electrode Assembly
__SoA__: State of the Art
__OEM__: Original Equipment Manufacturer
__SRU__: Single Repeat Unit

Structure



WP1: Coordination (SINTEF)
WP2: Performance Model Development and Validation (FAST)
WP3: MEA Layer Development (JMFC)
WP4: Diagnosis of MEA Limitations (SINTEF)
WP5: SRU Validation and NG-MEA Proof of Concept (PC)
WP6: Knowledge Management, Communication and Dissemination (PXO)
Material Flow
Information Flow

WP2 Performance model development and validation

- FAST-FC Open-souce modeling toolbox for FC and EL
- Built in C++ on top of open-source CFD code that provides a highly parallel and robust finite volume approach
- Performance and durability modeling toolbox with modes for steady-state and transient simulations
- Simulation of drive-cycles, ASTs and diagnostic methods
- Originally developed as part of DOE Apollo project and Dr. Harveys PhD work
- Further development in CAMELOT
    - Improved membrane model: hydration and dehydration
- Development done in COMSOL
- Deployed in OpenFOAM at the end of the project

FAST-FC
GitHub http://www.github.com/fastsimulations
Use the git protocol:
git clone https://github.com/fastSimulations/FastFC.git

WP2 - Performance model development and validation

- FAST-FC was developed on last generation MEAs.
- In order to capture transport losses in ultra-thin MEAs, improvements are needed:
    - **T2.1** Physical description of water transport in thin ionomeric materials/membranes
    - **T2.2** Physical description of liquid water transport with the pore structure of the MEA (CLs, GDLs) and flow field channels of BPP
    - **T2.3** Understanding transport limitations from simulation of SoA MEAs
- **T2.4** Recommendations for Beyond-SoA ultra-low loaded high performance MEAs
    - Parametrization of model through development of thin layers in WP3
- **T2.5** Source code repository development and release management
    - GitHub

FAST-FC
GitHub http://www.github.com/fastsimulations
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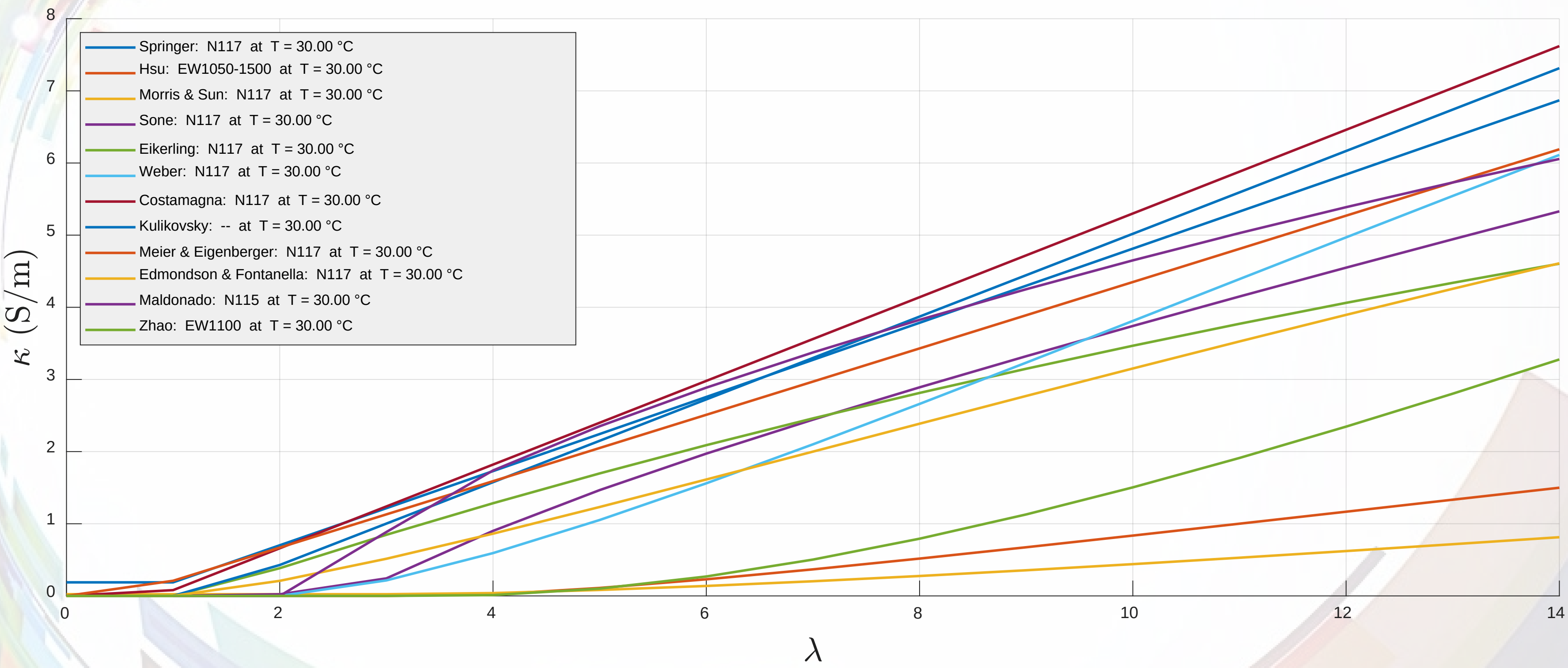
WP2 Performance model development and validation

Closure of the governing equations – parametrization of the protonic conductivity

Due to the wide spread of parametrisations, even at 30 °C, measurement data are needed to represent the intended material set.

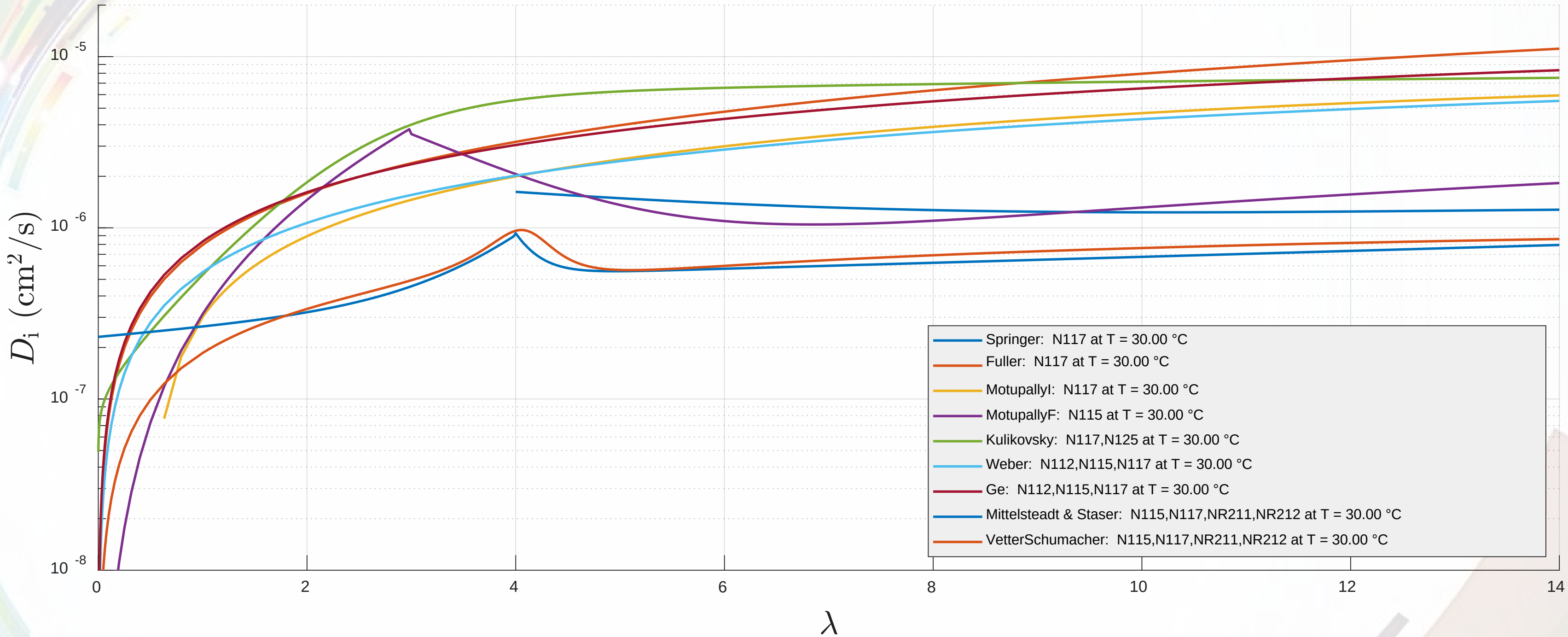
-> Performed in WP4



WP2 - Performance model development and validation

Closure of the governing equations – diffusivity of water in the ionomer

Diffusivity of the ionomer used in CAMELOT needs to be measured to reduce uncertainty involved in available parametrizations.



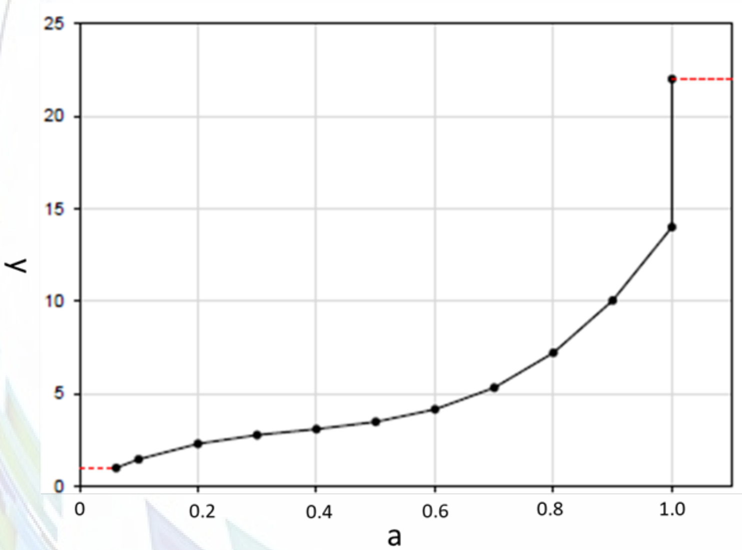
Source: Journal of Power Sources 438 (2019), 227018

WP2 - Performance model development and validation

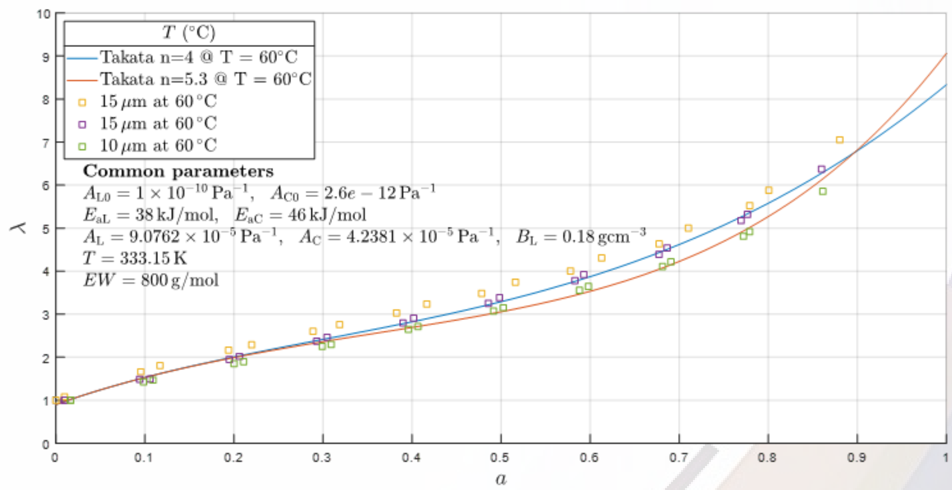
Activity vs water uptake – Limitation in original model for thin layers

Good correlation between experimental data for JM 10 and 15 µm membranes and the sorption model of Takata

Original FAST_FC

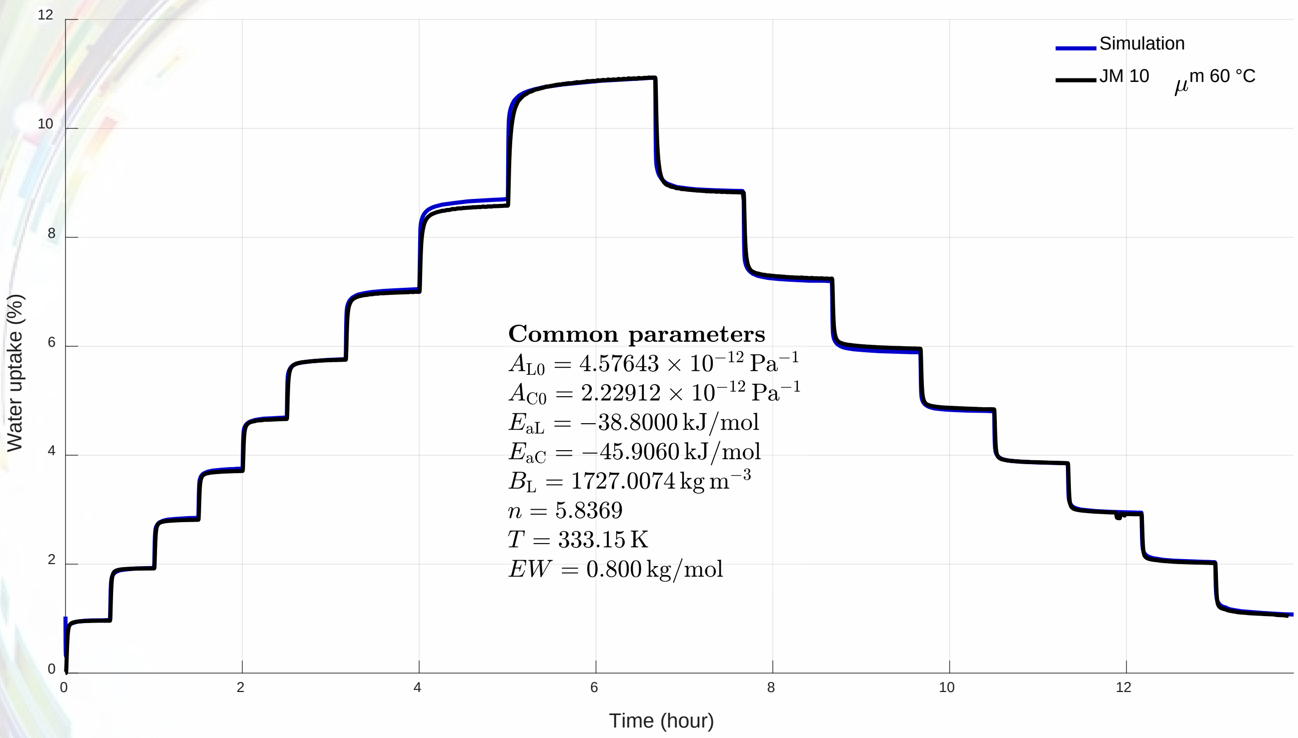


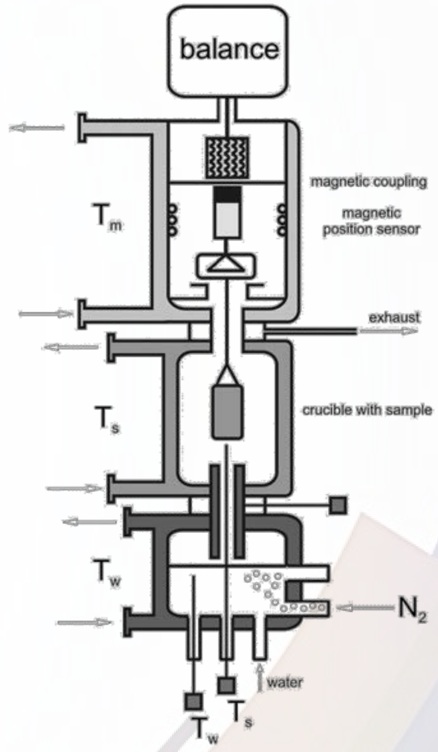
Experimental data and Takata



WP2 - Performance model development and validation

Dynamic Vapor Sorption: Takata sorption model vs JM's 10-µm membrane @ 60 °C



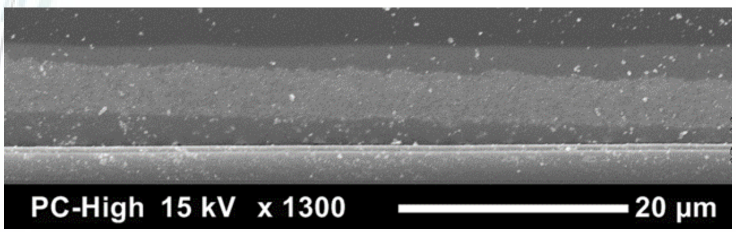


WP3 - MEA layer development

T3.1 Ultra-thin MEA construction

Several techniques explored

- Target: ≤ 10 µm
- Testing down to 6.5 µm
- Currently stable at 8 µm



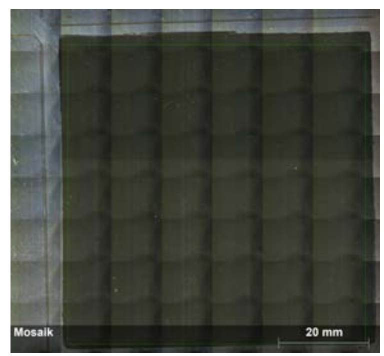
T3.2 X-Y-Z CCM layer construction

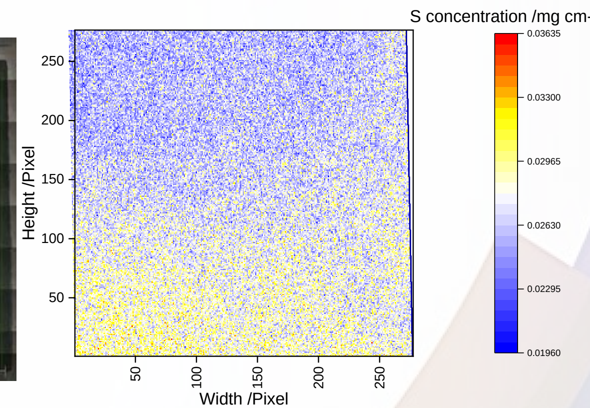
Started production of graded layers

- Catalyst
- Ionomer content

For characterisation in WP4

- Segmented cell measurements



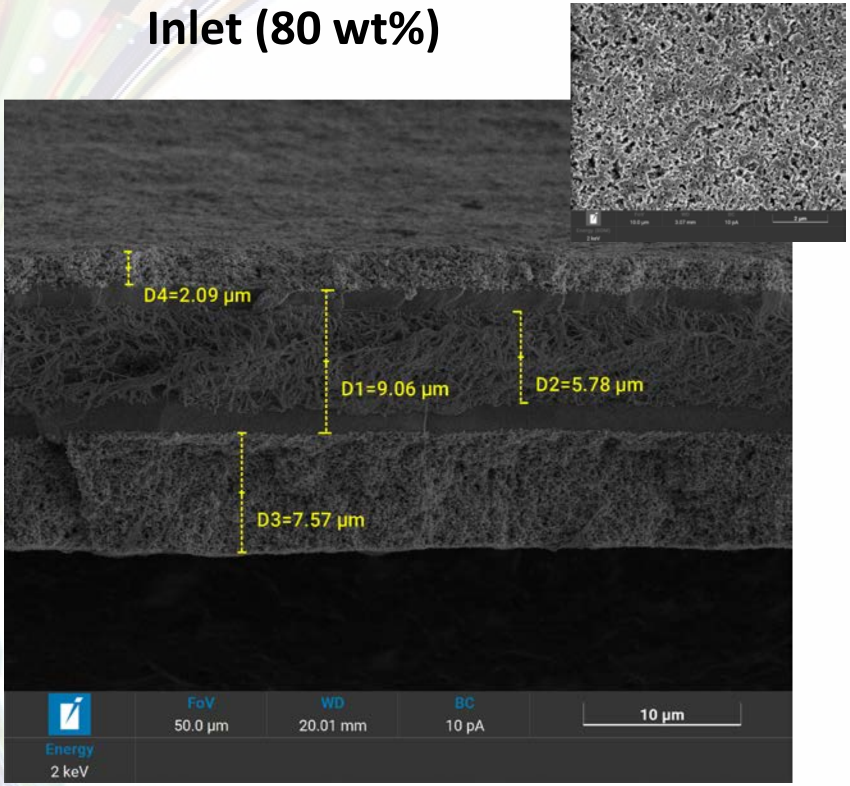


XRF of high-low graded ionomer content MEA

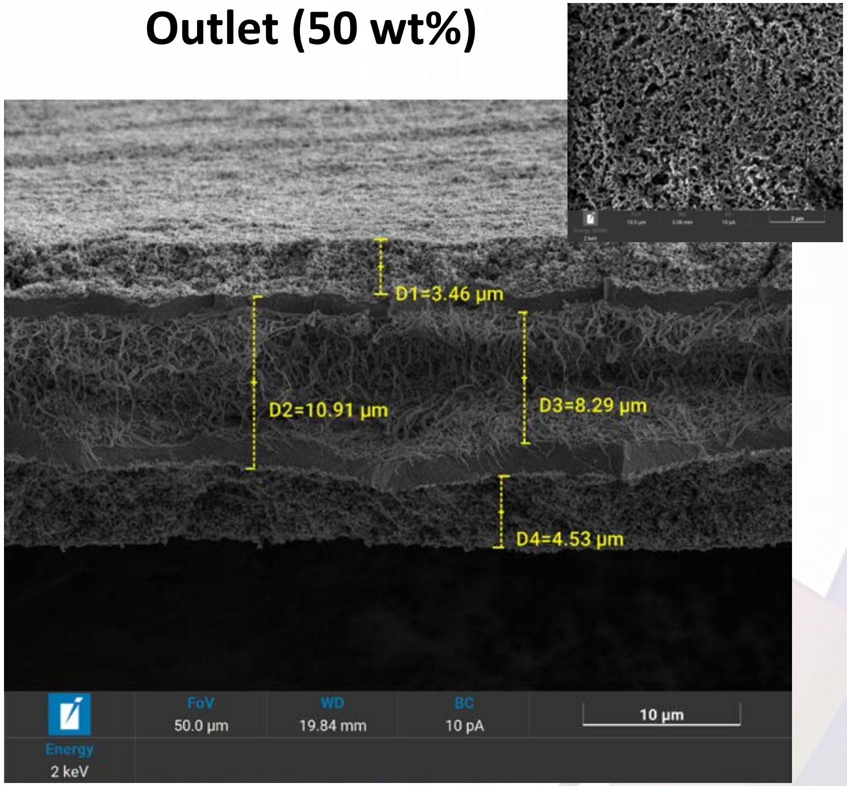
WP4 - Diagnosis of MEA limitations

SEM of ionomer content graded MEA

Inlet (80 wt%)



Outlet (50 wt%)



Acknowledgement

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Clean Hydrogen Partnership

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