CAMELOT

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

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Call year: 2020

Call topic: FCH-01-4-2019 - Towards a better understanding of charge, mass and heat transports in new generation PEMFC MEA for automotive applications

Project dates: January 1, 2020 - December 31, 2023

% stage of implementation 01/11/2023: 95%

Total project budget: 2 295 783.50 €

Clean Hydrogen Partnership max. contribution: 2 295 783.50 €

Other financial contribution: -

Partners: SINTEF AS, Johnson Matthey Fuel Cells Ltd, Chemnitz University of Technology, BMW, University of Freiburg IMTEK, PRETEXO, Fast Simulations UG, Powercell Sweden AB
Project Partners

[Map showing locations of project partners across Europe]

- SINTEF
- PowerCell Group
- Johnson Matthey
- FAST Simulations
- PRETEXO

Co-funded by the European Union
Objectives

- Improve the power density of fuel cells by understanding the performance limitations of MEAs
- Diagnose the fundamental transport properties that limit performance in SoA and prototype MEAs
- Extend a leading open-source model to enable the accurate simulation of SoA MEAs using automotive SRU hardware
- Produce MEAs with features that have the potential to enable disruptive performance increases and to validate the open-source model for beyond-SoA MEAs
- 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
We have achieved power densities of 0.75 W/cm² using 0.1 mg_{Pt}/cm² at the cathode.

- Polarization curves collected using conditions outlined in the EU Harmonised Test Protocols for PEMFCs:
  - 80 °C;
  - anode: ~50% RH, 1.5 bar_{g}, \lambda = 2.0
  - cathode: ~30% RH, 1.3 bar_{g}, \lambda = 2.5
Concentration, temperature, and pressure gradients exist during PEMFC operation.
Can we take advantage of additive manufacturing techniques to overcome concentration gradients?

Project Targets - Graded Catalyst Layers

The respective effect of under-rib convection and pressure drop of flow fields on the performance of PEM fuel cells.
Chao Wang, Qinglei Zhang, Shuiyun Shen, Xiaohui Yan, Fengjuan Zhu, Xiaojing Cheng & Junliang
Scientific Reports, 7:43447. DOI: 10.1038/srep43447

Tailoring the Membrane-Electrode Interface in PEM Fuel Cells: A Review and Perspective on Novel Engineering Approaches
Matthias Breitwieser, Matthias Klingele, Severin Vierrath, Roland Zengerle, and Simon Thiele*
Project Targets - Graded Catalyst Layers

- Optimized by having a gradient layer at the cathode and anode, part loading to 0.04 mg/cm².
- Total part loading 0.104 mg/cm².
- Current distribution measurements on an automotive PEMFC stack.
- Higher catalyst loadings towards the cathode outlet improve the homogeneity of current density distribution and mass transport limitations.
- Lower performance in kinetic and Ohmic region.

Current distribution measurements on an automotive PEMFC stack:
- Homogeneous Catalyst Layer (0.1 mg/cm²)
- Graded Catalyst Layer (0.1 mg/cm²)

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As catalyst loadings approach 0.08 mg$_{\text{Pt}}$/cm$^2$ significant kinetic and mass transport limitations must be overcome.

Kinetics can be overcome through the development of new oxygen reduction reaction catalysts with high mass activities, e.g., shape-controlled Pt-alloys or PGM-free metal-nitrogen-carbon materials.

Mass transport limitations must be overcome through catalyst layer structure/morphology engineering, e.g., optimized carbon support porosity and surface area, optimized oxygen permeability of the ionomer, and maximizing triple-phase boundary.

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Exploitation Plan/Expected Impact

**Exploitation**

Open-source 3D model developed that can be used to predict performance of PEMFC MEAs

**Impact**

- Quantifying and predicting the local operating conditions inside a MEA
- MEA and MEA-component based design recommendations for increased performance
Dissemination Activities

We're hosting a workshop!

Join us in Chemnitz for a hands-on demonstration of our PEMFC model.
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Thank you for your attention!