camelot

UNDERSTANDING CHARGE, MASS AND HEAT TRANSFER
IN FUEL CELLS FOR TRANSPORT APPLICATIONS

www.camelot-fuelcell.eu

Clean Hydrogen Partnership

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CAMELOT IS A EU SUPPORTED PROJECT TO IMPROVE THE POWER DENSITY OF FUEL CELLS BY UNDERSTANDING THE LIMITATIONS ON THE PERFORMANCE OF MEMBRANE ELECTRODE ASSEMBLY.

CAMELOT brings together highly experienced research institutes, universities, fuel cell membrane electrode assembly suppliers and transport original equipment manufacturers to improve understanding of the limitations of fuel cell electrodes. This will enable the partners to provide guidance on the next generation of membrane electrode assemblies required to achieve the 2024 performance targets.

Major outcomes of the project include advancing computational understanding of key water transport and mass balance models. More specifically, FAST Simulations have developed and validated a thin ionomer dissolved water transport model, a pressure-driven liquid water transport model, and a voltage loss breakdown methodology within the model framework that has been verified against data experimental data collected within the project. Through this they were able to provide recommendations for Beyond-SoA MEAs that have the ability to meet performance targets >670mV at 2.7 A/cm². The COMSOL-based FAST-FC model framework has been released and is available through the FAST Simulations GitHub repository:https://github.com/fastSimulations/EU-CAMELOT.

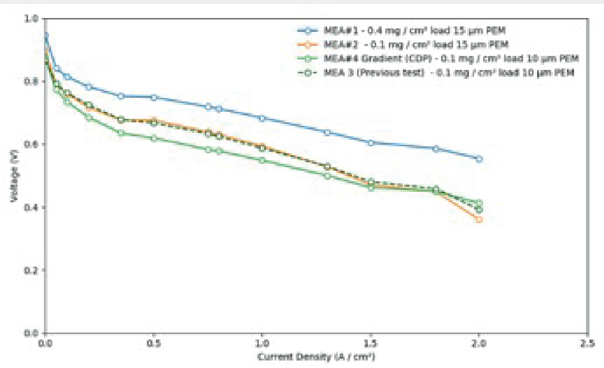
Strong performance improvements were also achieved in the area of CCM development at Johnson Matthey where CCM designs incorporating low loadings, i.e., 0.1 mgPt/cm² at the cathode, were able to reach power densities up to 1.42 W/cm² in air at the single-cell level. Through optimisation of membrane fabrication, membranes as thin as 8 µm were developed to provide a balance of high performance and minimised H_2 permeation The development of XY and Z gradient catalyst layer structures was an additional highlight where graded catalyst layers were shown to exhibit different electrochemical behaviour depending on the orientation of the gradient with respect to the fuel cell inlet/outlet.
Finally, advanced coating methods were developed to produce CCMs with smooth Pt gradients and/or complex geometries. These next-generation CCMs were produced at large scale, i.e., ~300 cm², and delivered to Powercell for short stack testing.

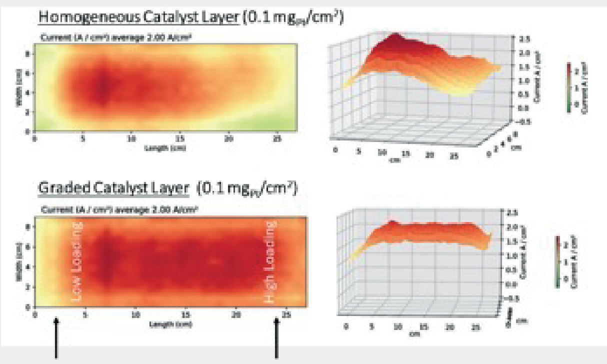
At SINTEF, comprehensive electrochemical characterisation of state-of-the-art and beyond state-of-the-art CCMs was performed to elucidate the influence of membrane thickness and catalyst loading on performance limitations. This advanced characterisation data was provided to the modelling team in WP2 to feed the open source model with state-of-the-art fuel cell parameters. In-situ fuel cell characterization using a current distribution plate has provided insight into the current density (and temperature) distribution across the fuel cell when graded catalyst layers are employed.

At PowerCell, short stack testing of automotive-scale (~300 cm²) CCMs with graded catalyst layers, equipped with a current density plate, was performed and the spatial distribution of current density from inlet to outlet was observed. Experimental data from the industrially relevant PEMFC geometries was provided to the modeling team to carry out simulations that can make suggestions towards optimal catalyst layer architectures for automotive fuel cell applications.

HIGHLIGHTS

Graded catalyst coated membranes with an active area of ~300 cm² were prepared to be tested in PowerCell's automotive PEMFC short stack. In the left figure, polarisation curves were collected and compared for CCMs with uniform cathode catalyst layers with high (MEA #1, blue) and low (MEA #2, orange) Pt loadings, as well as CCM with graded cathode catalyst layer and low Pt loading (MEA #4, green). A current distribution plate was used to map the current density distribution (right figure). It was found that when the graded CCM was assembled with the higher catalyst loadings towards the cathode outlet, the homogeneity of current density distribution was greatly improved compared with a uniform catalyst layer distribution. The polarization curves also suggest that increased Pt loadings at the cathode outlet may improve mass transport limitations at high current density operation. This comes at the expense of lower performance in the kinetic and Ohmic regions of the polarization curve for the graded CCM.





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