Newsletter #2
November 2020

GAIA

next Generation AutomotIve
membrane electrode Assemblies

Onward and upward

GAIA has the overall aim of developing high power and high current density automotive membrane electrode assemblies (MEAs) well beyond the current state of the art. The project goal is to provide significantly higher performance MEAs while ensuring the designs satisfy operational (beginning of life power density of 1.8 W/cm² at 0.6 V), durability (6,000 hours) and cost (6 €/kW) targets. Despite the inevitable slowing of experimental work since March of this year due to complete laboratory closures and restricted access on-site working, and to delays in deliveries from suppliers, GAIA has achieved the goals it set for the project mid-term point in June 2020. Exciting breakthroughs have been made over the past 18 months in all materials development and deposition work packages. Following further validation, new ionomer, membrane, catalyst compositions and designs and catalyst layer constructions, along with tailored gas diffusion and microporous layers, will be associated, and integrated into successive generations of MEAs for testing at short stack level. To date, two iterations of MEA have been assessed in 10-cell short stacks using the comprehensive testing protocols developed in GAIA, and the EU harmonised conditions, and the mid-term power density target of 1.5 W/cm² at 0.6 V was reached. The achievements of a mass activity of 0.89 A/mg_{Pt} in an MEA at 0.1 mg_{Pt}/cm² loading and of a voltage decay rate of 6 µV/hour over 2600 hours of drive cycle testing are two examples of project successes that will underpin the partners' endeavours to reach the final target MEA performance and durability in the second half of the project.

www.gaia-fuelcell.eu

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GAIA VIDEO - *Working Steps During The Preparation Of An Automotive Membrane Electrode Assembly Starting With A Carbon-based Pt Catalyst Used In A Proton Exchange Membrane Fuel Cell*

Technical University of Berlin (TUB) and Technical University of Munich (TUM) jointly recorded a video clip about the most relevant working steps during the fabrication of an MEA for proton exchange membrane (PEM) fuel cells.
The team at TUB, whose focus within GAIA is the development of advanced electrocatalysts, illustrates in this movie the various steps in catalyst synthesis and in catalyst screening via the rotating disc electrode (RDE) technique. The TUM team, focusing on catalyst integration into MEAs and diagnosing MEA performance losses, shows in this movie the various steps involved in MEA preparation and in-MEA testing/diagnostics in small-active-area single-cell PEM fuel cells.

GAIA Youtube channel: https://www.youtube.com/channel/UCF_Hj5PdYtXhHw3dYDmDNGg

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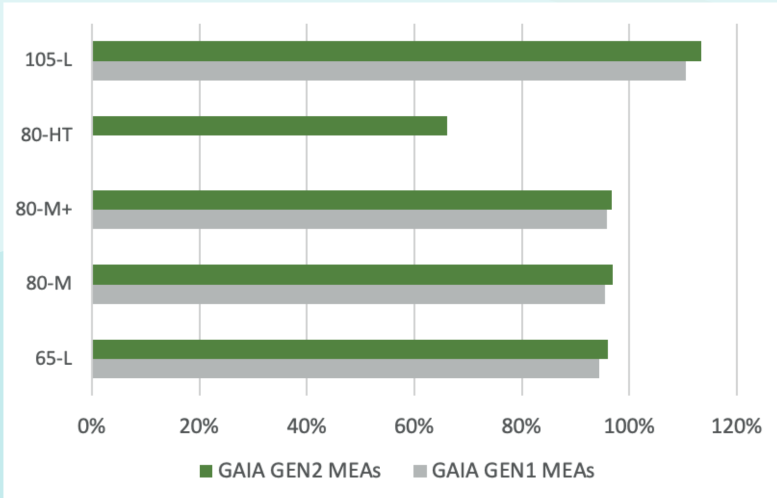
PROJECT PARTNERS

CNRS, Technische Universität Berlin, Johnson Matthey – Inspiring science, enhancing life, FREUDENBERG – INNOVATING TOGETHER, dyneon, TUM, elmarco, BMW Group, ZSW, PR3TEXO

WP2 - WP5 - WP6

Stack level validation

The first 10-cell short stack, assembled at BMW and tested at ZSW, reached the project mid-term target by providing 1.46 W/cm² under the EU harmonised operating conditions. This stack (GEN1) comprised catalyst coated membranes prepared at JMFC, and gas diffusion and microporous layers developed at Freudenberg. A second stack (GEN2) included a further gas diffusion layer improvement, and new cathode catalyst layer technology using new materials from WP4 and optimisations to improve stability. This second stack provided higher cell voltage at all GAIA operating points as well as significantly greater stability, in particular on high temperature (105 °C) operation.

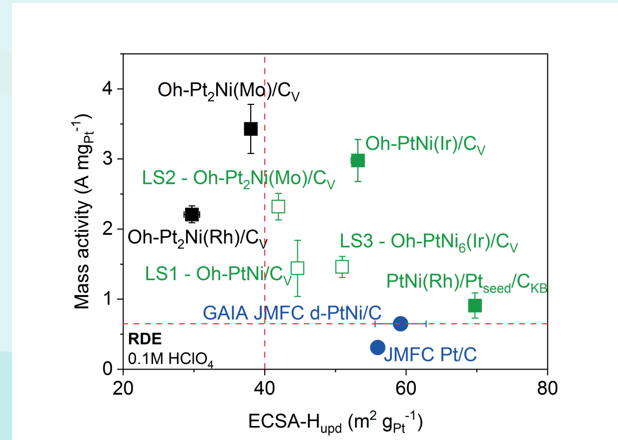


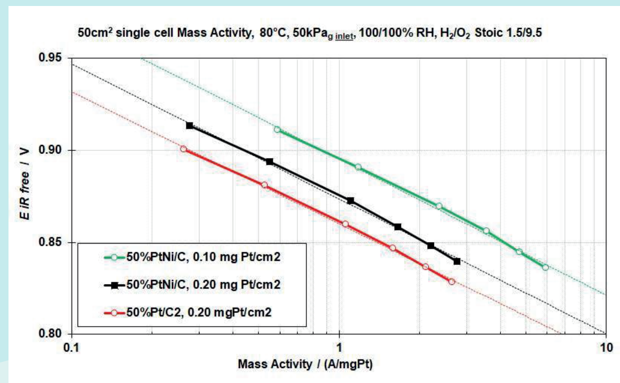
GAIA
Some Highlights

WP4

Pushing the platinum mass activity ceiling upwards

Oxygen reduction reaction (ORR) electrocatalysts have been further advanced in the second year of GAIA. TUB have synthesised octahedral-shaped ternary catalysts (Oh-PtNiX/C, where X=Mo, Ir, Rh) with an unprecedented level of control over particle size and composition. In particular, an Oh-PtNiIr/C catalyst showed a mass activity (MA) in the rotating disc electrode (RDE) of >3 A/mg$_{Pt}$ and an electrochemical active surface area (ECSA) of 50 m²/g$_{Pt}$. Work at JMFC on carbon-supported de-alloyed 50% PtNi catalysts led to material with an ECSA of ~65m²/g$_{Pt}$.

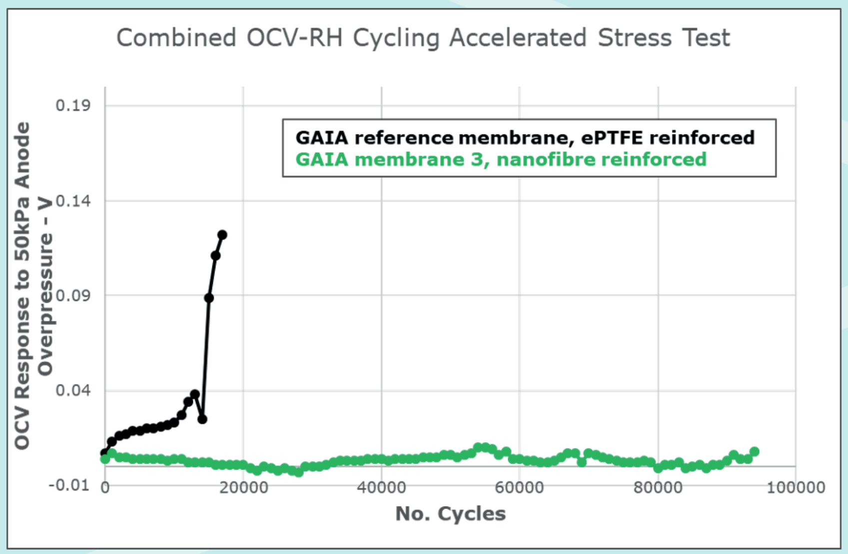




Performance testing as MEAs in 50 cm² single cells gave a MA of 0.44 A/mg$_{Pt}$ using a cathode loading of 0.20 mg$_{Pt}$/cm², but a formulation tested at a reduced cathode loading of 0.1 mg$_{Pt}$/cm² yielded an exceptionally high MA of 0.89 A/mg$_{Pt}$, which comfortably exceeds the project target of 0.7 A/mg$_{Pt}$. In addition, the teams at CNRS and TUM progressed with the synthesis of Pt-rare earth alloy catalysts achieving electrochemical surface areas higher than 40 m²/g$_{Pt}$ and MA greater than 0.6 A/mg$_{Pt}$ in the RDE.

WP3

Indestructible membrane



An MEA comprising a thermostable nanofibre reinforced perfluorosulfonic acid membrane of 15 µm thickness has withstood an exceptional 100,000 accelerated stress test cycles of combined open circuit voltage hold and relative humidity cycling at 90 °C, considerably exceeding the target 20,000 AST cycles for light duty vehicles.

Milestones Status

M0 — M12 — M14 — M18 — M36

MS2 (M14): Electrospun nanofibre thermostable polymer reinforced membranes are consistently more stable and durable than ePTFE reinforced membranes in MEAs subjected to RH cycles at OCV, and in drive cycle testing.

MS1 (M12): Five GAIA catalyst designs exceed 0.7 A/mg$_{Pt}$ and, after 30,000 voltage cycles, >40 m²/g$_{Pt}$ ECSA in RDE. A further catalyst reaches 0.89 A/mg$_{Pt}$ in an MEA (0.9 VIR free).

MS3 (M18): In a GAIA 10-cell short stack, GAIA GEN1 CCMs achieved the project intermediate performance target of 1.5 W/cm² at 0.6 V, at EU reference conditions.