ARTEMIS

Automotive PEMFC Range Extender with High Temperature Improved MEAs and Stacks

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications
START & END DATE	1 Oct. 2012 - 31 Dec. 2015
TOTAL BUDGET	€ 2,822,692.00
FCH JU CONTRIBUTION	€ 1,747,884.00
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Centre National de la Recherche Scientifique (CNRS)

Partners: Commissariat à l'Energie Atomique et aux Energies Renouvelables (CEA), Nedstack, Fundaçion Cidetec, Centro Ricerche FIAT (CRF), Politecnico di Torino (PDT)

PROJECT WEBSITE/URL

http://www.artemis-htpem.eu/

PROJECT CONTACT INFORMATION

Deborah Jones
Deborah.Jones@umontpellier.fr

MAIN OBJECTIVES OF THE PROJECT

The purpose of ARTEMIS is to develop and optimise alternative materials for a new generation of European MEAs to be integrated into a high temperature PEMFC stack. The MEAs will be based on novel acid doped polybenzimidazole type membranes and improved catalytic layers providing low catalyst loading and high efficiency at high temperature as well as a high tolerance to pollutants (CO, H2S). Modelling tools will help to the understanding of degradation mechanisms and failure modes and will lead to increased durability and lifetime of the system.

PROGRESS/RESULTS TO-DATE

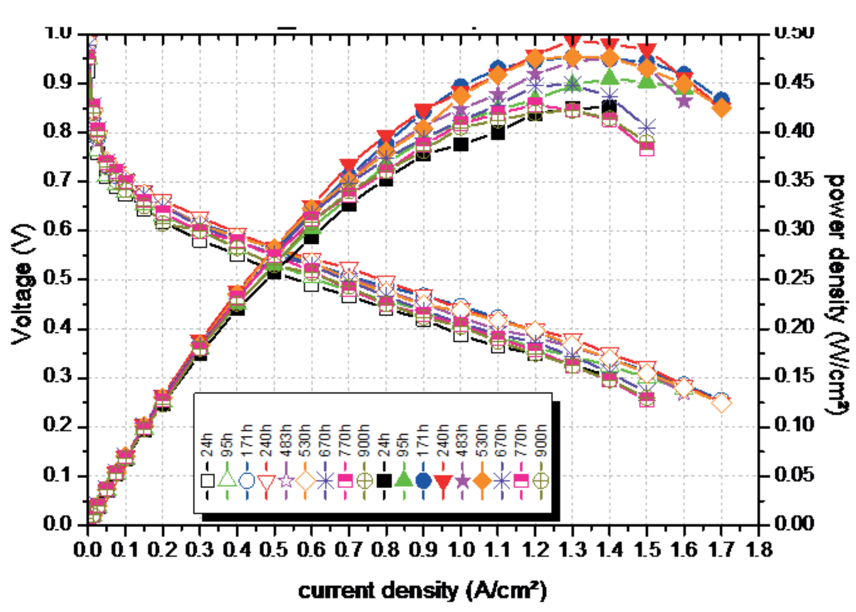
- Membrane conductivity of 0.15 S/cm at 140°C, ambient pressure, no humidification; final membrane generation delivered comprising polymer cross-linking and membrane reinforcement
- Anode catalysts undergoing scale-up
- Power density of 0.49 W/cm^2 at 1 A/cm^2 with MEAs comprising project membrane and project GDEs
- Plate materials stable in high temperature phosphoric acid environment and applied voltage relevant to operation conditions
- Modelling tools have provided input to the catalyst layer structure and acid loss mitigation strategies

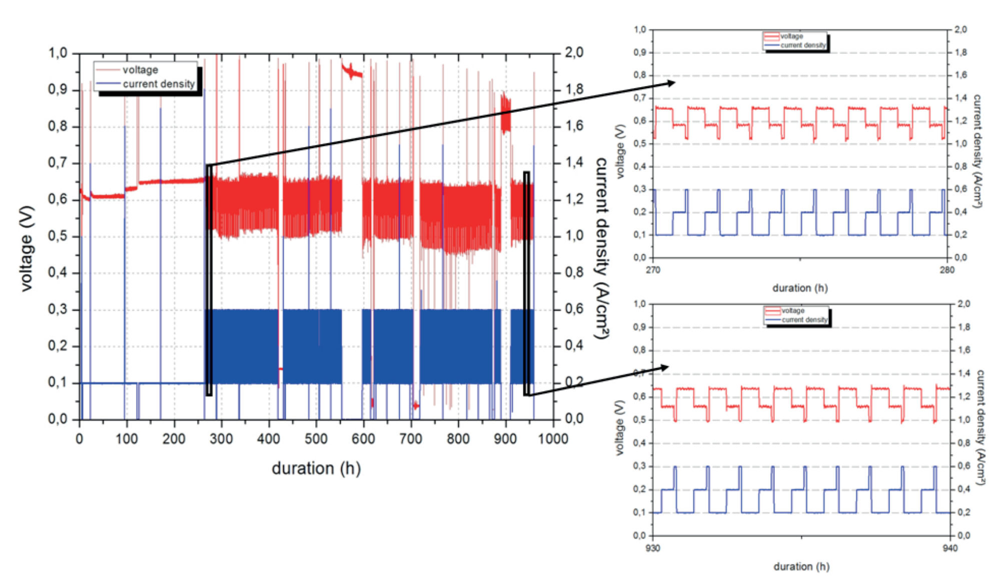
FUTURE STEPS

- Complete on-going validation of MEA technology at large single cell level
- Supply of components for 0.3 kW stack and 0.3 kW stack build and test
- Complete upscale of anode catalysts and finalise activities on cathode catalyst
- ARTEMIS workshop on HT-PEMFC science and technology
- Larger scale stack build and test

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Results on project MEAs comprising project membranes and project electrodes at 25 and 50 cm^2 level are excellent (0.49 W/cm^2 @ 1A/cm^2) and surpass targets.
- Results on project MEAs provide >20% power density gain over international state of the art with membrane and GDEs from the project, and >13% with a mixture (50/50 wt%) of project catalyst and commercial catalyst on the anode side and project cathode GDE (0.45 W/cm^2 @ 1A/cm^2)
- New virtual methodology has been developed to simulate the range extender vehicle applications in particular using HT-PEMFC technology
- Project MEAs have been operated using a range extender protocol for close to1000 h, validating HT-PEMFC as a viable technology for automotive range extender application.





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	New materials for high temperature MEAs a	Component dependent	Activity, stability	Two components satisfy final targets
MAIP 2008-2013	2014 target high temperature operation	Operation @ 130 °C and beyond	Operate @ 160 and 180 °C	Materials operate 130 - 180 °C
AIP 2011	MEA power density	First generation MEA performance; 0.3 W/cm^2	0.35 -0. 4 W/cm^2 achieved @ 1 A/cm^2	0.49 W/cm^2 achieved @ 1 A/cm^2
AIP 2011	Membrane conductivity	Conductivity >0.1 S/cm @ operation temperature	0.15 S/cm at 140 °C	0.15 S/cm at 140 °C, ambient pressure, no humidification

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

AutoStack-CORE

Automotive Fuel Cell Stack Cluster Initiative for Europe II

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.2: Next Generation European Automotive Stack
START & END DATE	01 May 2013 - 30 Aug. 2016
TOTAL BUDGET	€ 14,715,529.60
FCH JU CONTRIBUTION	€ 7,757,273
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)

Partners: Belenos Clean Power Holding, BMW AG, Commisariat à l'énergie atomique et aux énergies alternatives (CEA), Reinz Dichtungs GmbH, European Commission Driectorate Joint Research Centre(JRC-IET), Freudenberg Fuel Cell Components Technologies (FFCCT), Paul Scherrer Institut (PSI), Powercell Sweden AG, Solvicore, Symbio FCell, Volkswagen AG, VOLVO

PROJECT WEBSITE/URL

http://autostack.zsw-bw.de

PROJECT CONTACT INFORMATION

Ludwig Jörissen
Ludwig.joerissen@zsw-bw.de

MAIN OBJECTIVES OF THE PROJECT

Development of an automotive PEM fuel cell stack fulfilling the specifications set out in the Auto-Stack Project (GA 245142) in three evolutions.

Evolutions 1 and 2 will be designed, built and tested in hardware, evolution 2 will be designed.

The stack and key components will be developed to automotive standards.

Component development will be done based on industrial manufacturing concepts.

Cost engineering is carried out, to make sure the design meets automotive cost targets.

PROGRESS/RESULTS TO-DATE

- Target specifications and design for evolution 1 stack and components established and validated
- Benchmark analysis confirming that specifications are state of the art and above
- 20 short stacks and 1 full sized stack assembled and tested for performance and endurance.
- 94 kW continuous power full size stack demonstrated
- Evolution 2 design underway.

FUTURE STEPS

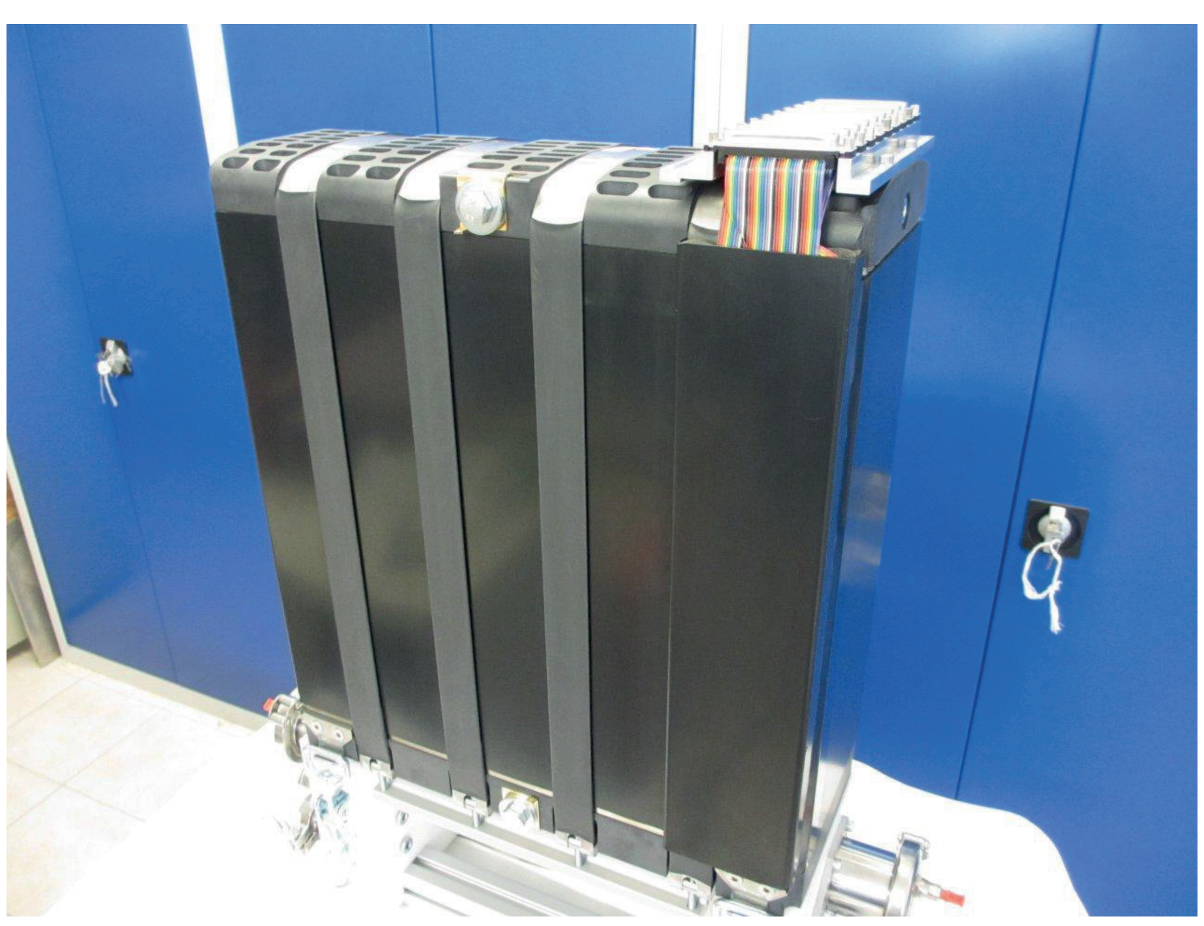
- Completion of evolution 2 design, increasing power density.
- Refinement of cost engineering based on evolution 2 design.
- Manufacturing and testing of evolution 2 design.
- Continuation of benchmark studies.
- Evolution 3 design documentation.

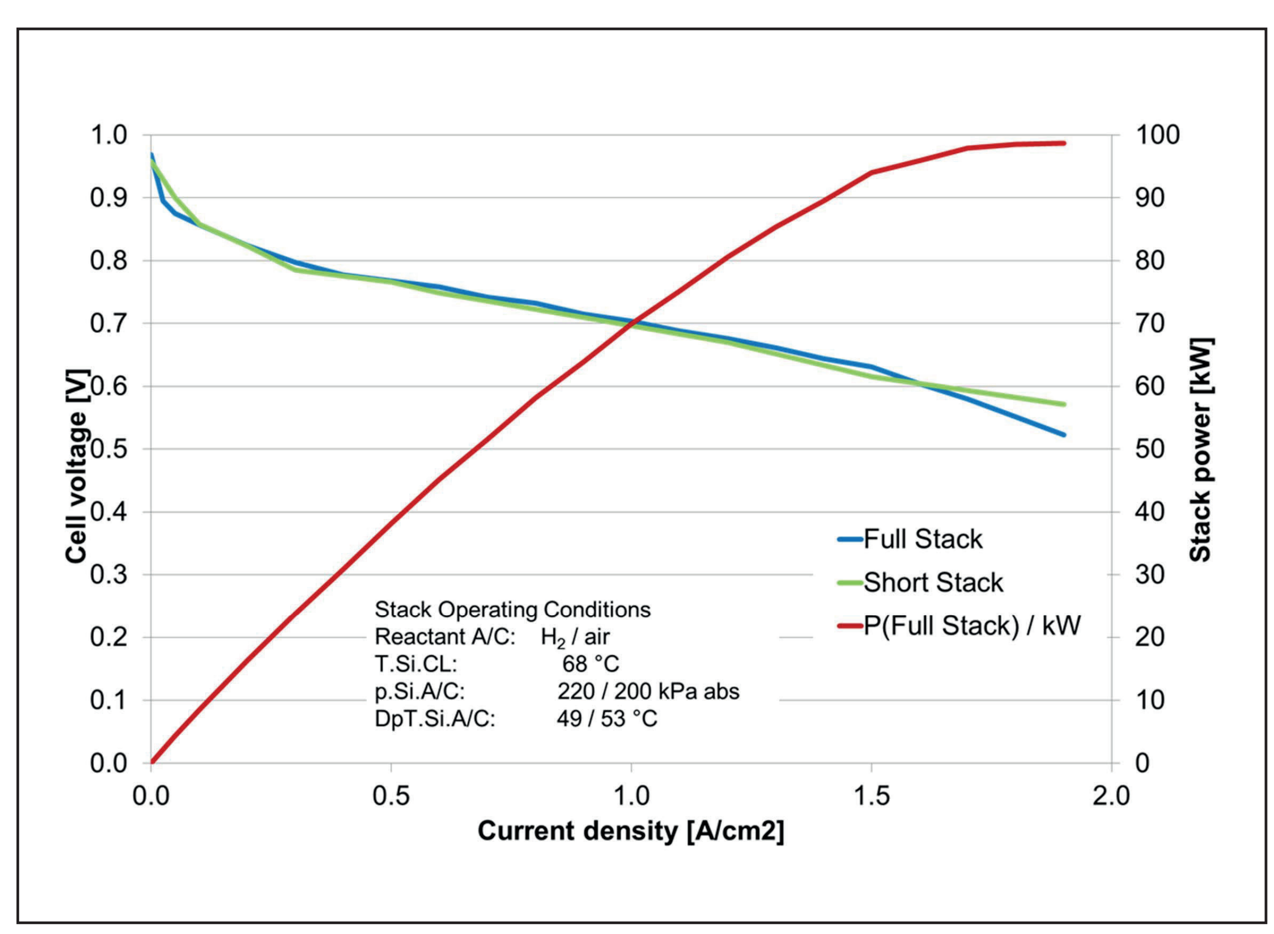
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Evolution 1 hardware successfully designed, built and tested as short and full sized stacks 2.0 kW•kg^{-1}, 2.7 kW•l^{-1}, 47.32 €•kW^{-1}
- Successful proof of concept.
- Design based on industrially validated materials and components.
- Optimization potential identified and used for evolution 2.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	e.g. FC system life time (h)	Integrate fragmented PEM stack research and development activities within Europe	Formation of a consortium of European key players from automotive industry, component manufacturers, stack integrators and research organizations	Consortium formed
AIP 2012	Development of a high power density automotive PEM fuel cell stack	Power 95 kW > 2 kW/kg > 2 kW/l > 5000 h	Final project objectives Power 95 kW 2.15 kW/kg 2.57 kW/l Degradation < 12 μV/h	Evolution 1 results Power 94 kW 2.03 kW/kg 2.7 kW/l Degradation 49.6 μV/h





CATAPULT

Novel Catalyst Structures Employing Pt at Ultra Low and Zero Loadings for Automotive MEAs

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START & END DATE	01 Jun. 2013 - 31 May 2016
TOTAL BUDGET	€ 4,678,599
FCH JU CONTRIBUTION	€ 2,255,690
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Montpellier

Partners: Johnson Matthey Fuel Cells Ltd, Volkswagen, Beneq, Technical University of Munich, Teknologian Tutkimuskeskus, Ulm University, PRETEXO

PROJECT WEBSITE/URL

http://www.catapult-fuelcells.eu

PROJECT CONTACT INFORMATION

Deborah Jones
Deborah.Jones@univ-montp2.fr

MAIN OBJECTIVES OF THE PROJECT

To develop ultra-low Pt loading MEAs using ultra-thin extended film coatings on novel nanostructured supports, and non-PGM catalysts and catalyst layers, to achieve platinum mass activity ≥ 0.44 A/mg Pt and platinum specific power density of ≤ 0.1 g/kW Pt, providing ≥ 2 kW/l in a short stack, demonstrated for complete MEAs on representative power train profiles.

PROGRESS/RESULTS TO-DATE

- Nanofibre supports and tie-layers developed using electrospinning and atomic layer deposition are corrosion-resistant, electronically conducting and scaleable
- Pt films deposited by atomic layer deposition on corrosion resistant fibrous supports display mass activity of 0.5 A/mg Pt.
- Novel non-PGM catalysts with ultra-low Pt content demonstrate high stability in MEAs
- Two patent filings and four journal publications
- Organisation of an international conference «Challenges towards Zero Platinum for Oxygen Reduction» 14-16 September 2015 www.efcd2015.eu, comprising a joint session with FCH-JU SmartCat, NanoCat and CathCat, and a satellite Fuel Cells Fundamentals Short Course on 13/09/2015.

FUTURE STEPS

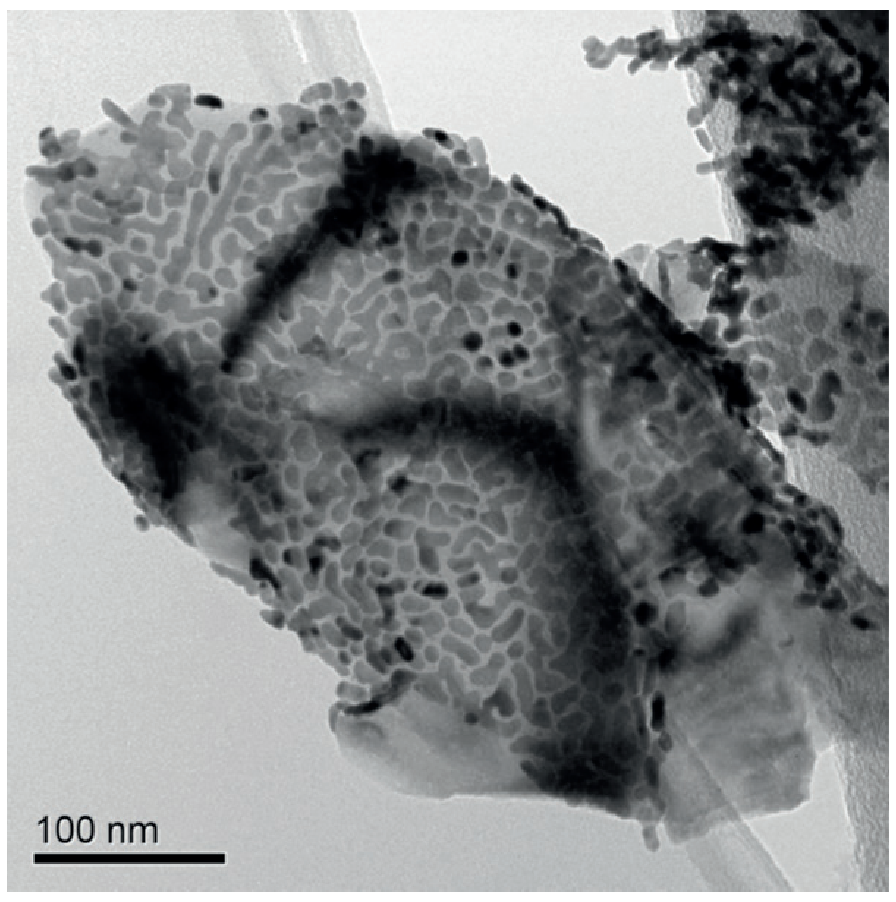
- Pursue process optimisation to obtain ultra-thin continuous Pt films on corrosion-resistant supports by atomic layer deposition and alternative, electrochemical deposition approaches
- Intensify efforts on MEA development and testing using nanofibre supported extended Pt films
- Develop stable hybrid PGM/non-PGM catalysts using most active non-PGM catalysts and initiate catalyst layer optimisation for non-PGM catalyst systems
- Determine structure—reactivity relation of the ORR on low index Pt surfaces using molecular dynamics calculations and pursue development of a voltage breakdown tool
- Evaluate MEAs in larger cell areas and undertake techno-economic assessment

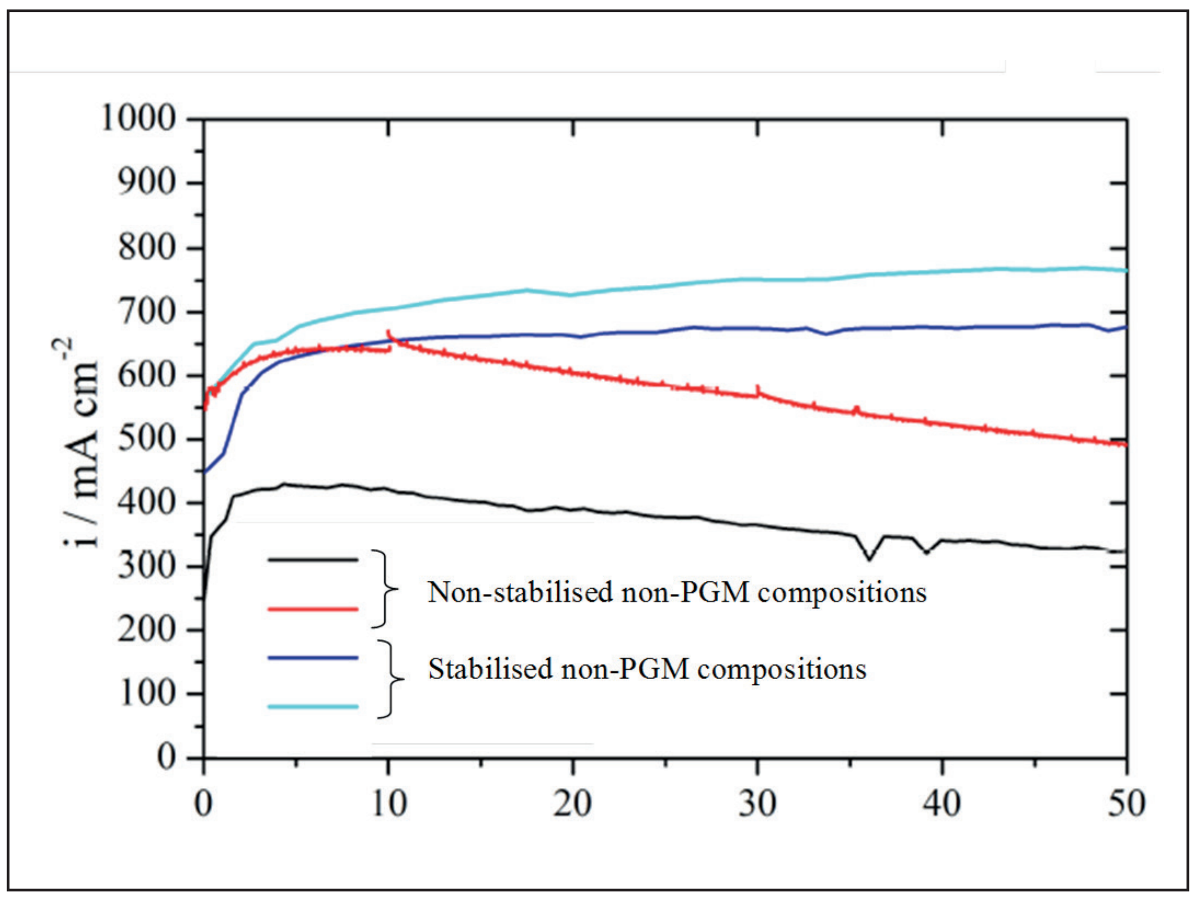
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- CATAPULT is a very ambitious project covering development of novel nanostructured architectures for fuel cell catalyst materials with extremely challenging technical targets for the new materials and MEAs, as well as a level of scale-up.
- CATAPULT achieved its final mass activity target for nanofibre supported extended Pt films in ex situ electrochemical measurements by the project mid-term stage
- Current focus is on the further challenges presented by catalyst layer development from nanofibre supported extended Pt films to also achieve this target with MEAs
- Focus is also on use of alternative tie-layer compositions favouring Pt deposition as ultra-thin films
- A means to stabilise highly active non-PGM catalysts against voltage loss with time shows high promise for future development

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	FC system life time (h)	>5,000	1000 h (accelerated protocol)	Planned in Project Year 3
AIP 2012	Pt specific power density (g/kW)	<0.1	Mass activity 0.44 A/mg Pt	Mass activity 0.5 A/mg Pt with nanofibre supported extended Pt films
AIP 2012	MEA power density	≥ 1.0 W/cm^2 at 0.67 V	≥ 1.0 W/cm^2 at 0.67 V	Too early to assess





FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

CATHCAT

Novel Catalyst Materials for the Cathode Side of MEAs Suitable for Transportation Applications

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.5 & SP1-JTI-FCH.2011.1.6: Next generation European MEAs for transportation applications
START & END DATE	01 Jan. 2013 - 31 Dec. 2015
TOTAL BUDGET	€ 3,088,327.80
FCH JU CONTRIBUTION	€ 1,895,862.00
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: TU München

Partners: JRC, Université de Poitiers, Danmarks Tekniske Universitet, Chalmers UT, University of Padova, Ion Power, Forth Institute, Toyota Motor Europe

PROJECT WEBSITE/URL

Cathcat.eu

PROJECT CONTACT INFORMATION

Oliver Schneider
oliver_m.schneider@tum.de

MAIN OBJECTIVES OF THE PROJECT

Development of improved MEAs for low and intermediate temperature PEM, based on binary alloy catalysts with reduced Pt loading for the oxygen reduction reaction (ORR), and advanced carbon and oxide-based support materials. DFT calculations suggested a range of Pt and Pd – Rare Earth Element alloy compositions to be studied. Bulk analogues of those were to be manufactured and tested. Good performing materials are produced as catalyst nanoparticles. Synthesis of promising catalysts is up-scaled and integrated with advanced supports into MEAs for single cell testing. Both MEAs based on Nafion and on high temperature polymer electrolytes are applied.

PROGRESS/RESULTS TO-DATE

- Theoretical studies for all Pt-RE alloys of interest were carried out and validated with experimental studies on polycrystalline Pt-RE alloys, indicating that Pt_5Gd represents the best comprise between activity and durability, and outperforms Pt by a factor of 5.
- Pt-Gd nanoparticles are 3.6 times more active than Pt nanoparticles, from RDE tests a current density of 0.8 – 1.4 A cm^2 at a voltage of 0.9 V can be extrapolated.
- Chemical reduction, reduction in solid state at elevated temperatures and electrochemical deposition were explored to fabricated Pt-RE nanoparticles. Chemical reduction enabled RE-NP formation, but alloy formation was not successful. Solid state reduction resulted in partial formation of Pt-Y- alloy nanoparticles showing electrochemical performance exceeding a benchmark catalyst. Electrochemical deposition from ionic liquids and organic solvents enabled RE metal deposition.
- Modified supported materials have been developed and are now being upscaled for MEA testing with Pt catalyst
- First CathCat catalyst tested in single cell MEA

FUTURE STEPS

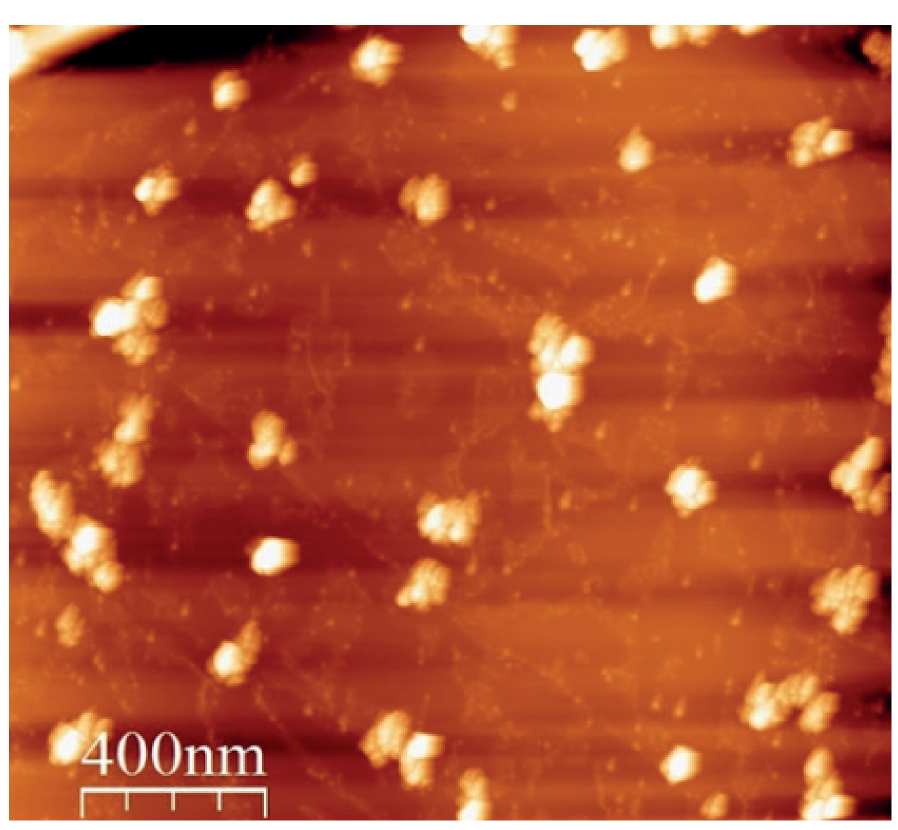
- Upscaling of Pt-Y alloy catalyst for MEA fabrication and subsequent testing
- MEA testing of Pt on NMC support and Pt/doped TiO_2-C support.
- Pt-RE NP preparation from ionic liquids/organic solvents and testing in RDE and MEAs
- Completion of studies on model alloys using nanoplasmonic sensing and scanning probe microscopy techniques

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Pt –rare earth alloys represent a group of improved catalysts permitting a reduction of noble metal content of MEAs by a factor of 4-5.
- Modified support materials can cause a further increase in catalytic activity
- Pt-rare earth nanoparticles show the maximum mass activity at larger particle diameter reducing problems with agglomeration
- DFT calculations can serve as a guide for the development of new catalyst materials
- Preparation of these alloys in nanoparticulate form by non-vacuum based methods successful, but not trivial

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
AIP 2011	Pt loading	<0.15g/kW	<0.1 g/kW	0.4 g/kW (0.4 mg/cm^2)
AIP 2011	BOL efficiency	>55%	>55%	56% at 1 A cm^{-2}; 50% @ 1.5 A cm^{-2}
AIP 2011	BOL Power	>1 W cm^{-2} @ 1.5 A cm^{-2}	>>1 W cm^{-2} @ 1.5 A cm^{-2}	0.9 W cm^{-2} @ 1.5 A cm^{-2}
MAIP 2008-2013	Life Time	>5000h	>5000h	N/A (test not finalized)



COBRA

Coatings for Bipolar Plates

AIP / APPLICATION AREA	AIP 2013 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SPI-JTI-FCH.2013.1.2: Research & Development on Bipolar Plates for PEM fuel cells
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 3,809,234
FCH JU CONTRIBUTION	€ 2,339,595
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: BORIT, IMPACT COATINGS, SFC, CIDETEC, INSA LYON

PROJECT WEBSITE/URL

www.cobra-fuelcell.eu

PROJECT CONTACT INFORMATION

Gilles Moreau
Gilles.moreau1@cea.fr

MAIN OBJECTIVES OF THE PROJECT

The COBRA proposal aims to develop best-of-its-class bipolar plates for automotive stacks with superior corrosion resistance (corrosion <1µA/cm²), higher conductivity (<25mOhm.cm²) and durability (>5000h) while meeting commercial target cost (price <2,5€/kW). The project has a multidisciplinary character which implies joint efforts of specialists from various areas: chemistry, physics, material science, fuel cell engineering. Thus the COBRA consortium combines the collective expertise of bipolar plate and coating suppliers, system integrators and research institutes and thus removes critical disconnects between stakeholders.

PROGRESS/RESULTS TO-DATE

- Reference plates have been manufactured and tested on field in automotive and marine conditions.
- A complete post-mortem analysis has been done allowing new observations and understandings on corrosion topic.
- A model of Fuel Cells and Bipolar Plates ageing has been improved including corrosion behaviour.
- First coatings developments are on-going, with first results being very promising.

FUTURE STEPS

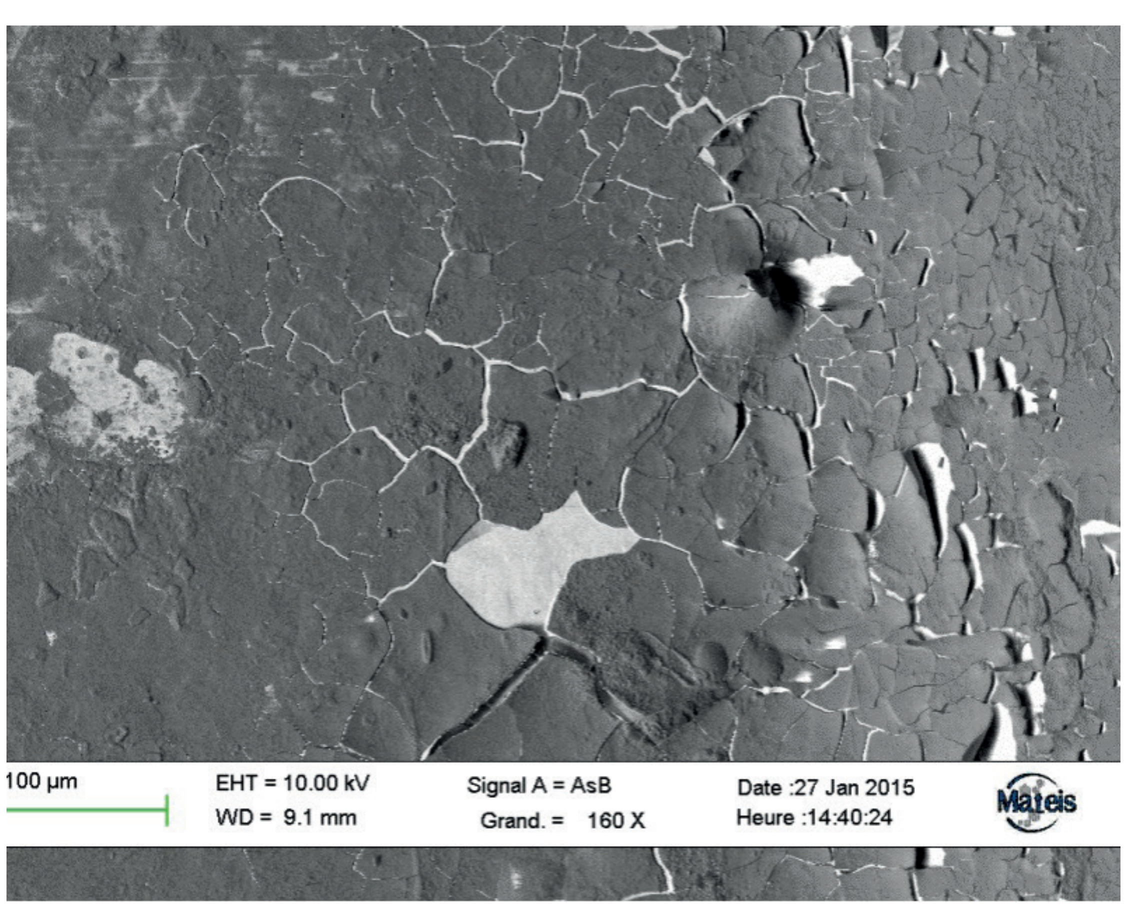
- Innovative manufacturing process and coatings will be further developed.
- As soon as the best coatings are defined, new plates will be manufactured
- New stacks, including innovative coatings, will be tested on-field in same conditions has references plates.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Corrosion mechanisms understanding
- Ageing tests developments
- Innovative coatings developments
- Innovative coatings commercialization

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Durability (h)	>5,000	>5,000	N/A (test not finalized)
AIP 2013	Corrosion, anode (µA/cm2)	<10	<10	N/A (test on-going)
AIP 2013	Corrosion, cathode (µA/cm2)	<10	<10	0,77 (in FC conditions – to be compared to gold value: 0.72)
AIP 2013	Areal specific resistance (mΩ.cm2)	<25	<25	11
AIP 2013	Cost (for a production of 500.000 units)	<2,5€/kW	<2,5€/kW	N/A (study not finalized)



COPERNIC

Cost & Performances Improvement for CGH2 Composite Tanks

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.3: Compressed hydrogen on board storage (CGH2)
START & END DATE	01 Jun. 2013 - 31 May 2016
TOTAL BUDGET	€ 3,445,217
FCH JU CONTRIBUTION	€ 2,005,396
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: RAIGI, SymbioFCell, Wroclaw University of Technology, Seifert & Skinner & Associates, H2LOGIC, ANLEG

PROJECT WEBSITE/URL

http://project-copernic.com/

PROJECT CONTACT INFORMATION

Fabien NONY
fabien.nony@cea.fr

MAIN OBJECTIVES OF THE PROJECT

The tank systems are likely to be greatly improved by means of:

- Enhanced materials (resins, partial replacement of carbon fibre with cheaper carbon grades, inserts)
- Innovative components (all-in-one on-tank valve with built-in pressure regulation, design with reduced number of parts, improved metal forming process, on/off board structural health monitoring)
- Enhanced composite design (less C-fibre, improved geometries, weight and volume reduction, maximum performance translation from fibre to composite, minimum degradation through processing)
- Improved composite quality (tank performance repeatability, porosity, ply thickness, reduced discrepancies between calculated and manufactured structures, quality control)
- Higher manufacturing process control and productivity (automation, improved winding numerical control)

PROGRESS/RESULTS TO-DATE

- Performance indicators defined and used for trade-off assessment and choice of alternative materials (fibre, resin)
- Improved low and high temperature behaviour of COPV (extreme temperature pressure cyclic test)
- Alternative pressure vessel geometries identified and benefit assessed compared SoA
- Optimized equipment configuration and winding patterns for fast robotic filament winding realised
- Integration of optical fiber based Structural Health Monitoring system with COPV (monitoring of manufacturing process, proof test)

FUTURE STEPS

- Conclusion on enhanced materials characterization
- Validation of optimized composite architecture and operational performance of COPV
- Conclude on multiscale model approach benefit compared to SoA
- Qualification of fully integrated on-tank-valve
- Validation of SHM system during COPV operation (cycling test)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Significant improvements of COPV manufacturing are feasible
- 15% Carbon Fiber weight reduction is achieved
- Benefit of SHM through whole product life (from manufacturing to end of life) is under assessment
- Extensive cost/performance assessment methodology developed and applied to the project with respect to SoA and Specifications

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Design and test criteria for high-pressure composite		Contribution to the advancement of relevant test methods by generation of accurate data material and processes sensitivity to tank performance and safety.	• Improvement of low and high temperature behaviour of COPV (extreme temperature pressure cyclic test). • Fulfilling of EC79 requirements for a chemical exposure test. • Monitoring strategies applied on COPV during testing to generate accurate data on materials and design behaviour • Identification and quantification of temperature increase inside COPV during extreme temperature cycling => potential feedback to Standard WG
AIP 2012	Development activities on materials		Assess alternative materials with the target to improve performance/cost ratio	• First choice of alternative materials selected • Vessels manufactured for alternative resin and fiber candidates. Behaviour is under characterization.
AIP 2012	Lower cost production processes		Assess manufacturing technology improvement strategies Reduce cost of metal bosses by a factor of 5	• Ongoing comparative assessment of conventional Vs. innovative winding technologies • Filament winding equipment upgraded and manufacturing cycle time reduction achieved • alternative boss manufacturing process under assessment. Optimization of boss design is ongoing in parallel to maximize performance/cost ratio and implement manufacturing process constraints
AIP 2012	Improved complete tank systems and related components characterised by reduced weight and volume. Pressure regulators, valves, sealing...	Gravimetric system density>4.8	• Improved composite designs for 15% weight savings • Increased gravimetric storage density system >4.8%wt • 20-30% cost reduction for innovative pressure components	• Improved design with >15% carbon fiber weight savings achieved • 5%wt achieved at tank level (37L@70MPa, still under optimization) • 4,4%wt achieved on system level (37L@70MPa, without Copernic OTV results) • Material characterization for improved hydrogen tightness • GHR exited the project at M18. Entrance of ANLEG is under validation by FCH to take over pressure component activities • OTV design defined. Waiting for FCH process validation to start the testing. Design compatible with targets.
AIP 2012	On- or off-board diagnosis systems for containers		Develop and assess non-destructive evaluation methods for structural health monitoring of COPV	Integration of SHM system during a high-pressure composite vessel manufacturing process (in order to control & improve it) and next use for monitoring of COPV integrity during proof test and regular operation (inspection of composite degradation during pressure loading: cyclic and static).

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

IMMEDIATE

Innovative Automotive MEA Development – Implementation of IPHE-GENIE Achievements Targeted at Excellence

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation application
START & END DATE	01 Jan. 2013 - 31 Mar. 2016
TOTAL BUDGET	€ 3,685,553
FCH JU CONTRIBUTION	€ 2,087,390
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: IRD Fuel Cells A/S

Partners: ICPF, CNRS, FUMA-TECH, SHANGHAI JIAO TONG UNIVERSITY, VOLVO TECHNOLOGY, SGL CARBON, JRC, Imerys Graphite & Carbon.

PROJECT WEBSITE/URL

www.immediate.ird.dk

PROJECT CONTACT INFORMATION

Madeleine Odgaard
mod@ird-fuelcell.com

MAIN OBJECTIVES OF THE PROJECT

The overall objective of the IMMEDIATE project is to develop a medium temperature PEM MEA °C that will fulfil the OEM requirements with respect to cost, performance and durability. The prime focus of Immediate to develop MEAs aimed for transportation applications is through material R&D & process oPGMimization and to screen and test precursor materials such as ionomers, membranes, catalyst, catalyst supports and gas diffusion layers aiming to demonstrate an oPGMimized MEA and accomplish the target with performance > 1.0 W/cm^2 @ η_{El}> 55%, T≥95°C, RH≤30%, P≤1.5 bar (abs).

PROGRESS/RESULTS TO-DATE

1. A range of carbon supports with a variety of surface properties and oPGMimised mesoporosity have been developed
2. A range of 60wt% PGM/C catalyst fabricated and evaluated (activity, AST, MEA performance)
3. New cross-linkable ionomers based on PFSA polymer have been developed.
4. A route has been developed to incorporate radical scavenger/hydrogen peroxide degradation catalysts in the membrane
5. First steps towards an improved gas diffusion layer with enhanced conductivity and water retention were taken

FUTURE STEPS

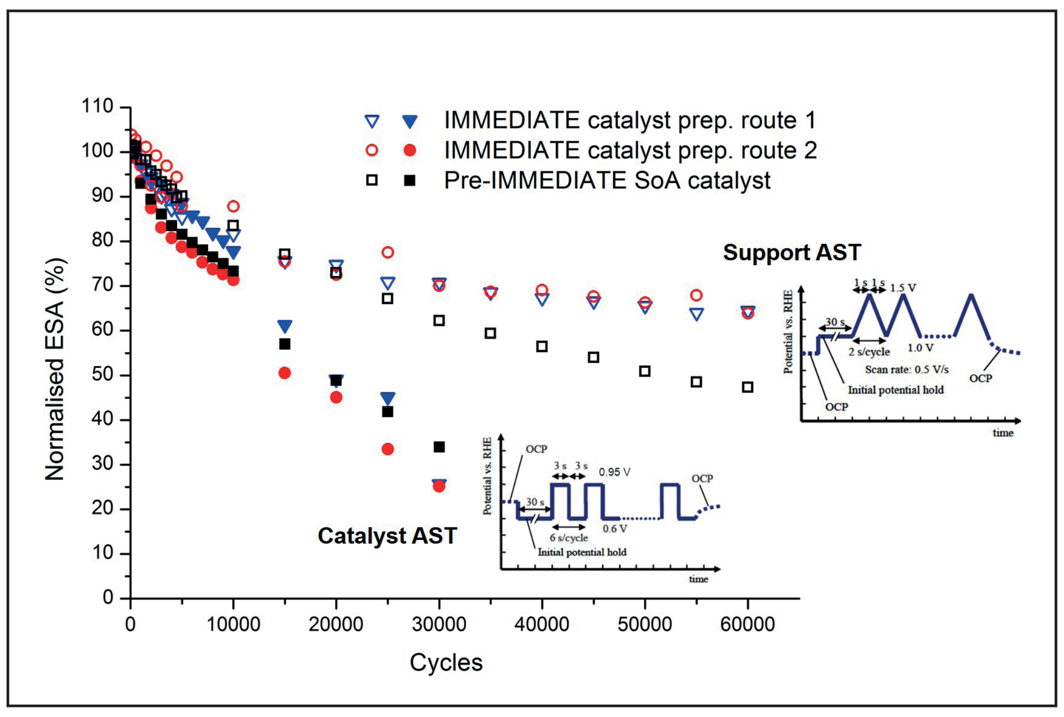
1. Development of low PGM MEA with developed catalyst and supports
2. Fabrication and validation of the developed MEA's in short stack
3. Demonstrate MEA performance > 1W/cm2
4. Reduce PGM content < 0.15 g/kW

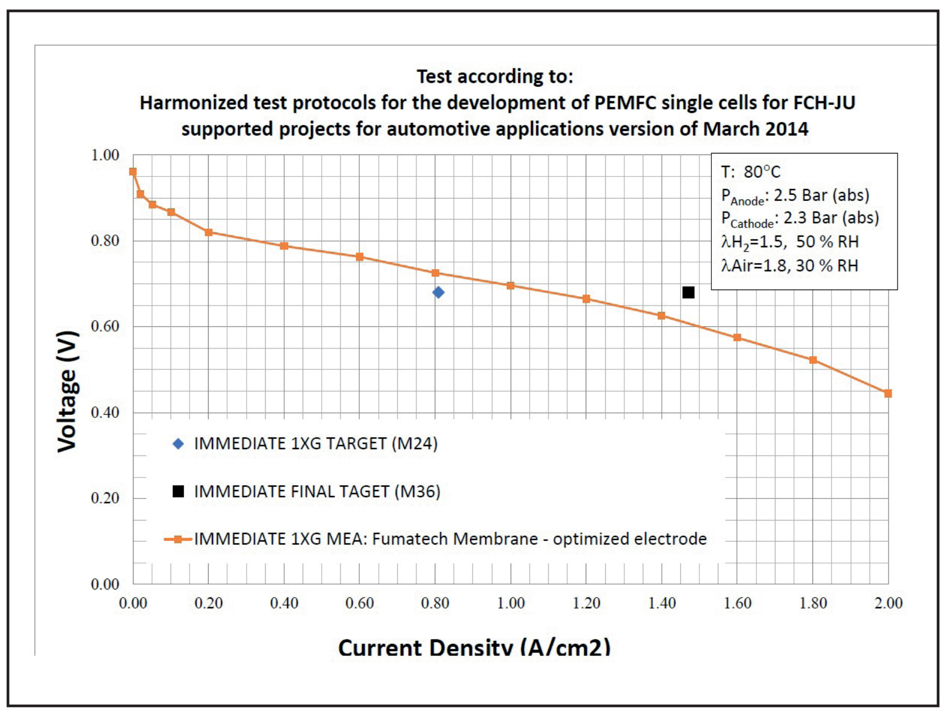
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

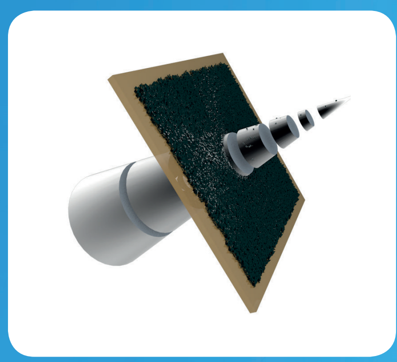
1. Through extensive characterisation as well as electrochemical screening of the various supports and catalysts, a synthesis methods have been developed and oPGMimised.
2. New membrane has been developed and demonstrated in single-cell test
3. Improved GDL has shown superior performance at low relative humidity
4. Performance > 0.75 W/cm2 of MEAs with improved electrodes resulted in reduced PGM-content from 0.9 g/kW to 0.45 g/kW

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	*Busses Vehicle* PEM-FC System:	<3,500€/kW	The overall aim is to develop Membrane Electrode Assemblies with significant specific cost reduction (i.e. cost/power) through development of processes and materials a) catalysts b) membrane and c) gas diffusion layers (GDLs). 2015 target: MEA with PGM-loading of < 0.15 g PGM/kW	MEA with <0.45 gPGM/kW
AIP 2011	2015: Membrane with proton conductivity ≥ 100mS/cm at ≤ 25% RH, 120°C	Membrane with proton conductivity of at least 0.1S/cm at 120°C & 25% RH	Membrane with proton conductivity of at least 0.1S/cm at 95°C & 25% RH	90 mS/cm at 100 °C and 50% RH
AIP 2011	2015: Membrane with thermal stability up to 160°C	Membrane with thermal stability up to 160°C	Membrane with thermal stability up to 120°C	Glass transition temperature *(Tg)* of 140–150 °C
AIP 2011	GDL with area conductivity (through plane) >2 S/cm at operating conditions	GDL with through plane conductivity >2 S/cm at nominal operating conditions	GDL with through plane conductivity >2 S/cm at nominal operating conditions	GDL with conductivity of 4.4 mOhm*cm2
AIP 2011	2015. MEA with PGM-loading of < 0.15 g PGM/kW	2015. MEA with PGM-loading of < 0.15 g PGM/kW	2015. MEA with PGM-loading of < 0.15 g PGM/kW	MEA with < 0.45 gPGM/kW
AIP 2011	MEA BOL of > 1.0 W/cm^2 @ U_{Cell}=0.68 V	MEA BOL of > 1.0 W/cm^2 @ U_{Cell}=0.68 V	MEA BOL of > 1.0 W/cm^2 @ U_{Cell}=0.68 V	MEA BOL of > 0.9 W/cm^2 @ U_{Cell}=0.68 V







IMPACT

Improved Lifetime of Automotive Application Fuel Cells with Ultra-Low Pt-Loading

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.6 Investigation of degradation phenomena SP1-JTI-FCH.2011.1.5 Next generation European MEAs for transportation applications
START & END DATE	01 Nov. 2012 - 31 Oct. 2016
TOTAL BUDGET	€ 9,144,498
FCH JU CONTRIBUTION	€ 3,902,403
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)

Partners: Commissariat à l'Energie Atomique (CEA), European Commission, Directora¬te-General Joint Research Centre, Institute for Energy (JRC-IE), Consiglio Nazionale delle Ricerche, Johnson Matthey Fuel Cells Limited, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), University of Applied Science Esslingen, TU Berlin, Institut National Polytechnique de Toulouse, Gwangju Institute of Science and Technology, Solvay Specialty Polymers Italy S.p.A.

PROJECT WEBSITE/URL

http://www.eu-project-impact.eu/

PROJECT CONTACT INFORMATION

Prof. Dr. K. Andreas Friedrich
Andreas.Friedrich@dlr.de

MAIN OBJECTIVES OF THE PROJECT

Identify the relevant degradation mechanisms of polymer electrolyte fuel cells at ultralow Pt content (< 0.2 mgcm-2) and derive mitigation strategies to obtain a lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 μVh-1, by material development, structural design of cells and materials, and integration of improvements into a best MEA. The results of the improved durability of the cell technology will be demonstrated in a relevant stack environment.

PROGRESS/RESULTS TO-DATE

- In-situ and ex-situ investigation of reference MEA
- In-situ and ex-situ investigation of improved MEAs (generation I – IV)
- Determination of reversible and permanent degradation in single cell and stack
- Locally resolved analysis of cell performance
- First stack durability tests ongoing

FUTURE STEPS

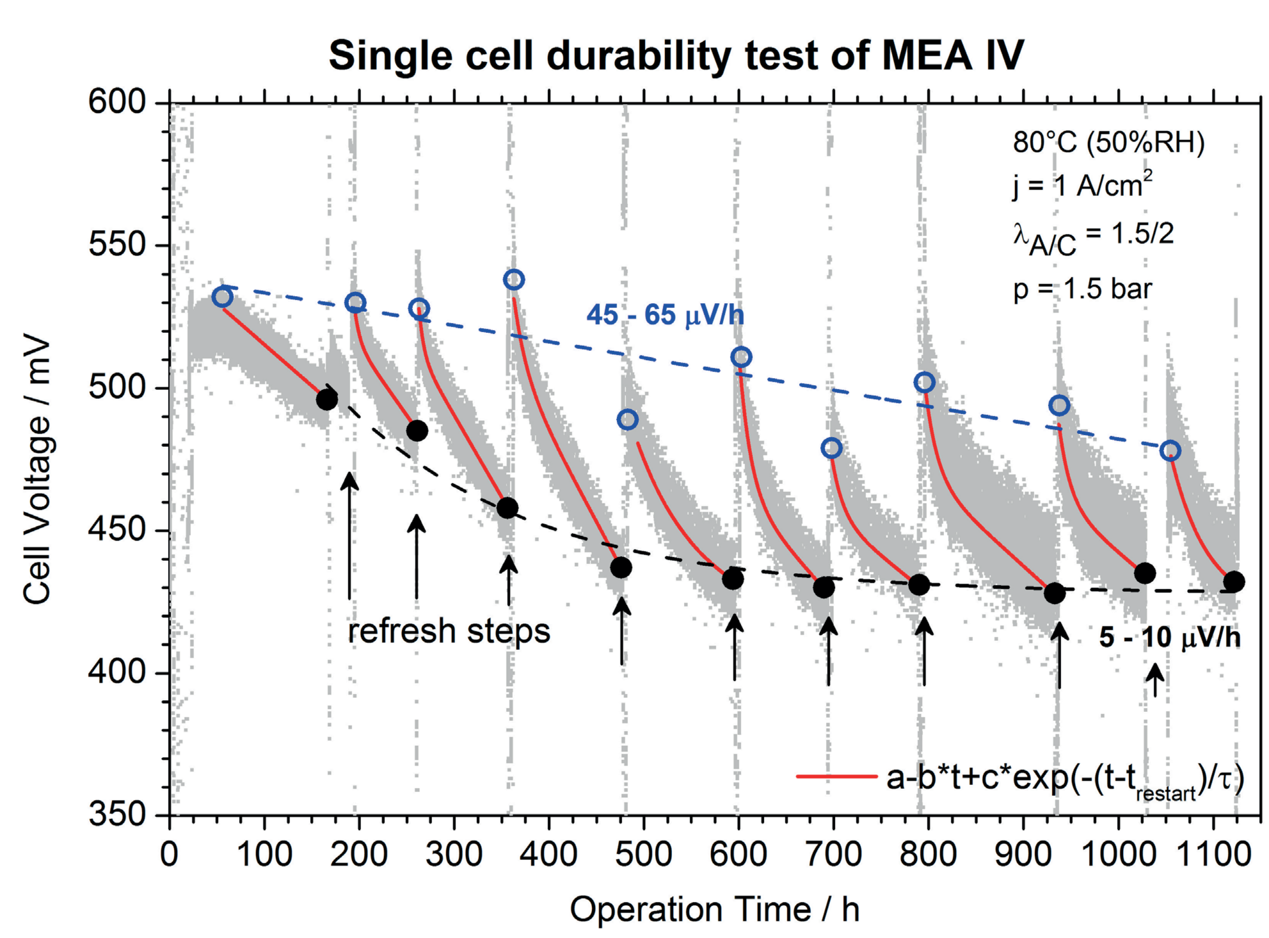
- Fabrication of next generation improved MEA
- Test of improved MEA in single cell and stack
- Selection of best materials for final MEA
- Start of final durability stack test (2500-5000 h)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Performance of 0.82 W/cm2 at 1.5 A/cm2 reached for overall Pt loading of 0.4 mg/cm2
- Performance of 0.57 W/cm2 at 1.5 A/cm2 reached for overall Pt loading of 0.25 mg/cm2
- For generation IV MEA (0.25 mgPt/cm2) irreversible degradation rate is ~10 – 65 μVh-1 Target cell performance durability (10 μVh-1 decay rate) will be probably reached in 2016

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Demonstration of long-term stability under automotive fuel cell conditions	lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 μVh-1,	lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 μVh-1,	test with >1000 h with regular refresh steps shows degradation rates of few tens of μVh-1 at
AIP 2011	Degradation	Irreversible and reversible degradation mechanism categorization	Irreversible and reversible degradation mechanism categorization	Methods to determine irreversible degradation rate and procedures for performance recovery analyzed
AIP 2011	MEA developement	Development of catalysts and electrode layers allowing for significant reduction in precious metal catalyst loadings	Pt loadings < 0.2 mgPt/cm2	Overall Pt loading of 0.25 mgPt/cm2 (anode+cathode)
AIP 2011	Development of durable ultra-low loaded MEAs for automotive applications	1 W/cm2 at 670mV (1.5 A/cm2) single cell performances	1 W/cm2 at 670mV (1.5 A/cm2) single cell performances	0.57 W/cm2 at 1.5 A/cm2 for Pt loading of 0.25 mgPt/cm2, 50%RH, stoich. 1.5/2, and 1.5 bara



IMPALA

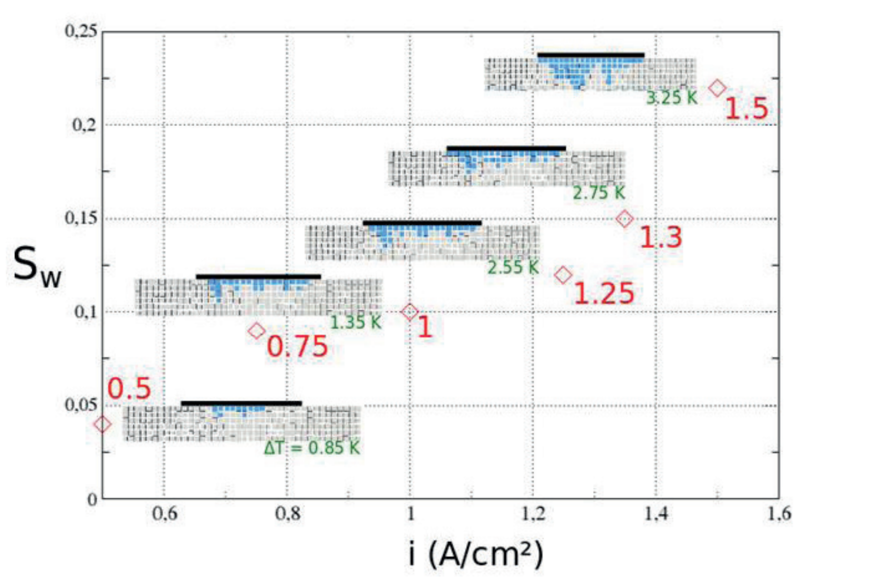
Improve PEMFC with Advanced Water Management and Gas Diffusion Layers for Automotive Application

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications
START & END DATE	01 Dec. 2012 - 30 Nov. 2015
TOTAL BUDGET	€ 5,081,586,8
FCH JU CONTRIBUTION	€ 2,640,535
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA (French Alternative Energies and Atomic Energy Commission)

Partners: DLR (Germany), PSI (Switzerland), JRC, (The Netherlands), INPT (France), SGL (Germany), NDSTK (The Netherlands)



Variation of overall water saturation as a function of current density for *RH* = 98% together with corresponding condensation invasion patterns (shown for *i* =0.5, 0.75, 1.25, 1.3 and 1.5 A/cm²). Each little square corresponds to a pore. Liquid phase in blue, gas phase in grey. The temperature difference across the GDL corresponding to the imposed current density is indicated for each pattern shown.

PROJECT WEBSITE/URL

www.impala-project.eu

PROJECT CONTACT INFORMATION

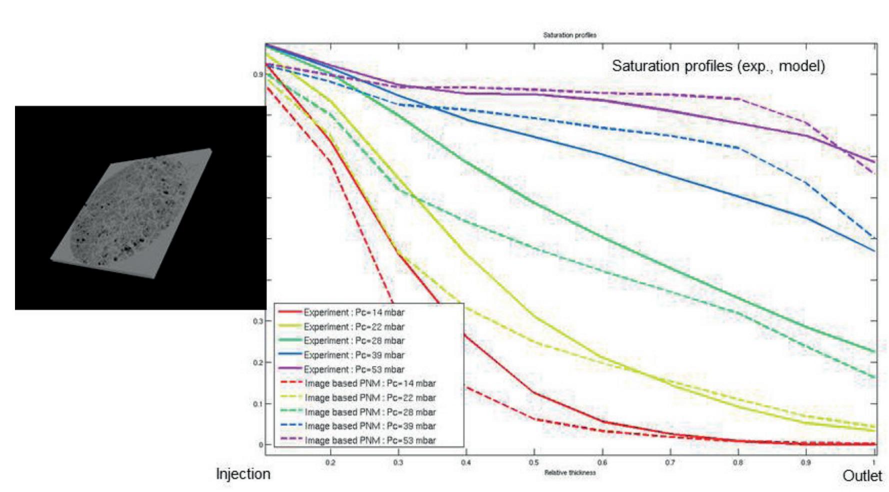
Joël Pauchet
joel.pauchet@cea.fr

MAIN OBJECTIVES OF THE PROJECT

The aim of IMPALA is to produce improved GDL to increase performance (up to 1 W/cm^2) of PEMFC by a twofold approach: a) modification of homogeneous GDL (MPL, wettability, additives...); b) development of innovative non-uniform GDL.

This technological work is supported by a deep water management analysis combining the most advanced two-phase models (Pore Network Modelling) and experimental diagnostics (X-Ray liquid visualisation). This will help better understand the link between GDL properties and performance and propose design recommendations.

The project is focused on automotive conditions but the improvements will be checked for different stack designs and back-up application.



Comparison between Pore Network Modeling and experimental X-Ray during a capillary pressure experiment; PNM is based on real 3D X-Ray images (left) and liquid saturation in the thickness of the GDL is compared (right) for increasing injection pressure (from red to purple) between experiments (continuous lines) and simulations by PNM (dashed lines)

PROGRESS/RESULTS TO-DATE

- First two targets have been reached by modifying GDL: reference/MEA Level 0 (0.75 W/cm^2) and MEA Level 1 (0.90 W/cm^2)
- Numerous modifications of GDL have been done: MPL, chemical grafting, structuration, combination of improvements...
- Pore Network Modelling of GDL has been improved: use of real 3D images, condensation effect
- Comparison has been done on two-phase pattern between PNM and X-Ray experiments

FUTURE STEPS

- Check increase of performance with improved GDL at stack level
- Introduce some last modifications of GDL and check (single-cell 25 cm^2) increase of performance
- Include in performance models some transfer properties from PNM (one-phase situation)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Performance has been increased by modifying properties of the backing and/or of the MPL of commercial reference GDL
- Final target (1W/cm^2) will most probably not be reached only by tuning the GDL properties but could be reached with a matching combination of improved membrane, electrodes, and GDL
- Improvements of GDL are not additive
- Pore Network Modelling of GDL has been improved: transfer properties based on real 3D images, condensation effect, successful comparison to X-Ray images of 3D liquid pattern
- Multiscale coupling of models in the case of two-phase flows inside the GDL is difficult and remains as a future step

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
AIP 2011	Increase of performance	Reach power density > 1 W/cm^2 at 1.5 A/cm^2 (BoL) and > 0.9 W/cm^2 at 1.4 A/cm^2 (EoL).	MEA Level 0: 0.75 W/cm^2 MEA Level 1: 0.9 W/cm^2 MEA Level 2: 1.0 W/cm^2 Operating conditions for automotive: H_2/air, gas hydration 50%, Stoe 1.2/2, 80°C, 1.5 bara	MEA Level 0 is reached MEA Level 1 is reached
AIP 2011	Improvement of material	Improve performance of ref GDL (SGL 24BC) at RH 20% for automotive operating conditions (see below)	Improve performance at standard automotive conditions (MEA Level 0-2) and check improvement at other conditions	Specific hydrophobic treatments can improve performance significantly at RH 20% or RH 100%, but not whatever the RH is. IMPALA#30 leads to lower increase of performance but for every RH.
		Conductivity > 2 S/cm (in-plane) and > 100 S/cm (through-plane)	Reduce through-plane resistance by 10%	Reached
AIP 2011	Durability	Demonstration of long term stability under automotive fuel cell conditions.	Verify that degradation rate of MEA Level 1 and 2 is not lower than the one of MEA Level 0 (ref)	Durability stack tests are planned in October/November 2015 with improved GDL.
AIP 2011	Industrialization	Optimization and demonstration of MEA processing at pilot scale based on these innovative GDL	Analyze the trade-off between increase of market thanks to improvement of performance, and new investments due to process modifications	This work has started in the frame of the cost analysis task
AIP 2011	Modeling	Development and improvement of multiscale and multiphenomena modelling tools for increased understanding of performance and degradation phenomena.	Pore Network Modeling (PNM): include condensation effect	Condensation has been included in PNM
			Performance modeling (PM) of MEA: improve predictability with better inputs (upscaling of PNM, experiments)	PM has been updated with more reliable properties of SGL24BC (from the project and literature). Active layer has been meshed to improve predictability. Inclusion of transfer properties of GDL from PNM is on-going (one-phase)
			3D tomography of liquid invasion during operation	3D images of liquid invasion have been obtained during capillary invasion and during operation
			Intensive characterization (modeling at pore scale, single and two-phase characterization) of GDL to propose more reliable inputs for performance models	Characterization of structural properties (geometry, pores, chemical structure), transport properties (electrical & thermal conductivity, diffusion, permeation) and two-phase properties. In-plane properties and inner surface wettability could not be characterized reliably.
			Comparison between models and experiments	Comparison between PNM and X-Ray liquid visualization has been done.
AIP 2011		Contribute to the development of European Industry solutions	Improve materials of SGL and PEMFC systems of NDSTK	SGL materials have been improved. Tests are planned at NDSTK

Nano-CAT

Development of Advanced Catalysts for PEMFC Automotive

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FHC.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START & END DATE	01 May 2013 - 30 Apr. 2016
TOTAL BUDGET	€ 4,394,330
FCH JU CONTRIBUTION	€ 2,418,439
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: DLR, Armines, Tecnalia, JRC, C-Tech, Nanocyl, Volvo

PROJECT WEBSITE/URL

http://nanocat-project.eu/

PROJECT CONTACT INFORMATION

Pierre-André JACQUES
pierre-andre.jacques@cea.fr

MAIN OBJECTIVES OF THE PROJECT

Nano-CAT aims at developing new catalysts to decrease the amount of Pt needed in PEMFC electrode. For that 2 routes are followed. One more fundamental dedicated to the synthesis of bio-inspired compound to produced Pt-free catalyst. A second, less risky, based on the deposition of Pt alloys on resistant supports (carbon nanotube and doped metal oxide). The MEA integrating the project catalysts are tested under conditions required for bus application.

PROGRESS/RESULTS TO-DATE

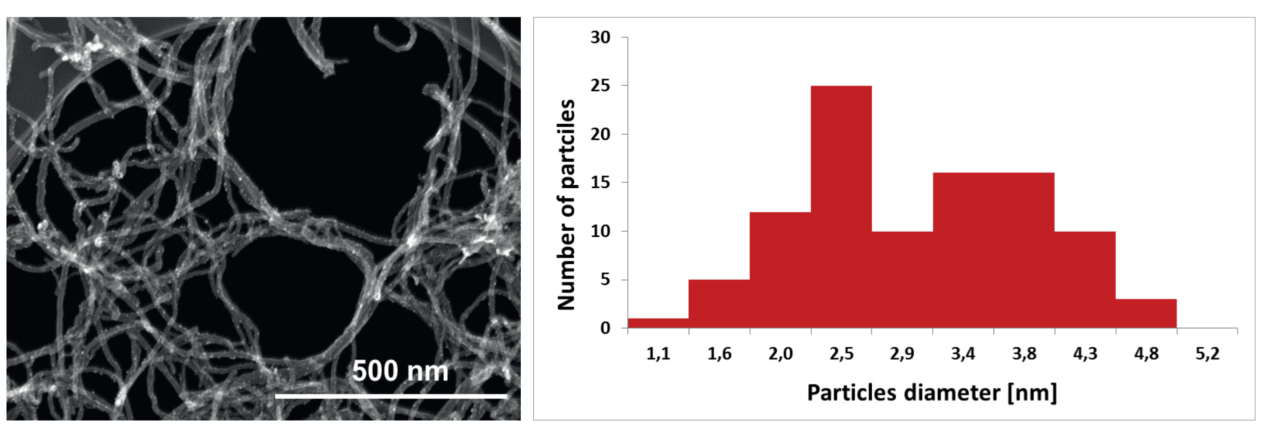
- 80 mV overvoltage for Pt catalyst for ORR (Vs Pt).
- 23 mA/mgPt @ 0.9 V/RHE with Pt3Co by Physical Vapor Deposition.
- Structuration of Pt alloy on Carbon NanoTubes.
- 0.22 gPt/kW @ 750 mw/cm^2

FUTURE STEPS

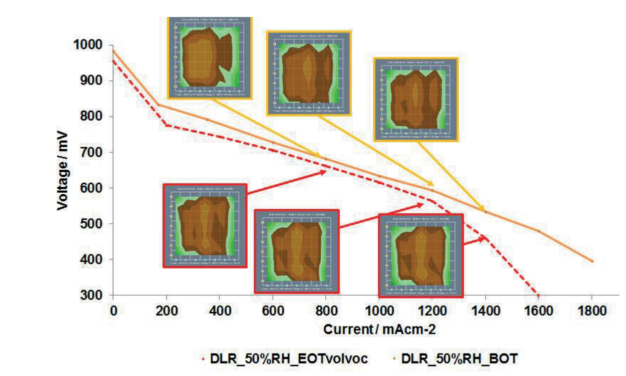
- Integration of Pt free catalyst in MEA and test in Single Cell
- Integration of catalyst supported on Carbon Nanotubes in MEA at anode and test in single Cell
- Test of reference catalysts using protocol for bus application in short stack.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

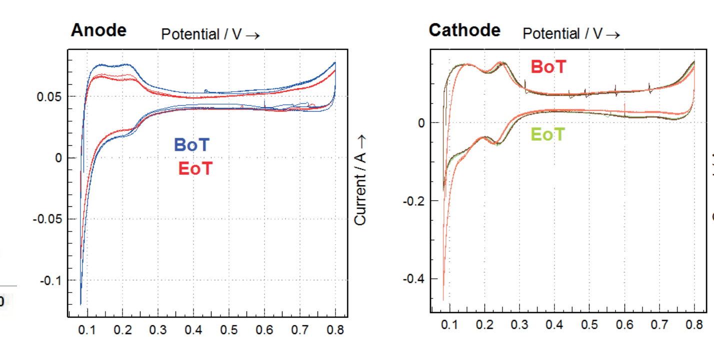
- Use of innovative catalyst and supports to reduce Pt loading and decrease degradation for buses application.



Pt on modifed CNT



Polarisation curves between BOT and EOT (300h) of the synthetic buse cycle
Degradation: 60 µV/h @ 1A/cm² reference MEA

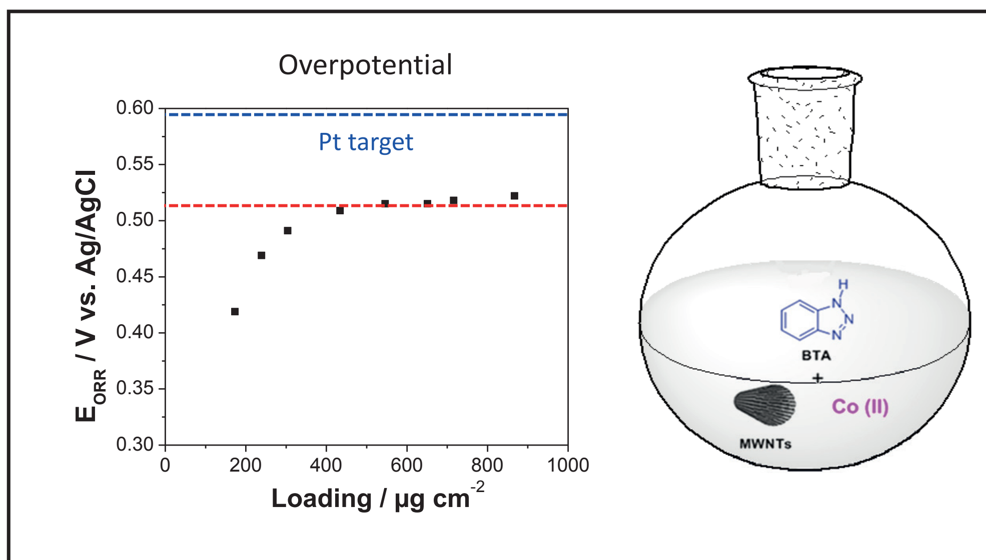


CVs on the anode and cathode at the BoT and EoT (300h), ECSA Changes: anode side (27%) cathode side (11%).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Reduce Pt cost in automotive PEMFC	< 0.1 gPt/kw	< 0.1 gPt/kW	0.22 gPt/kW
AIP 2012	Increase specific power for automotive PEMFC	1 W/cm^2 @ 1.5 A/cm^2	1 W/cm^2 @ 1.5 A/cm^2	750 mW/cm^2 @ 1.6 W/cm^2 (MEA 0.2 mgPt/cm^2) BoL.
AIP 2012	Increase lifetime of automotive PEMFC	h Lifetime: 5 000 hrs	10% loss after 5000 hours	53 µV/h @ 1 A/cm^2 on 300 hrs (aged with synthetic buses cycle) (MEA 0.6 mgPt/cm^2)

Metal oxyde characterisation as catalyst support



Ex situ characterisation of Pt free catalyst for ORR

PHAEDRUS

High Pressure Hydrogen all Electrochemical Decentralized Refueling Station

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	"SP1-JTI-FCH.2011.1.8: Research & Development of 700 bar refuelling concepts & technologies"
START & END DATE	01 Nov. 2012 – 31 Oct. 2015
TOTAL BUDGET	€ 6,309,832
FCH JU CONTRIBUTION	€ 3,566,343
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Hydrogen Efficiency Technologies (Netherlands)

Partners: ITM power Limited (UK), H2 Logic (Denmark), Raufoss Fuel Systems (Norway), Daimler (Germany), Shell Global Solution (Netherlands), Bundesanstalt fuer Materialforschung und Pruefung (Germany), Association pour la recherche et le développement des méthodes et processus industriels – ARMINES (France), Hochschule Esslingen (Germany), Uniresearch (Netherlands).

PROJECT WEBSITE/URL

www.phaedrus-project.eu/

PROJECT CONTACT INFORMATION

Technical coordinator: Peter Bouwman peter.bouwman@hyet.nl
Project Management: Anna Molinari a.molinari@uniresearch.com

MAIN OBJECTIVES OF THE PROJECT

The project objective is to develop and validate a new concept for 70 MPa hydrogen refuelling retail stations enabling self-sustained infrastructure roll-out for early vehicle deployment volumes, showing the applicability of the novel electrochemical hydrogen compression technology in combination with a PEM electrolyser, storage units and dispensing system. A step change is expected in both the efficiency and cost of ownership of an integrated hydrogen refuelling system. The applicability will be demonstrated in a fuelling system producing 5 kg hydrogen per day, while a design is made for a fuelling system capable of producing 200 kg hydrogen per day.

PROGRESS/RESULTS TO-DATE

- Construction of electrolysis unit delivering 8MPa
- Construction electrochemical compression unit with new membrane capable of pressures exceeding 90MPa.
- Storage tank configuration mainly targeting medium (50 MPa) pressure and smaller capacity at high pressure (100 MPa)
- A dispensing system equipped with a pre-cooling unit, with a capacity of 5 kg/3 min enabling back-to-back refuelling

FUTURE STEPS

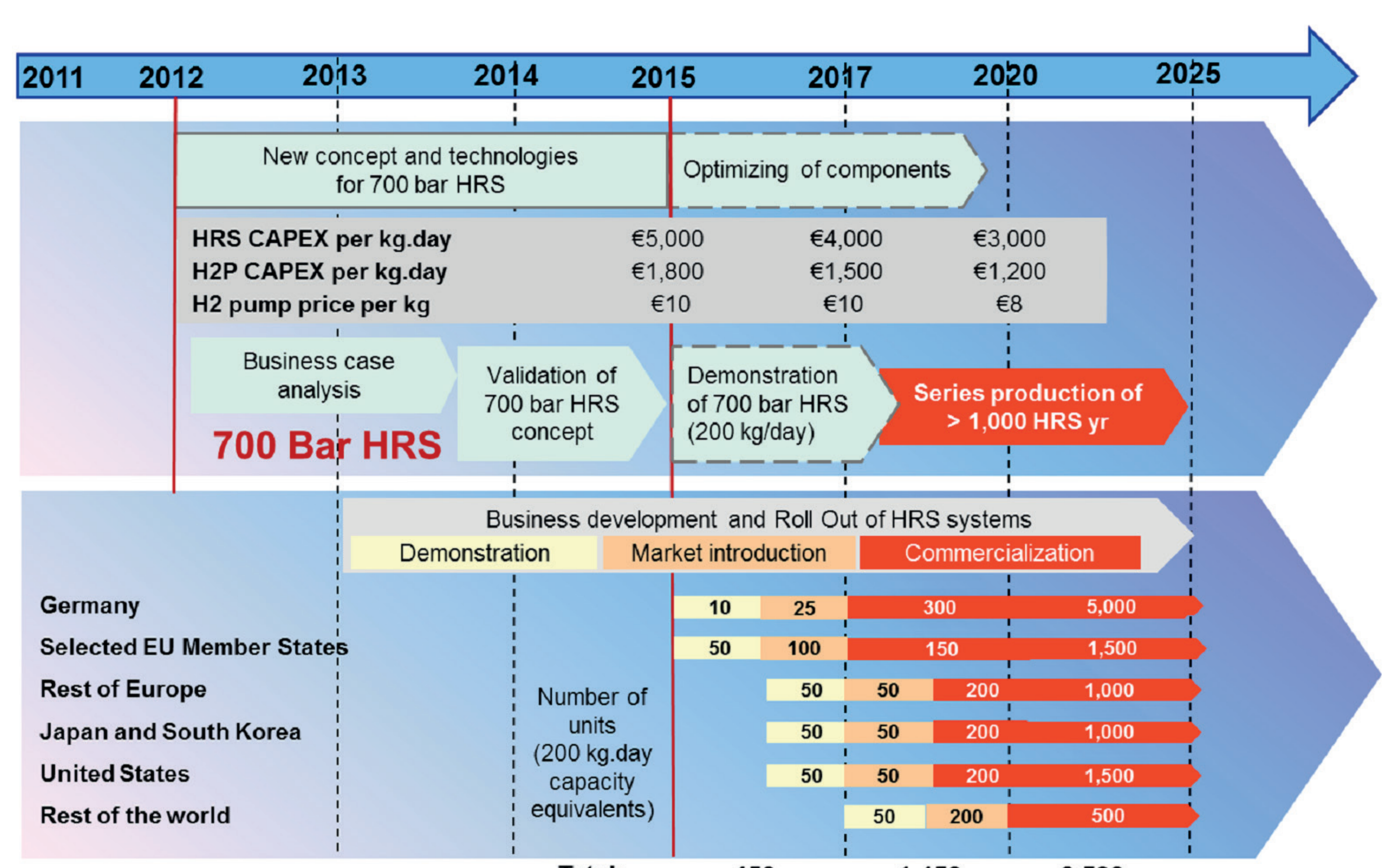
- Design 200 kg/day HRS based on new technology
- Integrate new technology into 5kg/day system
- Validate technology and cost efficiency improvement

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- New catalyst and membrane materials appear promising
- Model shows advantages of new system design, but significant costs are yet incurred due to multitude of state-of-art high pressure couplings, which are apparently still expensive specialty products.
- Measurement data being accumulated

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	HRS CAPEX (design 200kg/day)	2015 target: <1M€	Optimal system configuration with new technology	Model ready, accumulating data / awaiting system integration
MAIP 2008-2013	H2P CAPEX	2015: €3500 per Nm3/hr	Cost reduction and scalable design	Modular compression unit system, low membrane costs and catalyst loadings
AIP 2011	Optimisation of compression & storage systems with respect to cost, efficiency and capacity.	CAPEX and OPEX costs enabling self-sustained roll-out	Balance between component specifications in final system configuration	Components are being sized through modeling, tested separately anticipating integration, data being generated.
AIP 2011	Compliancy	SAE J2601, SAE J2799 and ISO 20100	Standardised compliance verification involving BAM evaluation	New SAE J2601refueling control system under development
AIP 2011	Hydrogen price	2015 target 10-15€/kg	Meeting target of 10€/kg	OPEX production/compression : €5.6/kg. Including depreciation and interest a price close to €10/kg



FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

PUMAMIND

Physical Bottom-Up Multiscale Modelling for Automotive PEMFC Innovative Performance and Durability Optimization

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.3 - Improvement of PEMFC performance and durability through multi-scale modelling and numerical simulation
START & END DATE	17 Dec. 2012 - 16 Dec. 2015
TOTAL BUDGET	€ 4,092,629.69
FCH JU CONTRIBUTION	€ 2,294,106
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: ENSL, LRCS, DLR, HSO, JRC, CSIC, UNISA, VODERA, SFU, IDIADA

PROJECT WEBSITE/URL

www.pumamind.eu

PROJECT CONTACT INFORMATION

Pascal Schott and Manuelle Quinaud
Pascal.schott@cea.fr , Manuelle.quinaud@cea.fr

MAIN OBJECTIVES OF THE PROJECT

In order to improve the PEMFCs systems durability, efficiency and to decrease the cost, time ofdevelopment, design of new diagnostic tools is crucial.

The project PUMAMIND will enhance the understanding of interaction, competitions and synergies among the mechanisms at multiple scales and lead to the development of robust dynamic macroscopic models for control-command purposes with predictive capabilities.

PROGRESS/RESULTS TO-DATE

- So far, a proof of concept has been reached by coupling the various scales from the nano to the system-level scale and permitted to develop new methodologies in the field of multi-scale simulation for fuel cells for optimization of both design and management of fuel cell systems. Therefore, the main objective of PumaMind has been reached.
- The direct use of activation energies for catalyst degradation in the local degradation model leads to a new physical bottom-up model, with results in good agreement with experimental data.
- Atomistic approaches at the nanoscale are key to understand the degradation mechanisms and to investigate the effect of material properties.
- PumaMind mitigation strategies at the system level rely on design observers at the cell level to estimate the key parameters that have to be considered for the control of the system.

FUTURE STEPS

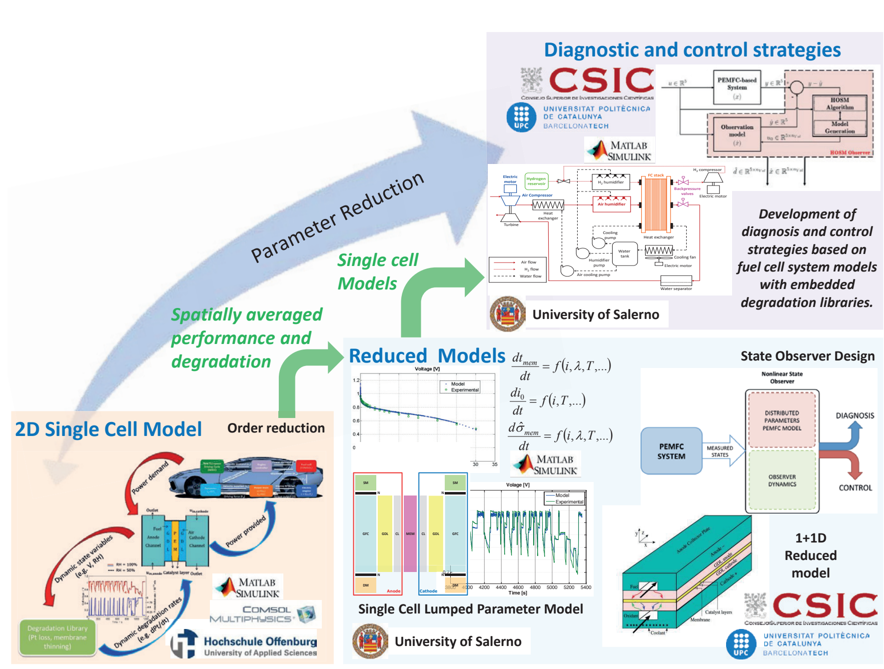
- Going-on with the fine understanding at the nanoscale of electrochemical mechanism, both in term of performance oxygen reduction reaction and degradation.
- Coupling of both the membrane degradation model and the catalyst degradation model with a performance model to simulate the effect of the operating conditions on global degradation of the PEMFC.
- Development of a simple tool to analyse the impact of both the design of the PEMFC and the operating conditions.
- Determination of mitigation strategies based on physical models in order to optimize both performance and durability.

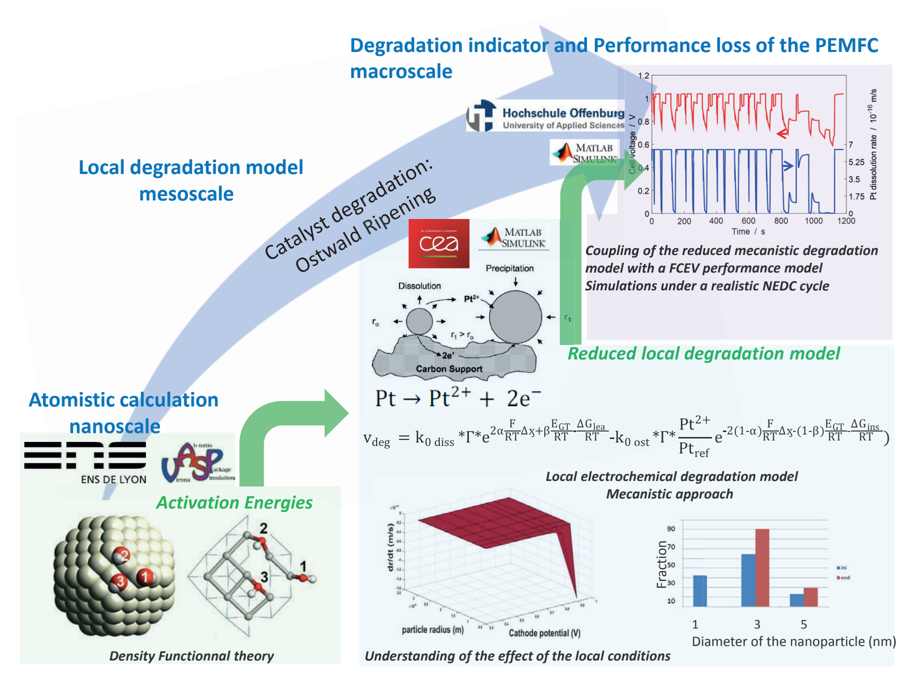
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- PumaMind is the unique on-going European project that focuses specifically on multi-scale modelling of PEMFC in Europe in order to bridge the gaps between the many different scales that have to be considered for a realistic overall picture of FC systems operation
- The new multiscale modelling approach brings key elements for an optimal design and management of PEMFCs by providing new insights on the physics behind these complex systems.
- Nanoscale models of catalyst performance and degradation in the context of the FC complex environment require intensive further efforts of computational and methodological developments, in order to offer accurate predictions.
- Phenomenological approaches are also needed to simplify several complex phenomena towards a mathematical modelling representation being able to run on-board of real systems; such an achievement is the basis of, e.g., lifetime prediction, quantitative diagnostics, advanced, robust and adaptive control;
- A special care has to be paid on experimental validation at all the working scales, including the lower scales. For example, local experimental electrochemical data about the composition of the electrochemical interface are promising to help in determining the most relevant degradation mechanisms by identifying intermediate species.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
			DFT calculation of adsorption energies on a Pt_{201} nanoparticule (Nano scale).	Linear relationships for the estimation of the adsorption energies.
			Kinetic Monte Carlo description of the adsorbed species in the electrochem. double layer (mesoscale).	Coupling of Kinetic Monte Carlo and transport model. Ready for the comparison between Kinetic Monte Carlo and the Mean Field approaches for the modelling of the electrochemical double layer.
MAIP 2008-2013	Development of modeling tools for PEMFC performance and durability	"Development of multi-scale modeling and numericalsimulation tools for increasing the performance anddurability of PEM fuel cells. These computer-based tools are to be validated through experimental work"	Integration of the modules at the mesoscale Study of the interplay (sensitivity study) Methodology for the reduction of the micromodel.	Development of a mechanistic catalyst degradation model (Ostwald Ripening) Ongoing: Coupling of the ab-initio electrochemical model with the local continuous model
			Bridge between the micromodel and the system-level models.	The reduced catalyst degradation model at the local scale has been coupled with a performance model corresponding to a fuel Cell Electric Vehicle.
			Real-time diagnostic model for optimum control-command strategies	Performance indicators for activation, diffusion and ohmic losses





FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

SMARTCat

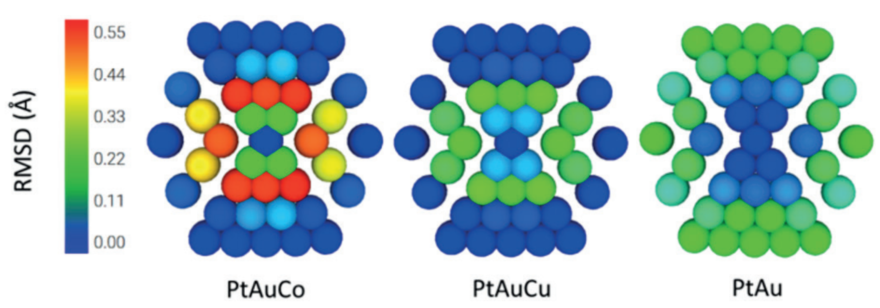
Systematic, Material-Oriented Approach Using Rational Design to Develop Break-Through Catalysts for Automotive PEMFC

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START & END DATE	01 Jun. 2013 - 31 May 2017
TOTAL BUDGET	€ 4,768,172.60
FCH JU CONTRIBUTION	€ 2,501,998.00
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CNRS

Partners: SINTEF, DTU, CEA, mxpolymers



PROJECT WEBSITE/URL

smartcat.cnrs.fr

PROJECT CONTACT INFORMATION

Pascal Brault
Pascal.Brault@univ-orleans.fr

MAIN OBJECTIVES OF THE PROJECT

- New and innovative electrodes using tri-metallic low Pt-content (0.01 mg^{-2}, 0.05g/kW)) based catalyst nanoparticles and nanostructured layers (CL) combined with new and corrosion resistant metal-doped oxide-based materials (CL-conductivity in the range from 1 to 10 S/cm).
- Upscaling HT membranes proton conductivity > 60 mS/cm @ 40 °C; > 200 mS/cm @ 180 °C.
- Enable to optimize and to automate the production of MEAs (60/day).
- Prove the viability of the new concept for automotive applications (220 cm^{-2}, 5000h durability).

PROGRESS/RESULTS TO-DATE

- PtNiAu tri-metallic catalysts gives FC performance of 733 mW/cm^2 at 80°C and 505 mW/cm^2 at 115 °C,
- synthetized (Sb,Nb)-doped SnO_2 support with conductivity > 0.1 Scm^{-1};pore size 20-100 nm, and active area above 80 m^2.g^{-1}.
- development of 1 kg polymer synthesis for new PYPO HT membranes with conductivity 0.5 Scm-1 at 110°C
- first automatized MEA fabrication (50 MEA processed per day)

FUTURE STEPS

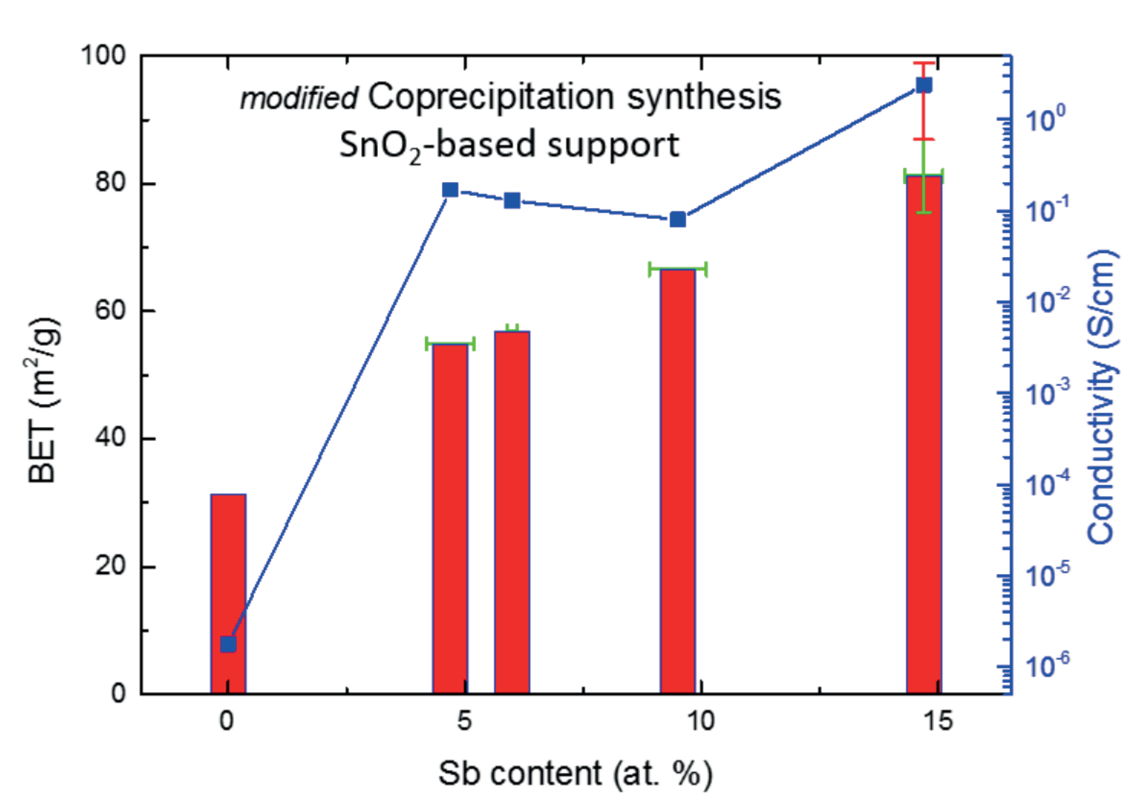
- optimization of deposition of trimetallic catalysts on SINTEF Antimony Tin Oxide (ATO) support
- optimization of the trimetallic catalyzed support in terms of improved corrosion resistance.
- optimized oxide support will be used to manufacture MEAs
- automatized MEA fabrication using SMARTCat materials

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Ongoing project is in time
- FC with tri-metallic electrodes power density > 700 mWcm^{-2}
- Support with expected conductivity reached around 0.1 Scm^{-1}
- 100 cm^2 HT membrane with 0.5 Scm^{-1} achieved
- Progress are expected for increasing FC performances and durability.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	• new electrodes materials for fuel cell car • lowering cost with targeted performances • developing low cost process fabrication of low cost catalyst, support materials and automated high rate MEA fabrication at the pilot scale.	Not defined	25 cm^2 Single Cell performance of 1Wcm^{-2} 100 cm^{-2} Single Cell performance of 0.9 Wcm^{-2} at EoL 220 cm^{-2} short stack >2kWL-1	0.7 Wcm^{-2} with 0.025 mg.cm^{-2} loaded cathode with PtNiAu trimetallic catalyst on 25 cm2 electrode.
AIP 2012	Pt loading	0.1 g/kW	0.1 g/kW	0.036 g/kW
AIP 2012	Support + catalyst conductivity	n/a	> 1 S/cm	0.01 S/cm in non-optimized Pt/ATO catalyst



PROGRAMME REVIEW 2015

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

STAMPEM

Stable and Low Cost Manufactured Bipolar Plates for PEM Fuel Cells

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.7: Research & development on Bipolar Plates
START & END DATE	01 Jul. 2012 - 30 Jun. 2015
TOTAL BUDGET (EUR)	€ 5,223,807
FCH JU CONTRIBUTION (EUR)	€ 2,576,505
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Stiftelsen SINTEF

Partners: Teer Coatings Ltd. Miba Coatings Group, ElringKlinger AG, Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V., University of Birmingham, Fronius International GmbH

PROJECT WEBSITE/URL

www.stampem.eu

PROJECT CONTACT INFORMATION

Anders Ødegård
anders.odegard@sintef.no

MAIN OBJECTIVES OF THE PROJECT

The main objective of STAMPEM is to develop durable coating materials for metal based bipolar plates (BPP), that can be mass produced for less than 2.5 € /kW of rated stack power at mass production volumes of 500 000 pieces annually. Properties after extrapolated 10 000 hours from accelerated stress test (AST) single cell testing shall still be within the AIP specifications. The main parameters are interfacial contact resistance (ICR, < 25 mohm cm^2) and corrosion resistance (< 10 μA/cm^2).

PROGRESS/RESULTS TO-DATE

- Several coatings (Physical Vapour Deposition -(PVD), polymer- and carbon composite-based) show promising performance in ex-situ and small scale in-situ tests
- Best PVD based coatings perform well in full scale in-situ testing, also pre-coated BPPs (coated before stamping).
- More than 6000 hours of operation of a coated metal based stack, without significant degradation
- Full size segmented test cell developed and tested
- Plasma cleaning process for in-line cleaning of BPP substrates developed.

FUTURE STEPS

- Project completed

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Coated metal BPPs perform according to requirements, at a lower cost compared to carbon composite plates, however the cost is still higher than the target 2.5 € /kW.
- Full coating coverage of the metal substrate is not required, i.e. post-stamping of coated plates is possible.
- Several potential low cost materials show promising performance and may be applied after optimisation and production scale-up has been achieved.
- Existing test protocols not fully representative for real time, in-situ BPP degradation
- Still lack in available information/knowledge on MEA ion tolerance

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	2015 target lifetime for vehicles	>5,000	Properties after extrapolated 10 000 hours from AST single cell testing shall still be within the AIP specifications.	A PEMFC stack based on coated metal BPPs has already operated for more than 6000 hours with a low degradation rate. On a smaller scale, several of the PVD-based coatings have shown promising properties/ durability.
AIP 2011	BPP interfacial contact resistance	< 25 mohm cm^2	< 25 mohm cm^2 after 10 000 hours extrapolated from AST	Same as last year (< 10 mohm cm^2 after small scale in-situ AST) The project is finished but not yet reported, and the final evaluation of results is not yet completed. Once long term testing and analysis has been completed the results will be disseminated.
AIP 2011	BPP/coating corrosion resistance	< 10 μA/cm^2	< 10 μA/cm^2 after 10 000 hours extrapolated from AST	Same as last year (< 10 μA/cm^2 in ex-situ tests (Beginning of Life (BoL) , 1 mM H_2SO_4 at 0.8 V_{SHE} and 80 °C at BoL) The project is finished but not yet reported, and the final evaluation of results is not yet completed. Once long term testing and analysis has been completed the results will be disseminated.