



## INTEGRATION OF NOVEL STACK COMPONENTS FOR PERFORMANCE, IMPROVED DURABILITY AND LOWER COST

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*Project Coordinator: Johnson Matthey plc*

### DELIVERABLE REPORT

#### D7.5: SURVEY OF DISSEMINATION ACTIVITIES AND FINAL PLAN FOR DISSEMINATION AND EXPLOITATION OF PROJECT RESULTS

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#### DISSEMINATION LEVEL

<b>PU</b>	Public	<b>X</b>
<b>PP</b>	Restricted to other programme participants (including the Commission Services)	
<b>RE</b>	Restricted to a group specified by the consortium (including the Commission Services)	
<b>CO</b>	Confidential, only for members of the consortium (including the Commission Services)	

#### NATURE OF THE DELIVERABLE

<b>R</b>	Report	<b>X</b>
<b>P</b>	Prototype	
<b>D</b>	Demonstrator	
<b>O</b>	Other	

<b>SUMMARY</b>	
<b>Keywords</b>	<b>Dissemination and Communication</b>
<b>Abstract</b>	<p><i>During the whole duration of the INSPIRE project, the consortium has undertaken various dissemination and communication measures. Target groups included industry, academia, government bodies and the public.</i></p> <p><i>At the end of the project, the consortium will be engaged in conducting further activities for promoting and disseminating the project results.</i></p> <p><i>Those activities will first receive the agreement of the partners to protect the intellectual property rights, confidentiality and the legitimate interests according to the Grant Agreement article II.30. and the internal dissemination protocol (D7.2)</i></p>

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## ***D7.5: SURVEY OF DISSEMINATION ACTIVITIES AND FINAL PLAN FOR DISSEMINATION AND EXPLOITATION OF PROJECT RESULTS***

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## 1. INTRODUCTION

During the whole duration of the INSPIRE project, the consortium has undertaken various dissemination and communication measures. Target groups included industry, academia, government bodies and the public.

At the end of the project, the consortium will be engaged in conducting further activities for promoting and disseminating the project results.

Those activities will first receive the agreement of the partners to protect the intellectual property rights, confidentiality and the legitimate interests according to the Grant Agreement article II.30. and the internal dissemination protocol (D7.2).

## 2. DISSEMINATION & COMMUNICATION ACTIVITIES

### 2.1. WEBSITE

The project website (<http://www.inspire-fuelcell.eu/>), fully operational since 31<sup>st</sup> July 2016, reflects the status and the progress of the project. Public deliverable reports, publishable summaries of confidential deliverable reports, updates on dissemination activities and other project news were communicated towards the public and the scientific community.

***This website will first of all be kept as an information source of the activities performed in the project. The website will also continue to receive and provide information on published papers from the project. The website will be updated to reflect the current status of the project as finished. Reports and final results will be clearly communicated through relevant news items and reports.***

### 2.2. NEWS UPDATES ON INDUSTRIAL PARTNER WEBSITES

Several press releases, either by industrial partners on their websites or by the FCH JU, have been made:

- ▶ SGL press release on the INSPIRE project: <http://www.sglnewsroom.com/en/reports/report-detail-page.19779.php>
- ▶ TUM press release (German) on the INSPIRE project (p24): [PDF](#)
- ▶ Fuel Cells Bulletin press release on the INSPIRE project (p14-p15): [PDF](#)
- ▶ DANA press release on the INSPIRE project: <http://dana.mediaroom.com/2016-06-21-Dana-Joins-Project-INSPIRE-Consortium-to-Develop-Advanced-Fuel-Cell-Technology-for-Automobiles>
- ▶ FCH JU press release on the INSPIRE project: <http://www.fch.europa.eu/news/new-fch-ju-project-inspire-develop-advanced-technology-fuel-cell-electric-vehicles>
- ▶ JM press release on the INSPIRE project: [http://matthey.com/media\\_and\\_news/news/2016/johnson-matthey-led-consortium-to-develop-advanced-technology-for-fuel-cell-electric-vehicles](http://matthey.com/media_and_news/news/2016/johnson-matthey-led-consortium-to-develop-advanced-technology-for-fuel-cell-electric-vehicles)

### 2.3. BROCHURE AND NEWSLETTER

To assist communication from INSPIRE, two different types of communication supports were designed and edited in agreement with all the consortium. Both communication supports are available from the public website. Furthermore, to increase their availability and efficiency, they were also printed and distributed to the partners for their use during attendance at conferences and technical fair events.

- ▶ Project brochure: [PDF](#)
- ▶ Project newsletter was issued at M18: [PDF](#)

***The INSPIRE consortium will continue to disseminate its results; in particular, a second newsletter is planned for November 2019, which will focus on highlights from each of the work packages – Catalyst achievements will focus on the Pt/Ni scale-up and octahedral PtNi(X); MEA achievements will focus on the new ionomer's durability with the main thrust being durability results; BPP***

**achievements will focus on the GEN 3.0 BPP development; and Stack achievements will focus on the GEN 1.5/GEN 2.0 stack performance and durability.**

**This final newsletter will be made available from the public website and relayed on LinkedIn through the partners' accounts.**

#### 2.4. OUTREACH ACTIVITY

- ▶ June 2016, Sonning Common Primary School, UK – Engaging with the Fuel Cell Vehicle Drivers of Tomorrow - <http://www.inspire-fuelcell.eu/index.php/inspire-blog/june-2016>

As part of the communication activities in the INSPIRE project, a team from Johnson Matthey took part in STEM (Science, Technology, Engineering and Math) week in the UK. This provided an opportunity for over 400 children from primary and secondary schools to experience science and technology close-up and see how important it is for our future well-being, particularly in the area of energy and fuel cells. It was also a chance to take JM's fuel cell car around the community, allowing children and parents to experience fuel cells in action.

- ▶ October 2018 – The chicken and the egg – <http://www.inspire-fuelcell.eu/index.php/inspire-blog/october-2018>

This blog was written for the INSPIRE website following the opening of the 7<sup>th</sup> UK Hydrogen Refuelling Station (HRS), at the JMFC manufacturing facility in Swindon.

#### 2.5. TWITTER ACCOUNT

A Twitter account #INSPIREFuelCell was created in early 2019. 43 posts were released.

**Latest news will be posted with the main outputs achieved during the project lifetime.**

#### 2.6. PUBLICATIONS

- ▶ **Controlling Near-Surface Ni Composition in Octahedral PtNi(Mo) Nanoparticles by Mo Doping for a Highly Active Oxygen Reduction Reaction Catalyst**, F. Dionigi, C. Cesar Weber, M. Primbs, M. Gocyla, A. Martinez Bonastre, C. Spöri, H. Schmies, E. Hornberger, S. Kühl, J. Drnec, M. Heggen, J. Sharman, R. Edward Dunin-Borkowski, and P. Strasser, *Nano Letters* 2019 19 (10), 6876-6885.  
DOI: 10.1021/acs.nanolett.9b02116 – **OPEN ACCESS**
- ▶ **Electrodeposition of Platinum Catalyst from Ionic Liquids**, J. Diederich, S. Martens, L. Asen, and O. Schneider, *ECS Transactions*, 92(8) (2019) 533-546.  
DOI: 10.1149/09208.0533ecst – **OPEN ACCESS**
- ▶ **Revealing the nature of active sites in electrocatalysis**, B. Garlyyev, J. Fichtner, O. Piqué, O. Schneider, A. S. Bandarenka and F. Calle-Vallejo, *Chem. Sci.*, 2019,10, 8060-8075  
DOI: 10.1039/C9SC02654A – **OPEN ACCESS**
- ▶ **Impact of Carbon Support Corrosion on Performance Losses in Polymer Electrolyte Membrane Fuel Cells**, F. Hegge, J. Sharman, R. Moroni, S. Thiele, R. Zengerle, M. Breitwieser and S. Vierrath, *Electrochem. Soc.* 2019 volume 166, issue 13, F956-F962  
DOI: 10.1149/2.0611913jes – **OPEN ACCESS**
- ▶ **A comparison of rotating disc electrode, floating electrode technique and membrane electrode assembly measurements for catalyst testing**, S. Martens, L. Asen, G. Ercolano, F. Dionigi, C. Zalis, A. Hawkins, A. Martinez Bonastre, L. Seidl, A. C. Knoll, J. Sharman, P. Strasser, D. J. Jones, O. Schneider, *J Journal of Power Sources* 392 (2018) 274–284  
DOI: 10.1016/j.jpowsour.2018.04.084 – **OPEN ACCESS**
- ▶ **Recent developments in electrocatalyst design thriving noble metals in fuel cells**, G. Ercolano, S. Cavaliere, D. J. Jones, J. Rozière, *Current Opinion in Electrochemistry* Volume 9, June 2018, Pages 271-277  
DOI: 10.1016/j.coelec.2018.05.019 - HAL: <https://hal.archives-ouvertes.fr/hal-02125684>

- ▶ **Multilayer Hierarchical Nanofibrillar Electrodes with Tunable Lacunarity with 2D like Pt Deposits for PEMFC**, G. Ercolano, F. Farina, S. Cavaliere, D. J. Jones, J. Rozière, ECS Trans. 2017, 80, 757-762  
DOI: 10.1149/08008.0757ecst - HAL: <https://hal.archives-ouvertes.fr/hal-01615244/>

**Other publications are planned or already submitted, among them:**

- **Fuel Cells: BMW (EFCF2019 proceedings): “Cathode catalyst layer degradation of PEMFC of an automotive full-size stack under local fuel starvation conditions”**
- **ACS applied energy materials: BMW publication: “Local degradation effects of automotive size membrane electrode assemblies under realistic system operating conditions”**
- **ECS transaction: TUM publication: “Electrodeposition of Platinum Catalyst from Ionic Liquids”**

## 2.7. PRESENTATIONS AT INTERNATIONAL CONFERENCES

INSPIRE partners have disseminated project results at conferences through oral or poster presentations including:

- ▶ **236<sup>th</sup> ECS meeting, 13-17 October 2019, Atlanta, USA - <https://www.electrochem.org/236>**
  - 1) TUM oral presentation: Electrochemical Deposition of Platinum Catalyst from Ionic Liquids
- ▶ **EFCD2019, 15-18 September 2019, La Grande Motte, France - <http://www.efcd2019.eu>**
  - 1) TUB invited lecture: PGM-poor and PGM-free ORR fuel cell electrocatalysts
  - 2) JMFC invited lecture: The labyrinth around low PGM fuel cells for the electrification of the power train
  - 3) INSPIRE project poster
- ▶ **EFCF2019, 5 July 2019, Lucerne, Switzerland - <https://www.efcf.com/>**
  - 1) BMW presentation: Degradation analysis of PEMFCs of an automotive full-size stack
- ▶ **680<sup>th</sup> Wilhelm and Else Heraeus Seminar "Materials development for automotive propulsion", 14-17 October 2018, Physikzentrum Bad Honnef, Germany - <https://www.mawi.tu-darmstadt.de/>**
  - 1) TUB oral presentation: Octahedral Fuel Cell Nano Catalysts
- ▶ **COST Action MP1402 - HERALD Hooking together European research in Atomic Layer Deposition, 25-28 September 2018, Braga, Portugal**
  - 1) VTT oral presentation: New ALD approaches for catalysts and support materials
- ▶ **Electrochemistry 2018, Electrochemical Surface Science: From Fundamentals to Applications", September 24 - 26, 2018, Ulm, Germany - <https://veranstaltungen.gdch.de/>**
  - 1) TUB poster presentation: Molybdenum doped Pt-Ni octahedral shaped nanoparticles for the oxygen reduction reaction
- ▶ **Aimes2018 conference (ECS and SMEQ Joint International Meeting)", September 30-October 4, 2018, Cancun, Mexico - [www.electrochem.org/aim2018](http://www.electrochem.org/aim2018)**
  - 1) TUB oral presentation: Controlling near surface Ni composition in octahedral PtNi(Mo) nanoparticles by Mo doping for highly active oxygen reduction reaction catalyst
  - 2) TUM oral presentation: Electrodeposition of Pt and Gd from the Same Ionic Liquid
- ▶ **69<sup>th</sup> Annual ISE conference, 2-7 September 2018, Bologna, Italy - <http://annual69.ise-online.org/>**
  - 1) IMTEK oral presentation: Electrolyte Fuel Cells Investigated with Tomography
- ▶ **GRC fuel cell conference, 29 July-3 August 2018, Smithfield, RI, US - <https://www.grc.org/fuel-cells-conference/2018/>**
  - 1) TUM oral presentation: Controlling near surface Ni composition in octahedral PtNi(Mo) nanoparticles by Mo doping for Controlling near surface Ni composition in octahedral PtNi(Mo) nanoparticles by Mo doping for highly active oxygen reduction reaction catalyst
- ▶ **233<sup>rd</sup> ECS Meeting, 13 -17 May 2018, Seattle, USA - <https://www.electrochem.org/233>**
  - 1) CNRS invited presentation: Pt thin films on nanofibres: ORR electrocatalysts with high performance and stability

- ▶ **232<sup>nd</sup> ECS Meeting, October 1-6, 2017, National Harbor, MD** - <http://www.electrochem.org/232>
  - 1) CNRS presentation: Multilayer hierarchical nanofibrillar electrodes with tuneable lacunarity with 2D like Pt deposits for PEMFC
  - 2) CNRS presentation: A core-shell fibrillar electrocatalyst for the PEMFC cathode by microwave accelerated galvanic displacement of nickel with platinum
- ▶ **68<sup>th</sup> Annual International Society of Electrochemistry (ISE) Meeting, 27 August - 1 September 2017, Providence, Rhode Island, USA** - <http://annual68.ise-online.org/>
  - 1) TUB Poster presentation: Improving the Durability of Shape-controlled Octahedral Pt Alloy Nanoparticle Catalysts for use in fuel cell cathodes
- ▶ **EFCF (6<sup>th</sup> European PEFC & Electrolyser Forum), 04/07-07/07/2017, Lucerne** - <http://www.efcf.com/>
  - 1) CNRS oral presentation: Ultra-Low Pt Stabilises Fe-N-C PEM Fuel Cell Cathode Catalysts
  - 2) JMFC oral presentation: Opportunities and challenges for dealloyed PtNi cathode catalysts for automotive applications
- ▶ **European Fuel Cell Car Workshop (EFCW2017), 1-3 March 2017, Orléans, France** - <https://efcw2017.sciencesconf.org/>
  - 1) JMFC lecture: Recent Advances and Remaining Challenges for Automotive PEM Fuel Cell Membrane Electrode Assemblies and Components
  - 2) CNRS poster presentation: RDE Testing Protocol Harmonisation: A Reliable Tool for Fuel Cell Electrocatalyst Screening
  - 3) TUM poster presentation: Electrodeposition of Pt - Rare Earth Alloys as ORR Catalysts for Fuel Cells
- ▶ **Fundamentals and Development of Fuel Cells, 31/01-02/02 2017, Stuttgart, Germany** - <http://event.dlr.de/en/event/7th-international-conference-on-fundamentals-and-development-of-fuel-cells/>
  - 1) CNRS Oral presentation: Towards ultrathin platinum films on carbon nanofibres for the fuel cell cathode by self-limited electrodeposition
  - 2) CNRS Poster presentation: A core-shell fibrillar electrocatalyst for the PEMFC cathode by microwave accelerated galvanic displacement of nickel with platinum
- ▶ **PRIME 2016, 2-7 October 2016, Honolulu, Hawaii** - <http://www.prime-intl.org/>
  - 1) TUM poster presentation: "Electrodeposition of Pt - Rare Earth Alloys as ORR Catalysts for Fuel Cells" - <https://ecs.confex.com/ecs/230/webprogram/Paper90478.html>

In addition, the INSPIRE project was represented by a poster at the FCH JU Programme Review Days in 2017 and 2018 and the coordinator will be giving an oral presentation in 2019.

## 2.8. WORKSHOP ORGANISATION

The INSPIRE team hosted the project workshop in **Marseille on 5<sup>th</sup> and 6<sup>th</sup> March 2019**, combining several FCH JU H2020 projects focused on PEM fuel cell components together for poster sessions, forums and project presentations. The workshop was free of charge for the participants.

The website for this workshop may be found at <http://www.inspire-fuelcell.eu/>

The workshop presented recent advances relating to catalysts and catalyst supports, membrane, MEA, bipolar plates, stack assembly and fuel cell characterisation testing, and was an opportunity for FCH JU projects to network and exchange both information and technical developments.

The following projects were represented:

- CRESCENDO: [www.crescendo-fuelcell.eu](http://www.crescendo-fuelcell.eu)
- DIGIMAN: [www.digiman.eu](http://www.digiman.eu)
- Fit-4-AMANDA: [www.fit-4-amanda.eu](http://www.fit-4-amanda.eu)
- GAIA: [www.gaia-fuelcell.eu](http://www.gaia-fuelcell.eu)
- GRASSHOPPER: [www.grasshopperproject.eu](http://www.grasshopperproject.eu)
- HYDRAITE: [www.hydraite.eu](http://www.hydraite.eu)
- ID-FAST: [www.id-fast.eu/](http://www.id-fast.eu/)
- INSPIRE: [www.inspire-fuelcell.eu](http://www.inspire-fuelcell.eu)
- MAMA-MEA: [www.mama-mea.eu](http://www.mama-mea.eu)
- VOLUMETRIQ: [www.volumetriq.eu](http://www.volumetriq.eu)

Overall this was a very successful workshop which enabled FCH JU projects with common interests to share their successes and best practices and create new links which will benefit the industry throughout.

### 3. EXPLOITATION OF THE RESULTS

#### - JM

Johnson Matthey's direct involvement with suppliers for INSPIRE both within (SGL, DANA) and outside the project environment has proven extremely valuable. SGL was already a supplier to JM and the development of the SGL22BB within the project has brought new partnership opportunities to both companies. The relationship with DANA is also extremely valuable and has the potential to open new avenues for both companies.

The work in WP2 has helped JM to understand in greater detail the needs of the automotive industry and the types of solutions that are required.

In WP3, the opportunities presented by newly developed catalyst alloys which have been scaled up to the 00's g to kg scale is providing JM with the potential for new products and improved performance competitiveness, not only in the automotive arena but also in the stationary market where the alloys' kinetic benefits are more marked as they do not need to operate at high current densities. New catalyst and support approaches introduced within the project could also form the basis of future developments and inventions. The scale-up of catalyst at the 2 kg scale within the INSPIRE project has also brought full validation processes to the fore with respect to environmental, safety and process friendly chemistry.

The work in WP4, as well as the input from VOLUMETRIQ, has provided the team with the opportunity to assess the world's best ionomer providers for membrane and catalyst layers in an automotive relevant environment. The optimisation of catalyst layers in combination with hardware and GDLs is also bringing new targeted solutions which will provide valuable learning in a wide range of applications.

The MEA scale-up for BMW stack hardware has also provided a full manufacturing evaluation of a new MEA platform with full quality control assessment and will ensure that both JM and BMW have a full understanding of the MEAs' capabilities in readiness for market introduction.

Finally, the direct involvement with BMW and the validation of the TP288 single cell within JM's test facility has provided both organisations with a common development platform which can provide a joint development impetus outside the project. The link between JM and BMW, reinforced by the MEA performance success during INSPIRE, will also provide both commercial teams with the chance to explore further commercial opportunities inside or outside the automotive applications.

#### - DANA

The baseline for the DANA metallic bipolar plate (MBPP) technology developed in INSPIRE was generated in the FCH JU FP 7 AutoStack Core project (FCH-JU-2012-1 GAN 325335). In AutoStack the MBPP achieved a TLR5. It was possible in the AutoStack project to demonstrate the technological and commercial feasibility of the metallic bipolar plates. Because of the achievements, the AutoStack partner PowerCell was able to become engaged in a number of commercial activities including the development of a hydrogen powered class 8 truck with Nikola Motor and Bosch GmbH (verbally announced by Pietro Caloprisco at the FCH-JU review days on 24<sup>th</sup> November 2017 and on PowerCell website news).

In INSPIRE the focus of the development of the bipolar plate was to leverage the AutoStack know-how by an adjustment of the design to the INSPIRE specification and a better robustness of the production to enable TLR6 and higher, but not compromising on the high-power density demonstrated in AutoStack.

The manufacturing of the bipolar plates showed a clear improvement, and the design for manufacturing approach enabled a more robust production.

The bipolar plates provided to BMW for short and full-size stack assembly and testing met the agreed specifications. Potential bipolar plate deliveries may take place in the future in addition to the INSPIRE activities to introduce the INSPIRE hardware as a BMW internal validation hardware.

The learnings generated by the improvements from AutoStack to INSPIRE will be introduced into DANA's design approach for upcoming bipolar plate inquiries of the fuel cell industry. The added know-how will improve DANA's competitiveness in the fuel cell market.



- BMW

BMW intends to exploit the results and learning from this project in several ways. As the technology being developed will reach TRL6 by the end of the project, this could enable BMW to carry out further work with the industrial partners to optimise these components and technologies towards a future commercial application to reach higher TRL levels, allowing introduction to “series” vehicles. Another exploitation route is to further develop the stack concept advanced to TRL6 in this project and use it for integration to prototype vehicles. This route will of course depend on other decisions such as vehicle packaging dimensions, but BMW will strive to be sufficiently flexible to allow the stack(s) generated under this project to be directly integrated in vehicles.

- SGL

From the viewpoint of SGL, exploitation of the GDL improvements developed in INSPIRE will comprise scale-up of novel approaches of GDL design, filing patents with regards to new technologies (if applicable) accompanied by marketing activities (scientific or technical publications, conference presentations, fairs/exhibitions, SGL newsletters) and roll-out of new GDL grades. SGL considers INSPIRE as a significant milestone towards the industrialisation of GDLs for use in automotive PEMFCs, and as such have released a commercial product based on its development, the SGL 22BB. During the course of the project, crucial design parameters for high-performance GDLs have been identified along with aspects of manufacturability. The combination of an experienced consortium of academic and industrial partners alongside the attractive value chain and the achievement of the cost and performance targets addressed within INSPIRE, has enabled SGL to make a significant step towards high volume manufacturing. SGL is very interested in a further cooperation or joint exploitation with the industrial partners after the completion of the project. The fleet scenarios stated above equate to an EU demand of 2 million square metres of GDL per year in 2025. In the build-up to this, a demand of over 250,000 square meters from 2020 is expected which will, in turn, necessitate a timely building of appropriate GDL production capacity.

#### 4. CONCLUSIONS AND FUTURE WORK

With regards to the project objectives, the INSPIRE consortium has finalised all planned communication and dissemination actions and exceeded the targets for WP7.

The INSPIRE partners will continue collectively to implement dissemination and communication measures depending on the latest results obtained. This will be achieved through:

- A second edition of the newsletter
- An update of the public website: it will continue to receive and provide information on published papers related to the project. Reports and final results will be clearly communicated through relevant news items and reports.

Finally, partners, will undertake all the necessary measures to exploit the project results.