COBRA
COating for BipolaR plAtes

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Programme Review Days 2016
Brussels, 21-22 November

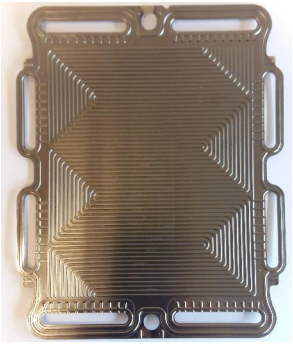
PROJECT OVERVIEW

Project Information	
Call topic	SP1-JTI-FCH.2013.1.2-"Research & development on Bipolar Plates for PEM Fuel Cells"
Grant agreement number	621193
Application area (FP7) or Pillar (Horizon 2020)	Transport and refueling infrastructure
Start date	01/04/2014
End date	31/03/2017
Total budget (€)	3 809 234
FCH JU contribution (€)	2 339 595
Other contribution (€, source)	-
Stage of implementation	86% project months elapsed vs total project duration, at date of November 1, 2016
Partners	CEA, Borit, Impact Coating, SymbioFC, IK4-CIDETEC and Mateis Laboratory (INSA Lyon)

PROJECT SUMMARY & OBJECTIVES

The COBRA project focuses on the technological choice of Metallic Bipolar Plates

- **Improvement of manufacturing processes and production capability** based on reference bipolar plates ("G" technology) from CEA
  - Plate forming and welding technologies → **BORIT**
  - Development and study of alternative coatings → **IMPACT COATING, CIDETEC & INSA Lyon**
- **Cost analysis :** impact of new processes on cost production for large scale commercialization → **CEA & SFC**
- **Validation from laboratory up to real field operations:** automotive & marine applications → **CEA & SFC**

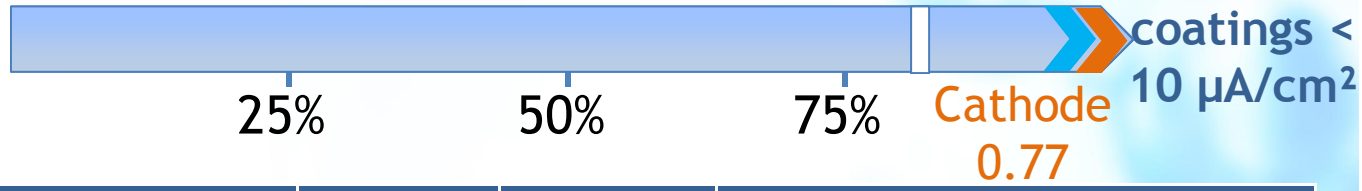


DEVELOPMENT OF BP COATINGS – Durability - Corrosion current rates

COBRA

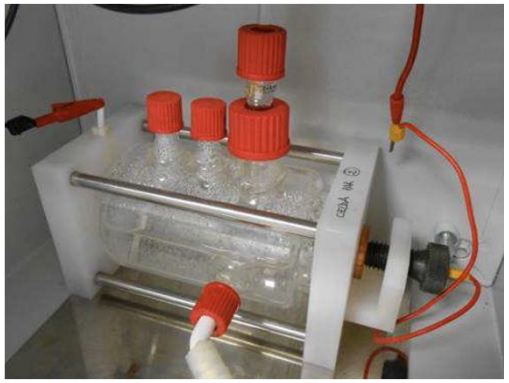
Achievement to-date
% stage of implement.

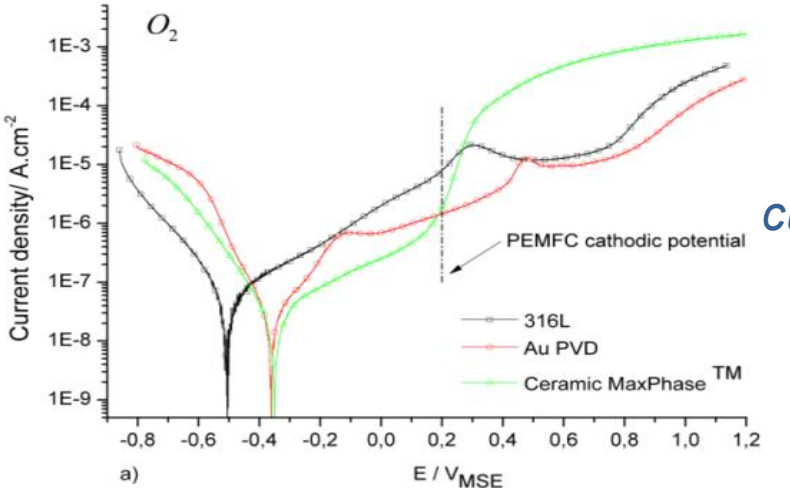
PVD Au Coating < 10 µA/cm²



Aspect addressed	Parameter (KPI)	Unit	SoA 2015 DoE	FCH JU Targets		
				Call topic	DoE 2017	DoE 2020
Durability	Anode corrosion current	µA/cm²	No active peak	< 10	< 1	< 1
Durability	Cath. corrosion current	µA/cm²	< 0.1	< 10	< 1	< 1

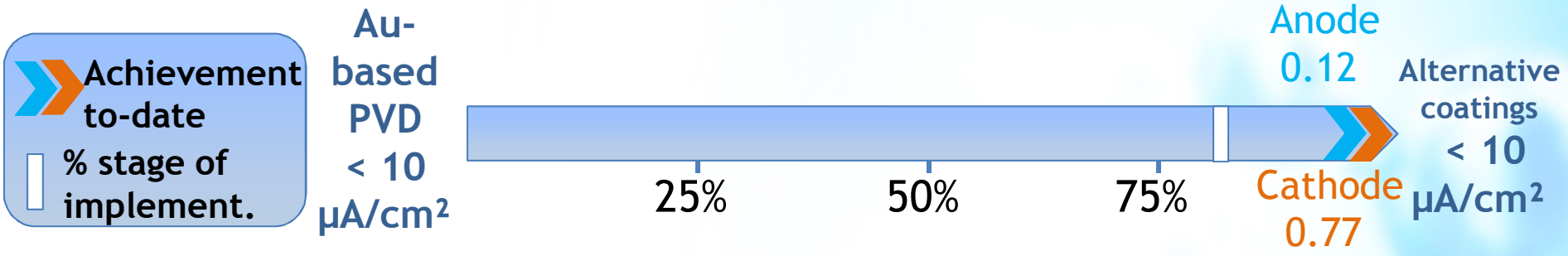
Corrosion set-up in liquid electrolyte





Polarization curves obtained on different samples

DEVELOPMENT OF COATINGS - Durability - Corrosion current rates



Coating	Anode corr. Current (µA/cm²)	Cath corr. Current (µA/cm²)	ICR (mΩ.cm²) Target : 10 mΩ.cm²	Pre-selection for BP test
Au-PVD	-0.10	0.07	5 mΩ.cm² (BP)	*As ref.*
Au-ED (ElectroDeposited - CIDETEC)	-2.25	0.09	3.5 - 5 mΩ.cm² (BP)	OK
Sol-gel Ni + CNT (CIDETEC)	--	0.08	98 mΩ.cm²	No
MaxPhase® (IMPACT COATING)	-0.10	1.07	4 - 5 mΩ.cm² (BP)	OK
Ti-C based (IMPACT COATING)	-0.12	0.08	6 - 12 mΩ.cm² (BP)	OK

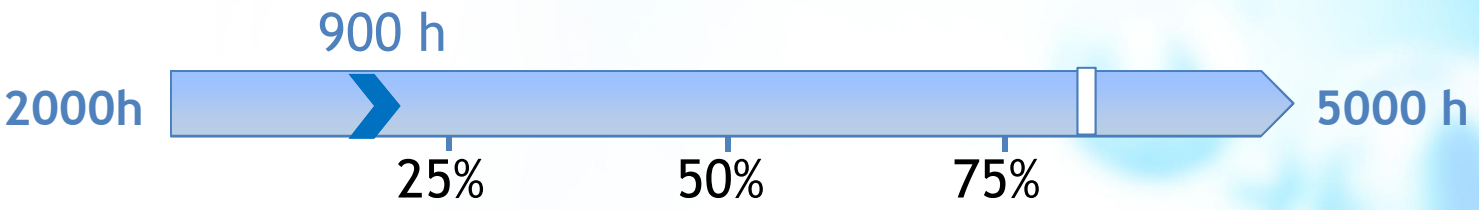
On-going & future steps:

- Further tests of the different pre-selected coatings in short PEMFC stack under FC-DLC (ex-NEDC) cycles
- Selection of the best coating for integration in real field testing

BIPOLAR PLATE TESTING - Durability

Achievement to-date

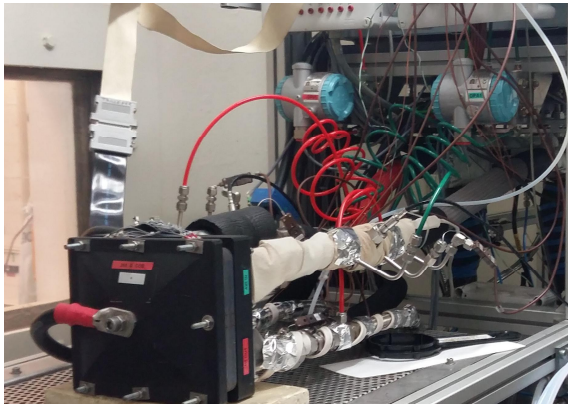
% stage of implement.

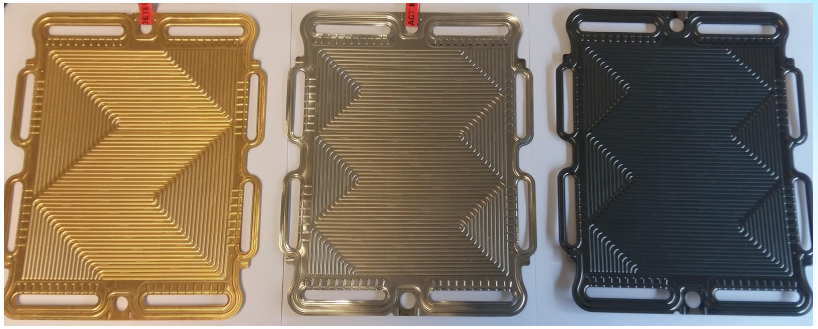


Aspect addressed	Parameter (KPI)	Unit	SoA CEA stack	FCH JU Targets		
				Call topic	2017	2020
Durability	System lifetime	h	2000-2500	5000	5000	6000

Short stack (1 kW) with COBRA BP and CEA reference MEA

Ageing under NEDC cycles in representative automotive conditions





Au-ED // ***MaxPhase™*** // ***Ti-C***

Coated bipolar plates

On-going & future steps:

- Selection of the best coating for integration in real field testing based on short stack results

BIPOLAR PLATE TESTING – Durability

COBRA

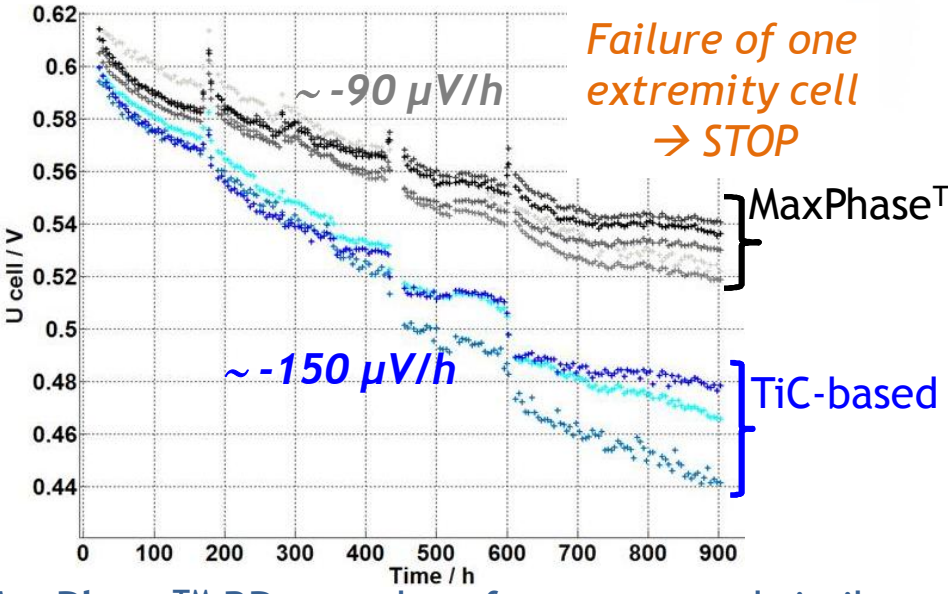
Achievement to-date

% stage of implement.

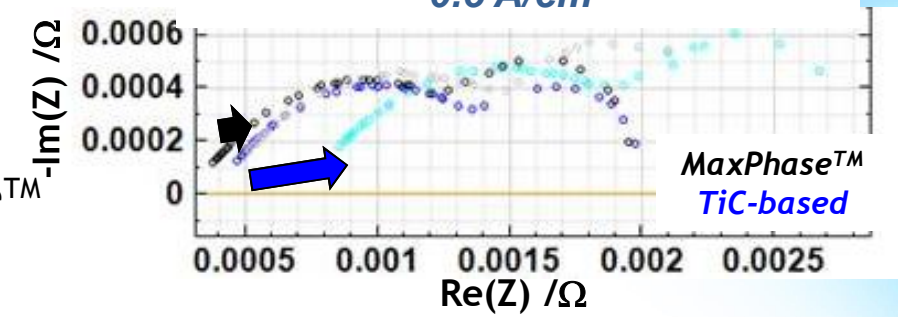
> 900 h

2000h — 25% — 50% — 75% — 5000 h

Rainbow stack with IC coatings
Cell voltage @ 0.8 A/cm²
80°C // 1.5 bar // RH 50/50 // Sto H_2/Air 1.5/2



EIS spectra between BoT (dark colour) and EoT (light colour) @ 0.5 A/cm²



- **MaxPhase™ BP** : good performances and similar degradation rates on SoA BP to both IMPALA and STACKTEST projects in comparable conditions
- **TiC-based BP**: lower initial performances and higher degradation rate

- **TiC-coated BP** : higher initial R_{HF} and important increase over ageing

→ Degradation of the coating responsible of the loss of performances

- **MaxPhase™ BP** : lower initial and more stable coating

→ Good candidate for automotive conditions and further field tests

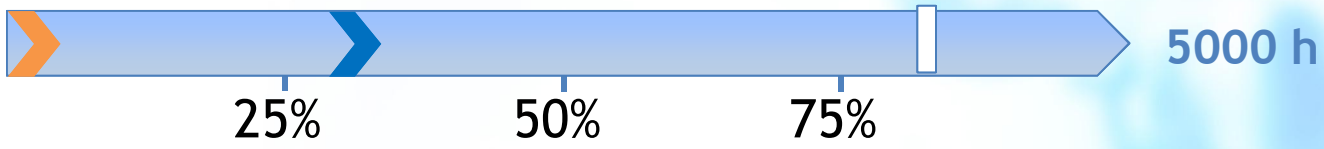
FIELD TESTING - Durability

Achievement to-date

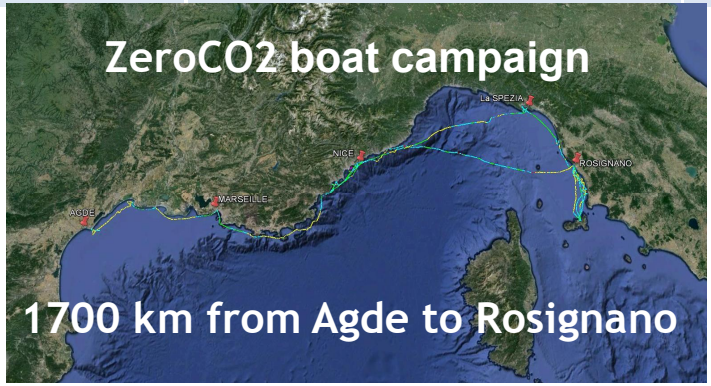
% stage of implement.

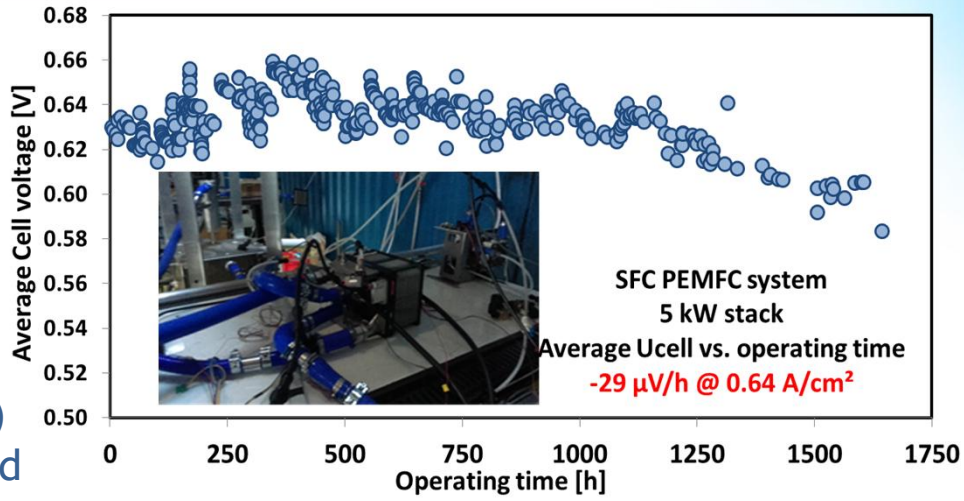
Not yet started (HyKangoo)

>1600 h SFC system



Aspect addressed	Parameter (KPI)	Unit	SoA 2015 (DoE)	FCH JU Targets		
				Call topic	2017	2020
Durability	Lifetime (system)	h	3900	5000	5000	6000
	Lifetime (vehicle)	h	3900	5000	5000	6000





225 h sailing (50% wind, 25% battery and 25% FC)
→ **Huge limitations for FC use on board** (limited H_2 storage and refillment possibility in harbour, weather, system failure and repair process…)

FIELD TESTING - CAMPAIGN IN 2017

- **Replacement of the second maritime campaign by real automotive experiments in 2017**
- **Link with the HyWAY project**
  - 1 vehicle purchased integrating the best coating
  - Conception/Integration of COBRA stack technology in the Kangoo : in progress
  - More simple for use vs. boat campaign constraints to reach over 10 000 km driving distance
- **Characterizations of the FC**
  - Periodically on test bench in controlled conditions
  - Post-mortem analysis of the degradation
  - Comparison possible between test bench, *ex-situ* system at SFC and 'real' on road use
  - Comparison of different BP technologies: reference stack used in the Hy-Kangoo and the COBRA BP.

SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

Interactions with projects funded under EU programmes	
STAMPEM	Participation to workshops on BP coating and corrosion tests (UK 2014, Austria 2015)
STACK TEST	Definition of test procedures for PEMFC stack. Use of the protocoles to characterize both performances and durability for the COBRA FC stacks.
Interactions with national and international-level projects and initiatives	
PBHT (French ANR)	Project focused on the development of bipolar plate coatings for medium temperature PEMFC and validation into stacks

EXPLOITATION PLAN/EXPECTED IMPACT

Exploitation

- **Hydroformed Bipolar Plate:** BORIT

estimated time to market:
between 1-2 years

- **Development of new suitable coatings:** IMPACT COATING/CIDETEC

estimated time to market/transfer:
1 year for IC / 4 years for CIDETEC

- **Stack components and systems for marine and automotive applications:** SFC and CEA

estimated time to market/transfer:
3-5 years for both

Impact / Market foreseen

Improvement of manufacturing processes and capability

Targets:

- 20% of the worldwide customer base for FC
- Production volumes between 100 and a couple of 100 000 BP/year per customer
- 15% of the market volume of BP (most customers are in prototyping phase)

Targets:

- 5% for coating of metallic PEMFC BP
- Production volume for each customer typically below a few thousand BP

SFC aims at being a **national leader** for range extender and high power FC systems.

Targets:

-10 % of EU market share for range extender and high power FC systems for mobile applications.

DISSEMINATION ACTIVITIES

Public deliverables

- Dissemination plan (updated May 2016)
- Stakeholder workshop on industrialization concept (2017)
- Final publishable project report (2017)

Workshops

- 1 to be organised by the project in 2017 at the end of the project
- 2 in which the project has participated in link with STAMPEM

Website: http://www.cobra-fuelcell.eu/

Inscription to newsletter possible

Publications: *in progress*

International Conferences: 2

- **EIS2016:** EIS investigation of galvanic coupling occurrence on gold coated 316L in oxygenated and hydrogenated acidic solutions M. Carradot *et al*.
- **Eurocorr2016:** Corrosion resistant metallic coating for bipolar plates of PEMFC E. Garcia-Lecina *et al*. /// Galvanic coupling criticality of passive stainless steel coated by noble materials: role of porosity morphology and distribution M. Carradot *et al*.

Thank You!

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