Second International Workshop

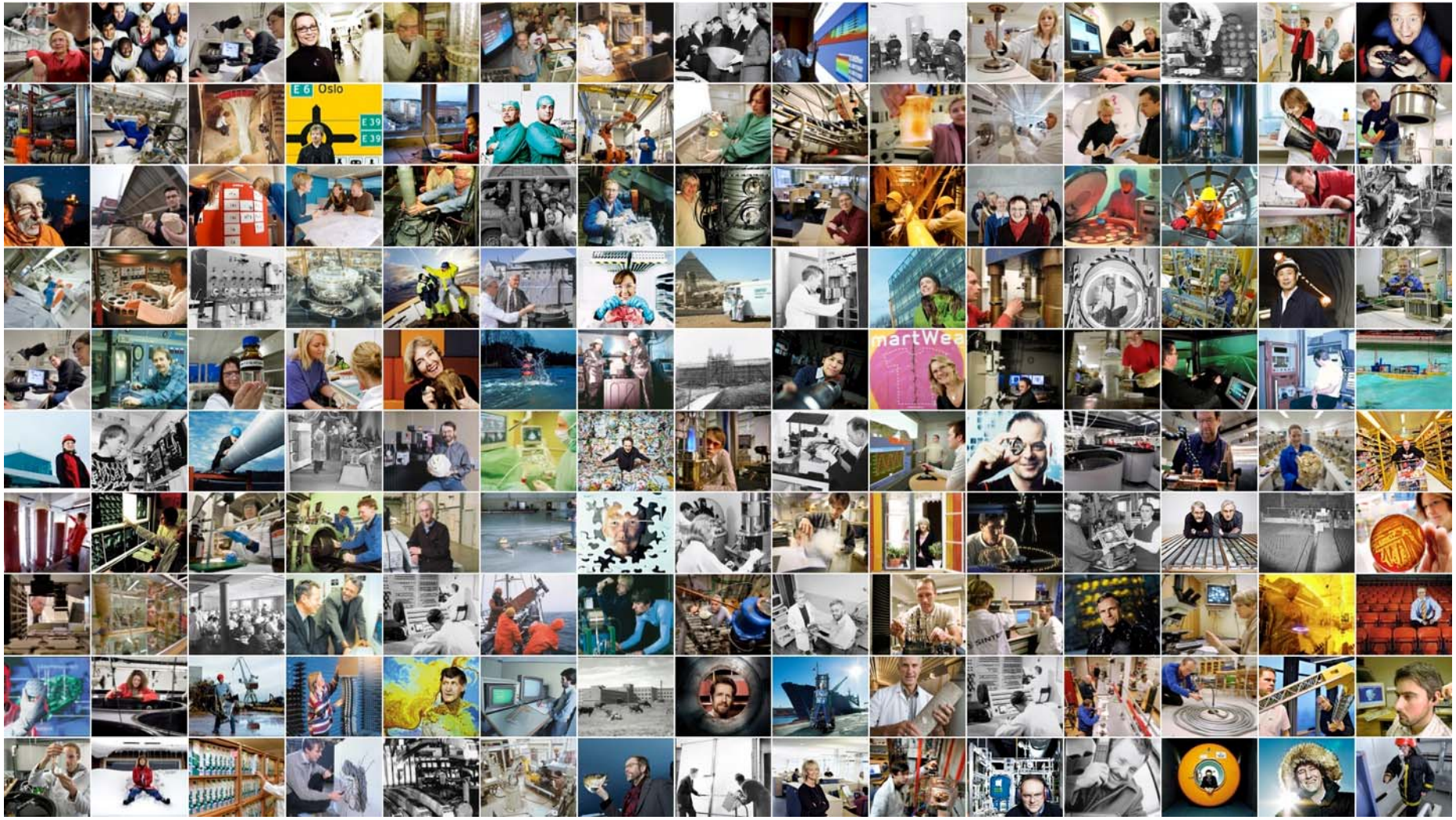
Durability and Degradation Issues in PEM Electrolysis Cells and its Components

The NOVEL Project

Novel Materials and System Designs for Low Cost, Efficient and Durable PEM Electrolysers

NOVEL

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) for the Fuel Cells and Hydrogen Joint Technology Initiative under grant agreement n°303484.



This is SINTEF

May 2015

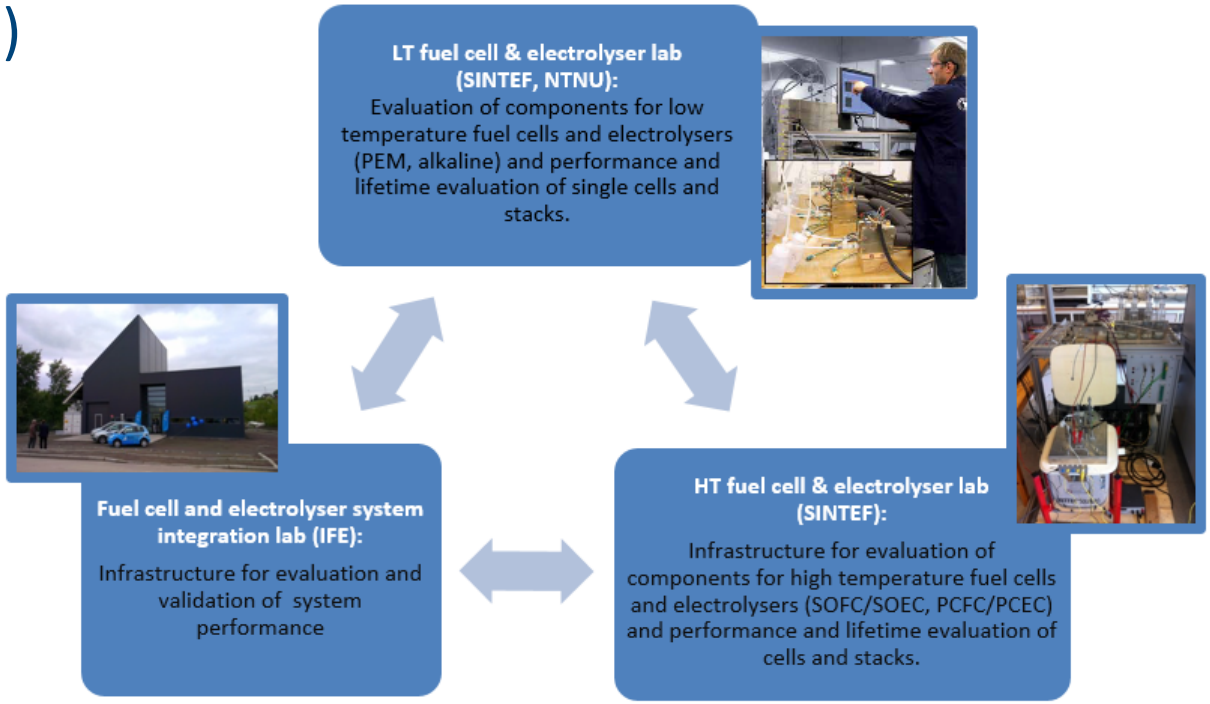
SINTEF

Technology for a better society

NORWEGIAN FUEL CELL
AND HYDROGEN CENTRE

National infrastructure for testing and analysis of fuel cells and electroysers

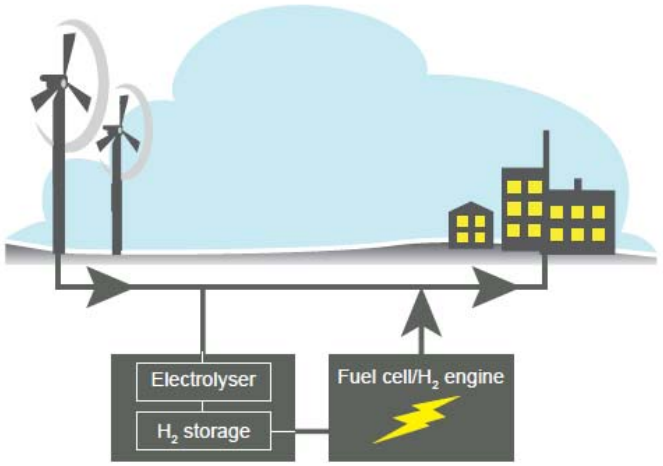
(under establishment)



NOVEL main objectives:

Develop and demonstrate a PEM water electrolyser using beyond state of the art materials.

75% Efficiency (LHV), electrolyser stack cost < €2,500 / Nm^3h^{-1}, target lifetime of 40,000 h (< 15 μVh^{-1})



NOVEL consortium

PAUL SCHERRER INSTITUT PSI

Johnson Matthey Fuel Cells — the power within

Fraunhofer ISE

New Materials Development (Electrocatalysts & Membranes) → Component development and testing → Increased understanding of lifetime and degradation → Stack and system design

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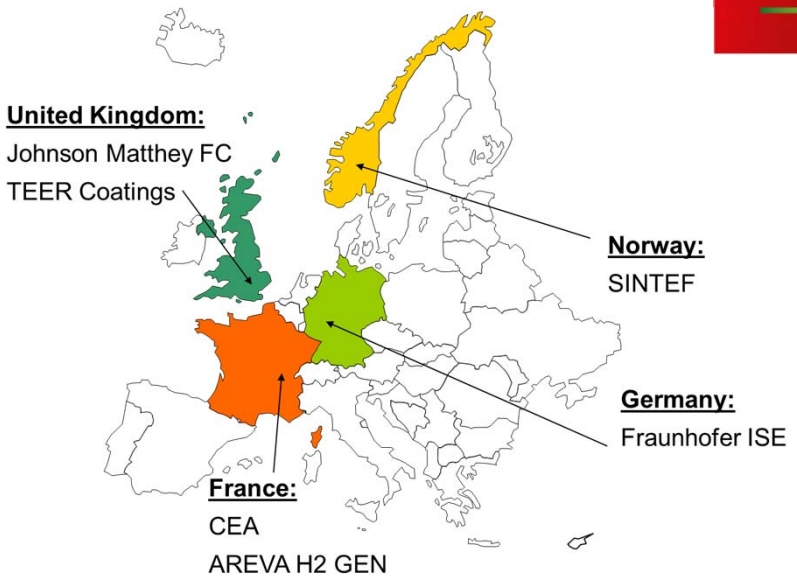
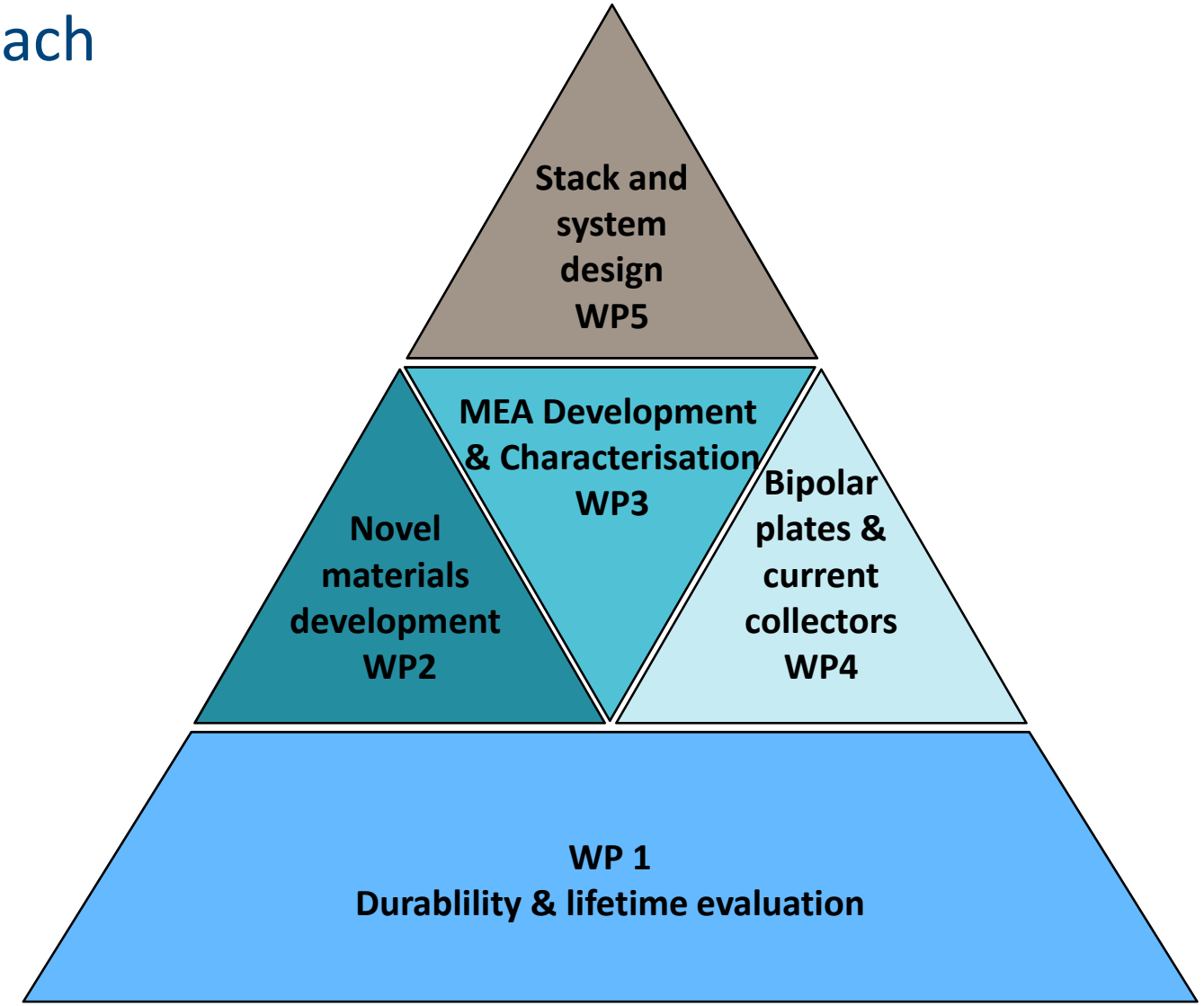
TEER COATINGS LTD — innovation and experience

DE LA RECHERCHE À L'INDUSTRIE cea

AREVA H_2Gen



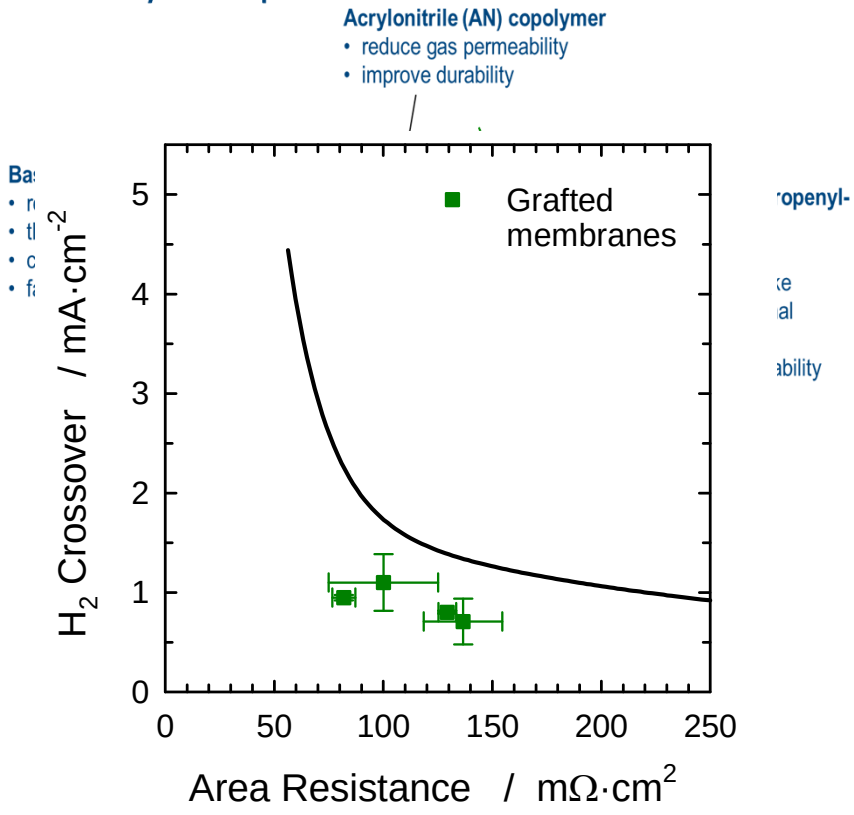
Approach


Stack and system design WP5
MEA Development & Characterisation WP3
Novel materials development WP2
Bipolar plates & current collectors WP4
WP 1
Durablility & lifetime evaluation

Approach and results - membranes

- Develop lower cost membranes suitable for electrolyser operation at elevated temperatures
  - Radiation grafted membranes based on ETFE base polymer
  - Significant reduction in H_2 crossover at similar area resistance vs PFSA
  - Lower material cost

Lorenz Gubler – PSI @ 11:00

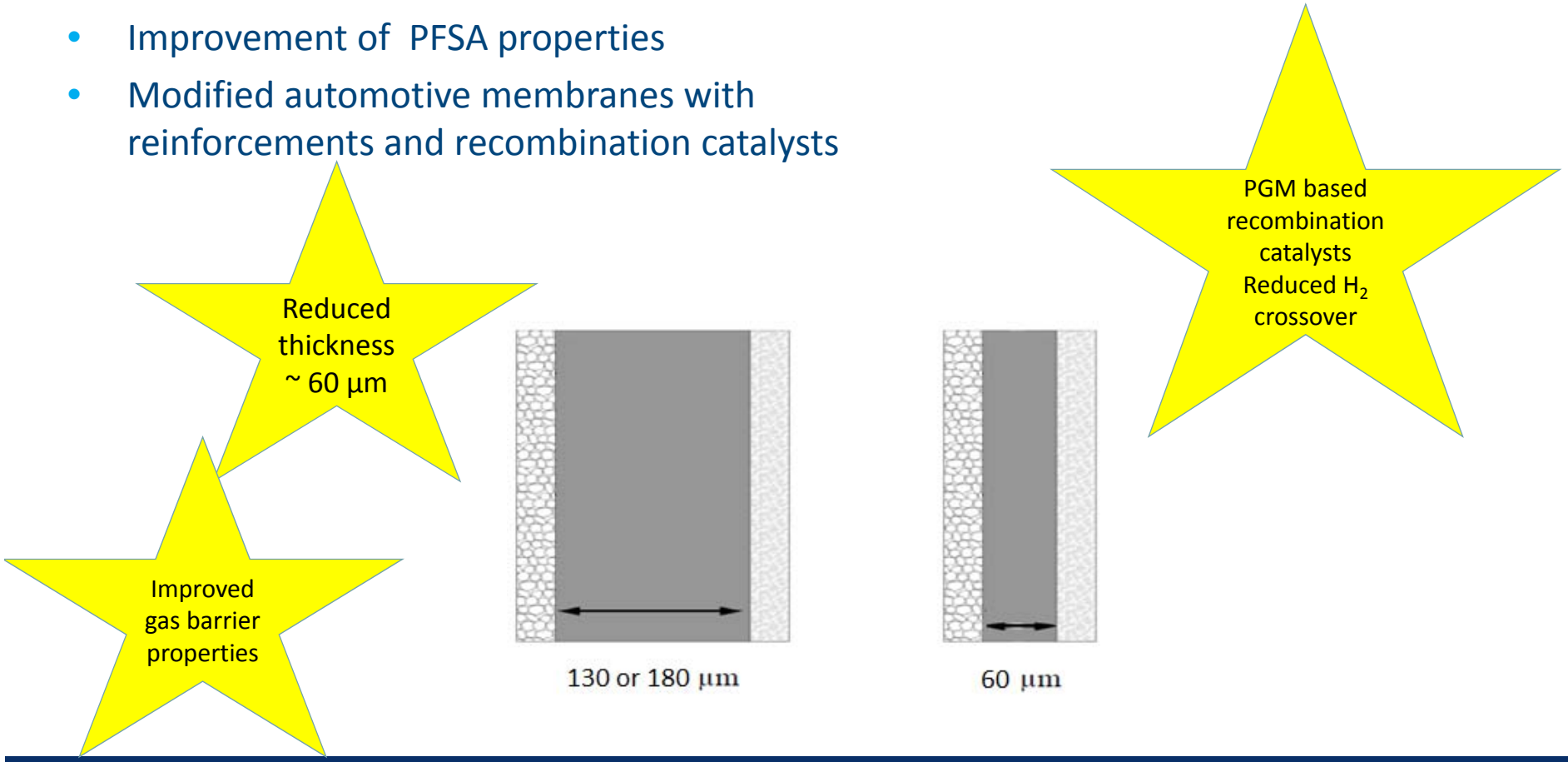


A. Albert, *ACS Appl. Mater. Interf.* 7 (2015) 22203

Johnson Matthey Fuel Cells
the power within

Approach and results - membranes

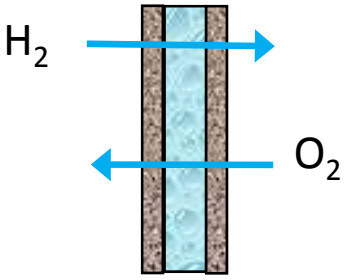
- Improvement of PFSA properties
- Modified automotive membranes with reinforcements and recombination catalysts

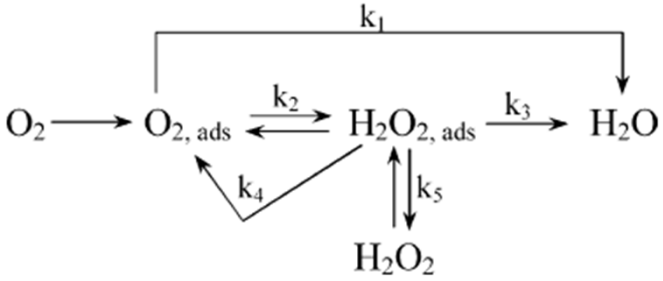


Approach and results - catalysts

- Increased utilisation of PGMs

- Increased lifetime through reduction of peroxide formation





Approach and results - catalysts

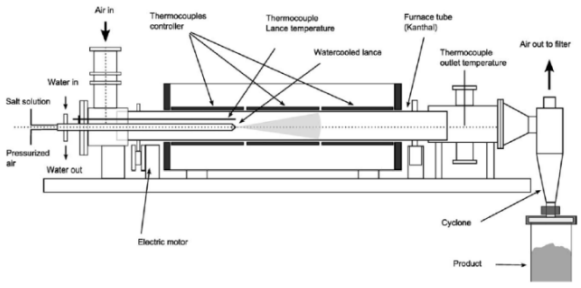
Spray pyrolysis

Spray water based precursors into heated chamber

Calcination + milling necessary

Several kg's pr day

SA = 30-50 m^2/g



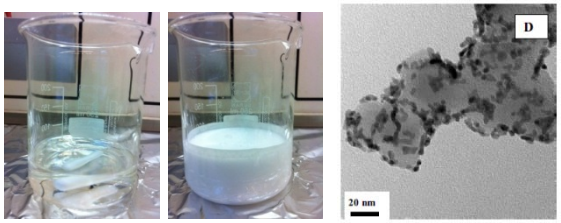
Co precipitation

Water -> hydrolysis (precipitation)

Calcination necessary

Nanosized spherical particles

SA = 100 m^2/g

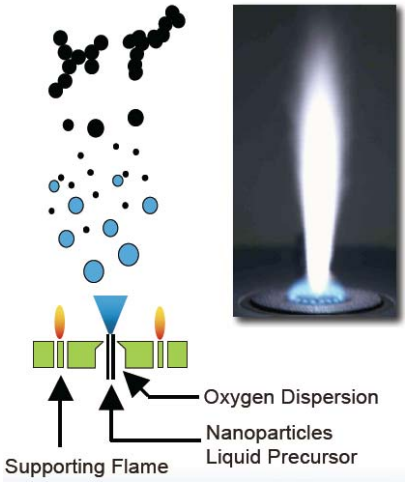


Flame Spray Pyrolysis

No post treatment necessary

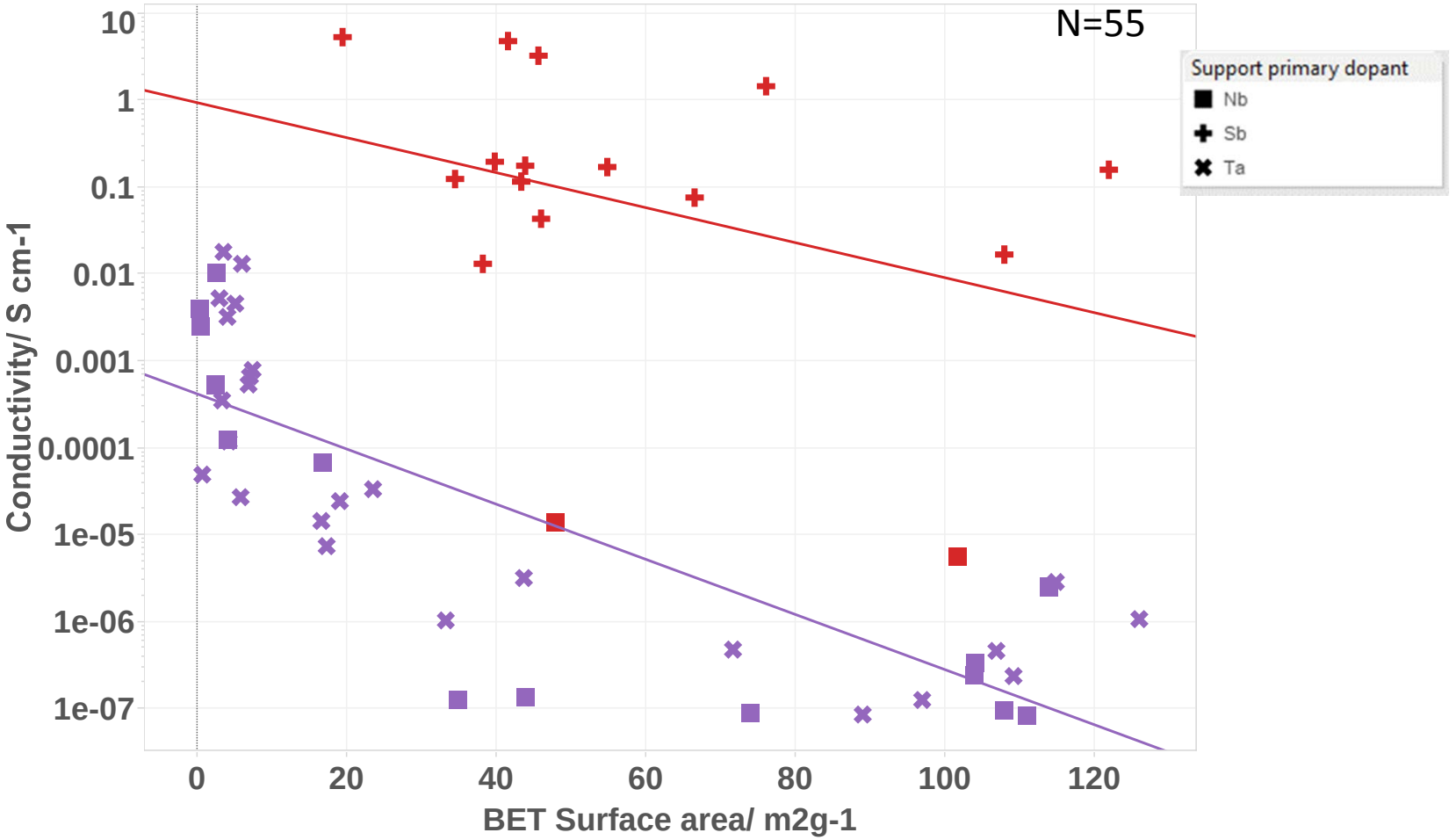
Small scale

SA = 100 m^2/g

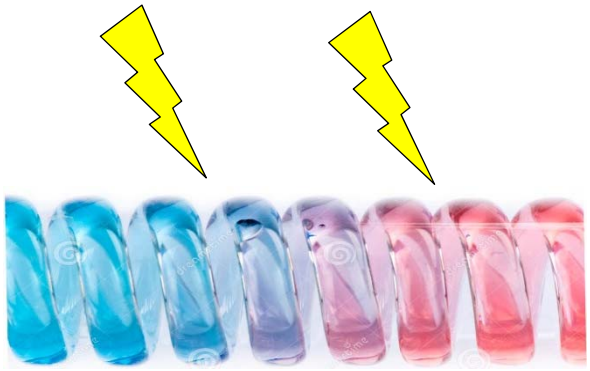


Approach and results - catalysts

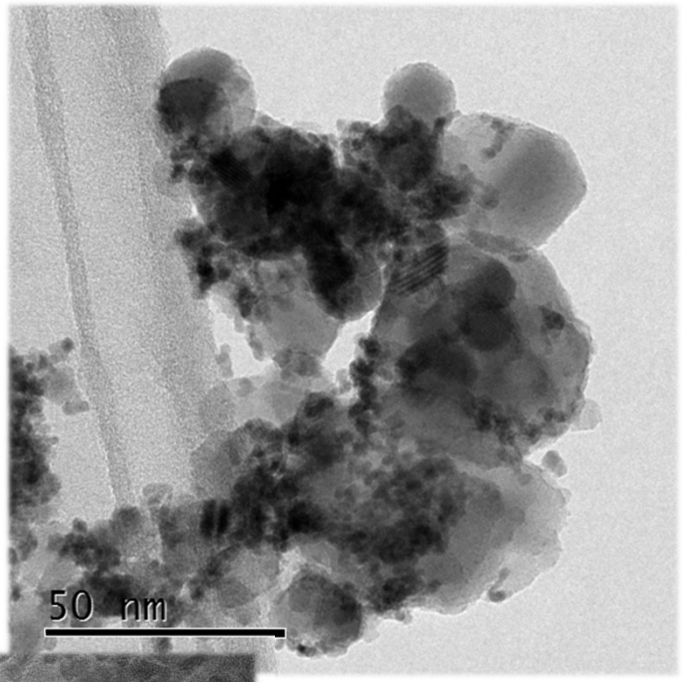
SnO_2 based supports
TiO_2 based supports
N=55

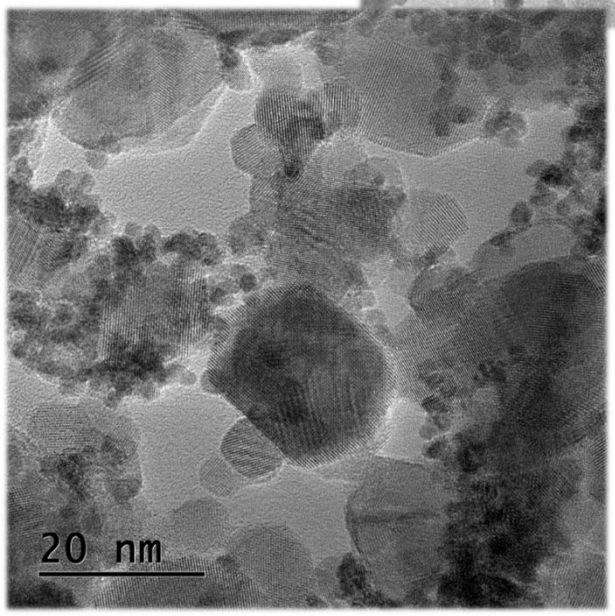


Approach and results - catalysts



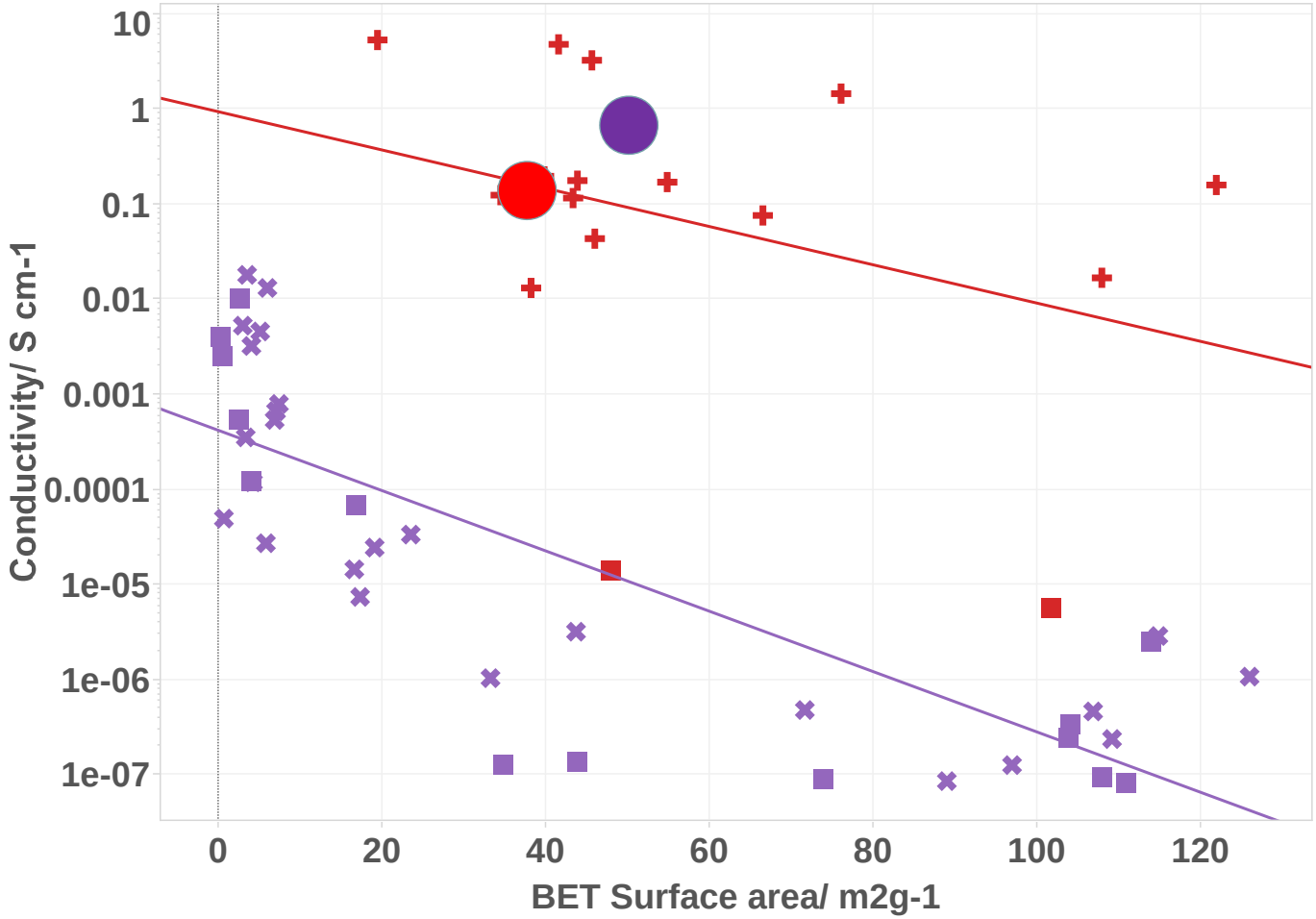
Microwave assisted polyol





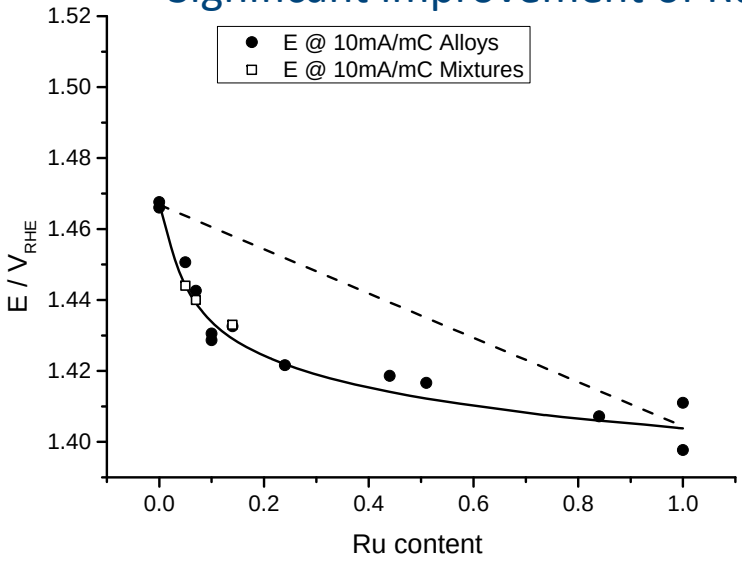
Approach and results - catalysts

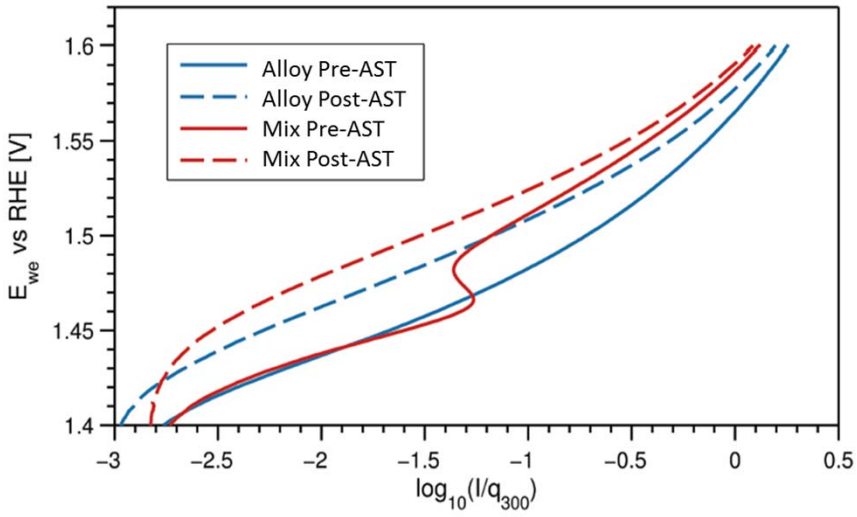
SnO_2 based supports
TiO_2 based supports



Technical highlights – catalysts

- Alloying Ru with Ir nanoparticles
  - Significant increase of activity with low Ru-addition
  - No reduction of Ru specific activity in alloys
    - Ru as active as in pure form
  - Significant improvement of Ru-stability compared to mixtures

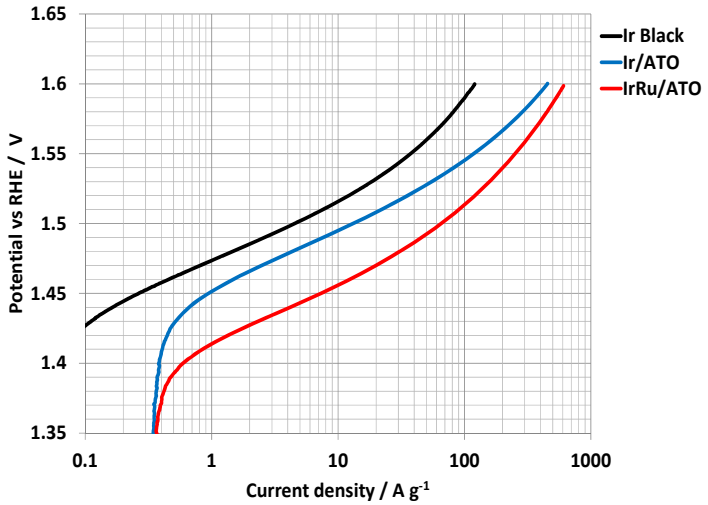


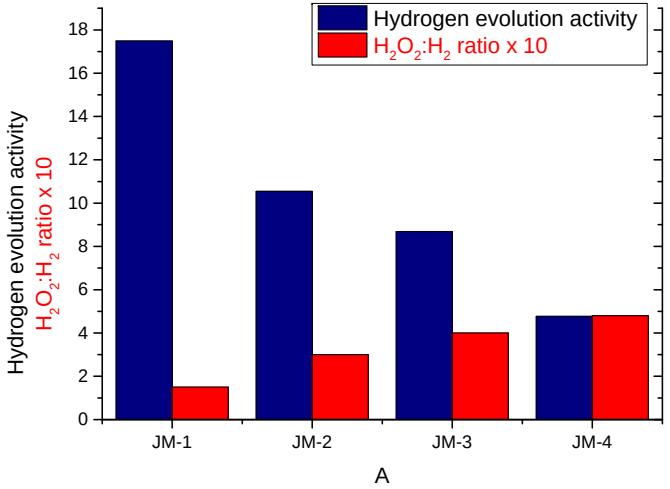


Technical highlights – catalysts

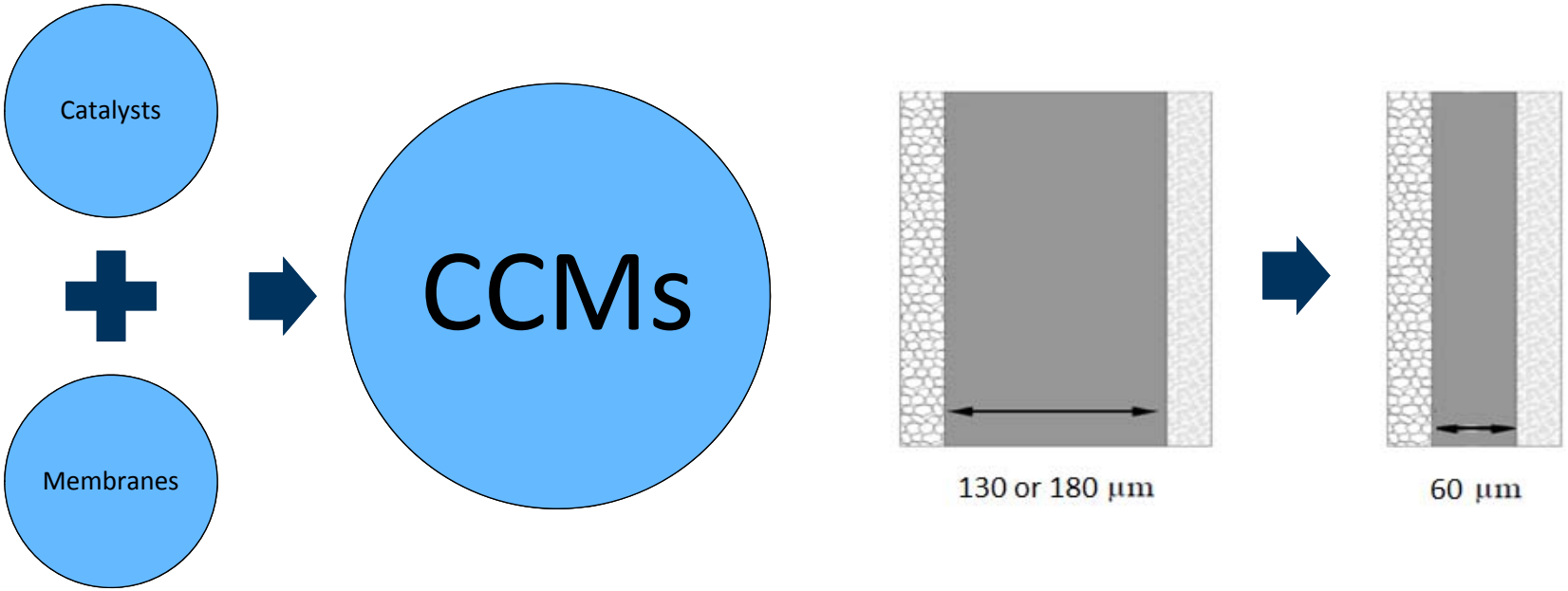
- Highly active oxygen evolution catalysts developed
  - 2 nm Ir and IrRu particles on conductive oxide supports
  - 3-25 times higher activity vs state of the art Ir catalysts

- Hydrogen evolution catalysts with high activity and low peroxide formation identified
  - Reduction in noble metal loading
  - Increased lifetime



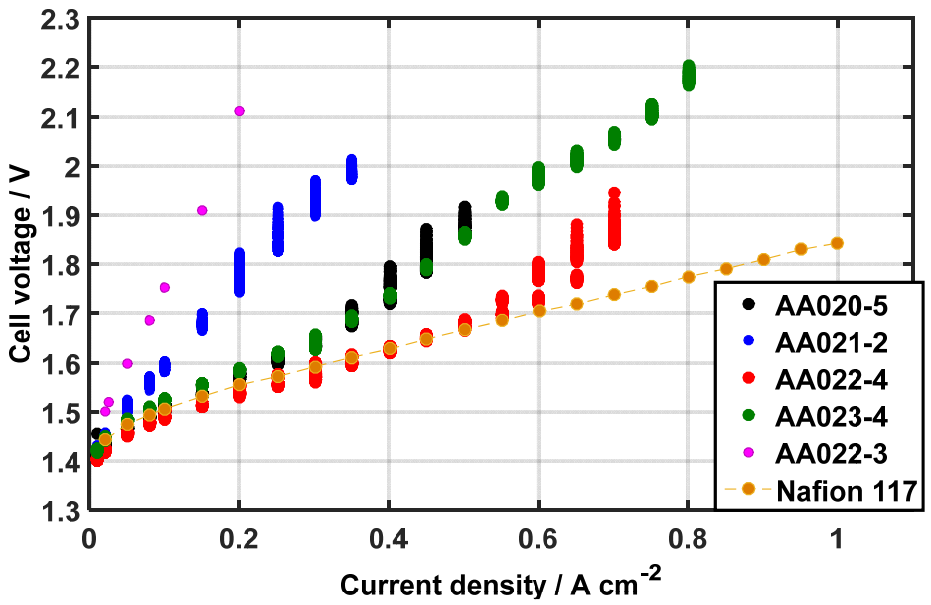


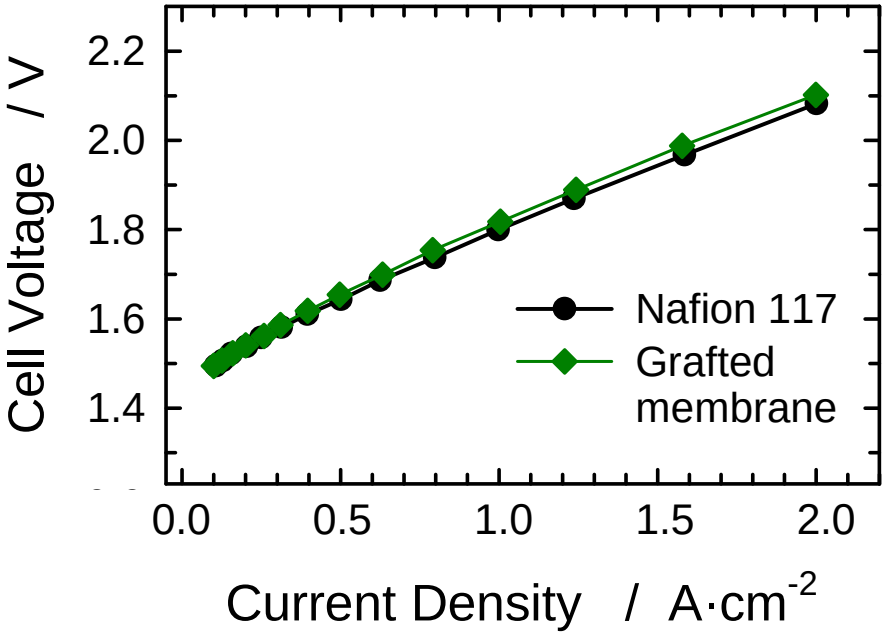
Approach and results – MEA development



Approach and results – MEA development

Radiation grafted membranes and state of the art catalysts

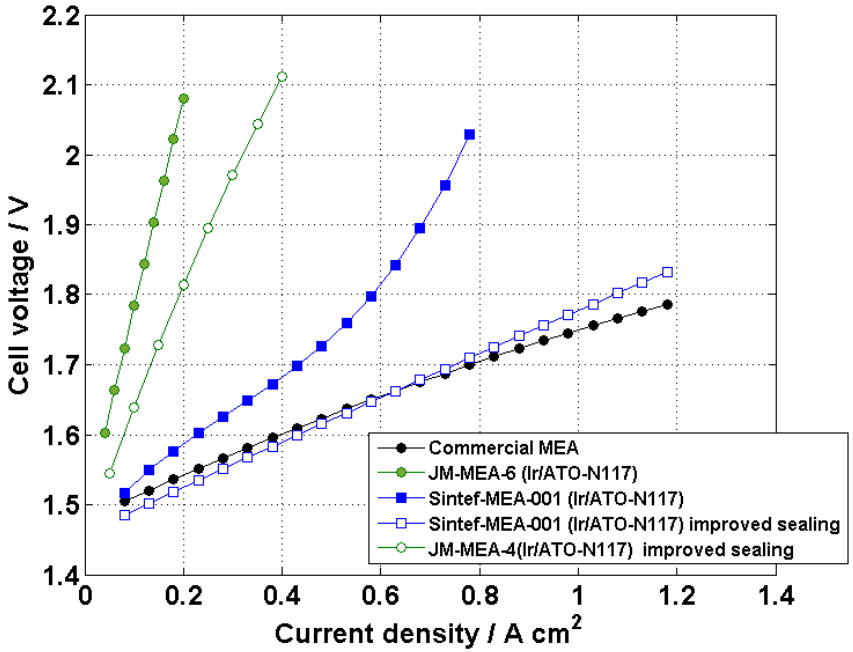


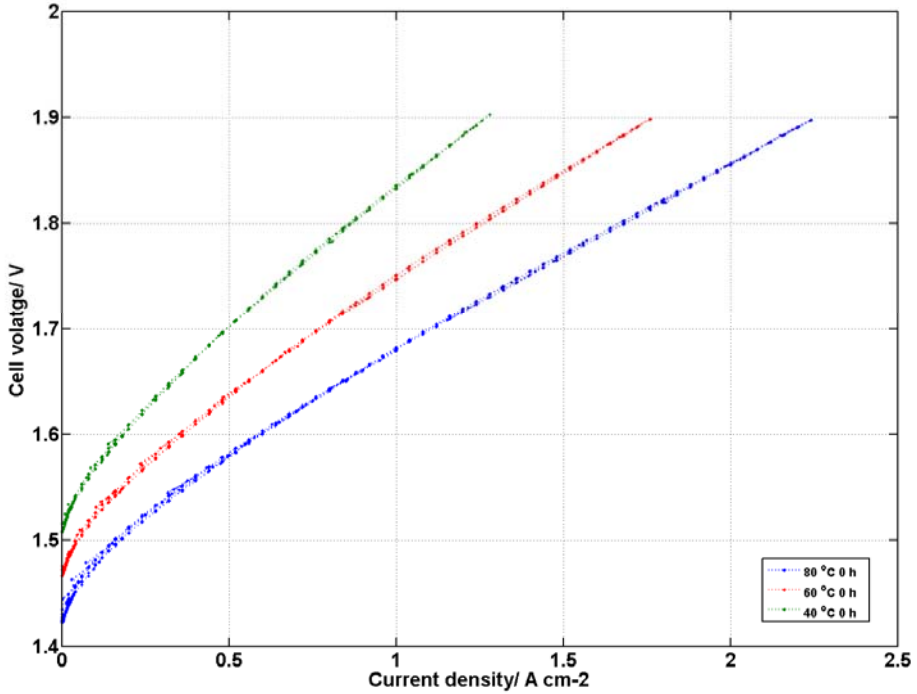


2013 → 2015

Approach and results – MEA development

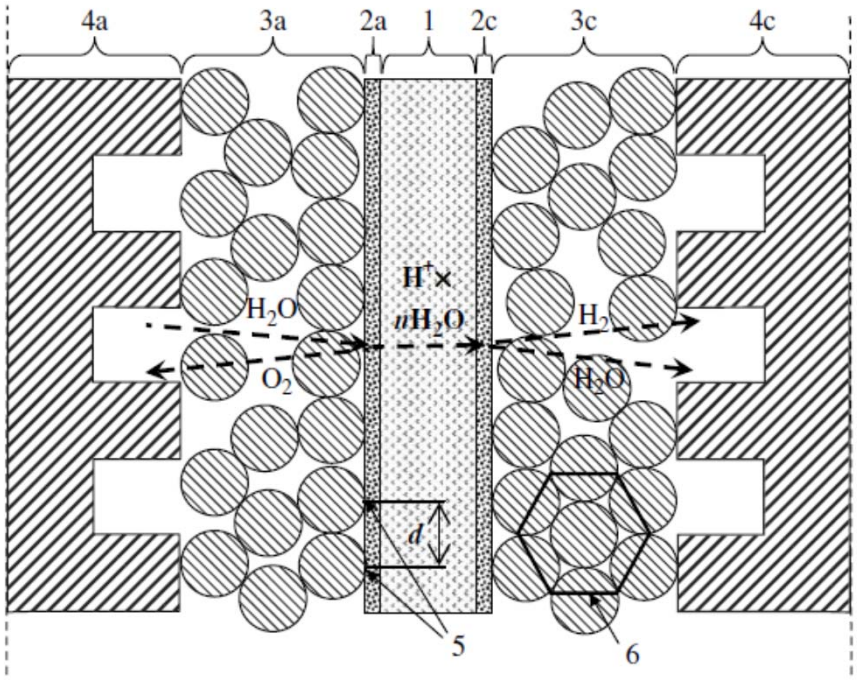
PFSA membranes and novel catalysts (Ir/ATO)





Approach and results – MEA testing

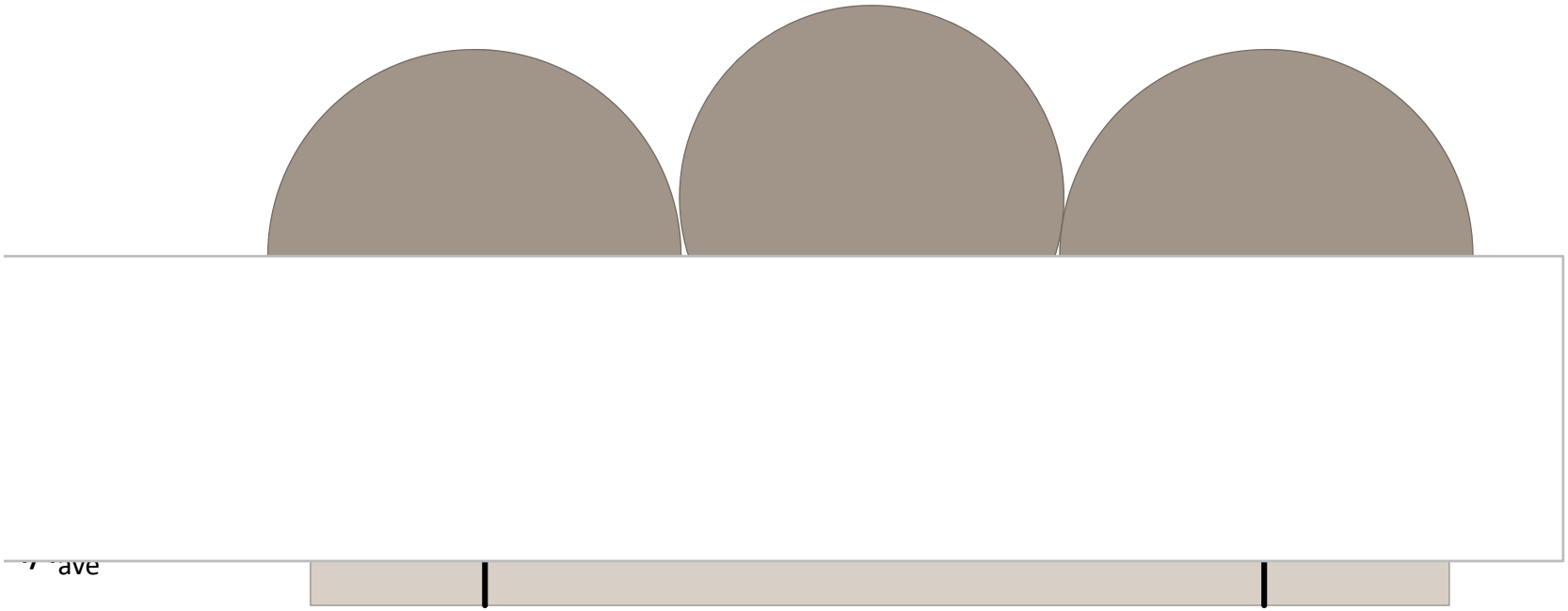
- Reducing membrane thickness and lowering catalyst loading
- Replacing highly conductive catalysts with lower conductivity options
- Avoiding the use of noble metal coatings on current collectors and bipolar plates

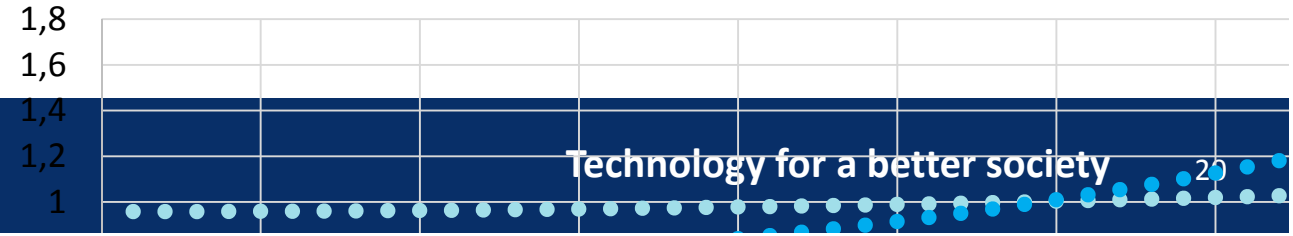


Ed Wright – Johnson Matthey @ 09:35 tomorrow

S.A. Grigoriev, P. Millet, S.A. Volobuev, V.N. Fateev
Int J Hydrogen Energy 34 (2009) p.4968

Approach and results – MEA testing



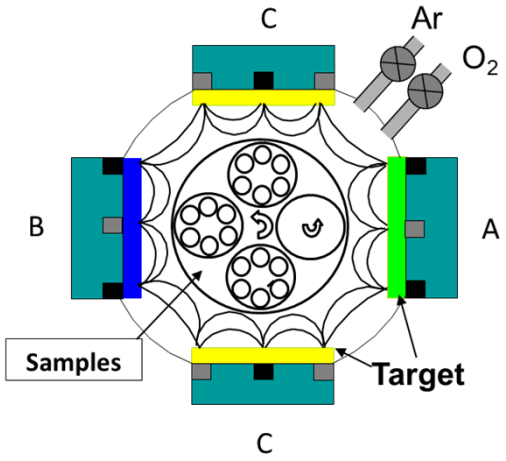


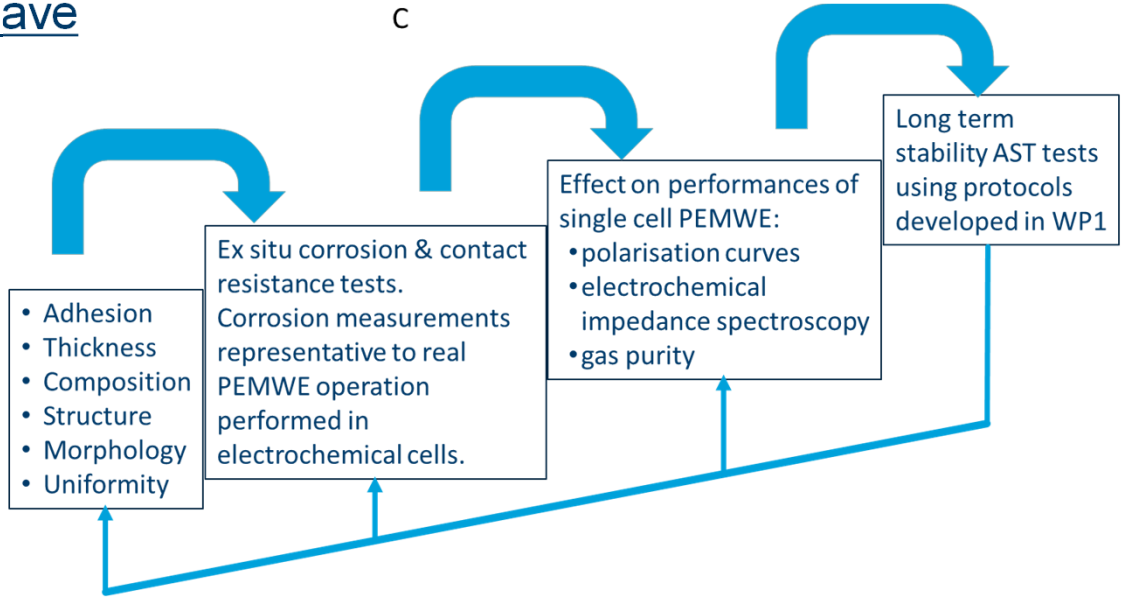
Coatings for bipolar plates

Fraunhofer ISE

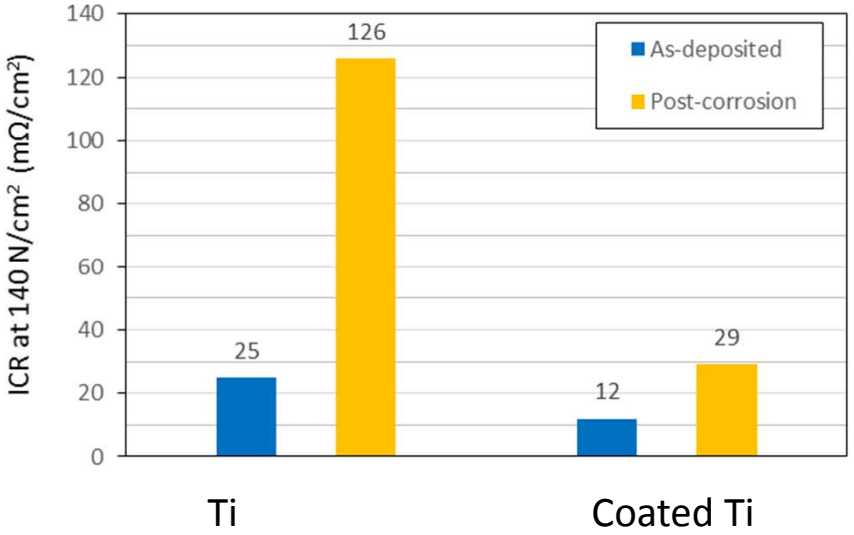
Closed field unbalanced magnetron sputter ion plating (CFUBMSIP) technology has been used as a primary procedure for coating development

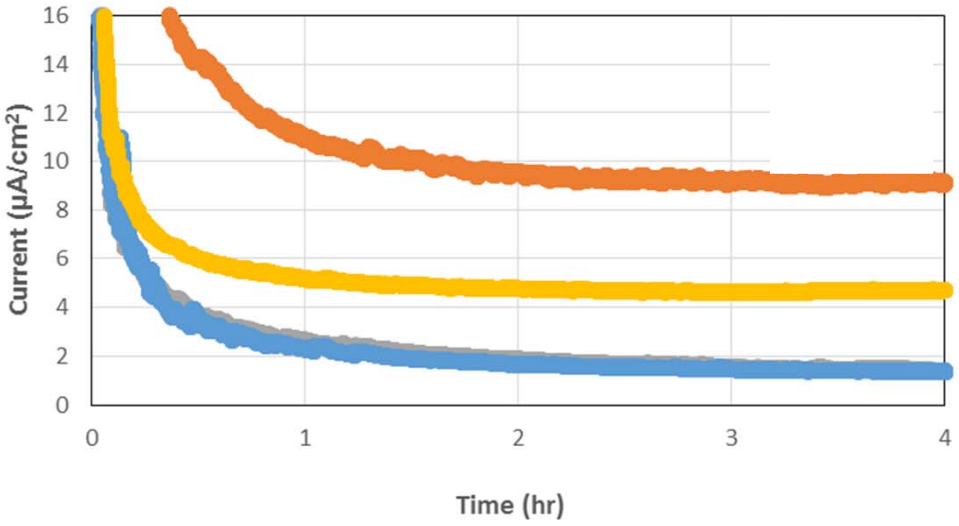
More than 75 different coatings have been investigated





Coatings for bipolar plates and current collectors



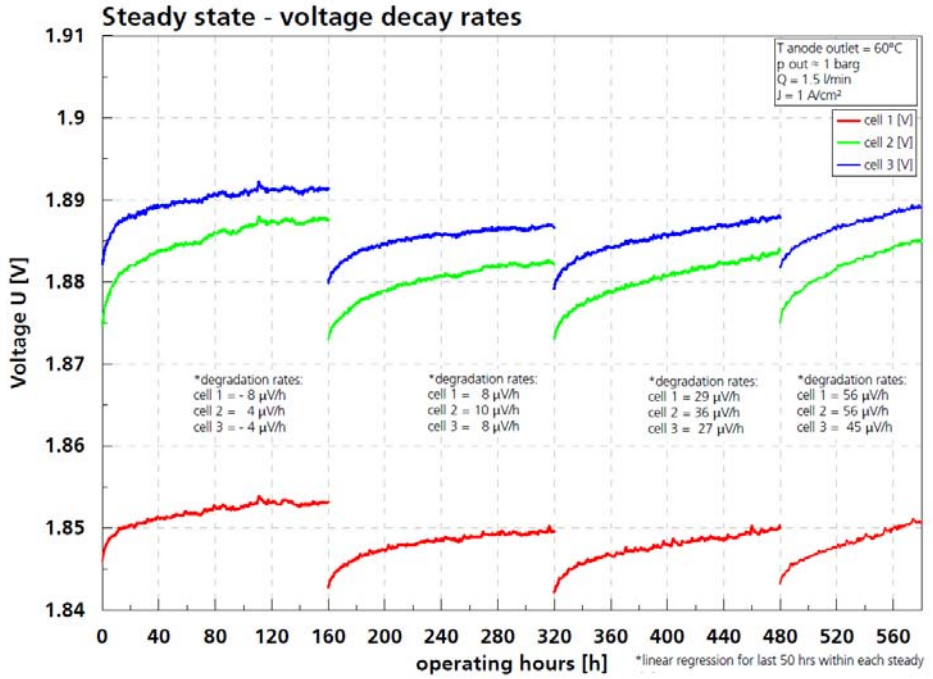


- The corrosion current of coated sample is 1/5 that of un-coated Ti
- ICR of as-deposited & post-corrosion coating is ½ & ¼ that of Ti sub respectively
- Coatings under testing in rainbow stacks at Fraunhofer & Areva H2Gen

Andreas Georg – Fraunhofer @ 11:30

Stack development and testing

- Five consecutive short stacks have been assembled and tested at Fraunhofer
- Rainbow stack constructed at Areva H2Gen tested for more than 1000h
- Final stack testing will start in Q2 2016.



Degradation and AST protocols

liten

Analytical Methods and main outcomes

AST-1: 48h AST signal @ 90°C repetaed at least 4 times

- 3 A/cm² (E > 2V) : spe
- 0,3 A/cm² : speed up m

AST-2: 48 h AST@ 90°C repeated at leat 4 times

- Longer step time at lov amplify the membrane

AST-3: : 48 h AST@ 90°C repeated at leat 4 times with ΔP (P_{O2} = 4 bar vs. P_{H2} = 1 bar)

- Suppose to amplify the and accelerate the men

AST- 4: 48 h AST@ 90°C repeated at leat 4 times with 5ppm Fe ions

- Adding metal ion impu the Fenton reaction.

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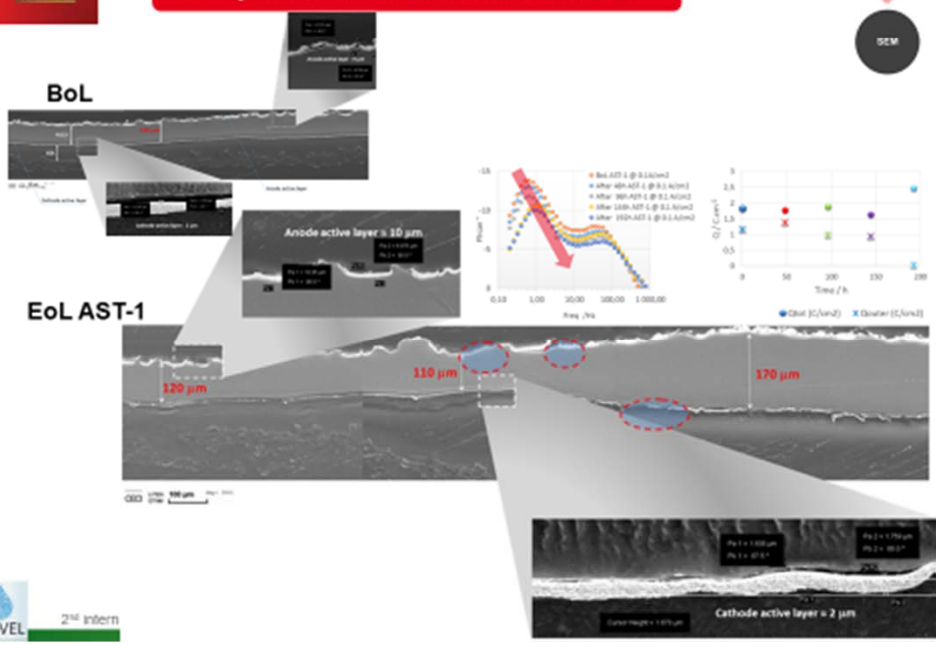
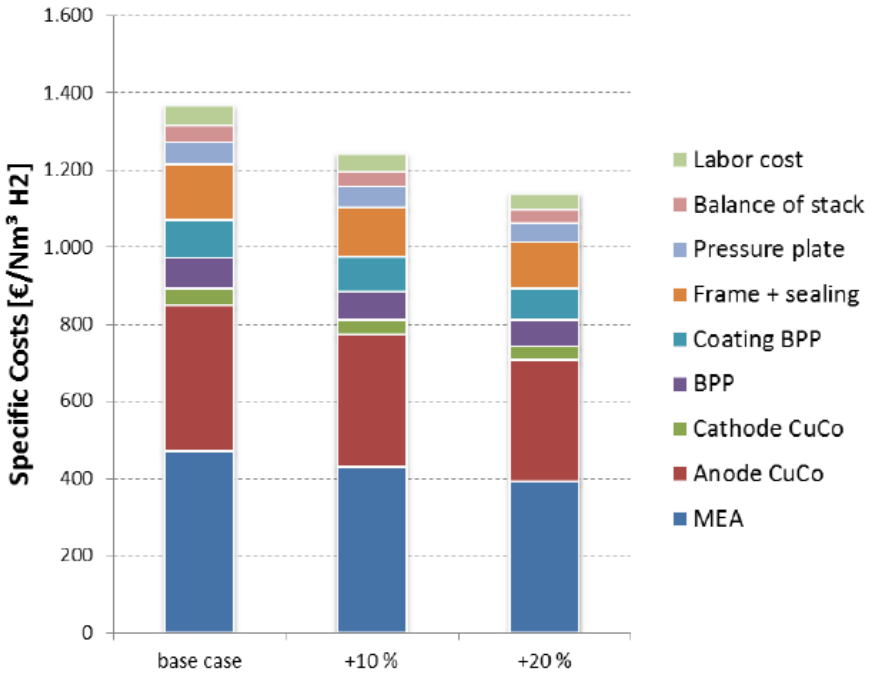
Analytical Methods and main outcomes



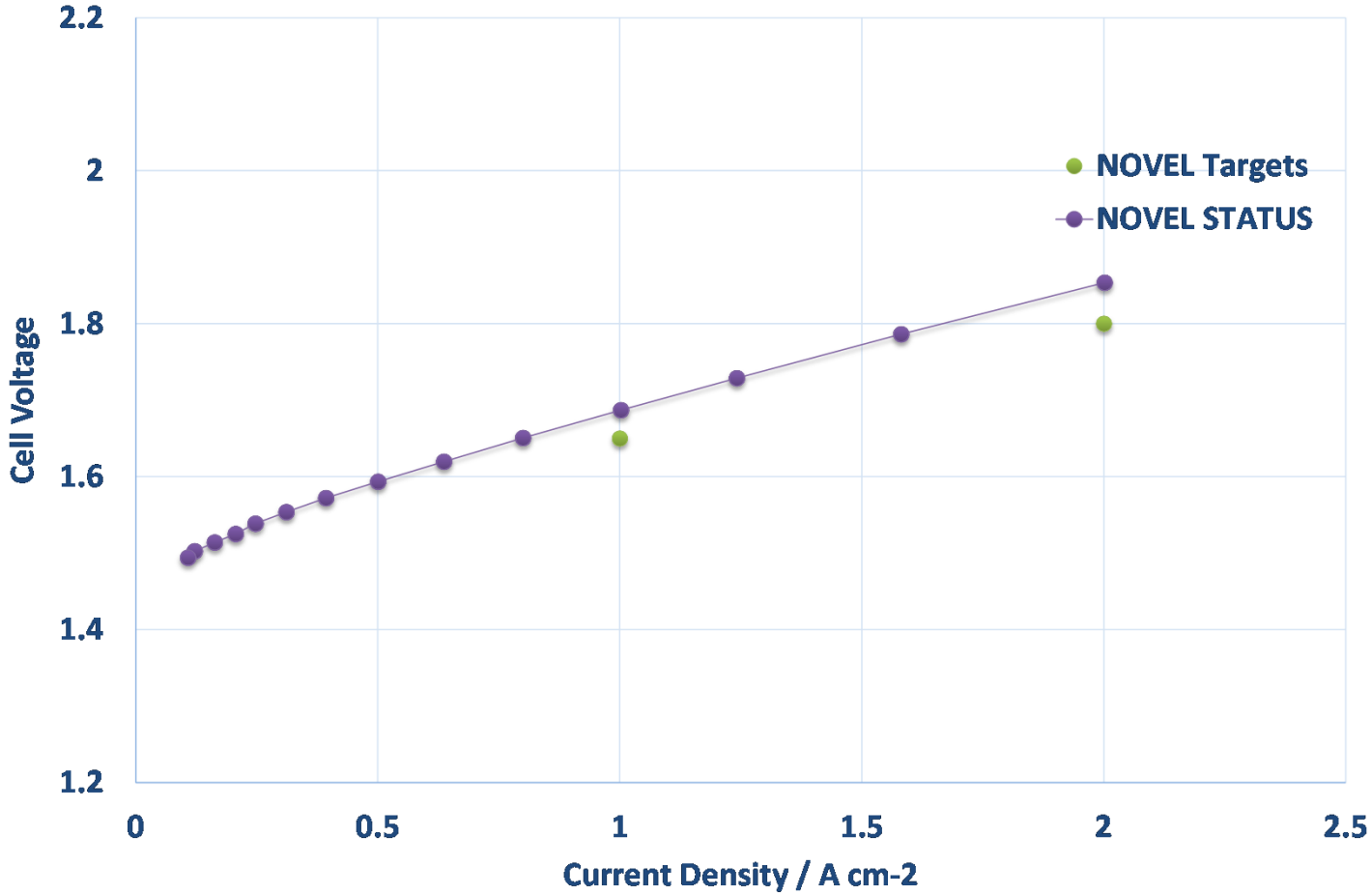
Frederic Fouda Onana – CEA @ 12:00

Cost break down – NOVEL Stack design

- Stack design with thin Ti sheets as bipolar plates
  - Non-precious metal coatings
- 600 cm^2 active electrode area
- 50 Nm^3h^{-1} production rate
- 1.8 V nominal cell voltage @ 2 Acm^{-2}
- Annual production of 100 stacks
- Anode current collector and MEA manufacturing major cost drivers.
  - MEA manufacturing costs will come down with increased numbers produced
- Target cost of 2500 € / Nm^3h^{-1} is reached.

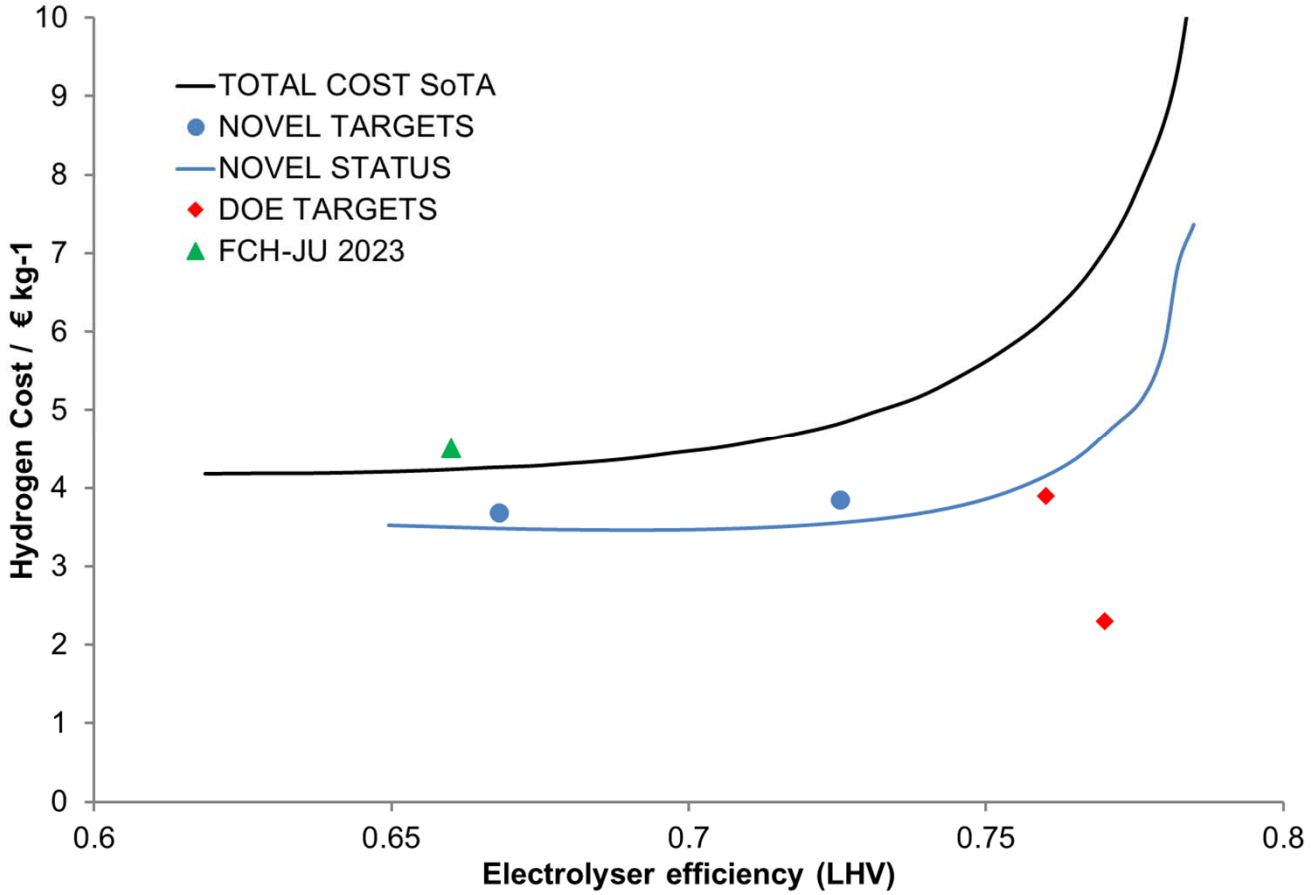


NOVEL status vs. targets – Single cell results



NOVEL status vs. targets

- 57c / kWh electricity cost.
- 60000 h stack lifetime




Thank you for your attention

Acknowledgements

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