

PRE-AGING STUDY ON POROUS TRANSPORT LAYER IN A SEGMENTED ALONG THE CHANNEL PEM ELECTROLYSIS CELL

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AGENDA

01 Introduction

02 Materials and Methods

03 Single PTLs tests

04 Rainbow configuration tests

05 Conclusion

01

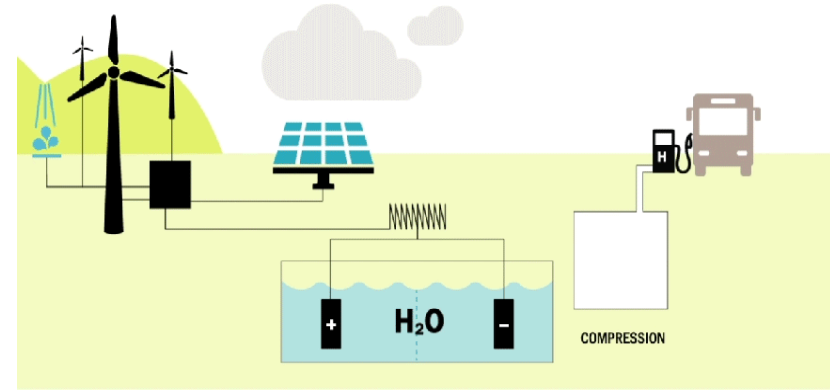
Introduction

INTRODUCTION

Climate change



In which the hydrogen is the driver of the energy transition



To reduce the use of fossil fuels



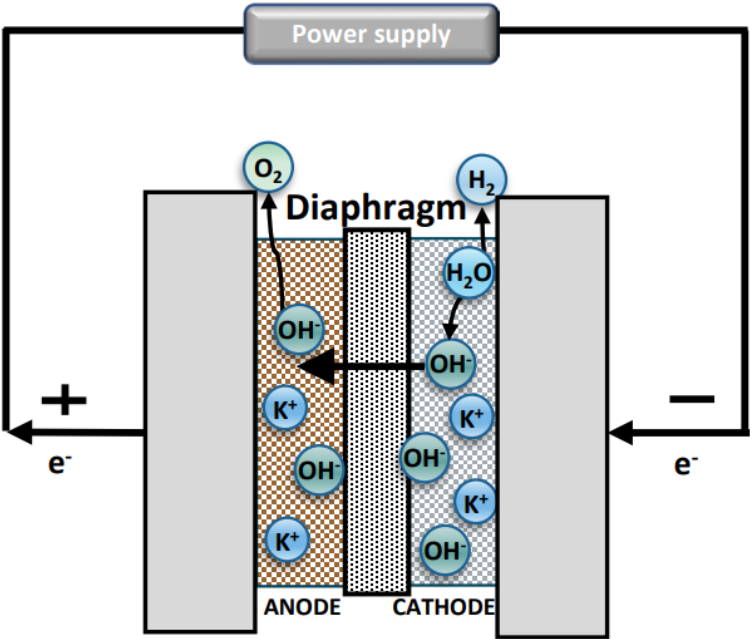
Moving towards a green perspective



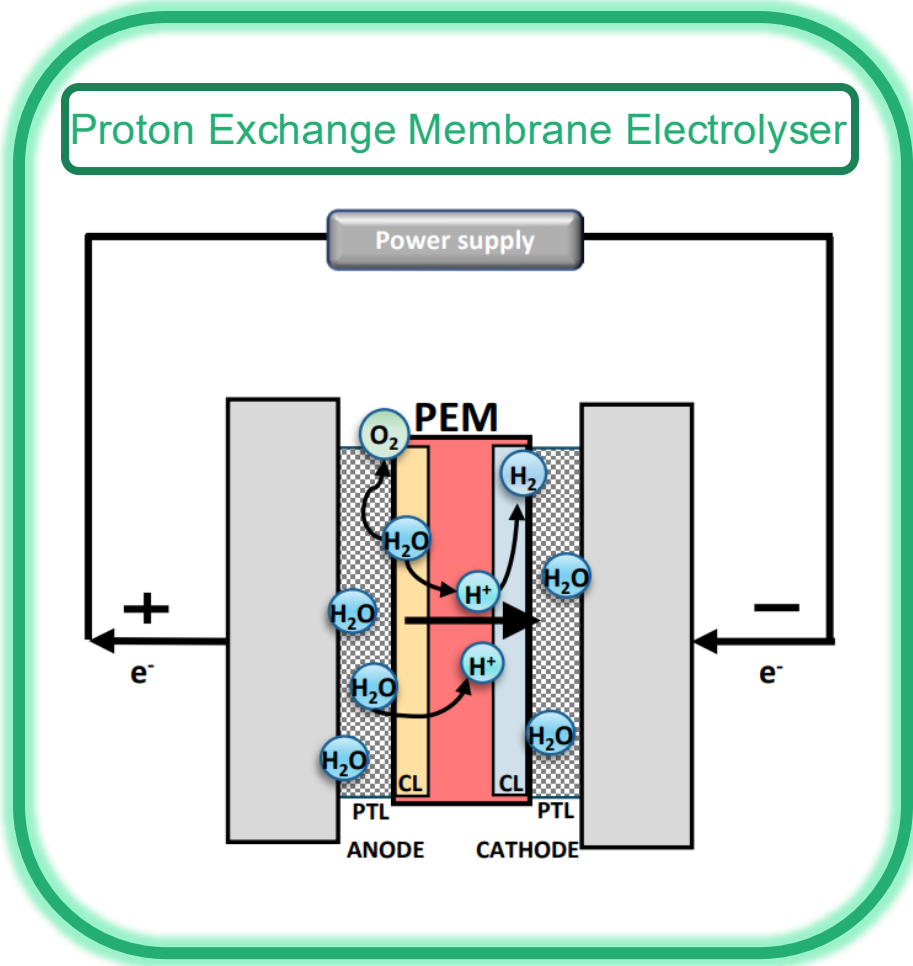
Increasing the global temperature

INTRODUCTION

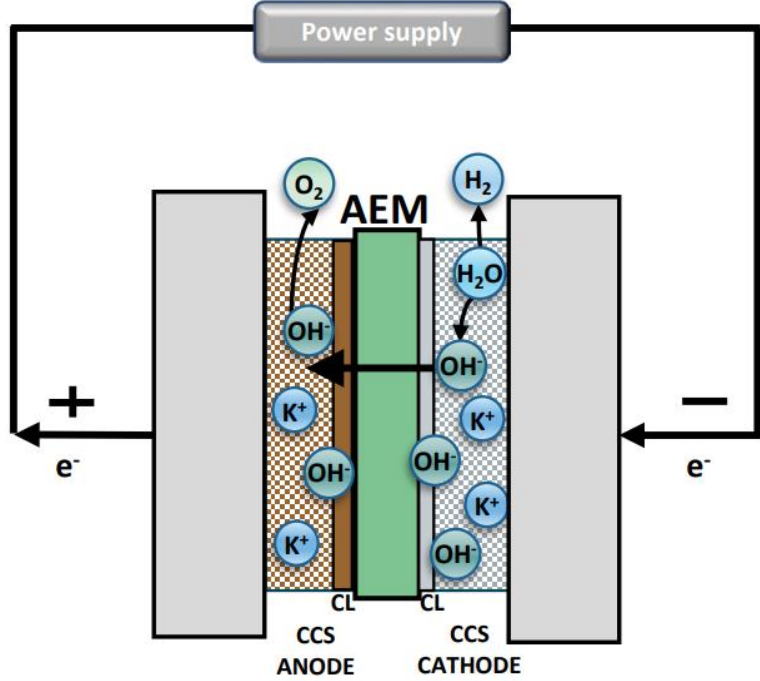
Alkaline Electrolyser



Proton Exchange Membrane Electrolyser

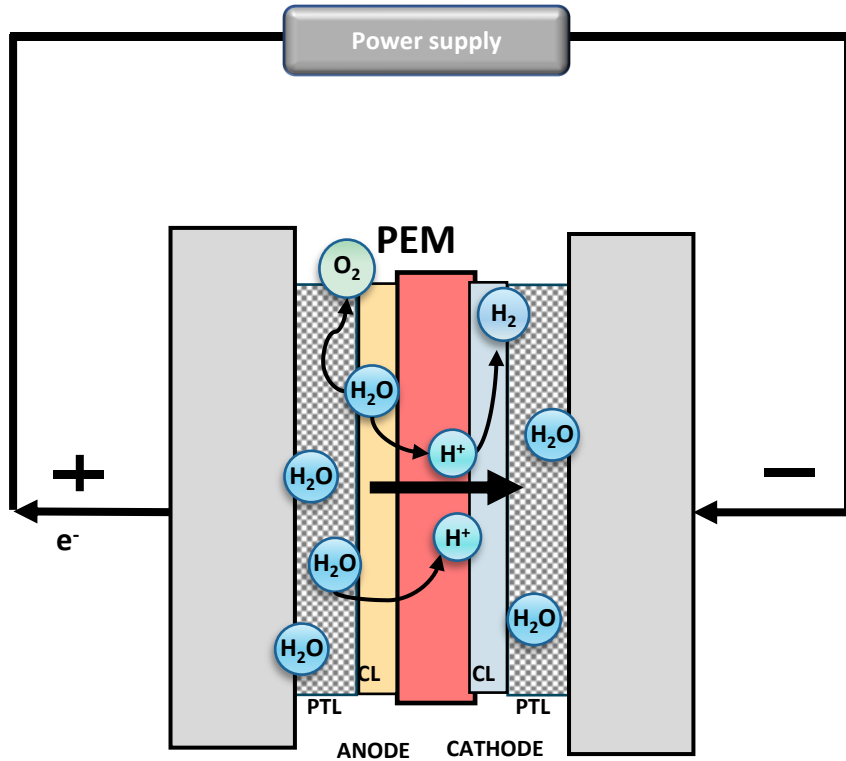


Anion Exchange Membrane Electrolyser



INTRODUCTION

The limitation of the technology:
Scale-up and durability issues.



The idea is to study an Along the Channel (AtC) segmented PEM cell, in order to investigate the influence of pre-aged Porous Transport Layers on the cell performances.

Experimental campaign carried out at

 **Fraunhofer**
ISE

In collaboration with

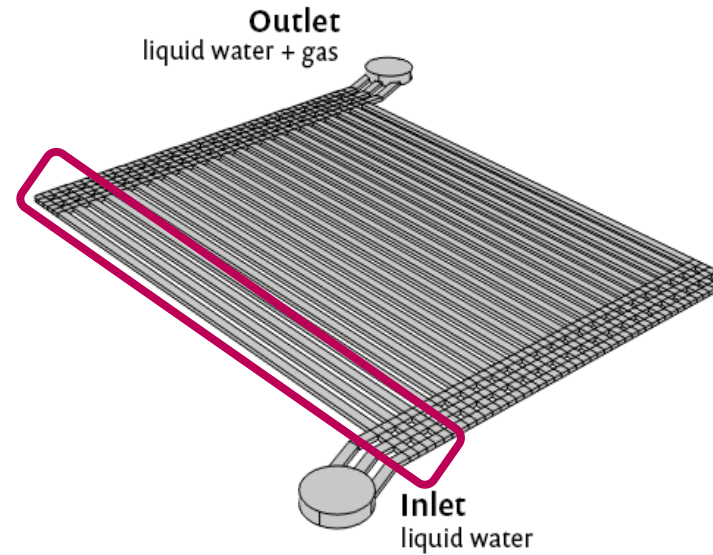
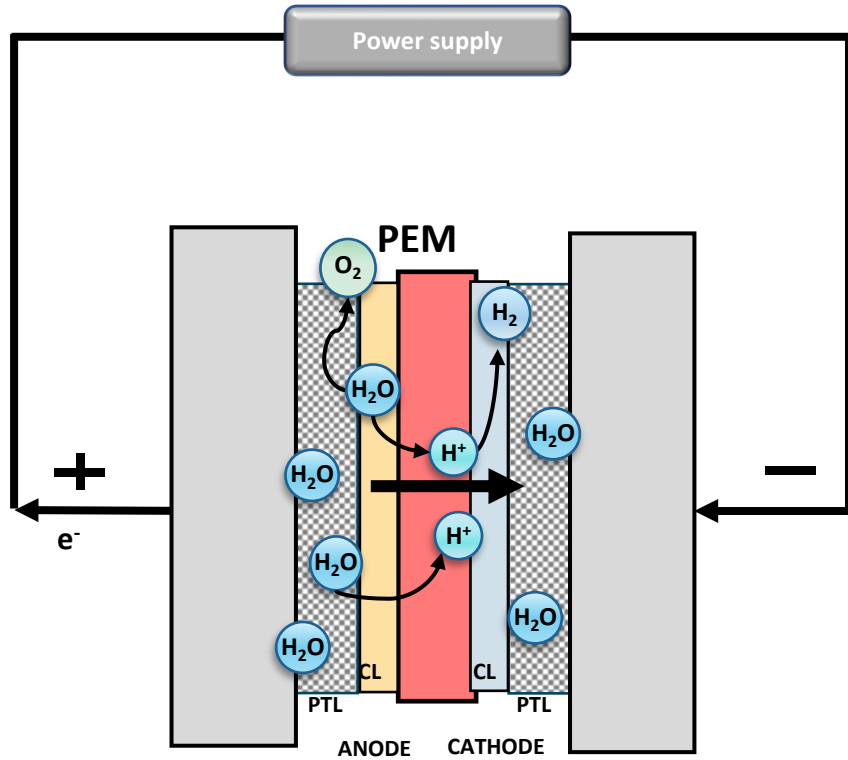


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di Palermo**

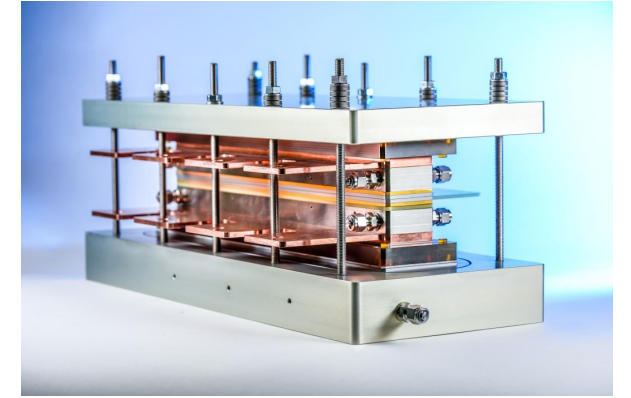
02

Materials and methods

What AtC Cell is?



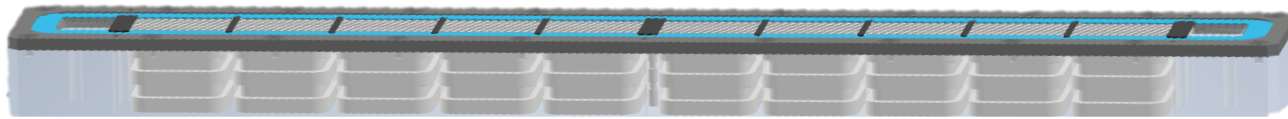
Along the Channel cell



Source: Fraunhofer ISE / Photo: Joscha Feuerstein

What AtC Cell is?

- Parallel flowfield dimension – active area: 2 x 30 cm²

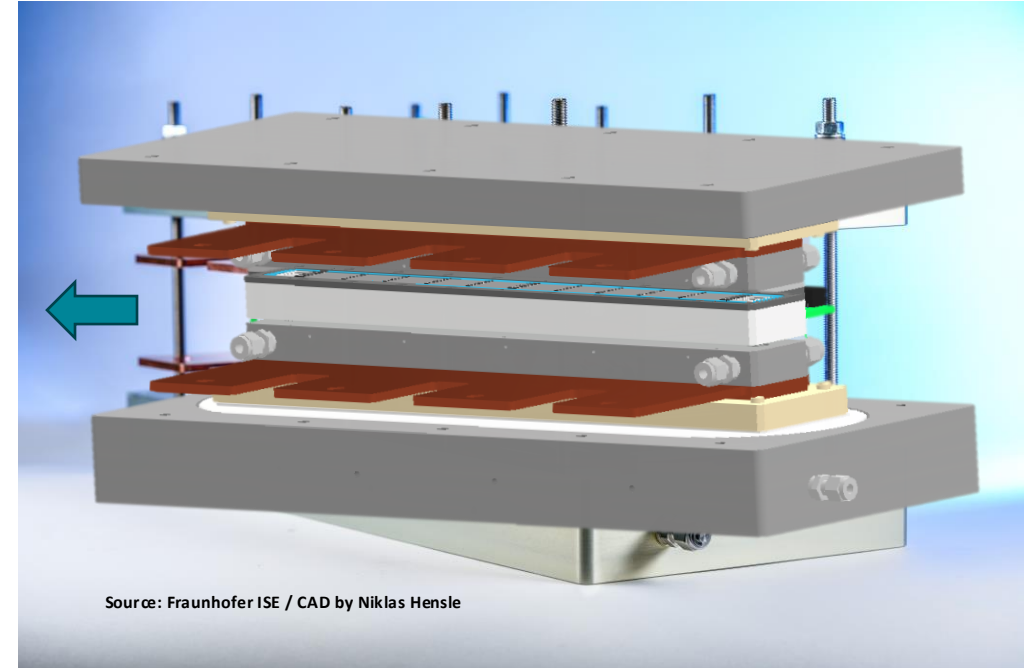


- Segmented in 10 equal parts

Experimental campaign:

Single PTLs tests

Performing tests with different PTLs in the cell. The cell has the same PTL in all the segments.



Source: Fraunhofer ISE / Photo: Incha Frenzel

Rainbow configuration

Having a different PTLs type in each segment of the cell.

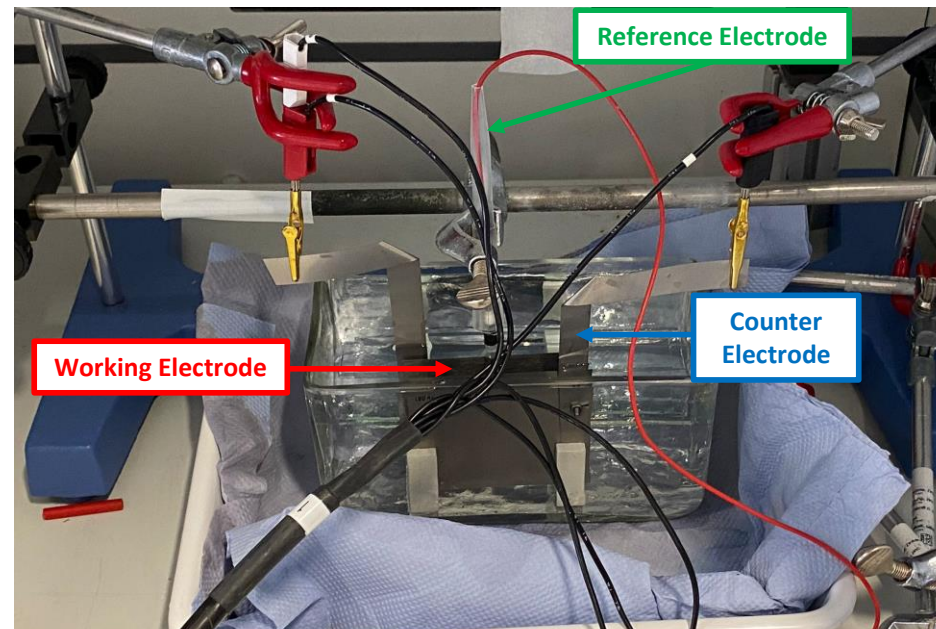
Current density tested: up to 5 A cm⁻²

Proton-Exchange Membrane Electrolyser

Single PTLs tests: Study focuses on the Porous Transport Layers

Uncoated vs. Pt Coated

- Uncoated Ti PTLs
- Pt Coated PTLs (Pt thickness 40 nm)
- Uncoated Ti PTLs anodised at 2 V for 24 h
- Pt coated PTLs anodised at 2 V for 24 h



Pre-aging procedure

0.5 M H₂SO₄ and 1 mg L⁻¹ HF

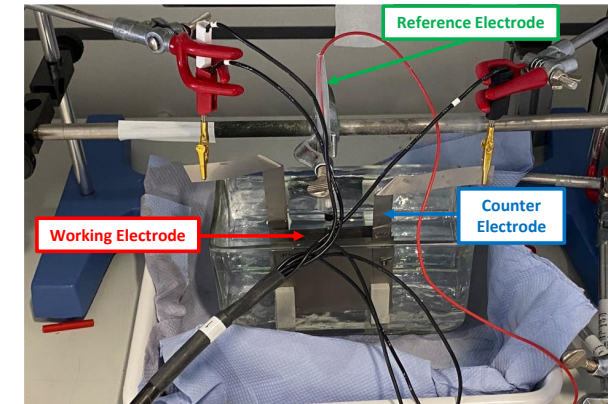
Proton-Exchange Membrane Electrolyser

Rainbow configuration: Study focuses on the PTLs and the performances with different membranes

Uncoated vs. Pt Coated

- Uncoated Ti PTLs
- Uncoated Ti PTLs anodised at 2 V for 24 h
- Uncoated Ti PTLs anodised at 5 V for 4 h
- Pt Coated PTLs (Pt thickness 40 nm)
- Pt coated PTLs anodised at 2 V for 24 h

Pre-aging procedure



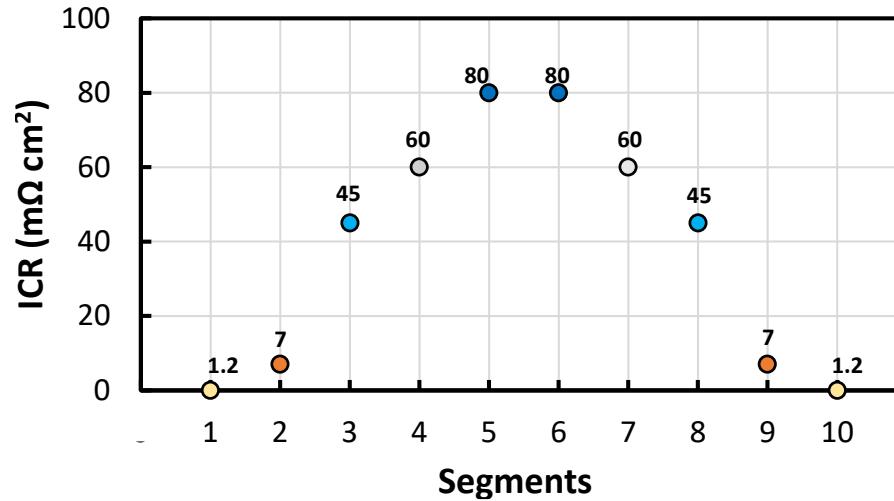
0.5 M H₂SO₄ and 1 mg L⁻¹ HF

40 nm Pt Coated Pt Coated anodised 2 V, 24 h Uncoated anodised 2 V, 24 h Uncoated Uncoated anodised 5 V, 4 h Uncoated anodised 5 V, 4 h Uncoated Uncoated anodised 2 V, 24 h Pt Coated anodised 2 V, 24 h 40 nm Pt Coated



Proton-Exchange Membrane Electrolyser

Rainbow configuration: Study focuses on the PTLs and the performances with different membranes



- Commercial Catalyst Coated Membrane (CCM)
- In-house made CCM (loading: Ir 0.6 mg cm⁻² and Pt 0.15 mg cm⁻²)

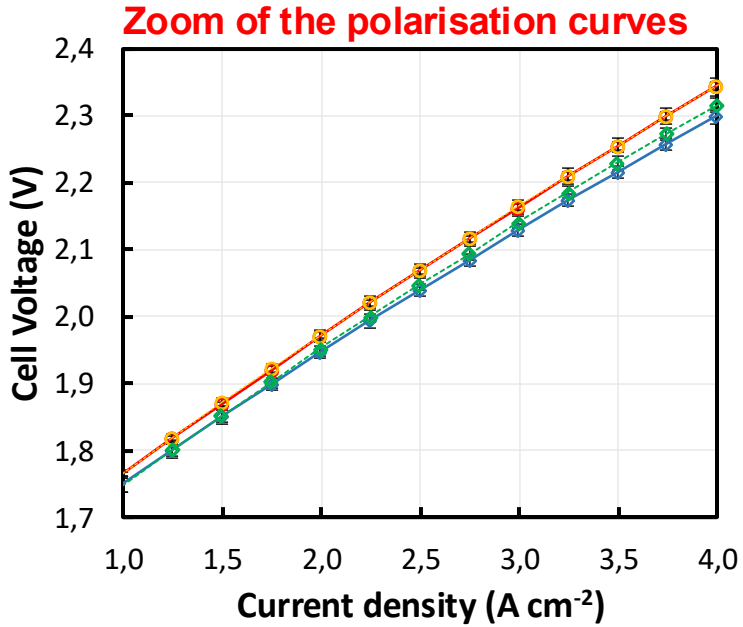
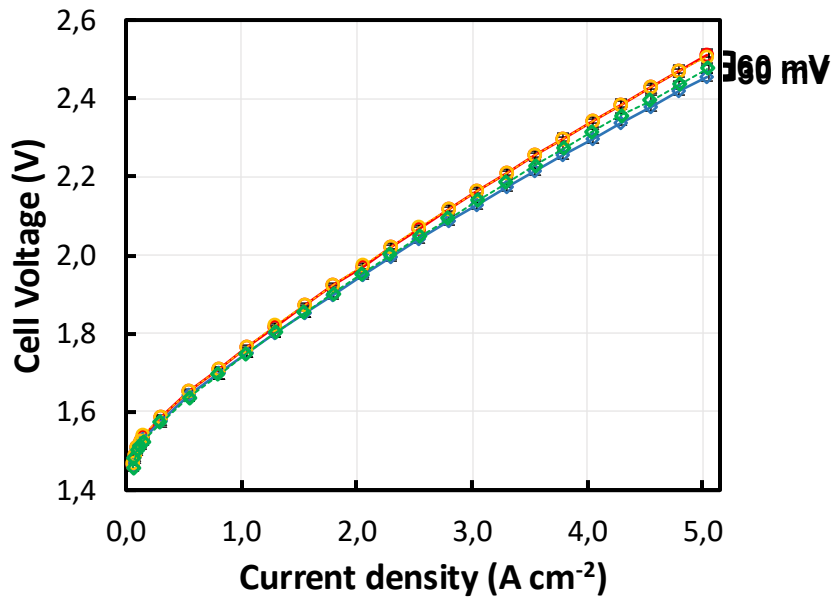
40 nm Pt Coated Pt Coated anodised 2 V, 24 h Uncoated anodised 2 V, 24 h Uncoated Uncoated anodised 5 V, 4 h Uncoated anodised 5 V, 4 h Uncoated Uncoated anodised 2 V, 24 h Pt Coated anodised 2 V, 24 h 40 nm Pt Coated



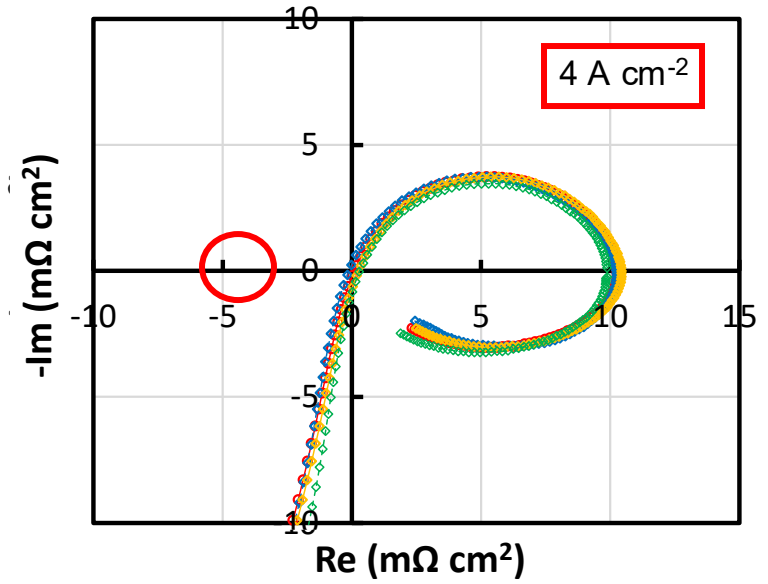
03

Single PTLs tests

Single PTLs tests



The Pt coated PTLs have the lowest ohmic resistance.



Except for HFR, spectroscopy results are totally consistent.

Why does the anodising procedure worsen performance only in the case of Pt coated PTLs?

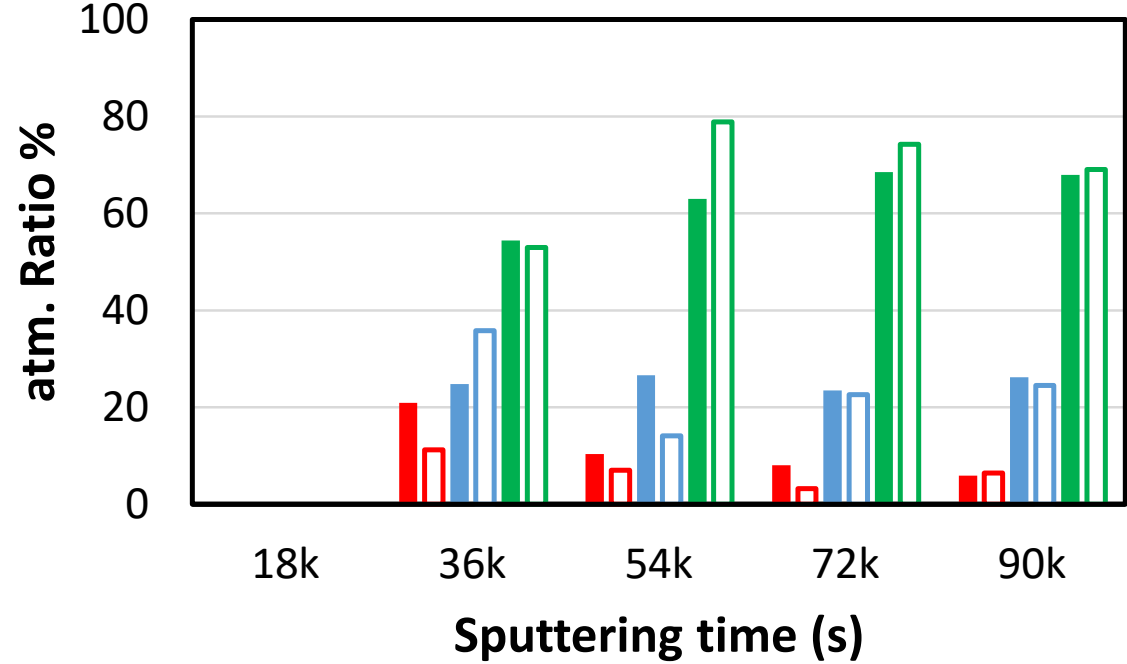


Single PTLs tests

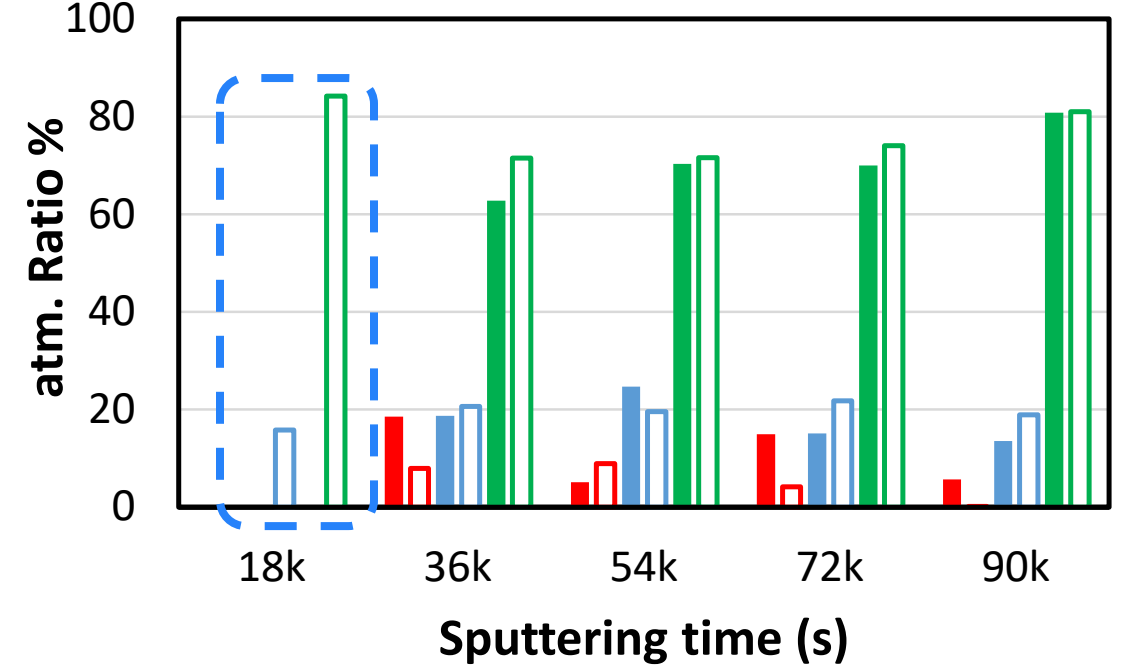
In the Pt coated anodised PTLs, Ti oxide is formed during the test, not present in the case of pristine Pt coated PTLs.

XPS analyses:

Before the tests



After tests

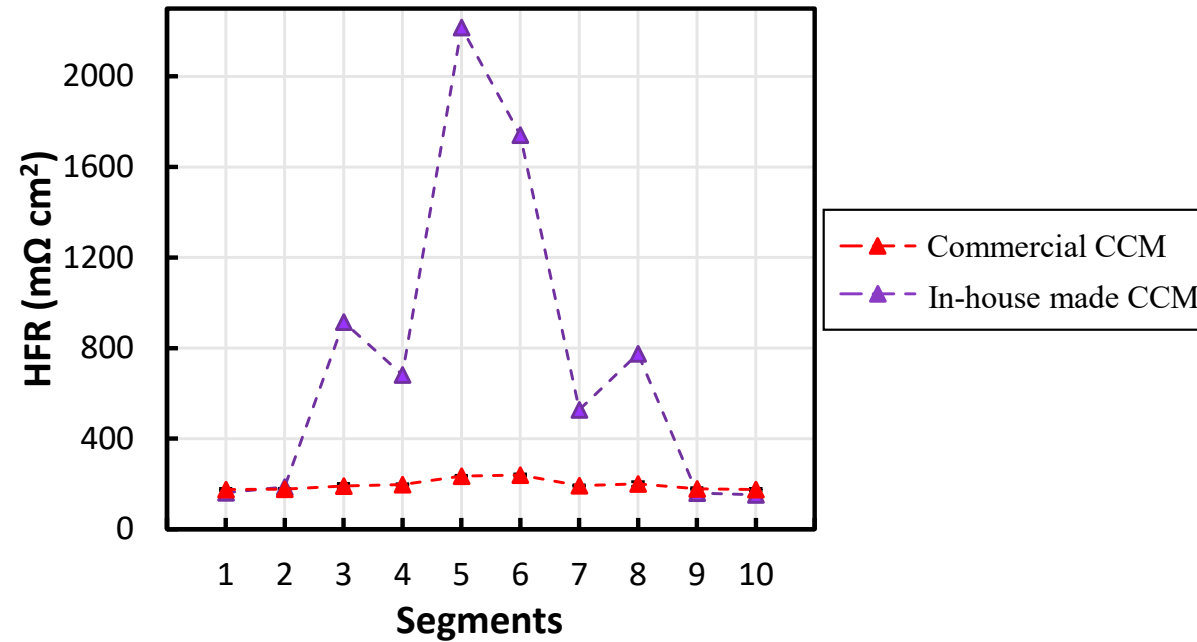
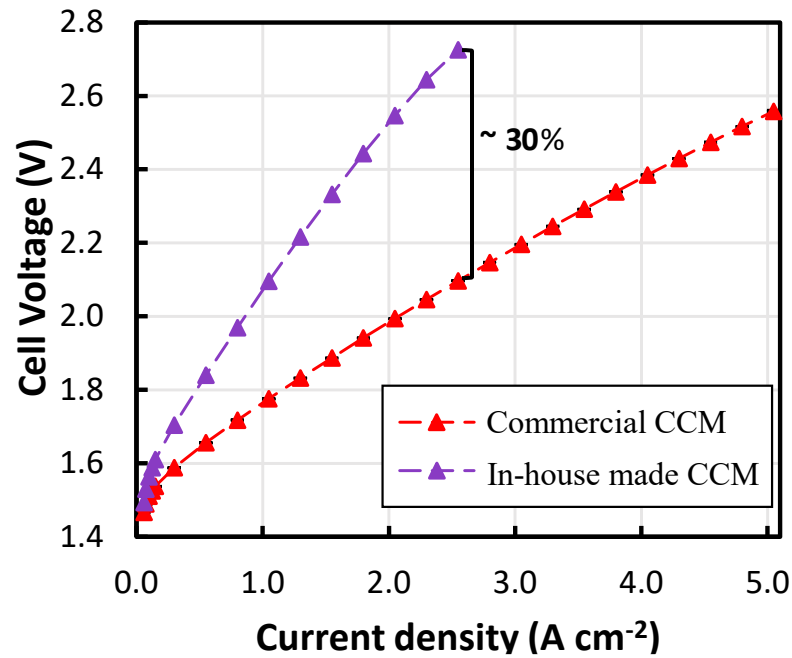
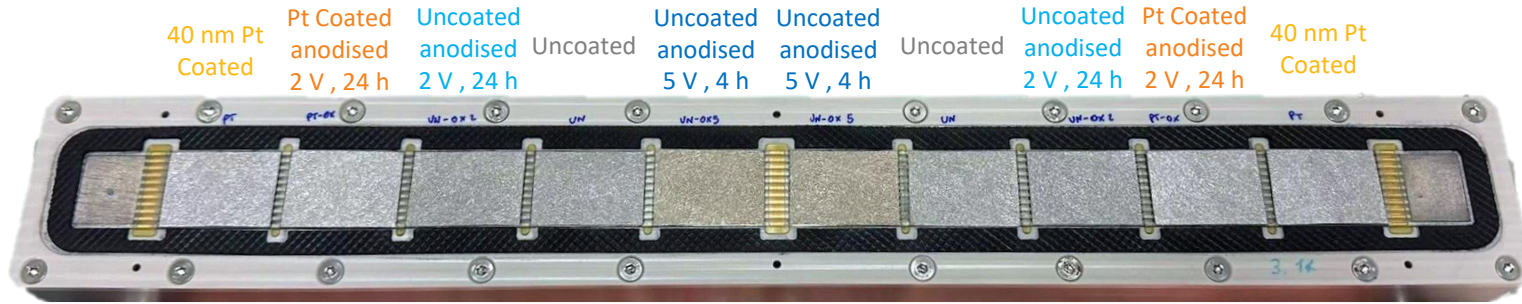


● Ti(0) / (Ti total)	 Coated PTLs
● Ti(II) / (Ti total)	 Coated anodised PTLs
● Ti(IV) / (Ti total)	

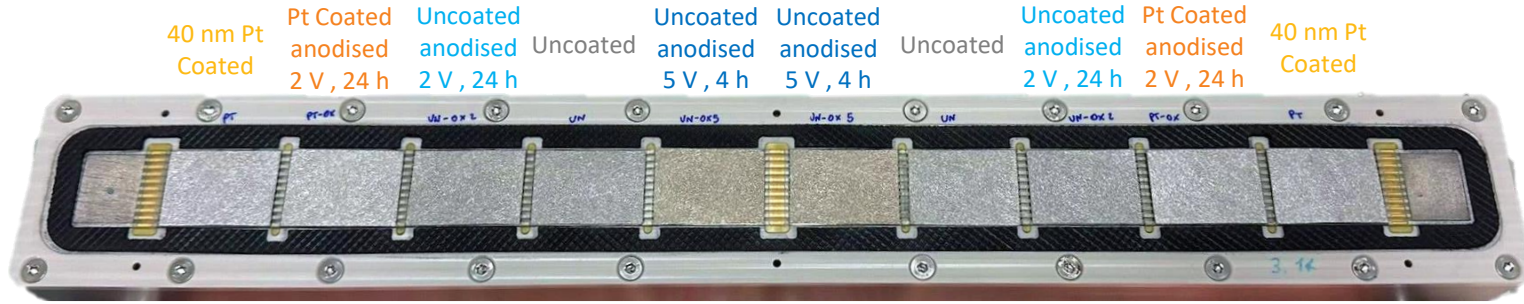
04

Rainbow configuration tests

Rainbow configuration tests

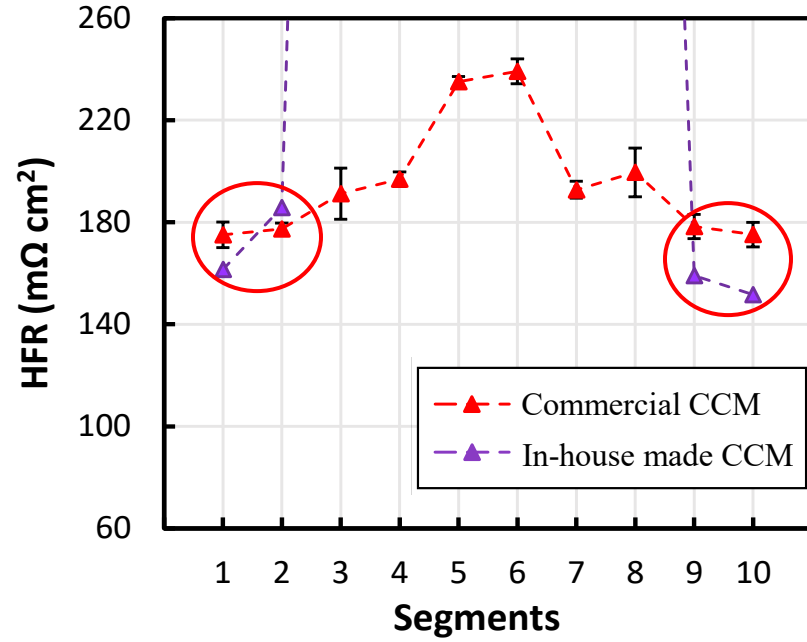
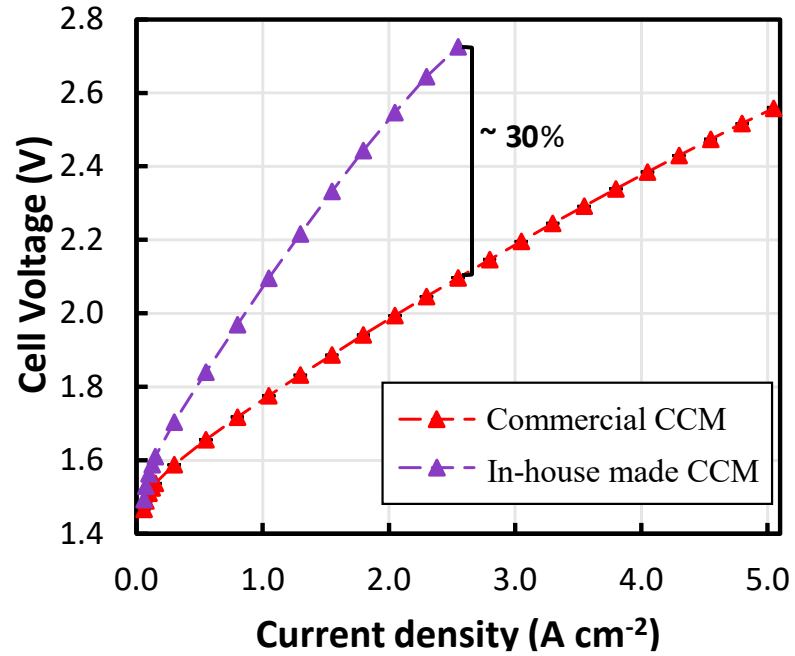


Rainbow configuration tests

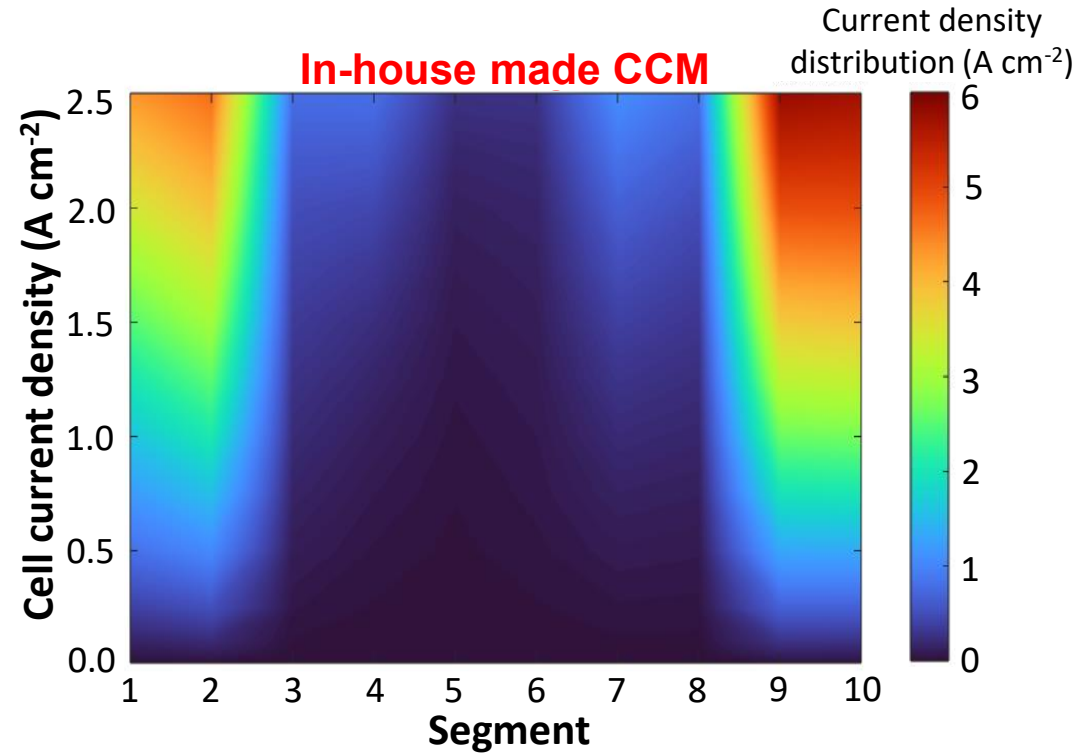
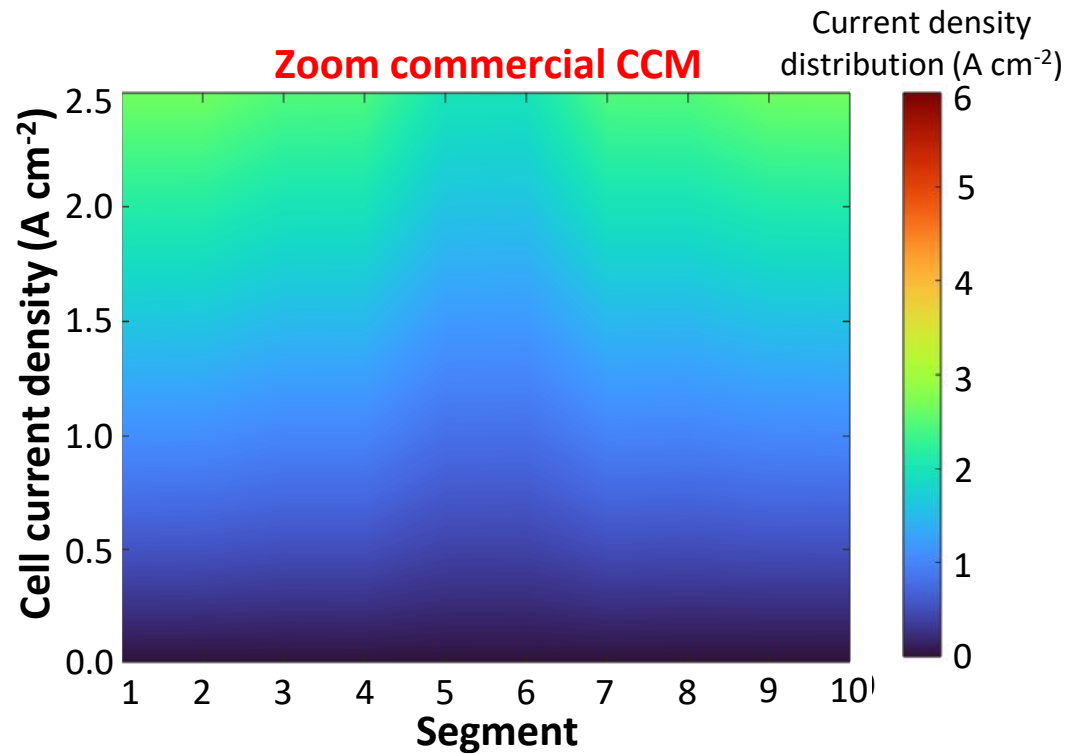


Both the CCMs clearly showed a bell-shape, having worst performances with uncoated PTLs.

PTLs Pt coated showed similar HFRs with both CCMs.



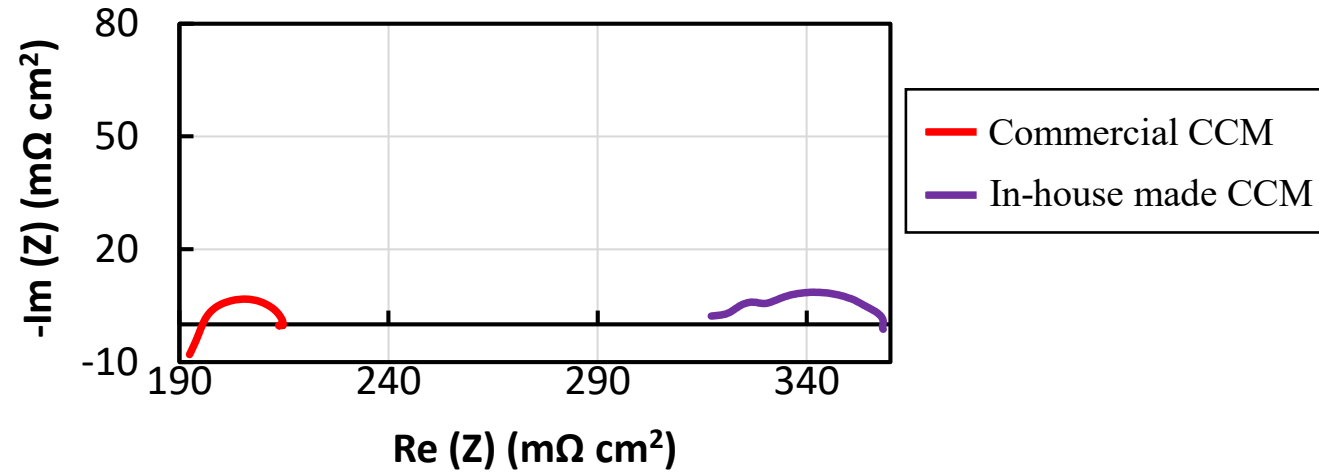
Rainbow configuration tests



The in-house made CCM showed a total incompatibility with uncoated PTLs, having a current density distribution profile totally inhomogeneous.

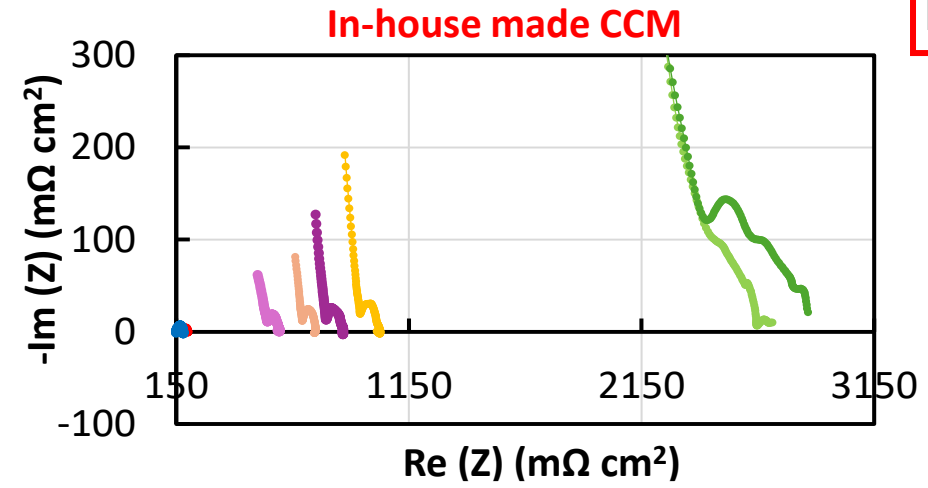
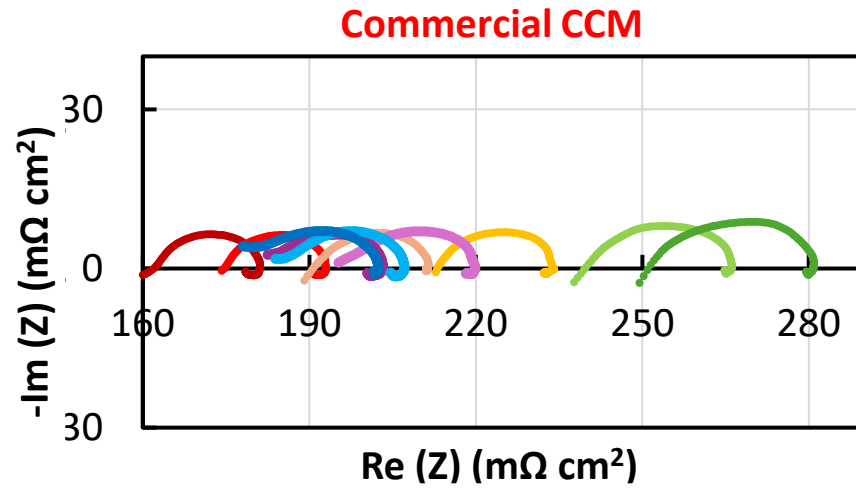
Whole cell EISs

EIS at 2 A cm⁻²



Rainbow configuration tests

EIS at 2 A cm⁻²

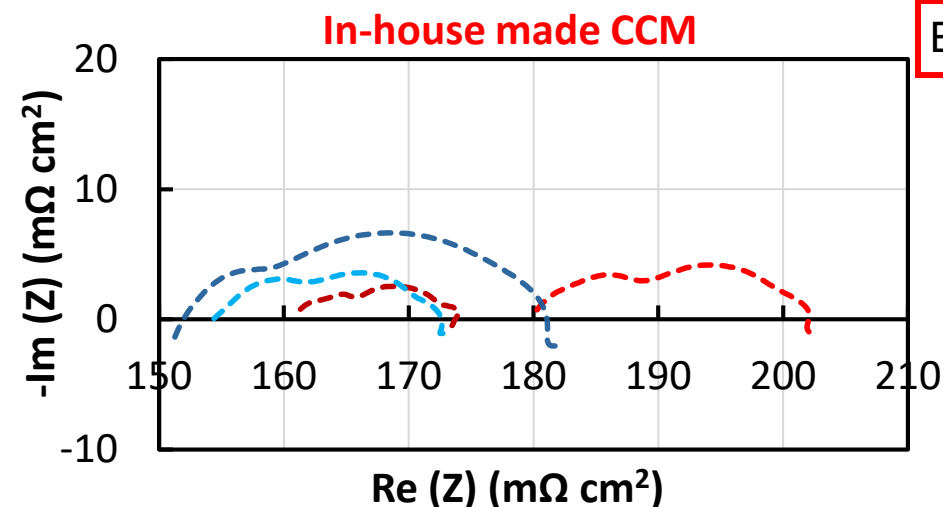
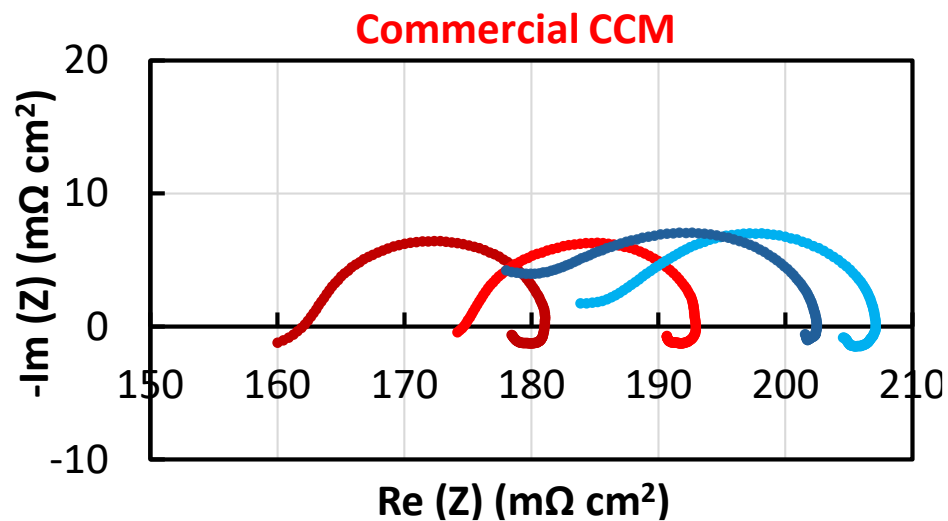


- Segment 1
- Segment 2
- Segment 3
- Segment 4
- Segment 5
- Segment 6
- Segment 7
- Segment 8
- Segment 9
- Segment 10



Rainbow configuration tests

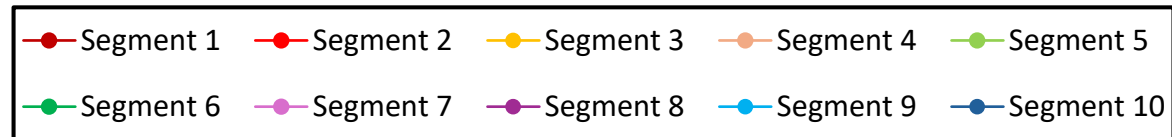
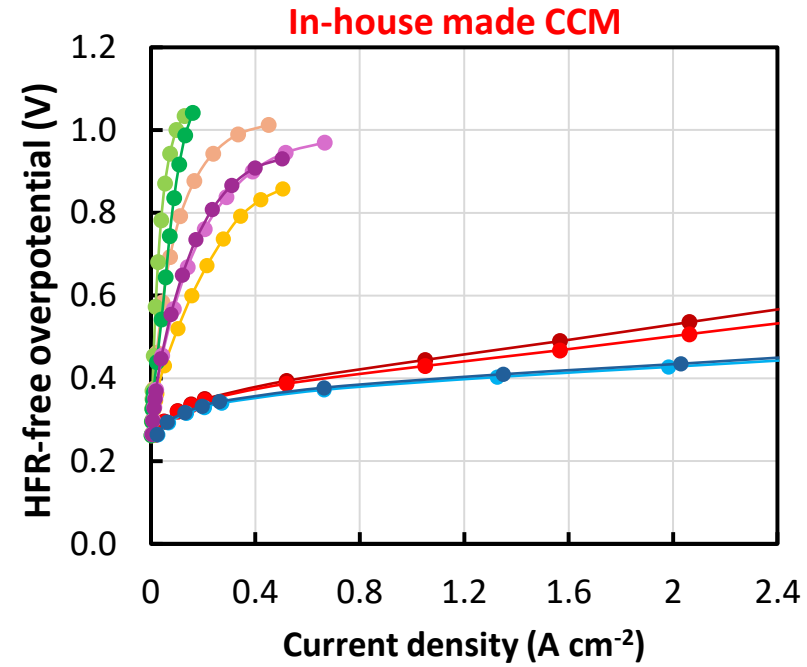
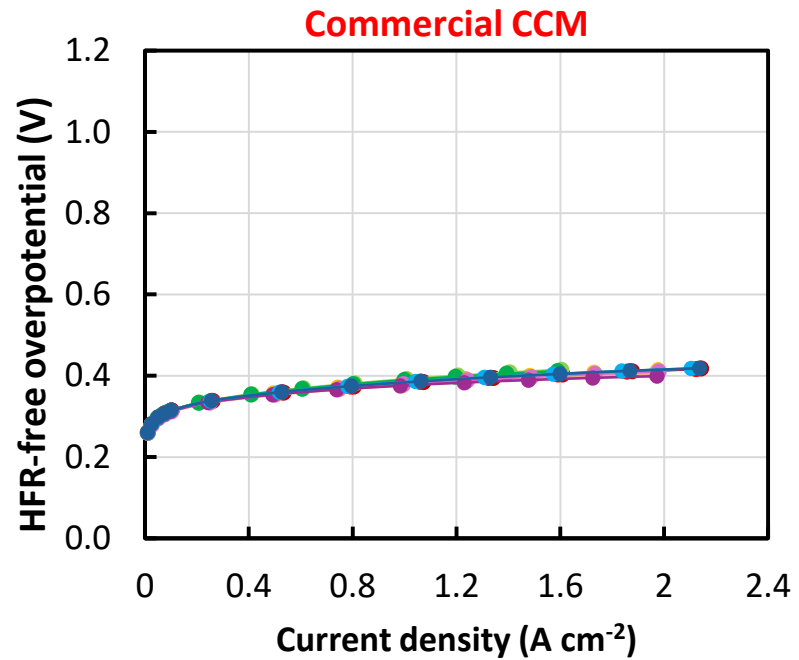
EIS at 2 A cm⁻²



- Segment 1
- Segment 2
- Segment 3
- Segment 4
- Segment 5
- Segment 6
- Segment 7
- Segment 8
- Segment 9
- Segment 10

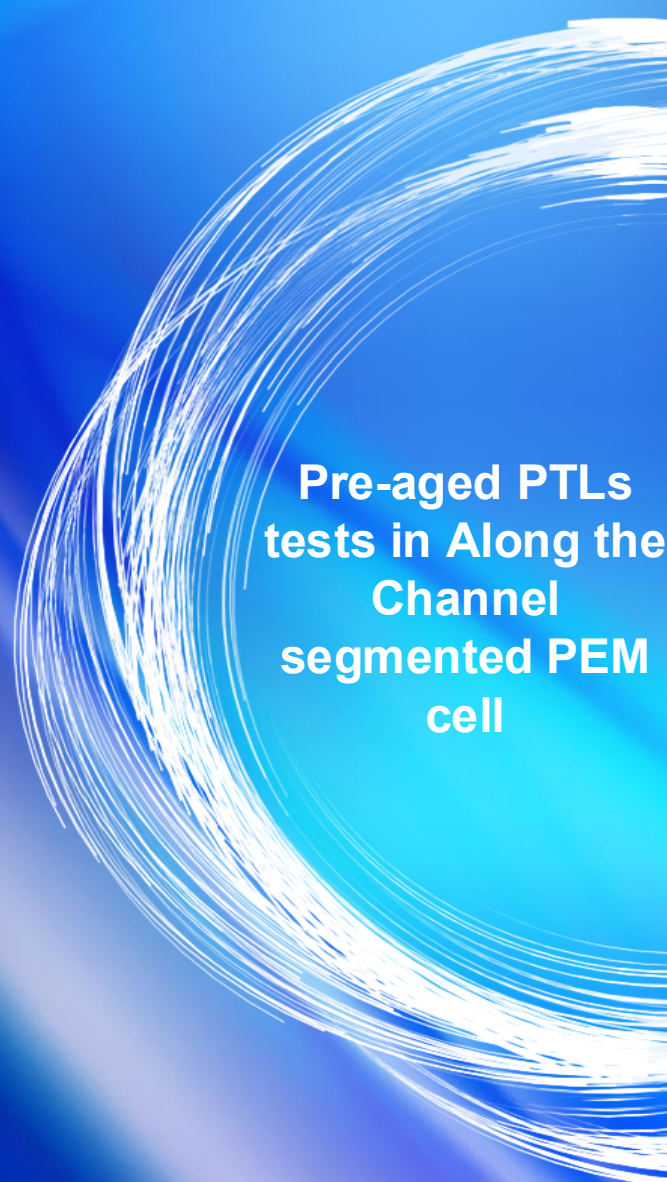


Rainbow configuration tests



05

Conclusion



Pre-aged PTLs
tests in Along the
Channel
segmented PEM
cell

- ✓ The single PTLs tests show that:
 - uncoated pre-aged PTLs have the same performances of uncoated PTLs;
 - Pt coated pre-aged PTLs have a worsening in performances due to formation of Ti ox. beyond the Pt coating layer.
- ✓ The commercial CCM can be used with both uncoated and Pt coated PTLs (anodised and not), showing a small inhomogeneity in current density distribution.
- ✓ The in-house made CCM shows a total incompatibility with uncoated PTLs (anodised and not), having lower catalyst loading and no additives.
- ✓ The in-house made CCM can be used only with Pt coated PTLs.

HYDEP



TH₂ank you for your kind attention



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