Assembling, running, and characterizing a 5 cm^2 single cell PEM-fuel cell

TRA275 Tracks Project Course (7.5 credits) - Jan – Mar 2024 (SP3) - Project #14

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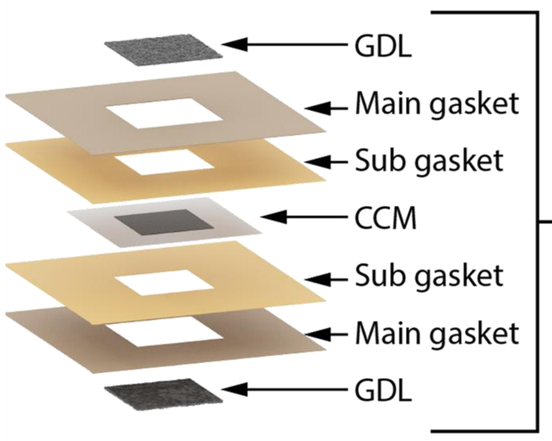
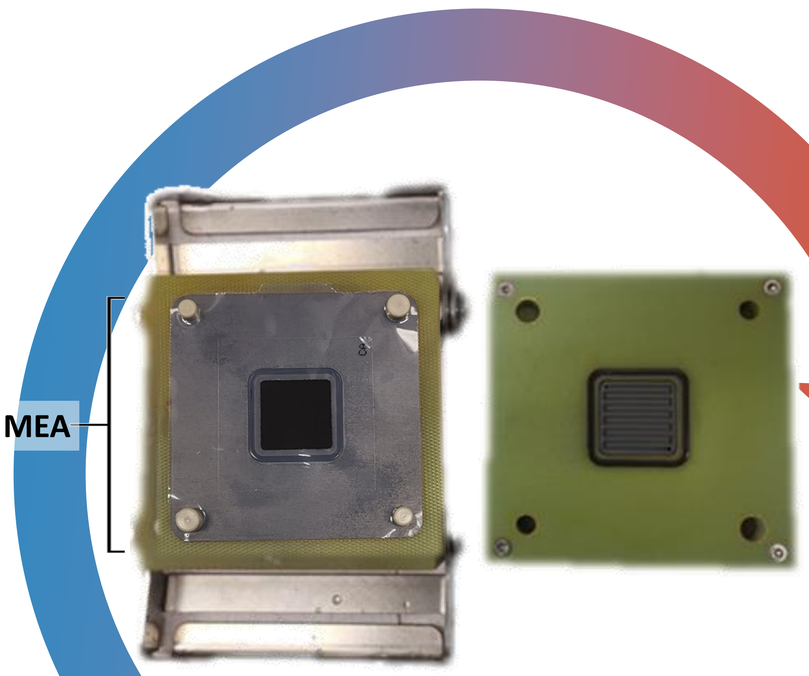
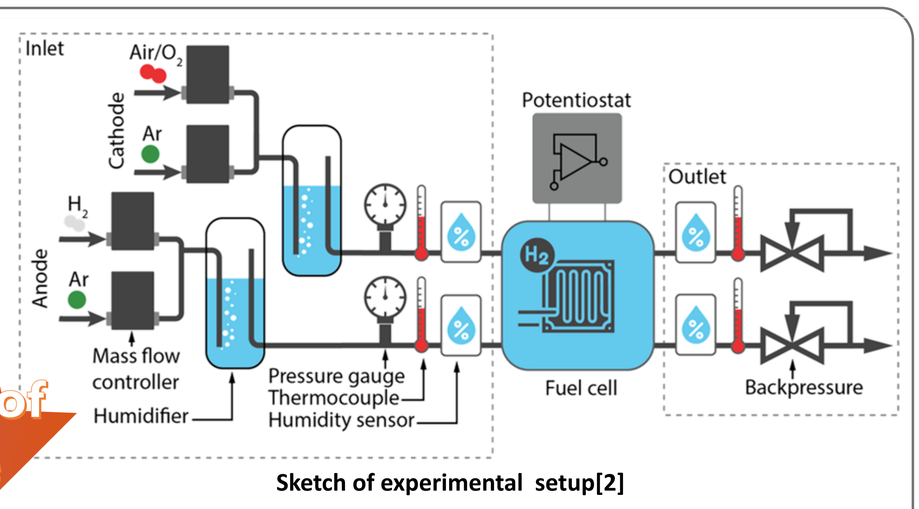
Assembling PEM Fuel cell

Structure of MEA layers[1]



CCM: Catalyst Coated Membrane
GDL: Gas Diffusion Layer
MEA: Membrane Electrode Assembly

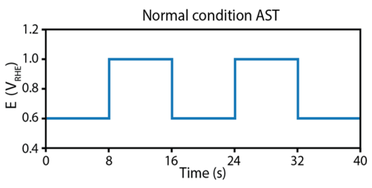




Sketch of experimental setup[2]

Activation, **Recovery,** **Cyclic voltammetry (CV)** and **Accelerated Stress Testing AST** are executed using H_2 and Argon

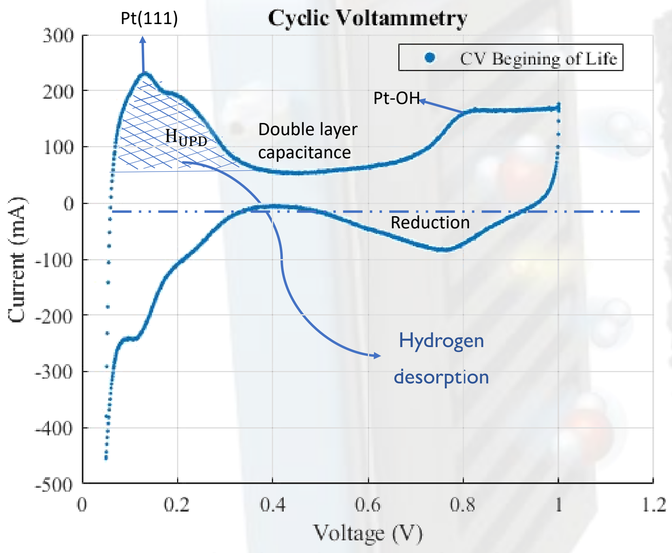
Polarisation curves produced using H_2 and Argon



Sketch of AST cycle[3]

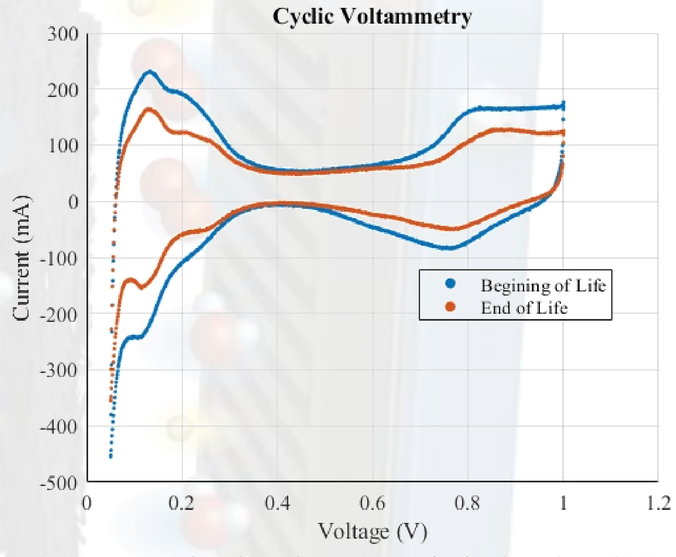
Assembling fuel cell → Activation procedure → Recovery → Data measuring BOL → Accelerated stress test → Data measuring EOL

Cyclic Voltammetry



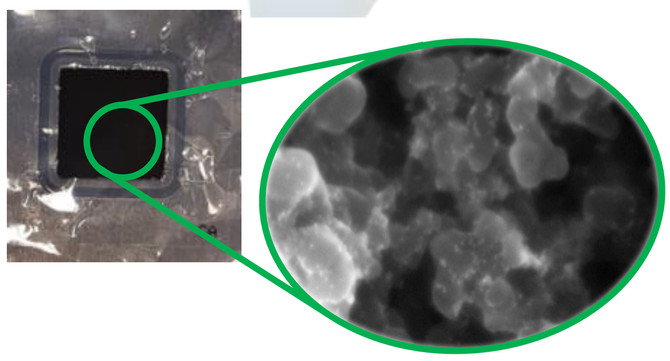
Features of Cyclic Voltammetry for a fresh MEA

- Linear rising and falling voltammetry sweep is conducted over multiple cycles
- The area of the operation fuel cell is taken into account - results are plotted as current density over voltage
- Area under the curve is proportional to the available surface area
- During operation the ECSA decreases
- Comparison CV at the beginning of life against the end of life portrays the diminished surface area



Comparison of Cyclic Voltammetry of a fresh and aged MEA

ECSA – Electrochemically actived surface area



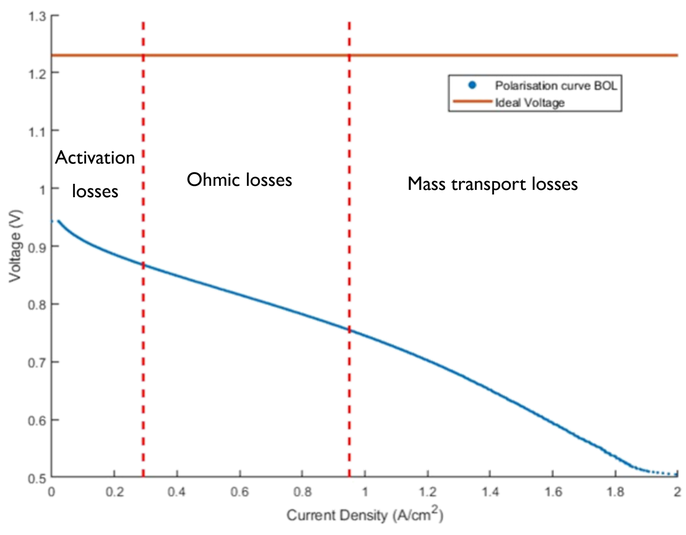
Characterisation of the surface[4]

Electrochemically actived surface area	
$A_{ECSA} = \frac{Q}{\theta * L * A_{elec}}$	
Deduct charge from double layer	$Q_{BOL} = 304.87$ $Q_{EOL} = 163.24$
Surface load of a full H^+ layer on polycrystalline Pt	$\theta_{Pt} = 210 \frac{\mu C}{cm^2{}_{Pt}}$
surface load	$L=0,4 \frac{mg}{cm^2}$
Area of the electrode	$A= 5cm^2$
$A_{ECSA_{BOL}} = 72.38 \frac{m^2}{g}$	$A_{ECSA_{EOL}} = 38.87 \frac{m^2}{g}$

- By operating the cell degredation occurs
- Limiting the performance over time

The ECSA from the end of life is about 53,7% of the total activated surface per grams from the beginning of life. This correlatets to the overall loss of performance.

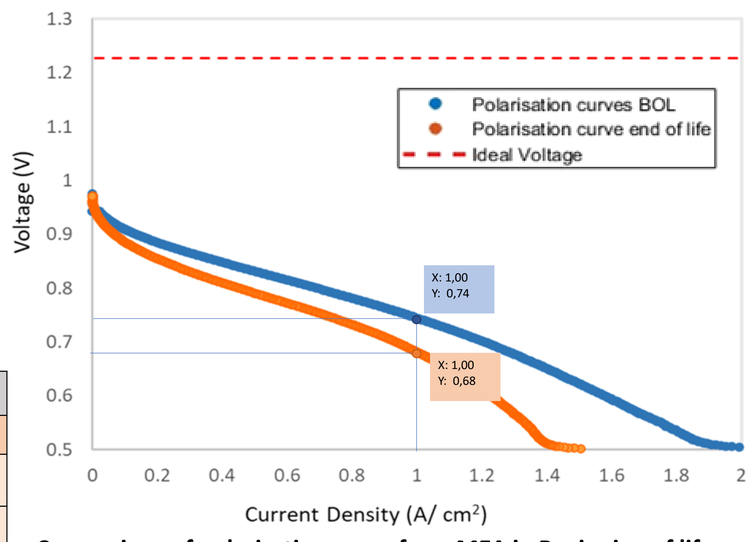
Polarisation Curves



Polarization curve of MEA in Beginning of life (BOL)

- The difference to the standard cell potential of 1,23 V can be explained by **activation-**, **ohmic-** and **mass transport losses**
- Higher current operating points show more severe losses due to mass transport at end of life
- The main factor in MEA attenuation is the aggregation of catalyst particles of electrode and membrane, which reduces the electrocatalytic reaction activity.

Performance comparison at 1 A/cm²			
		BOL	EOL
Power density	$P = i \; x \; V$	$0,74 \frac{W}{cm^2}$	$0,68 \frac{W}{cm^2}$
Practical efficency in %	$\varepsilon = \frac{cell\ potential}{1,48}$	50%	45,95 %



Comparison of polarization curve from MEA in Beginning of life (BOL) and End of life (EOL)

[1]: Victor Shokhen, Linnéa Strandberg, Magnus Skoglundh, Björn Wickman; Impact of Accelerated Stress Tests on the Cathodic Catalytic Layer in a Proton Exchange Membrane (PEM) Fuel Cell Studied by Identical Location Scanning Electron Microscopy; August 18, 2022.
[2]: Linnéa Strandberg, Powerpoint materials: Introduction of Fuel Cell. 2024. Slide 18.
[3]: Linnéa Strandberg, Powerpoint materials: Introduction of Fuel Cell. 2024. Slide 25.
[4]: Björn Wickman, Lecture slides: Seminar day 1 activity 2 -Fuel cell operation – efficiency, power and stability. Jannuary, 2024. Slide 31.