

Assembling, running, and characterizing a 5 cm² single cell PEM-fuel cell

TRA275 Tracks Project Course (7.5 credits) - 2025 (SP3) - Project #12

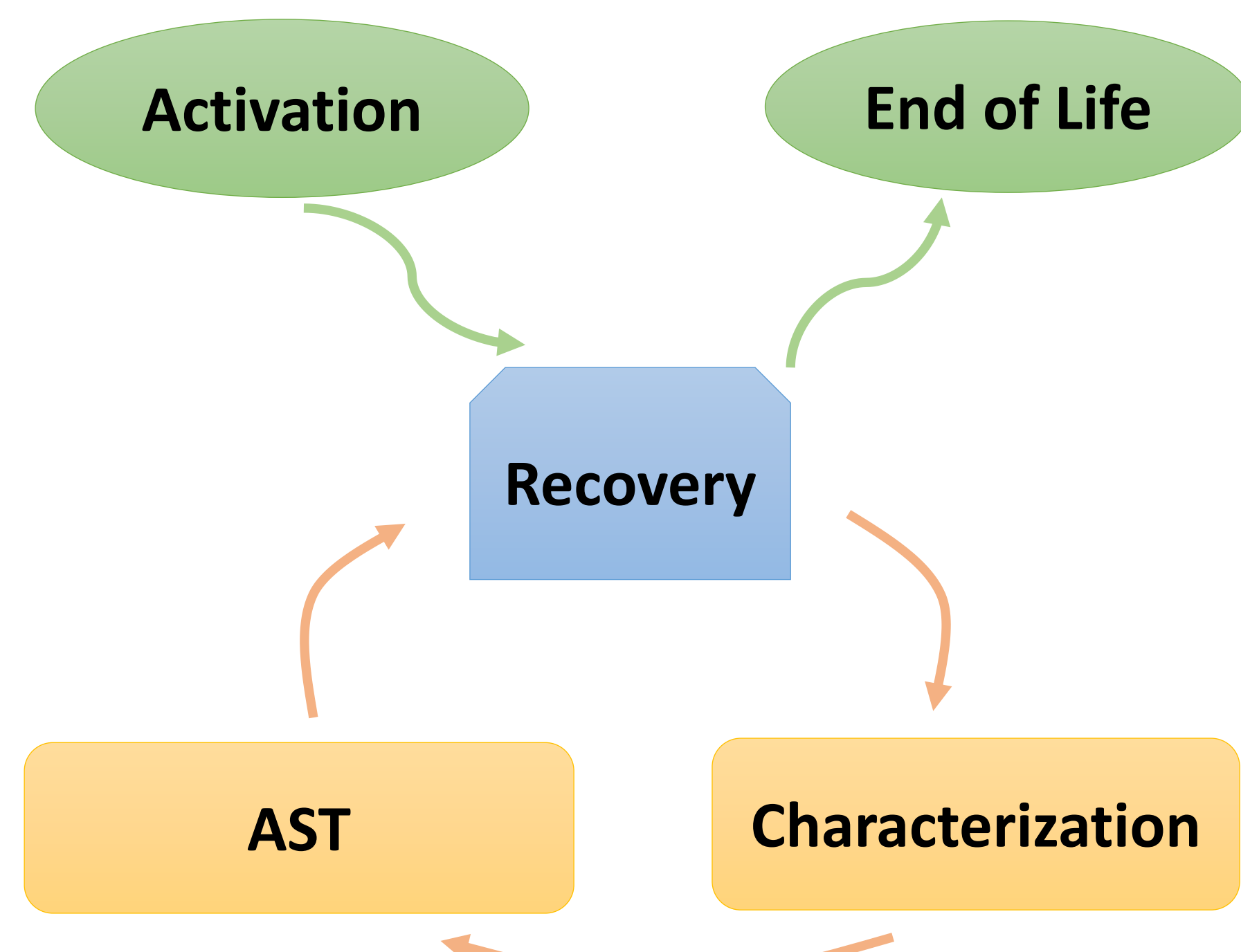
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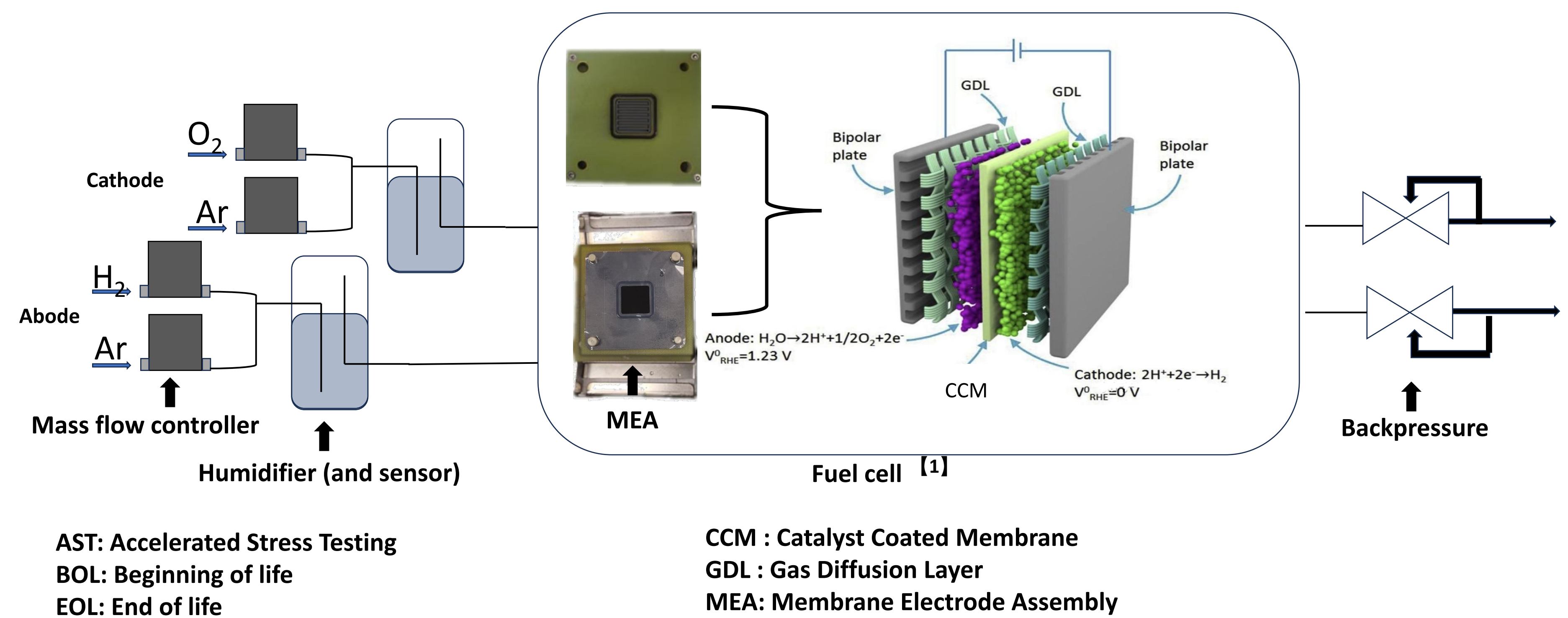
Introduction

In this project, a 5 cm² single cell PEM-fuel cell was assembled, operated and characterized. By comparing the performance of the fuel cell in polarization curve and electrochemically active surface area between the beginning of life and end of life, the degradation of the fuel cell can be observed and analyzed.

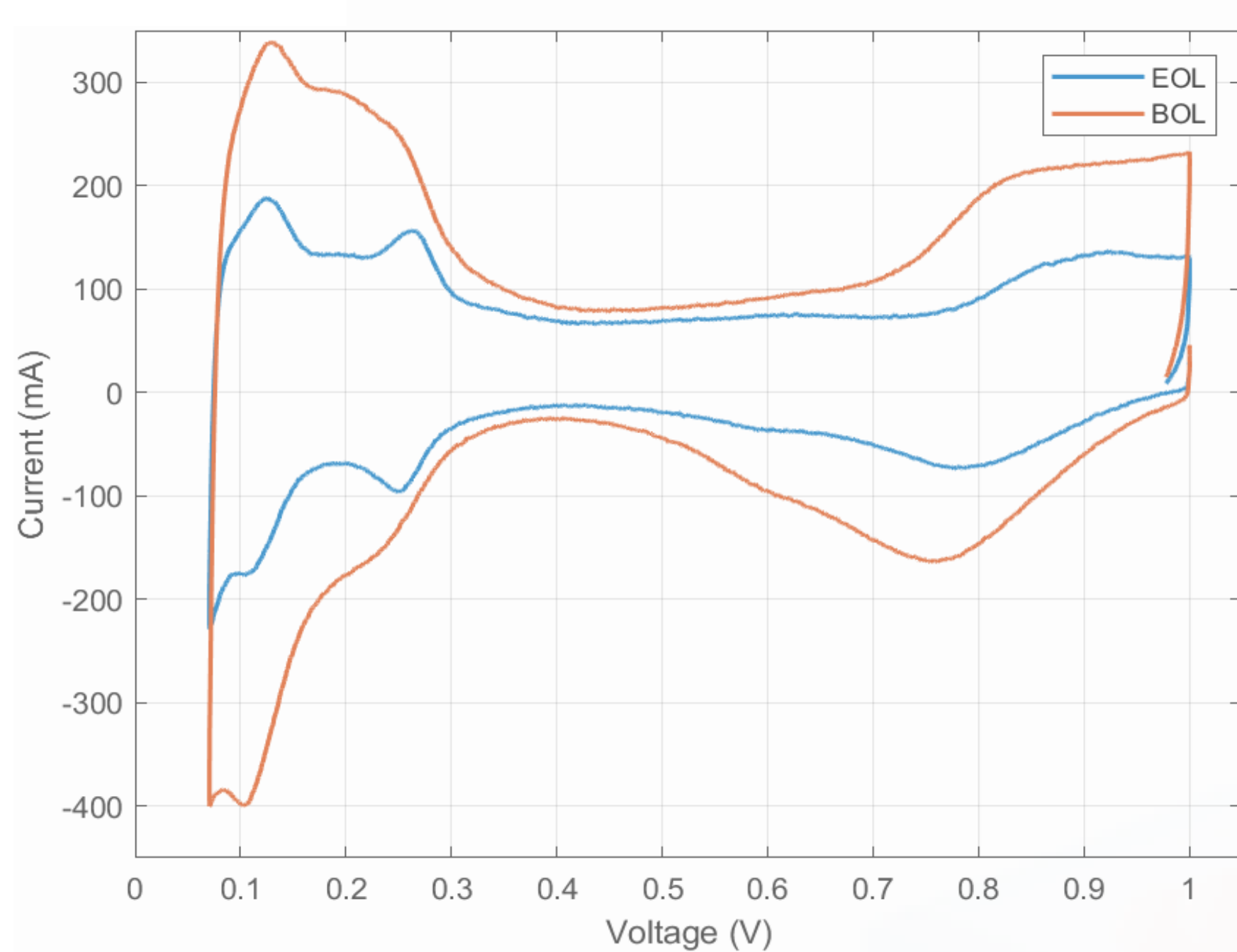
Experimental Procedure



Experimental Setup

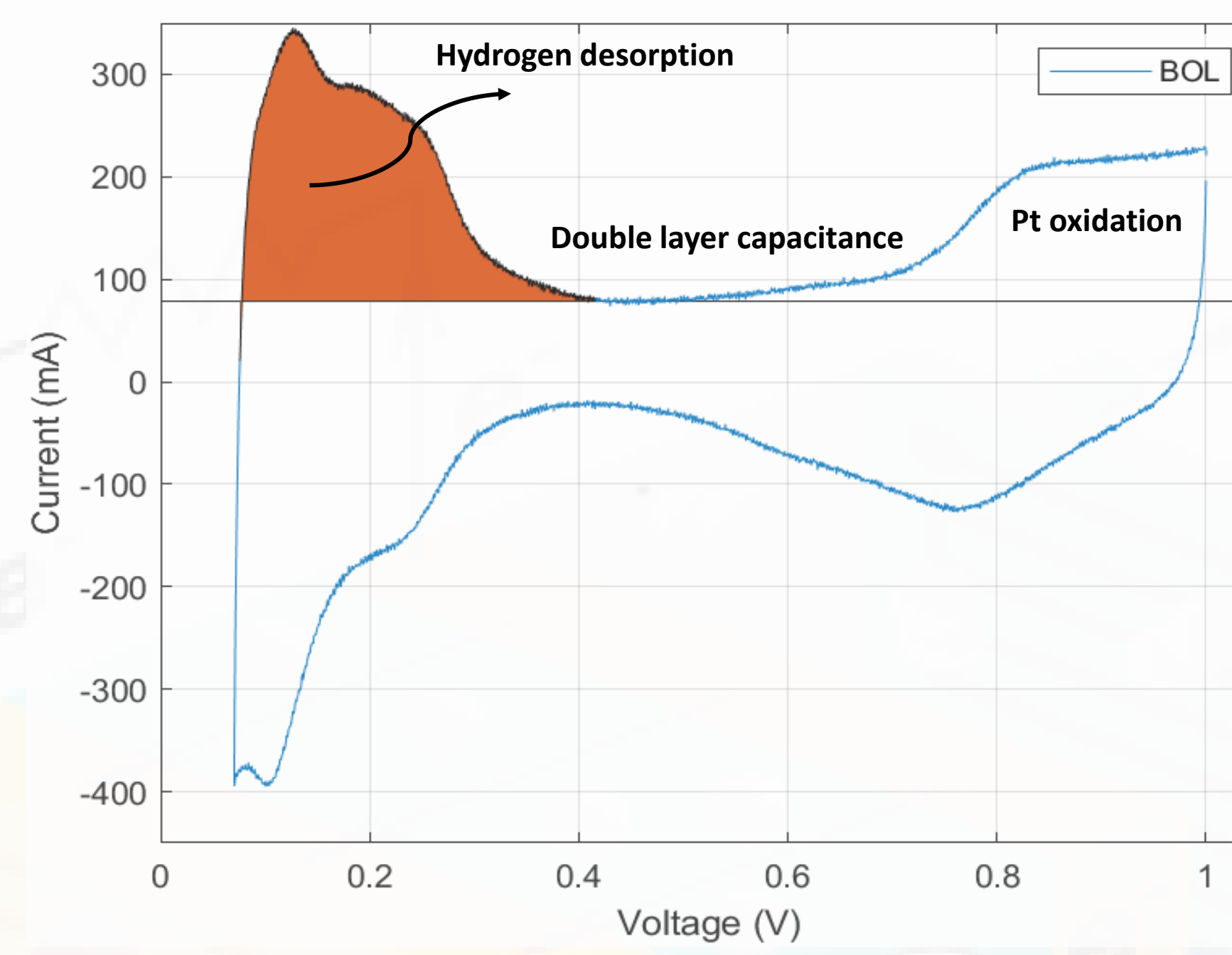


Cyclic Voltammetry



Comparison of Cyclic Voltammetry of a fresh and aged MEA

- Conduct cyclic voltammetry and plot current density vs. voltage
- All characteristic peaks exhibit strong current response
- Orange shaded area represents the hydrogen desorption area which directly correlates to catalyst active surface area (ECSA)
- Integrate orange area to get the deduct charge from double layer, which is proportional to ECSA
- Fresh MEA exhibits maximum hydrogen desorption area, and it decreases during operation



Features of Cyclic Voltammetry for a fresh MEA

ECSA – Electrochemically active surface area

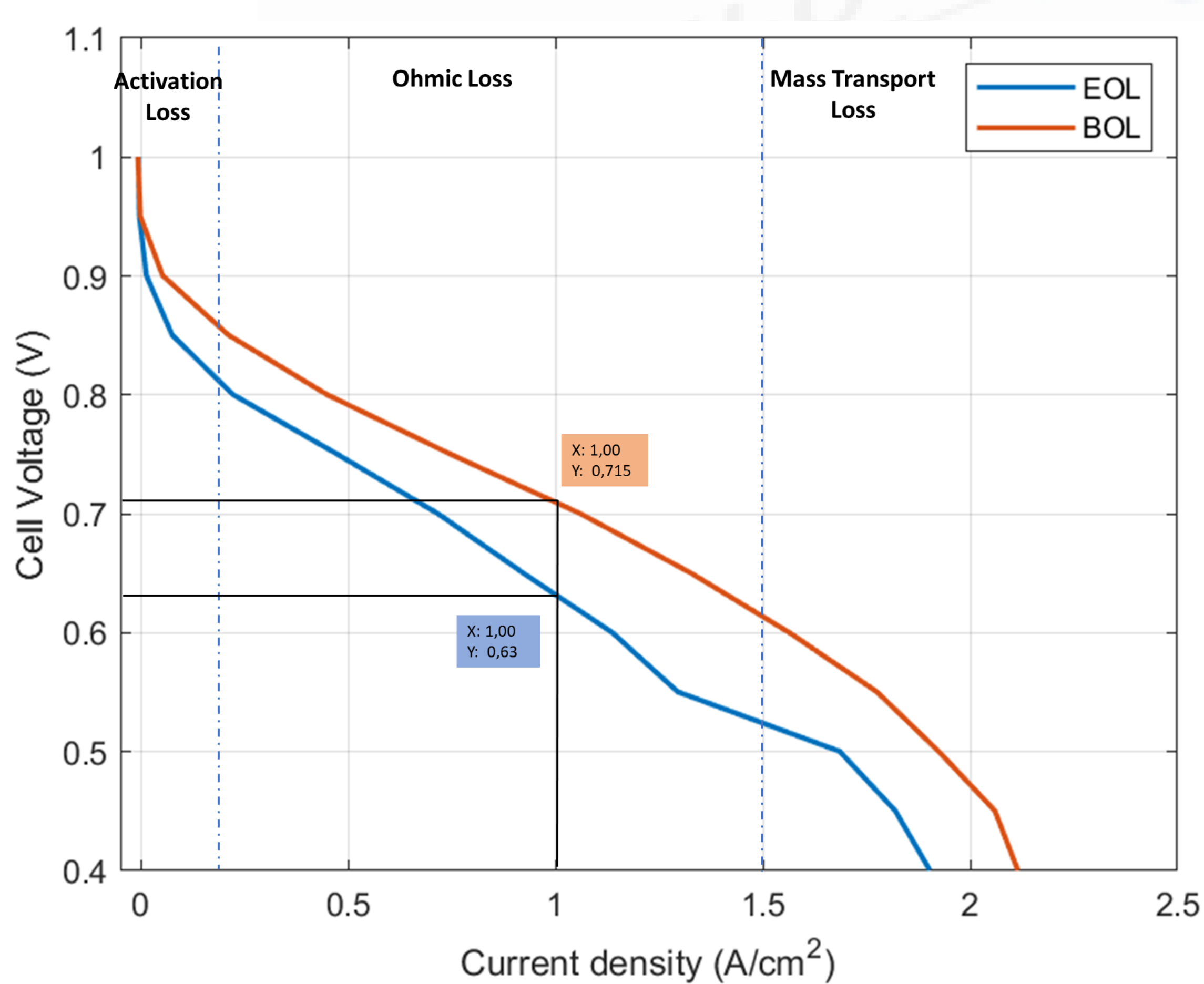
Electrochemically Active Surface Area

$$A_{ECSA} = \frac{Q}{\theta * L * A_{elec}}$$

The charge from double layer	$Q_{BOL} = 466.43$ $Q_{EOL} = 209.49$
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	$A = 5 cm^2$
$A_{ESSA_{BOL}} = 111.05 \frac{m^2}{g}$	$A_{ECSA_{EOL}} = 49.88 \frac{m^2}{g}$

- Degradation of catalysts, membranes, and gas diffusion layers during operation
- At the end of life, ECSA is around 44.9% of the total active surface area from the beginning of life

Polarization Curve



Comparison of polarization curve from MEA in BOL and EOL

Performance comparison for 1 A/cm²

		Beginning of life	End of life
Power density	$P = IV$	$0.715 \frac{W}{cm^2}$	$0.63 \frac{W}{cm^2}$
Practical efficiency	$\epsilon = \frac{cell\ potential}{1.48}$	48.31%	42.57%

- Significant voltage losses from the theoretical 1.23V due to three major losses: **activation, ohmic, and mass transport**
- Compared to BOL, for the same current density, the voltage decreases significantly at EOL, especially in ohmic and mass transport regions.
- The performance degradation primarily results from catalyst particle aggregation and membrane deterioration, reducing electrochemical active surface area and overall cell efficiency