Electrolysis Reference Electrode Methodology

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Abstract:

For the first time in a solid state hydrogen electrolysis cell, using only one membrane layer and external hydrogen circulation, a stable reference electrode was able to collect in-situ half-cell potential measurements. This external reversible hydrogen reference electrode did not affect the performance of the cell. Using this method, general cell performance can be improved given the accuracy of the additional information. The results presented, follow conventional electrochemical theory, reinforce the findings of previous work in this area, and demonstrate the functionality for future applications.

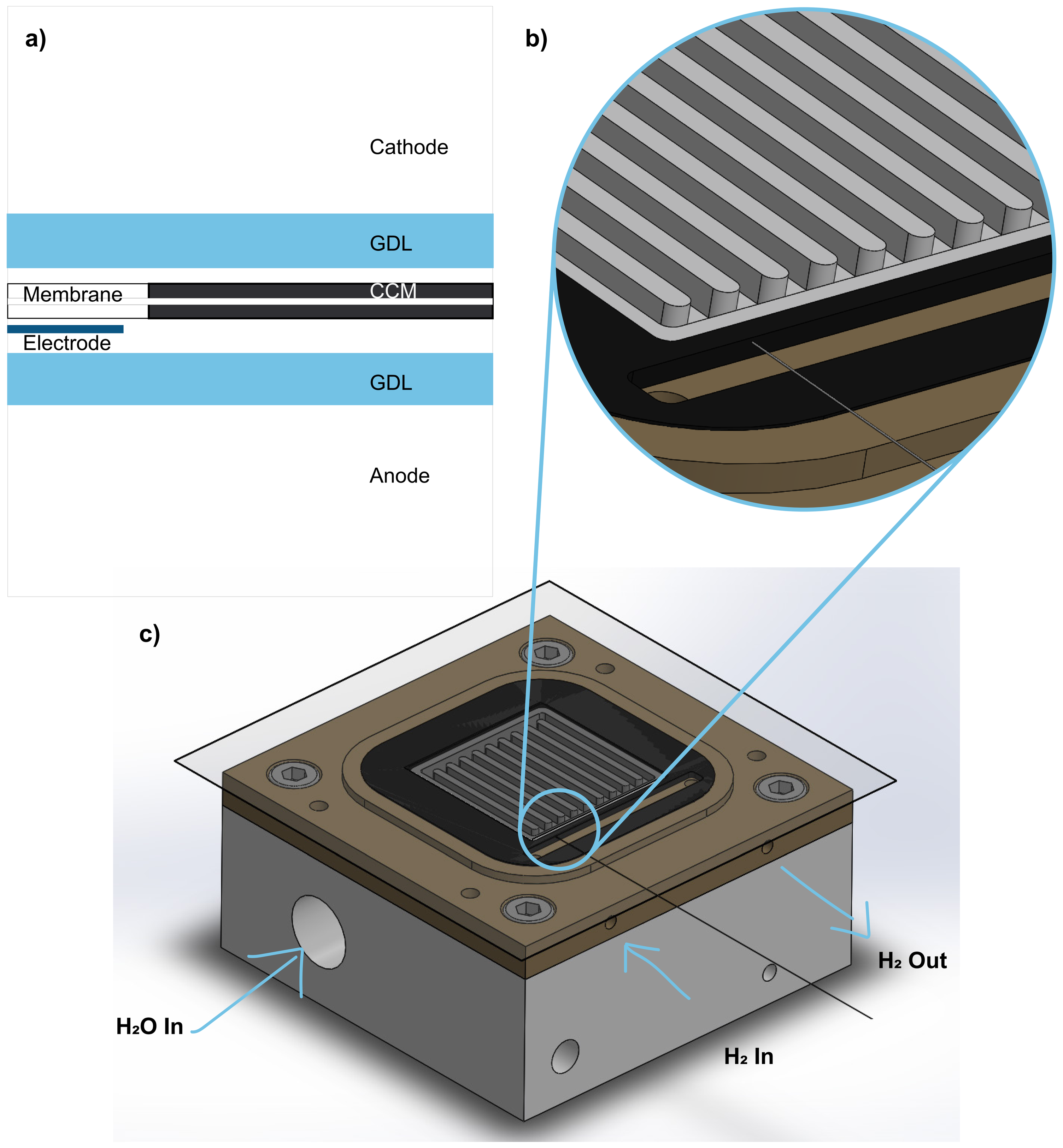

Figure 1. a) 2-D view of half the cell stack. b) Close-up view of the electrode placement. c) The anode side of the cell up to and including the membrane.

Main Features of The Cell:

- Custom built by Fraunhofer Germany
- Isolated humidified hydrogen recirculation chamber
- Gold-plated titanium electrode blocks
- Nafion 115® membrane with 4 cm^2 catalyst coated active area
  - 2 mg/cm² Iridium & 1 mg/cm² platinum
- 60 µm diameter, PTFE insulated, platinum wire reference electrode. Platinized using the method of Ives & Janz [1]
- Titanium fiber gas diffusion layer for the anode flow field
- Hydrophobic carbon gas diffusion layer for the cathode flow field

Experiment:

- The specific placement of the reversible hydrogen reference electrode makes it possible to sense the protonic potential in the middle of the membrane gradient [2].
- The measured half cell potentials follow the following equations:

$$U_{cell} = (U_{rev,a} + U_{rev,c})+(\eta_{act,a} + \eta_{act,c})+(\eta_{mxt,a} + \eta_{mxt,c})+(\eta_{Ohm,a}+\eta_{Ohm,c}+\eta_{Ohm,membrane})$$

$$U_{ref\text{-}cathode} = (U_{rev,c})+(\eta_{act,c})+(\eta_{mxt,c})+(\eta_{Ohm,c})+0.5(\eta_{Ohm,membrane})$$

$$U_{ref\text{-}anode} = (U_{rev,a})+(\eta_{act,a})+(\eta_{mxt,a})+(\eta_{Ohm,a})+0.5(\eta_{Ohm,membrane})$$

- Measurement protocals include: constant current stability tests and polarizations curves.

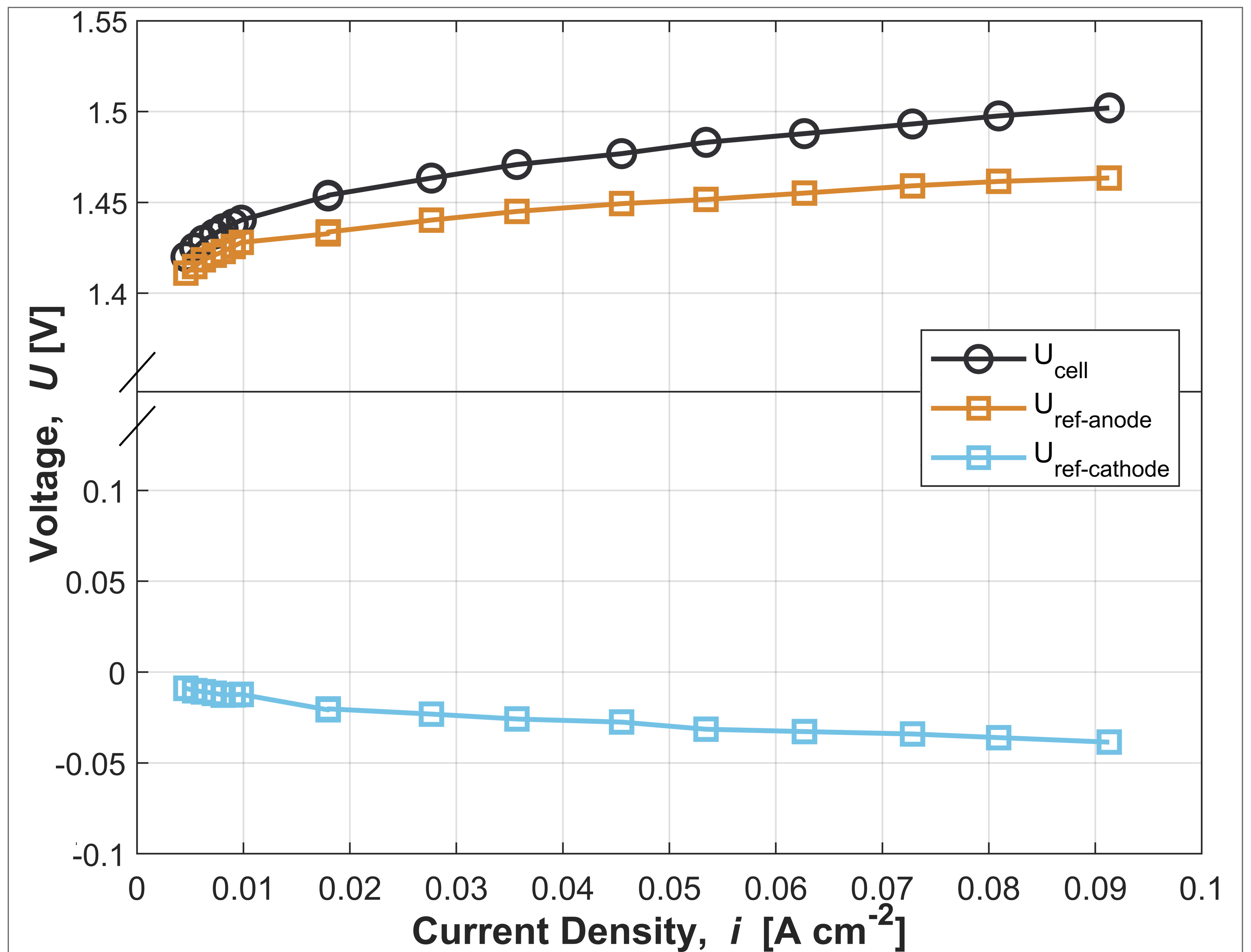

Figure 2. Polarization Curve from Reference Electrode Measurements

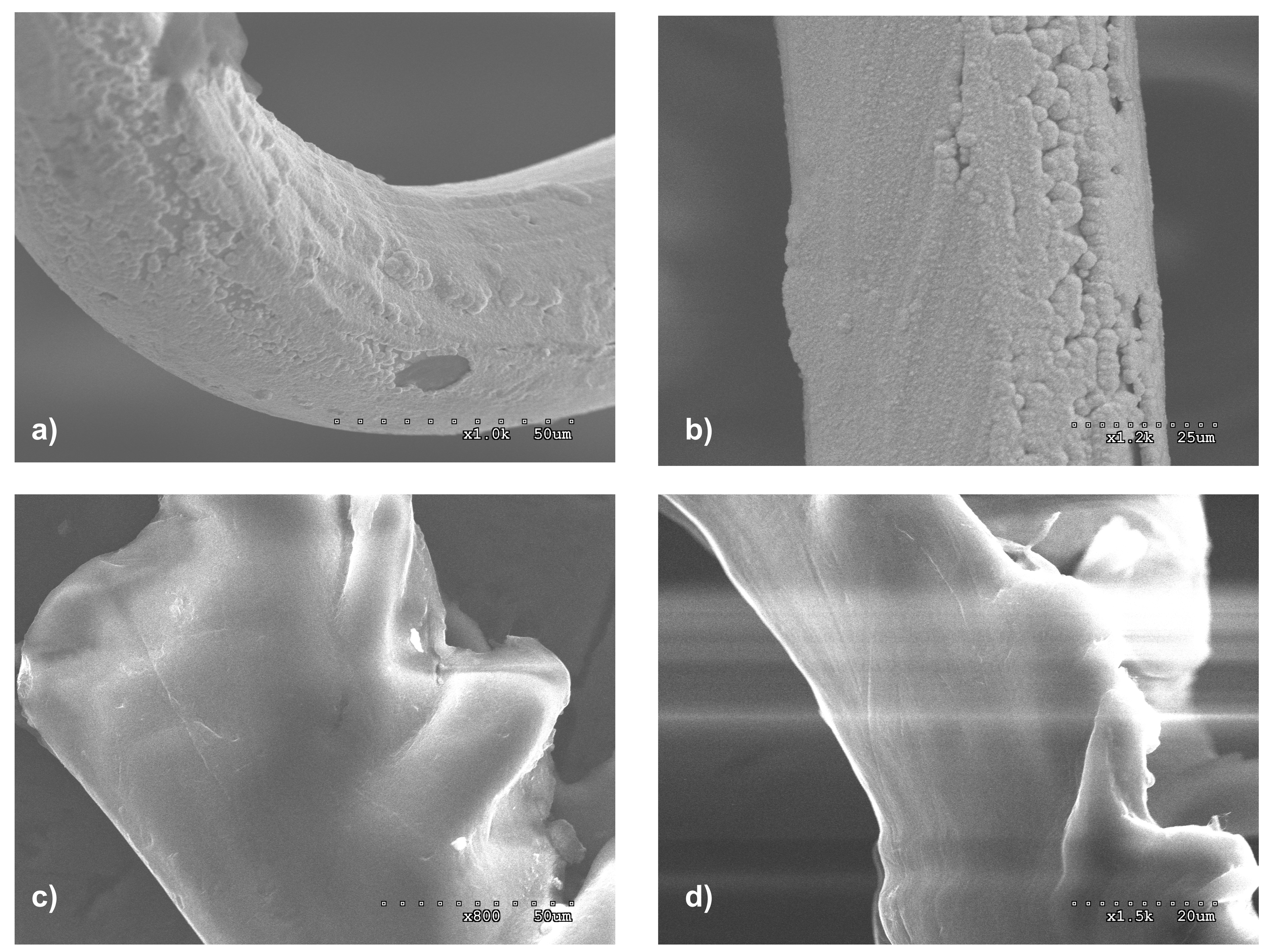

Figure 3. A collection Scanning Electron Microscopy images. a) & b) are wide and narrow angle views of the platinized end, respectively. c) & d) are, in the same order, views of the straight platinum wire.

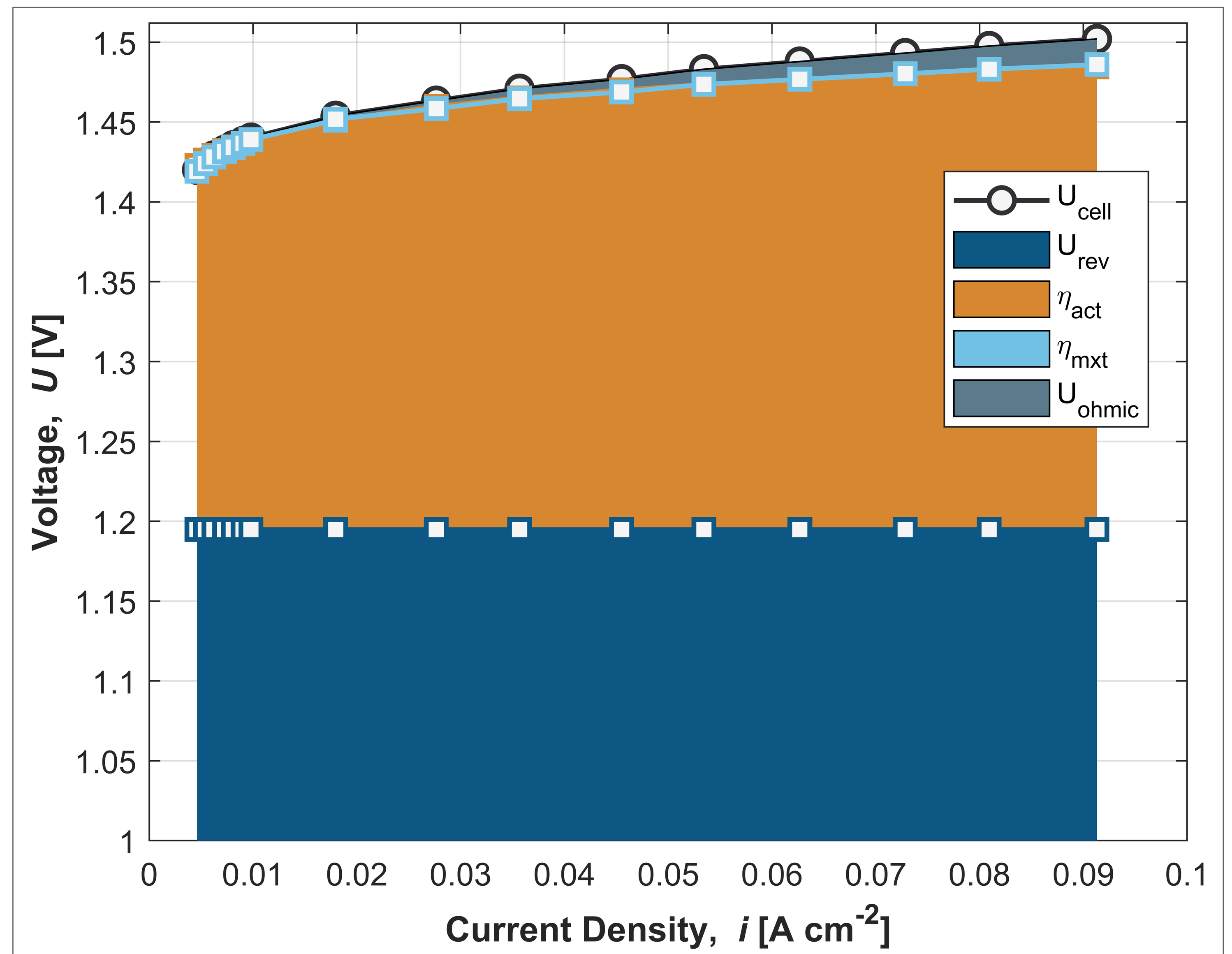

Figure 4. Breakdown of the attributed voltage losses within the cell. [3]

Conclusion:

- A solid state hydrogen electrolysis cell can operate effectively with a reference electrode placed within the cell, outside the active area, on the anode side of the membrane.
- Our platinum wire reference electrode has a stable discernable potential.
- Future electrochemical models can be defined based on these results given the key details provided for the full and half cell components.
- Half cell impedance data was collected and is still under investigation.

References:

1. Ives, D. J., & Janz, G. J. "Reference electrodes: theory and practice" *Journal of The Electrochemical Society*, **108**, 11, 246c, 1961.
2. Herrera, O. E., Mérida, W., & Wilkinson, D. P. "New Reference Electrode Approach for Fuel Cell Performance Evaluation" ECS Transactions, **16**, 1915-1926, 2009.
3. Altman, Y. "Export_Fig", github.com/altmany/export_fig/releases/tag/v3.27

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