Advanced Porous-Transport-Layer Interface Design for PEM Electrolyzers

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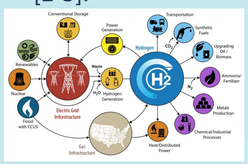
Background

- Catalyst layer and porous transport layer (CL-PTL) interface significantly influences PEM electrolyzer performance [2].
- Surge of interest has been in developing hierarchically structured PTLs – microporous layers. [2-3].



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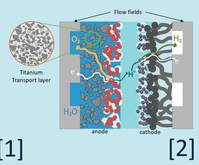

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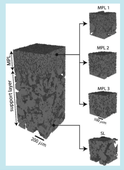
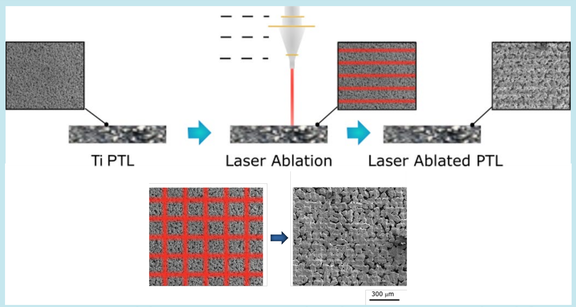


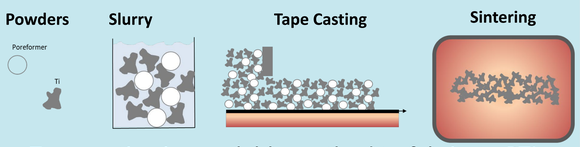
Laser Ablation on PTL



- Laser ablation is a novel subtractive method for modifying CL/PTL interface of a PEMWE.
- Ablating PTL surface with laser melts titanium phase of the PTL and creates uniform surface improving the contact at the CL/PTL interface.
- Laser ablation is adaptable and scalable, and can be used to modify commercial PTL.
- PTLs are etched and coated post to ablation.

**Refer to our publication for more information [3]*

Tape Casting PTLs



- Tape casting is a scalable method to fabricate PTLs.
- PTL interfacial and pore properties controlled by varying titanium and pore former sizes.

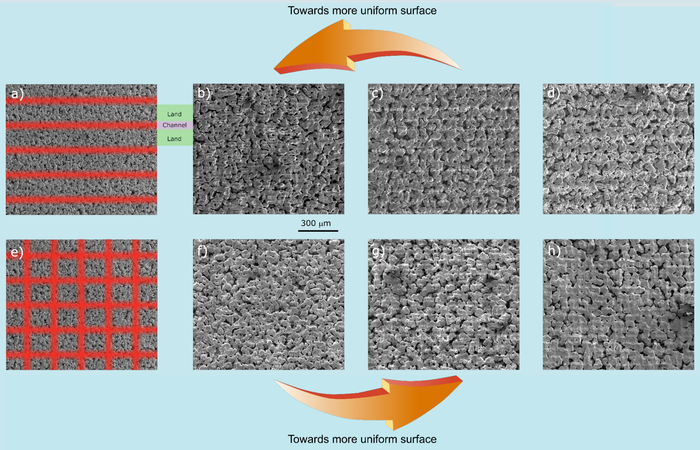
**Refer to our publication for more information [4]*

References

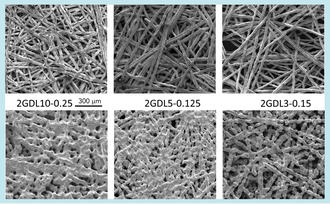
[1] B. Pivovar, N. Rustagi, S.. Satyapal, Electrochem. Soc. Interface 2018, 27 47.
[2] T. Schuler, J. M. Ciccone, B. Krentscher, F. Marone, C. Peter, T. J. Schmidt, F. N. Büchi, Adv. Energy Mater. 2020, 10, 1903216.
[3] J.K. Lee, T. Schuler, G. Bender, X. Peng, , A.Z. Weber, N. Danilovic. (2023) Interfacial Engineering via Laser Ablation for High-Performing PEM Water Electrolysis. Applied Energy 336, 120853.
[4] J.K. Lee, G.Y. Lau, M. Tucker, X. Peng, N. Danilovic, A.Z. Weber (2023) Designing Effective Porous Transport Layers for Water Electrolysis via Tape Casting. Journal of Power Sources 559, 232606.
[5] X. Peng, P. Satjaritanun, Z. Taie, L. Wiles, A. Keane, C. Capuano, I. V. Zenyuk, N. Danilovic, Adv. Sci. 2021, 8, DOI 10.1002/ADVS.202102950.

Results

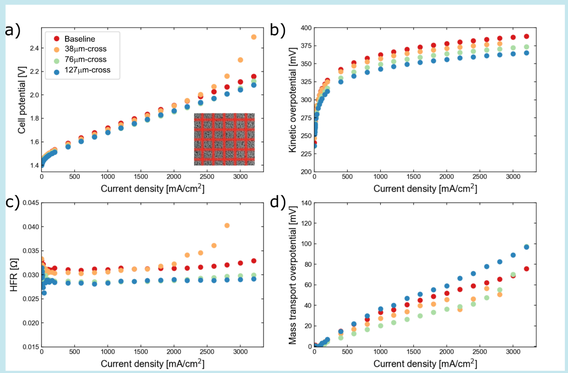
Laser Modified PTL – Interfacial Morphology

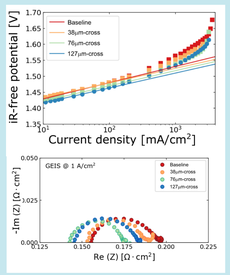


- Laser patterns can be controlled to have tailored interfacial properties at the PTL/CL interface.
- Laser ablation is compatible with various types of PTLs.



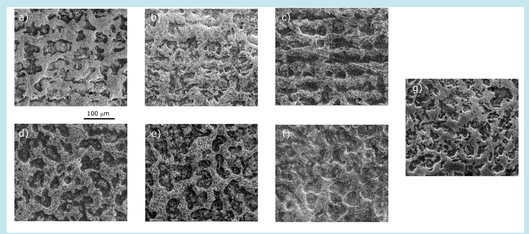
Impact of Laser Ablated CL-PTL Interface on Electrolyzer Performance



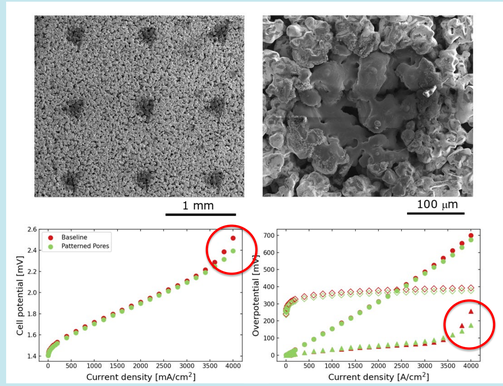


- Performance improvement due to enhanced contact.
- Improved catalyst utilization
- Performance improvement at ultra-low catalyst loading

Double Layer Capacitance and Accelerated Stress Tests

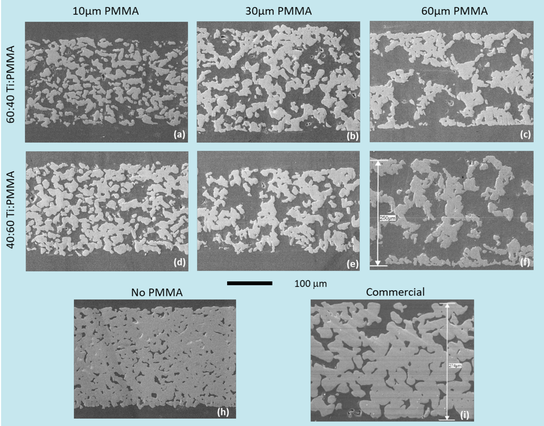


- Less severe membrane intrusion observed with laser ablated PTL. Less degradation observed.
- PTL modification at the flow field interface improves mass transport without sacrificing contact at the CL/PTL interface.



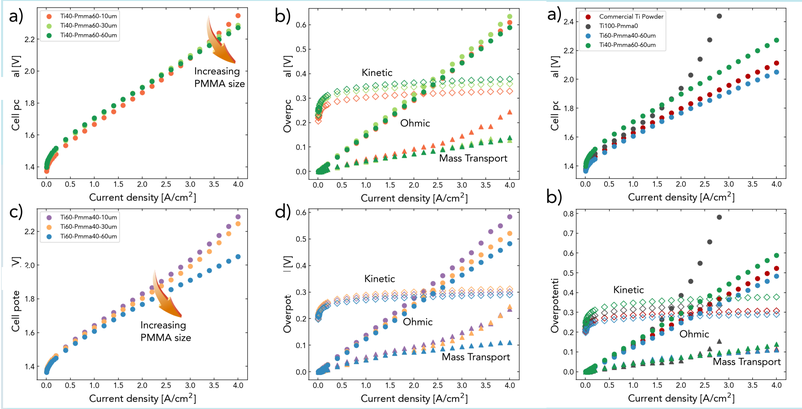
- Enables further optimization of the PTL specific to PEMWE applications.

Tape Casted PTLs – Interfacial Morphology



- CL/PTL interface and diameter of the pore were varied by changing Ti:PMMA ratio and PMMA diameter.
- Higher Ti grants better contact, higher PMMA gives more pores.
- Larger PMMA particles lead to wider pore sizes.

Controlling Pore Sizes and Titanium Weight Percentage

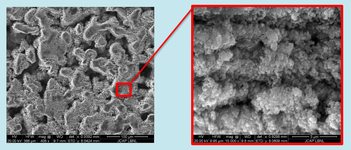


- Increasing PMMA particle sizes reduces mass transport – wider pores desired for gas removal.
- Higher Ti content improves kinetics and ohmic – grants better interface.

Conclusions and Future Work

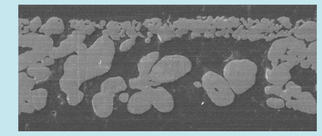
Laser Ablation

- Conclusion:
  - Laser ablation can be used to enhance CL/PTL interface of a commercial PTL.
- Future Work:
  - Create nanostructured PTLs



Tape Casting

- Conclusion:
  - Tape casting can be used to fabricate PTLs with controlled morphology.
- Future Work:
  - Created microporous layer



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