Mitigation and Diagnosis of Pin-Hole Formation in Polymer Electrolyte Membrane Fuel Cells

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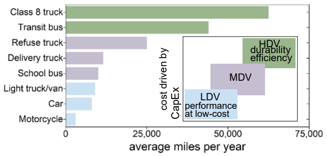
1. Heavy-duty vehicle (HDV) technical targets are focused to operational expenditures

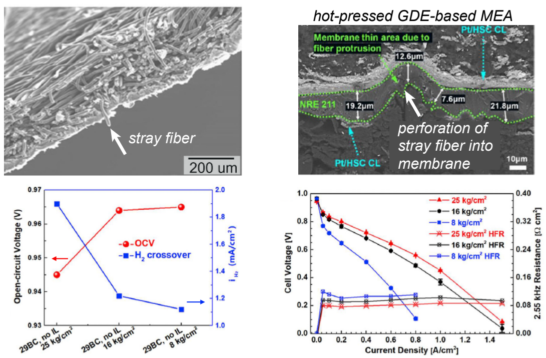


Routes Toward Enhanced Durability of HDV-Fuel Cell Electric Vehicles:

(i) Improved process-quality in MEA manufacturing
(ii) Material development approaches
(iii) Operational recovery strategies

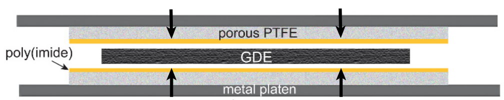
2. Irregularities Form During the Fabrication of Membrane Electrode Assemblies (MEAs)

Challenge: *Irregularities in gas diffusion electrodes (GDEs) result in membrane pin-holes at beginning of test (BOT)*

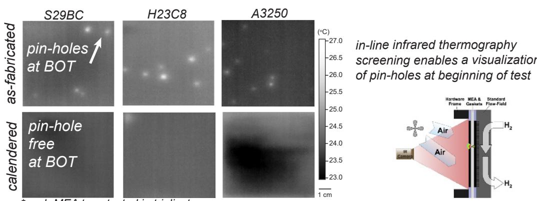


- *Fabrication artifacts go undetected during BOT performance assessments and can obscure a true durability assessment of the material properties*

Solution: *Mitigate pin-holes using a calendering pre-treatment to flatten stray fibers and irregularities found in the GDEs*



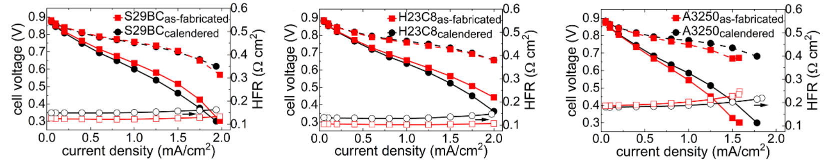
schematic of calendering process



in-line infrared thermography screening enables a visualization of pin-holes at beginning of test

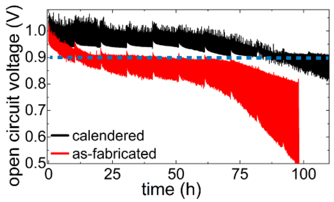
*each MEA type tested in triplicate

3. Performance of the MEAs at Beginning of Test (BOT)



- *iR-corrected current densities demonstrate that the influence of calendering on the MEA performance is negligible*

4. Combined Chemical and Mechanical Accelerated Stress Testing (AST)



AST Conditions:

- *90 °C, 30/45 s wet/dry, 2/2 slpm, H_2/air, 101/101 kPa, at OCV*

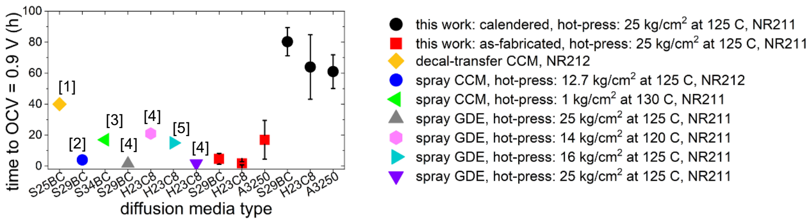
Mechanical Stressors:

- *RH cycling between wet and dry reactant gases*

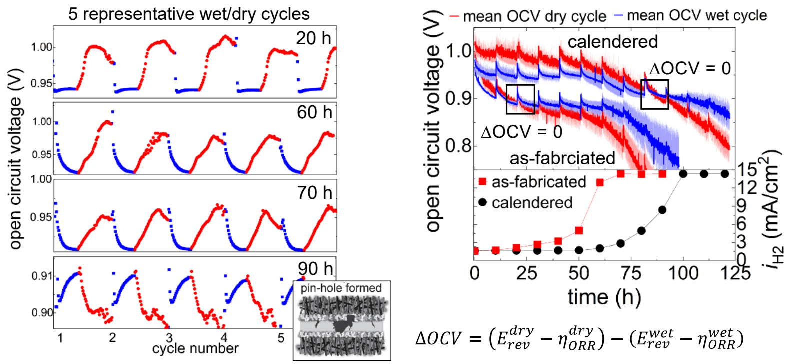
Chemical Degradation:

- *OCV hold at high temp promotes formation of radical species*

- *The calendered MEAs demonstrate a mean lifetime improvement of 77%*

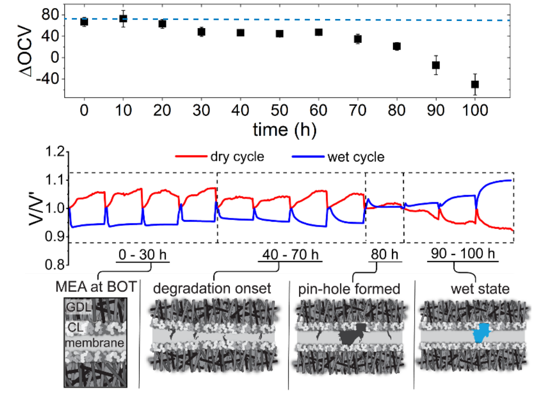


5. Following the Open Circuit Voltage (OCV) Response Under Wet and Dry Gas Flows



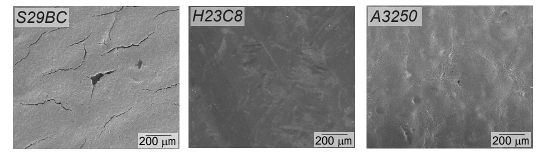
$$\Delta OCV = (E_{rev}^{dry} - \eta_{ORR}^{dry}) - (E_{rev}^{wet} - \eta_{ORR}^{wet})$$

6. Voltage Transients as an *In Situ* Diagnostic to Assess the Membrane State of Health



- *A single representative wet/dry OCV cycle is plotted every 10 h*
- *Deviation from the thermodynamically predicted ΔOCV inform membrane degradation events*

7. Physical Characterization of the Gas Diffusion Media



GDL type*	as-received thickness‡ (µm)	post-calendering thickness‡ (µm)	compressibility$^{\gamma}$
S29BC	241 ± 4.46	221 ± 3.76	8.75%
H23C8	220 ± 4.3	215 ± 4.81	1.86%
A3250	228 ± 3.42	184 ± 8.07	19.1%

* Abbreviations: S29BC = Sigracet 29BC; H23C8 = Freudenberg ; A3250 = Avcarb GDS 3250.
‡ The reported means were each calculated from nine measurements which included three measurements acquired for three separate pieces of gas diffusion media for each type. The error represents one standard deviation from the mean.
γ The compressibility represented as the percent change calculated from the as-received thickness and the resulting thickness after calendering at 25 kg/cm2.

- *Follow-up work to include structure-function correlations in durability assessments with artifact-free baselines using the estabilished methodologies*

References

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