LSM-20/YSZ Cathode Response to Elevated Steam Content in 500-1000 h Tests

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Objective

Investigate the effects of 3% Humidity on LSM/YSZ Cathodes at

- Temperature = 800, 850, 900, and 950°C
- Constant Current with Operating Voltage ~ 800 mV

Experimental Approach

6 Anode-Supported LSM/YSZ Button Cells were Operated at Each of the Above Temperatures

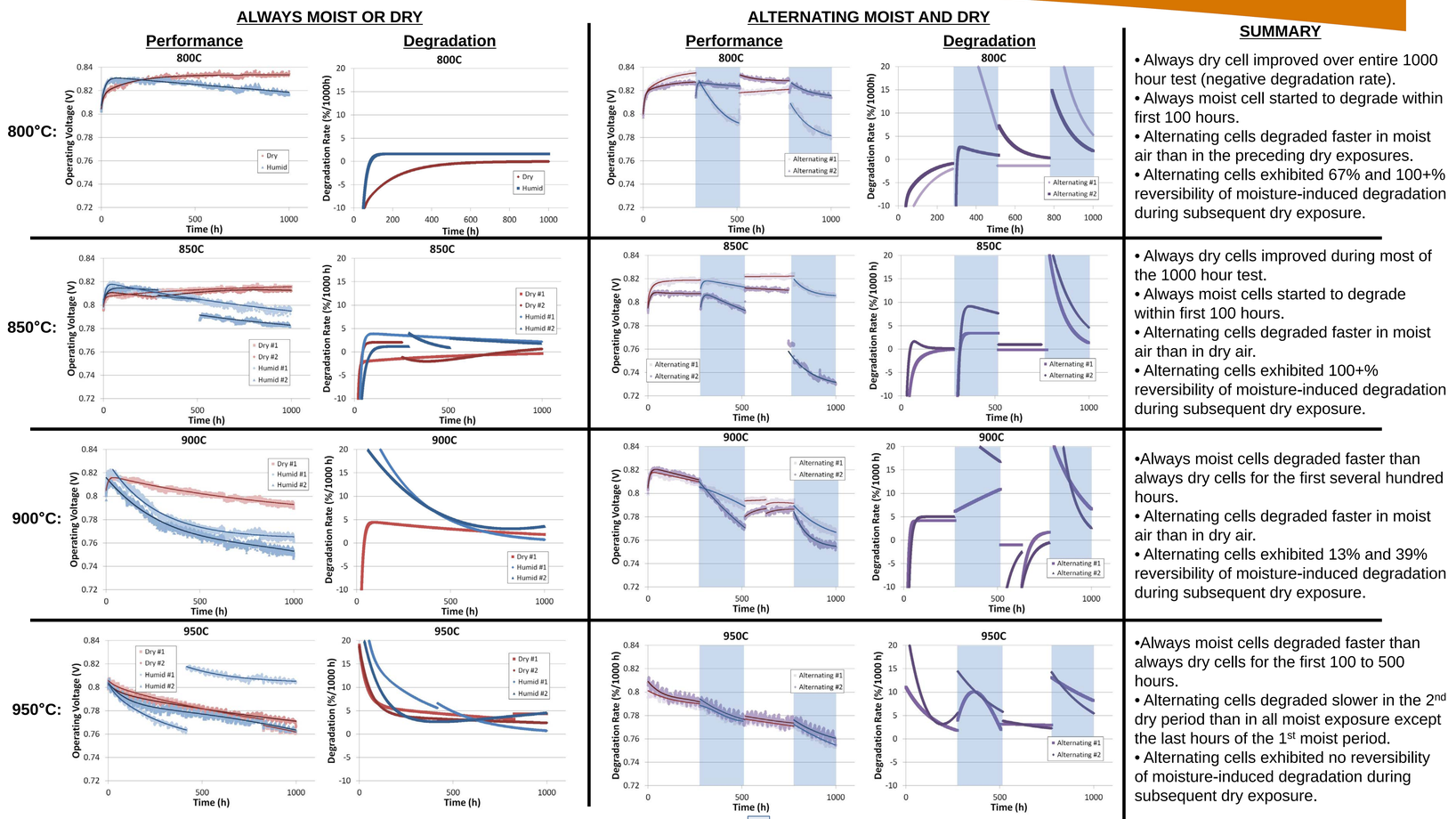
- 2 in dry air for entire test (1000 h)
- 2 in moist air (~3% H_2O) for entire test (1000 h)
- 2 Alternated between dry & moist every 250 h

Continuous segments of operating voltage data was fit with an exponential decay equation of the form:

$$V(t) = V_0 + ae^{-bt} + ge^{-ht} + me^{-nt}$$

The degradation rate in % per 1000 h as a function of time, D(t), can then be calculated:

$$D(t) = -\frac{1000\frac{dV}{dt}}{V} \times 100\% \qquad \frac{dV}{dt} = -abe^{-bt} - ghe^{-ht} - mne^{-nt}$$



SUMMARY

- Always dry cell improved over entire 1000 hour test (negative degradation rate).
- Always moist cell started to degrade within first 100 hours.
- Alternating cells degraded faster in moist air than in the preceding dry exposures.
- Alternating cells exhibited 67% and 100+% reversibility of moisture-induced degradation during subsequent dry exposure.

- Always dry cells improved during most of the 1000 hour test.
- Always moist cells started to degrade within first 100 hours.
- Alternating cells degraded faster in moist air than in dry air.
- Alternating cells exhibited 100+% reversibility of moisture-induced degradation during subsequent dry exposure.

- Always moist cells degraded faster than always dry cells for the first several hundred hours.
- Alternating cells degraded faster in moist air than in dry air.
- Alternating cells exhibited 13% and 39% reversibility of moisture-induced degradation during subsequent dry exposure.

- Always moist cells degraded faster than always dry cells for the first 100 to 500 hours.
- Alternating cells degraded slower in the 2nd dry period than in all moist exposure except the last hours of the 1st moist period.
- Alternating cells exhibited no reversibility of moisture-induced degradation during subsequent dry exposure.

Objective

Investigate the effects of greater than 3% Humidity on LSM/YSZ Cathodes at:

- Humidity Level = 10 and 20% (balance air)
- Temperature = 800°C
- Constant Current = 0.25 A/cm² (~920 mV) and 0.75 A/cm² (~775 mV)
- Air Source: Site Compressed Air

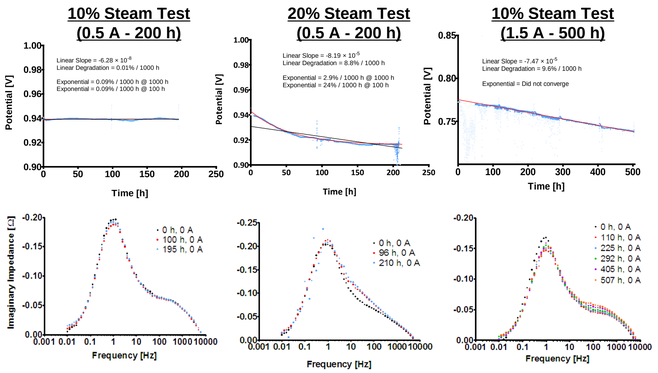
Experimental Approach

- Anode-Supported Button Cells from MSRI were Operated at the above Conditions, as shown in the results table.
- LSM $[(La_{0.8}Sr_{0.2})_{0.98}MnO_3]$ with an LSM-YSZ interlayer, YSZ electrolyte, and a Ni-YSZ anode
- Saturated steam is pressure/temperature controlled and injected through a restrictive flow orifice at choked flow conditions to obtain elevated steam content in air

Results

Test	Degradation rate at 100 h [per 1000 h]	Degradation rate at 1000 h [per 1000 h]	R_P at t=0 [Ω×cm²]	R_P at t_F [Ω×cm²]	Current Density [A/cm²]
0% Steam 380 h	1.8%*	1.8%*	0.22	0.15	0.75
10% Steam 100 h	1.2%	0.1%	0.28	0.30	0.25
10% Steam 200 h	0.1%	0.1%	0.32	0.32	0.25
10% Steam 500 h	9.6%*	9.6%*	0.17	0.19	0.75
20% Steam 200 h	24%	2.9%	0.36	0.44	0.25
20% Steam 500 h	25%	4.6%	0.34	0.50	0.25

* - Linear fit used in these cases due to non-convergence of one-phase decay model



- Degradation data is fitted with an exponential decay model of the form:
  $V = (V_0 - \text{Plateau})e^{-kx} + \text{Plateau}$
- This testing shows essentially no degradation with 10% steam in air at low current density.
- Testing shows rapid initial degradation at extended time with 20% steam in air.
- Testing at higher current density and 10% steam in air yields higher degradation rate, indicating a possible correlation with applied overpotential.

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