



INSIGHT INTO MEMBRANE DEGRADATION MECHANISMS THROUGH VERIFICATION OF CHEMICAL AND MECHANICAL DEGRADATION TEST CAPABILITIES



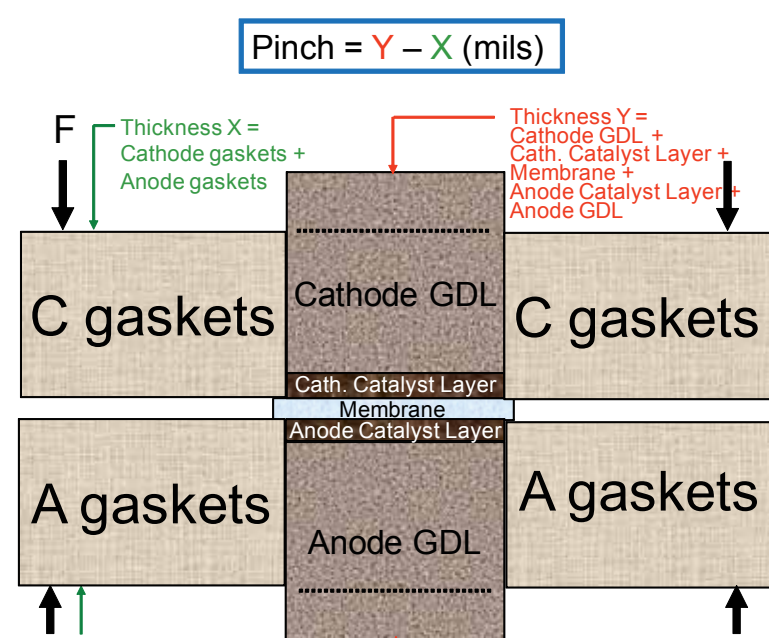
Darlene K. Slattery • Leonard Bonville • Marianne Rodgers • Paul Brooker
Florida Solar Energy Center • 1679 Clearlake Road • Cocoa, Florida 32922

Meads



A major goal of this project was to complete the verification of the high-throughput MEA Durability Test System (MEADS) that allows simultaneous, independent operation of eight cells at or near open circuit voltage (OCV). This fuel cell operation condition is frequently used in accelerated test protocols. Using this unique test equipment, FSEC has conducted chemical degradation tests on both commercial and FSEC MEA's on a multiple sample basis.

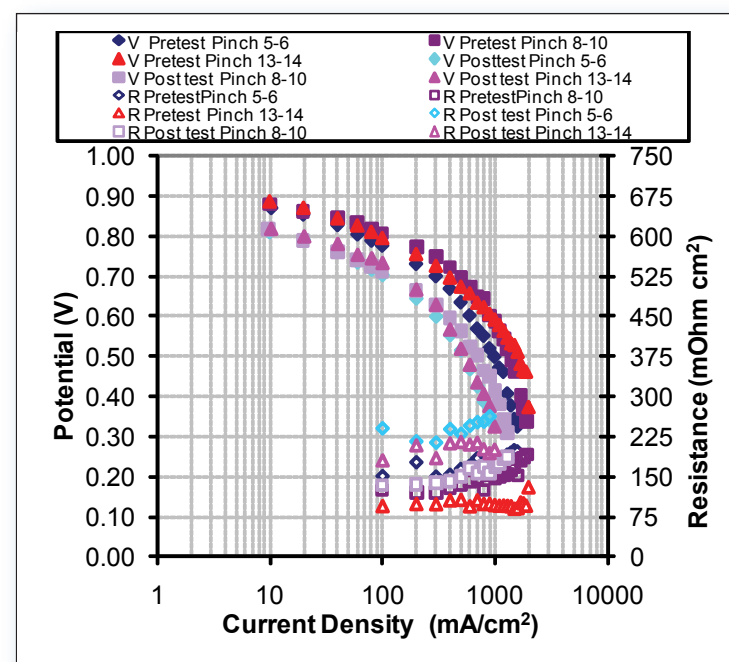
Pinch



- ♦ Axial load is a critical parameter for cell assembly
- ♦ The compressive load on the active area of the MEA is established by the cell "pinch" which is controlled by adjusting the thickness of the gaskets around the MEAs.

Results

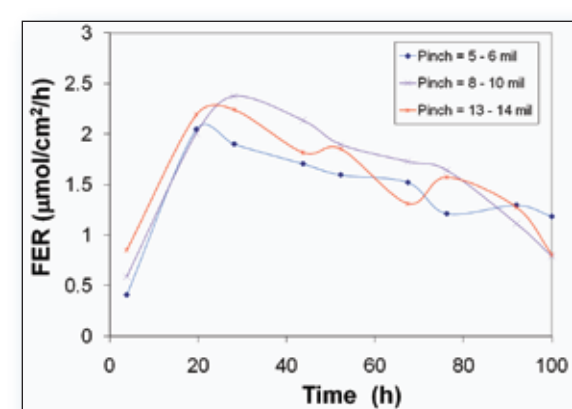
Cells were built with pinches of 5-6, 8-10, and 13-14 mil. All cells were humidified, performance tested, durability tested and finally performance tested again.



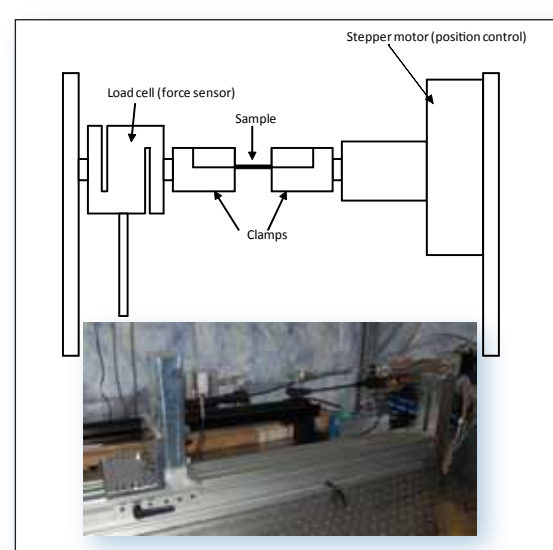
Degradation as a Function of Pinch

- ♦ The study determined that there is a wide range of pinch that does not affect membrane degradation

FER=Fluoride Emission Rate and is a measure of membrane degradation



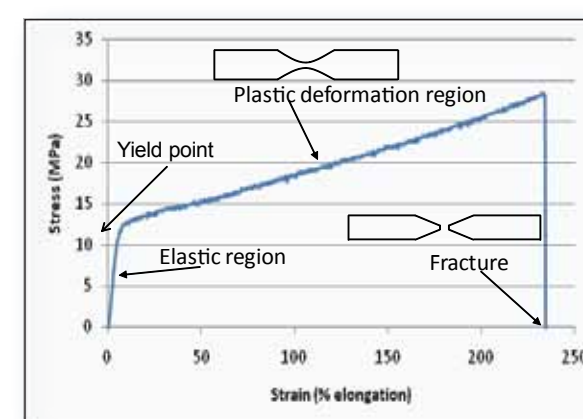
Use of Stress-Strain for Mechanical Durability Testing



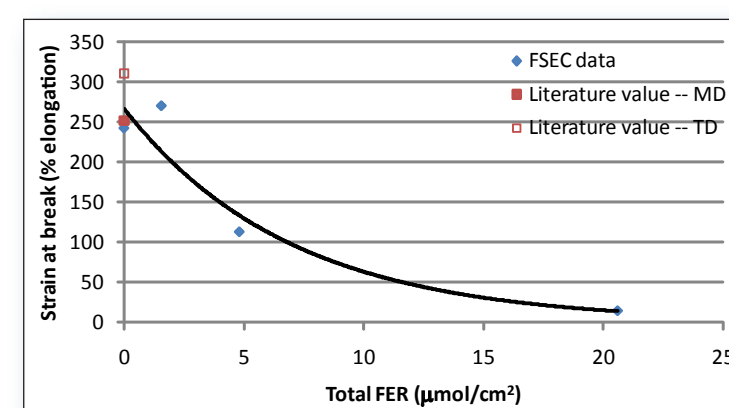
- ♦ Used to measure
 - Young's Modulus
 - Plastic deformation
 - Fracture Toughness

Example Stress-Strain Curve

- ♦ Degradation indicated by changes in:
 - Elastic region slope (Young's Modulus)
 - Strain/Stress at yield point
 - Strain/Stress at fracture
 - Plastic region slope

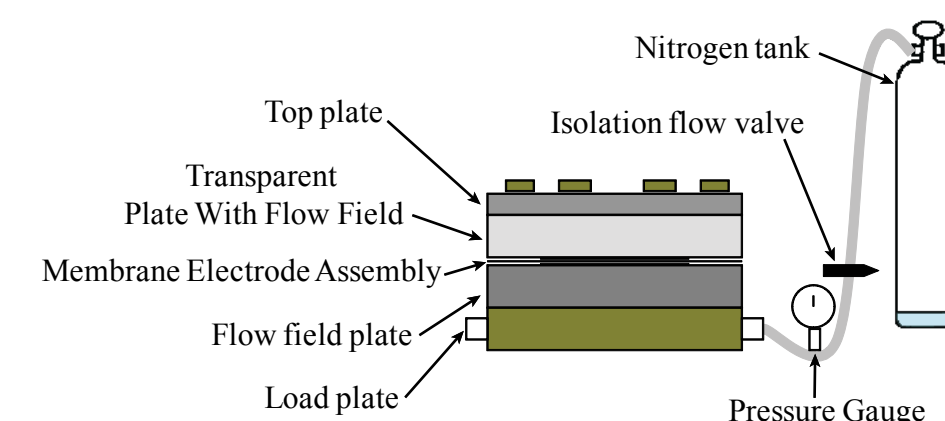


Stress-Strain as a Function of Total Fluoride Release



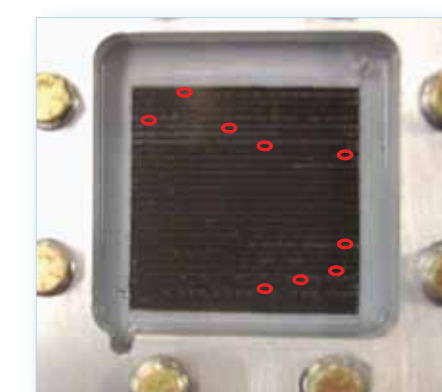
MD = Machine direction
TD = Transverse direction

Determination of Pinholes

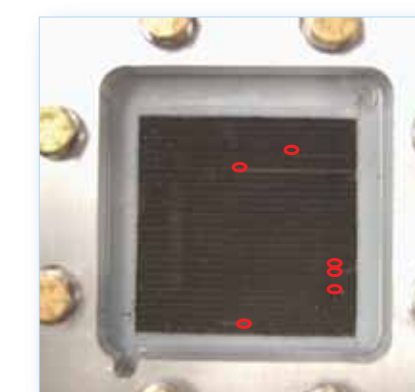


- ♦ Pinholes that develop in a membrane electrode assembly can lead to cell failure
- ♦ A method was developed for determining the location of pinholes:
 - A liquid is injected to the flow field of the transparent plate
 - Gas is flowed to the cell under controlled pressure
 - Locations where bubbles form are photographed and documented
- ♦ Method was evaluated and assessed to have insufficient reproducibility to meet development goals

B328 (NRE212, OCV Degradation Tested)



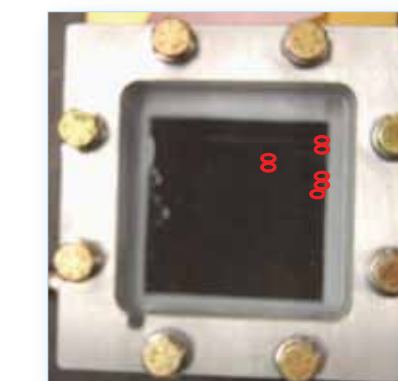
09/03/09, 0.3 psi



09/04/09, 0.3 psi

- ♦ Bubbles (circled in red) indicate pinhole locations
- ♦ When the same MEA was tested, then left in the holder overnight, pinholes appeared in different locations but at the same pressure

B327 (Ion Power, OCV Degradation Tested)



09/06/09, 33 psi



09/10/09, 0 psi

When the same MEA was tested, disassembled and retested, bubbles appeared at different locations and at lower pressure

Summary

The MEADS was verified and used to simultaneously test fuel cells for durability. One of the parameters examined was pinch. Cells were built with varying levels of pinch and tested. During the 11 day tests, water was collected and analyzed for the presence of fluoride ions, an indication of chemical degradation. After this and other testing, mechanical degradation was examined via stress-strain testing.

The project has been completed and development objectives have been met.