MEA Fabrication

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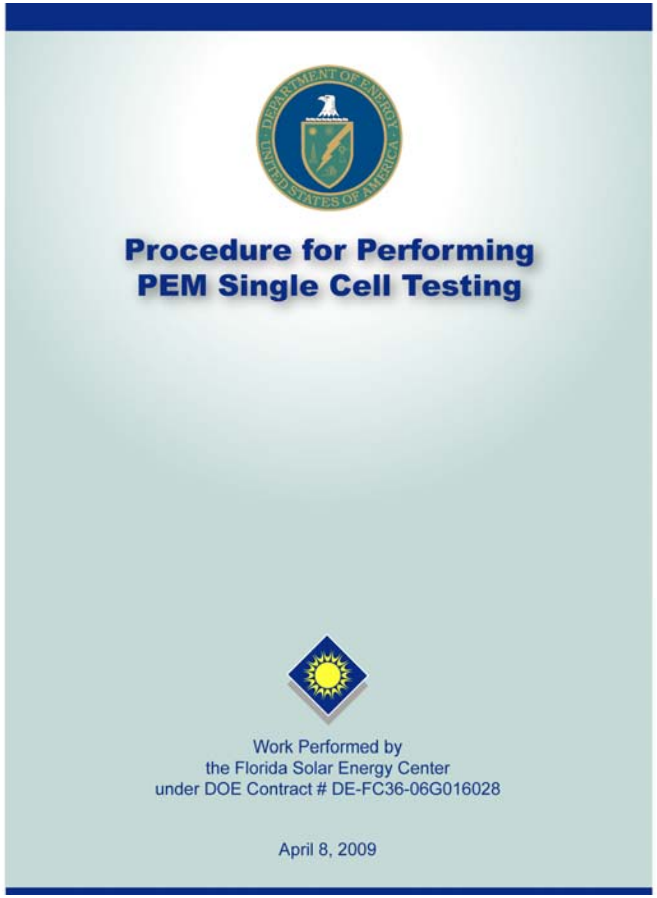
Outline

- Test Protocol
- FSEC Responsibilities
- Electrode Background
- Previous Studies
- FSEC Baseline Fabrication Procedures
- Cell Assembly
- CCM Fabrication from Team Membranes
- Membrane Tests and Test Results

MEA Test Protocol

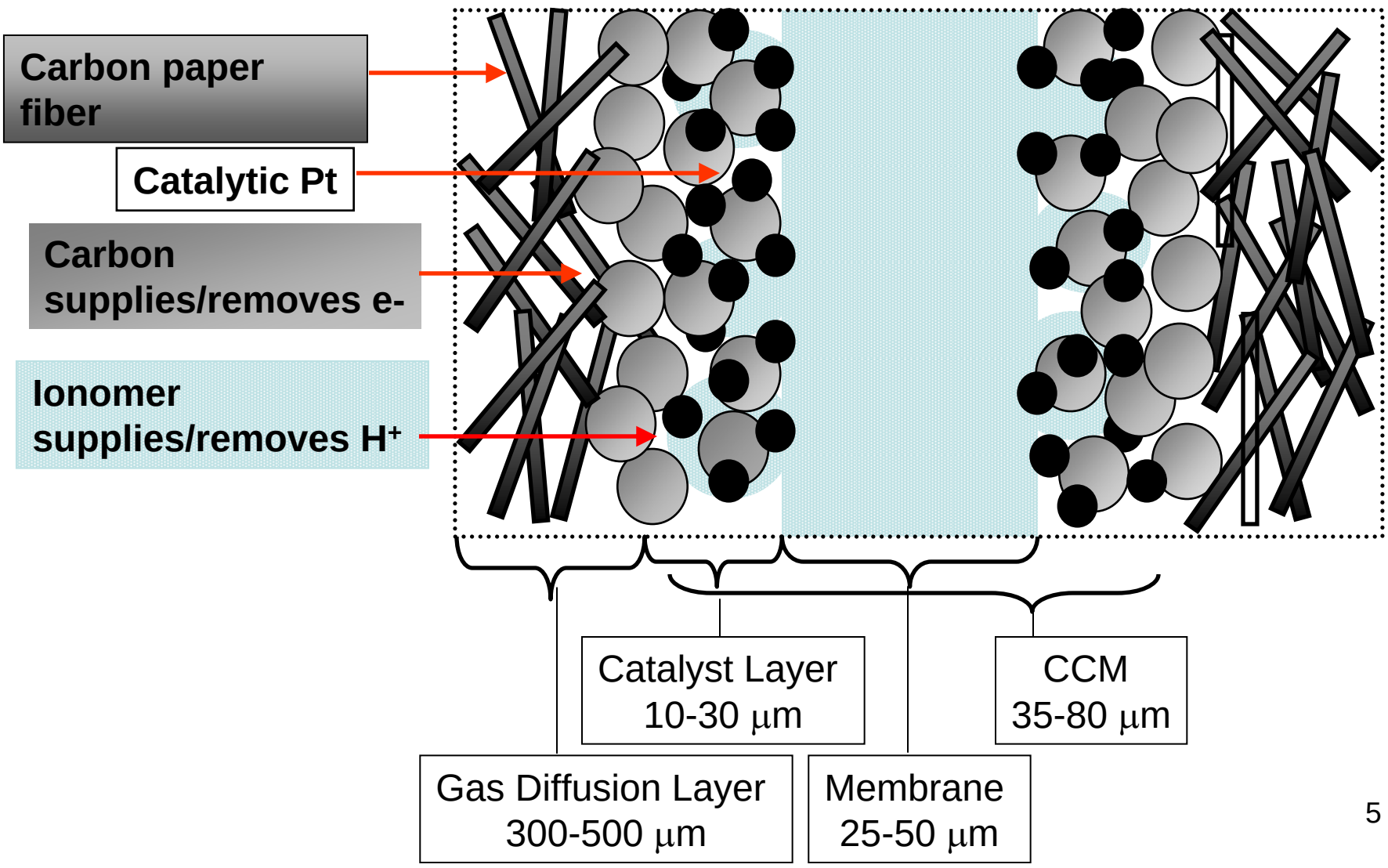
- Hard copies available
- First presented at fall meeting in Hawaii
- Additional tests run to verify procedure



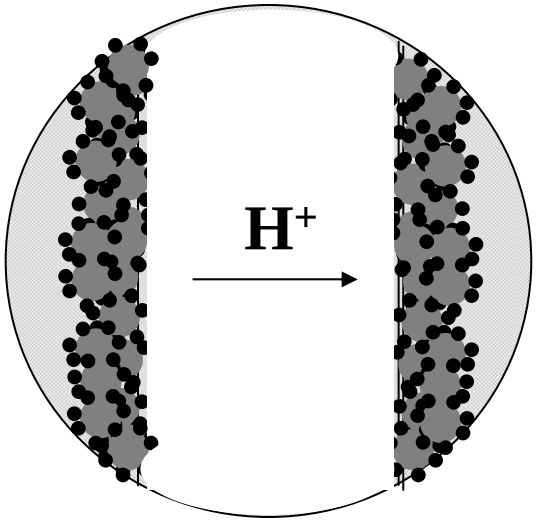
FSEC Responsibilities

- Make a good MEA according to membrane developers specifications
- Work closely with developer to apply an appropriate electrode for their membrane
  - FSEC has a baseline electrode application process
  - Ink composition, electrolyte type, loading, application conditions (e.g. heat), hot press conditions, etc.

Membrane Electrode Assembly (MEA)



Electrode Components



MOST Losses
3-phase reaction

- Kinetics (activation)
- Ohmic (ionic, electronic)
- Mass Transport (O_2)

Catalyst
(Active Site + Electronic)

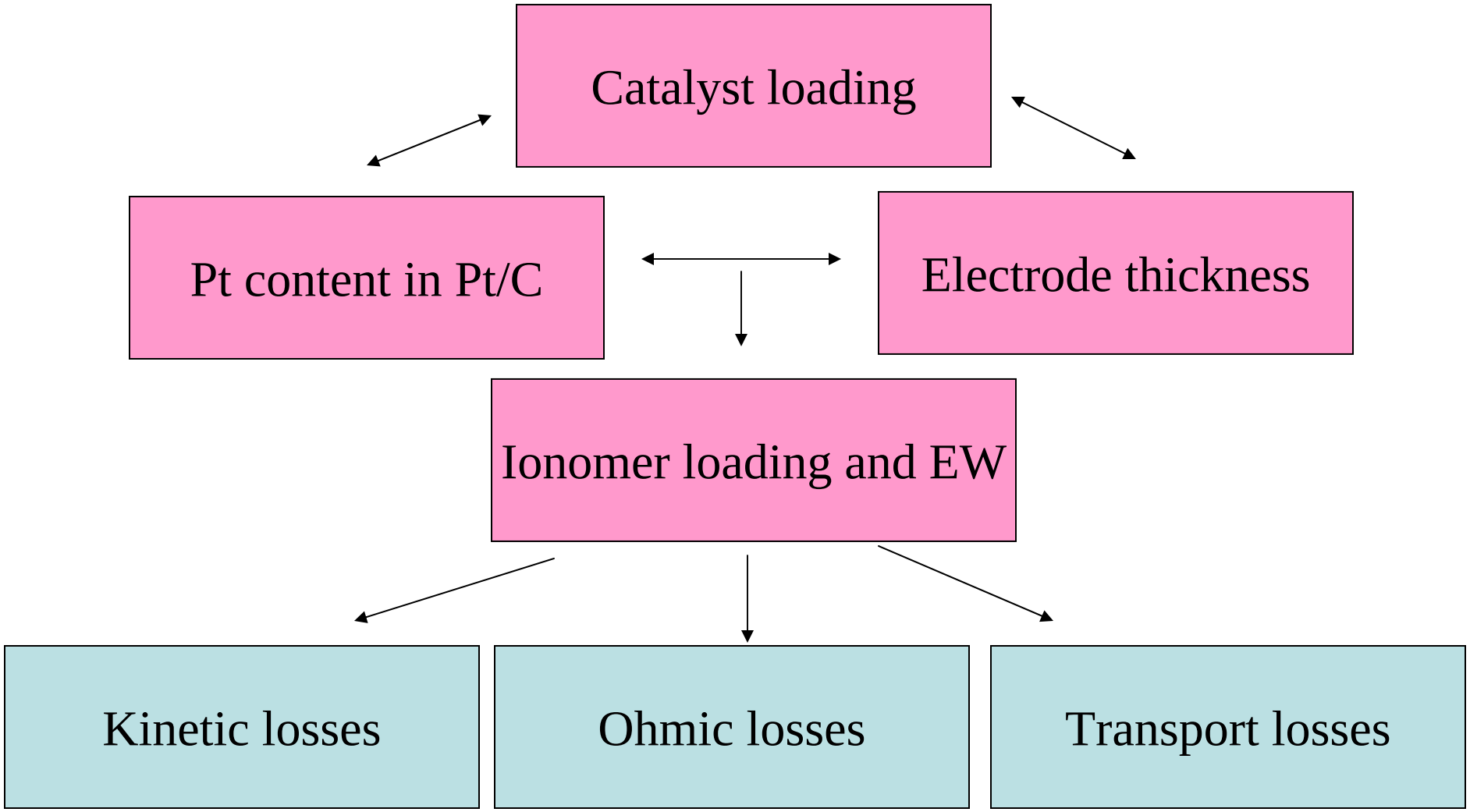
Ionomer
(Proton Transport)

Reactant
(Gas Transport)

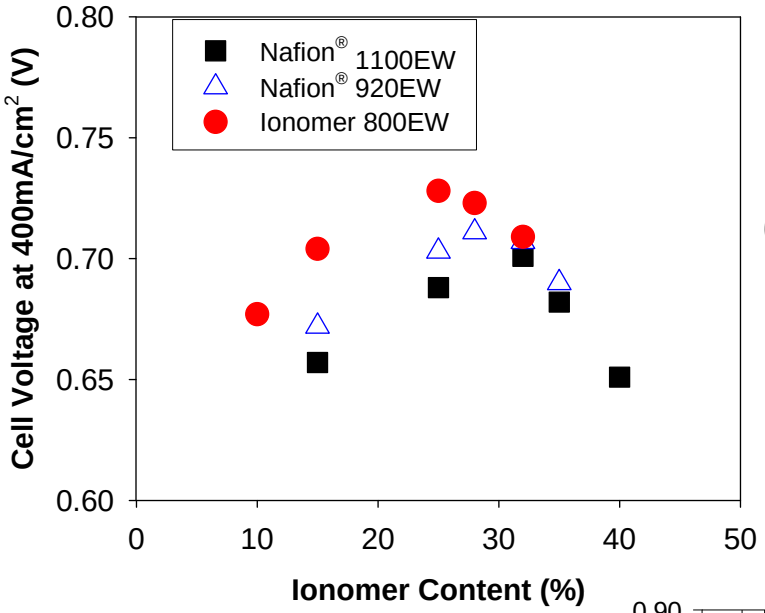
Anode: $H_2 \rightarrow 2\ H^+ + 2\ e^-$

Cathode: $\frac{1}{2}\ O_2 + 2\ H^+ + 2\ e^- \rightarrow \frac{1}{2}\ H_2O$

Complex Interplay Among Key Elements

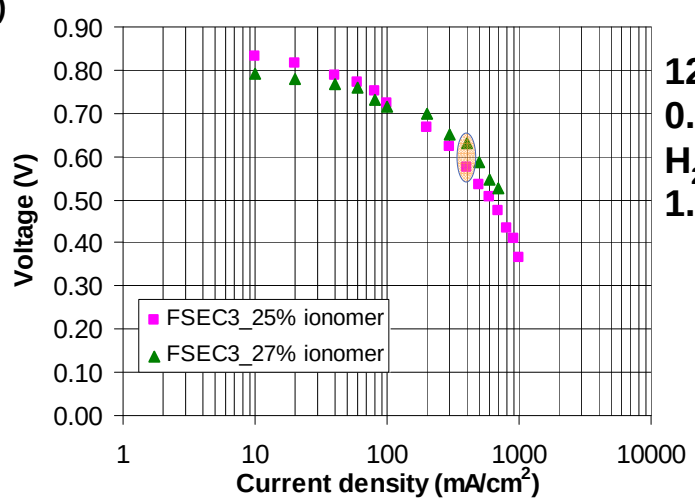


Previous Studies of CCM Fabrication: Effect of Ionomer Loading and EW



120/35/35
0.4mg/cm² Pt
H_2/Air
1atm

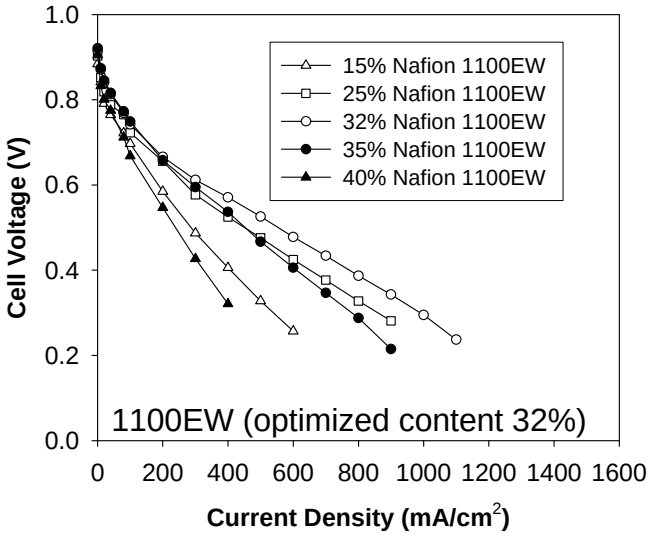
FSEC-1 CCM FSEC-3 CCM

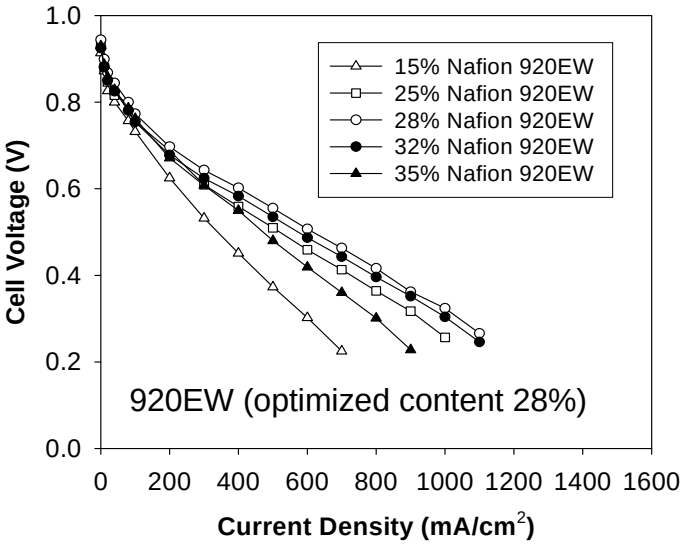


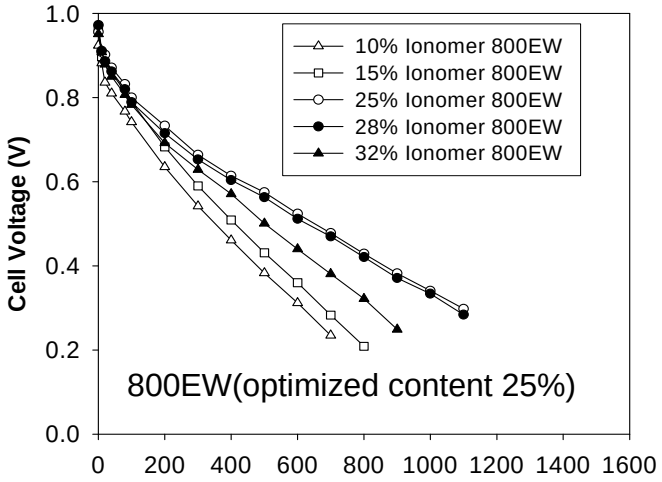
120/35/35
0.4mg/cm² Pt
H_2/Air
1.5 atm

*H. Xu, H.R. Kunz, L. Bonville, J.M. Fenton, *J. Electrochem. Soc.*, 154, B271-B378 (2007).

Effect of Ionomer EW and Content on Performance at 120 ºC and 35%RH







Membrane: Nafion®-Teflon®-Phosphotungstic Acid (NPTA) 25μm

Cathode: 0.4mg/cm^2 Pt (Tanaka Pt/C)

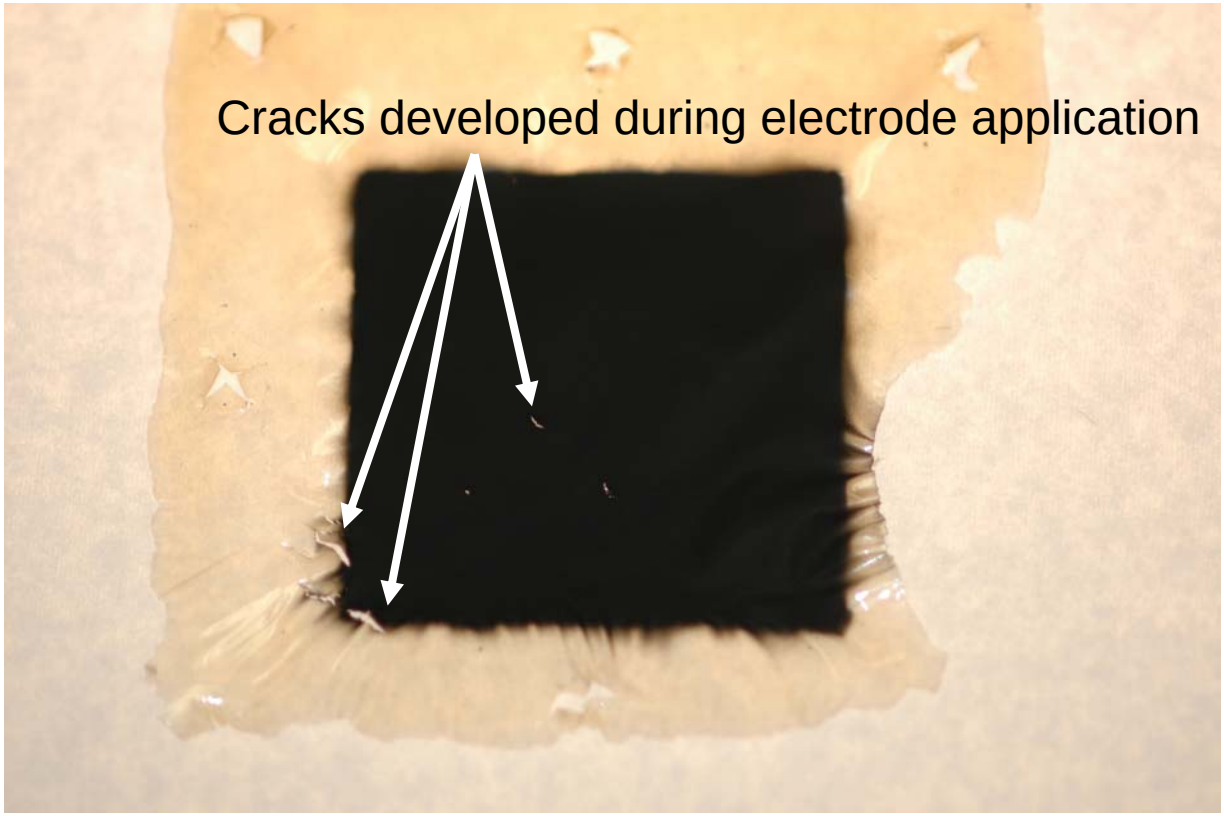
Anode: 0.4mg/cm^2 Pt (Tanaka Pt/C)

Reactant: H_2 (stoic 4)/air (stoic 3)

Total pressure: 1atm

Previous Studies of CCM Fabrication: Hydrocarbon Membranes

- Drying the membrane before and after spraying resulted in a brittle membrane

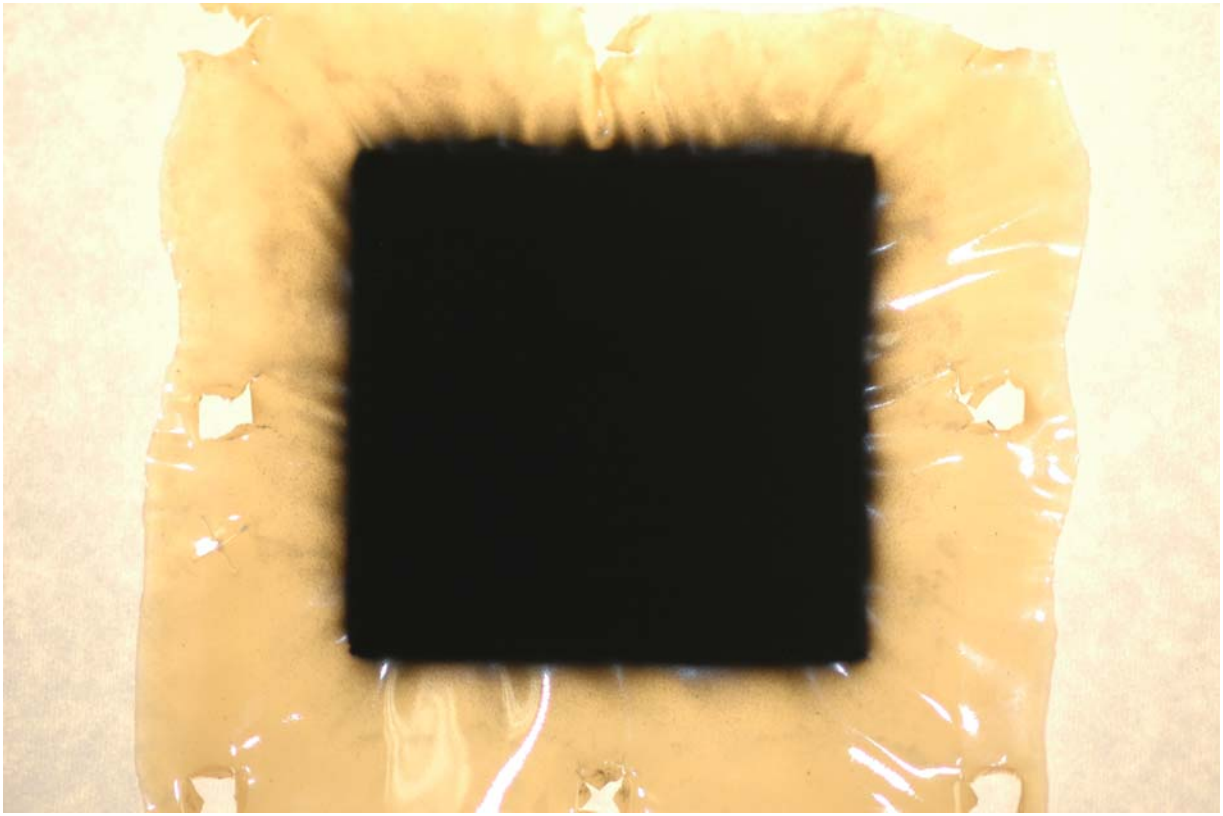


Previous Studies of CCM Fabrication: Hydrocarbon Membranes

- Solvents used in spraying caused significant swelling
  - The CCM never relaxed back to its original shape

Previous Studies of CCM Fabrication: Hydrocarbon Membranes

- Lower drying temperature and slower rate of spraying resulted in better CCM

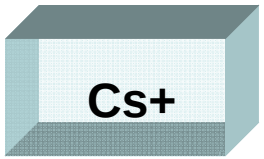


FSEC CCM Baseline Fabrication Procedure

1. Spraying

45.5 wt % Pt/C (TKK)
PFSA ionomer solution
Solvent

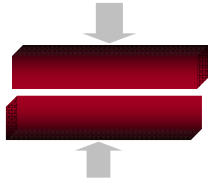
2. Cs^+ treatment



0.1 N Cs_2CO_3

- both membrane & electrode

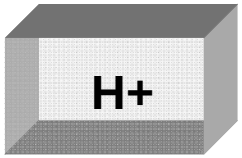
3. Heat treatment



-CCM is melt processed

75 psi
Cs exchanged CCMs, hot press at 180 °C
Non Cs exchanged CCMs, hot press at 136 °C

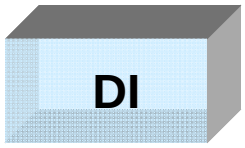
4. Protonation



0.5M H_2SO_4

- ionomer regains its protonic form

5. Cleaning



- remove residual acid

High performance, interfacial stability and improved durability

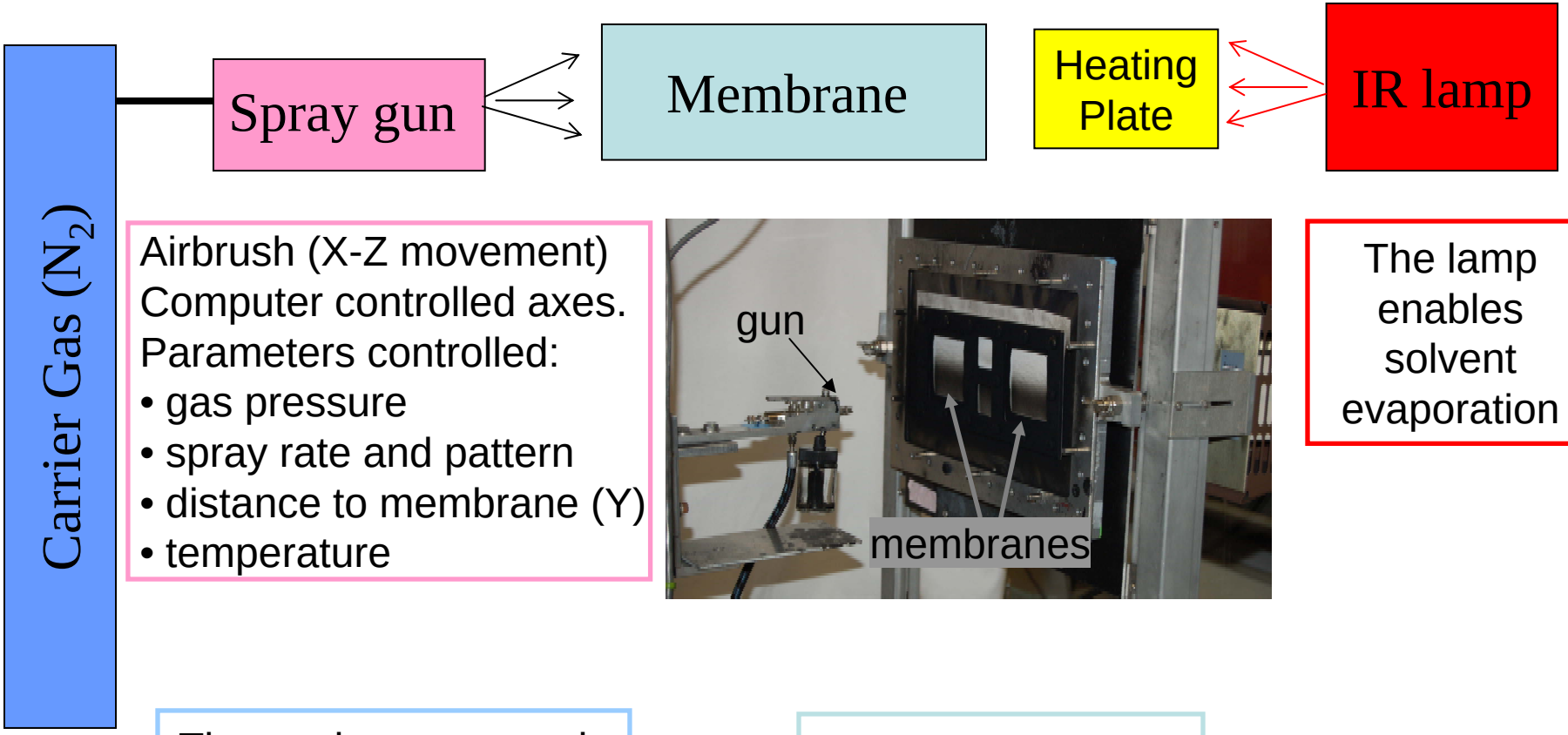
Ink Preparation

3 wt% Pt/C
+
10 wt% Water
+
65 wt% Methanol
+
22 wt% 1100 EW
5% Nafion® Dispersion

Homogenize
19,000 rpm
5.5-6 h

Store in a vial, stirring, for no more than one week

Membrane Spraying Setup



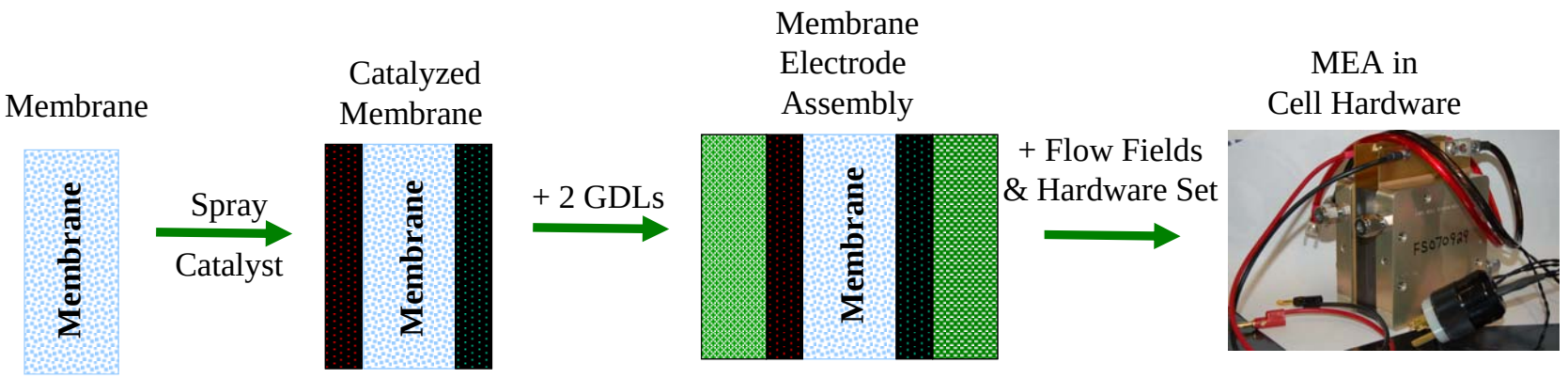
Airbrush (X-Z movement)
Computer controlled axes.
Parameters controlled:
- gas pressure
- spray rate and pattern
- distance to membrane (Y)
- temperature

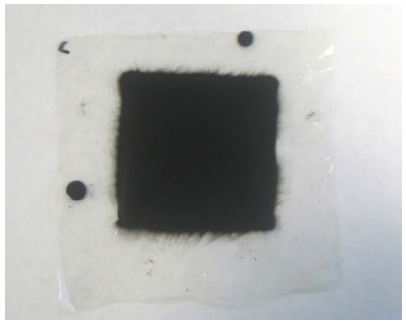
The lamp enables solvent evaporation

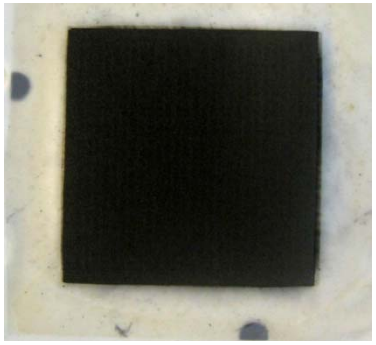
The carrier gas propels onto membrane surface.

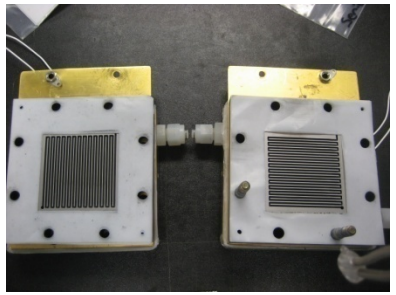
Final catalyst layer contains 68 wt% Pt/C and 32 wt% 1100 EW Nafion®

From Membrane to Testing



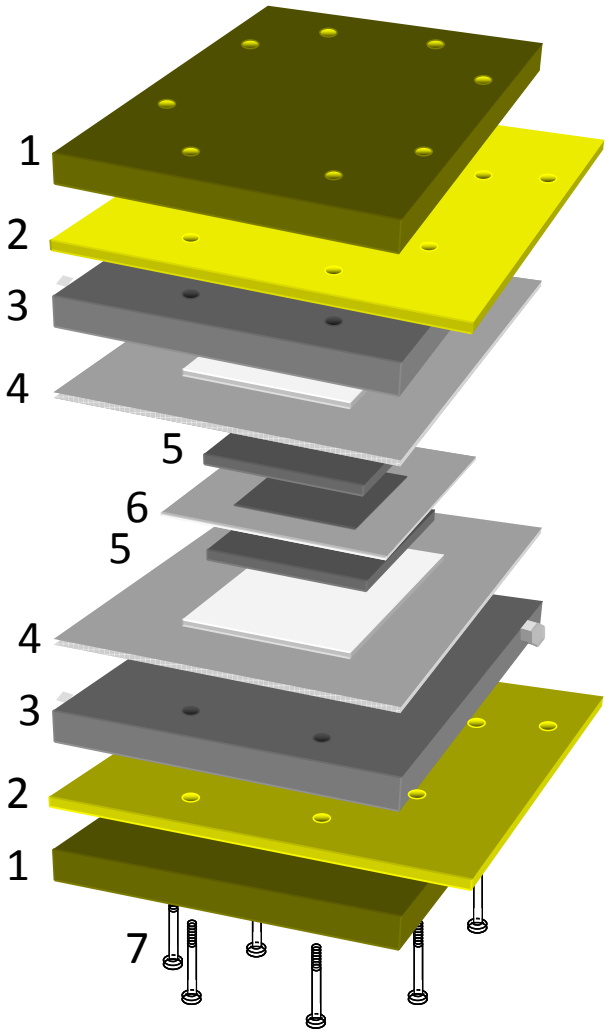






Electrocatalyst: **45.5 % Pt/C (TKK); 0.4 mg Pt/cm² for both the anode and cathode**

Cell Assembly



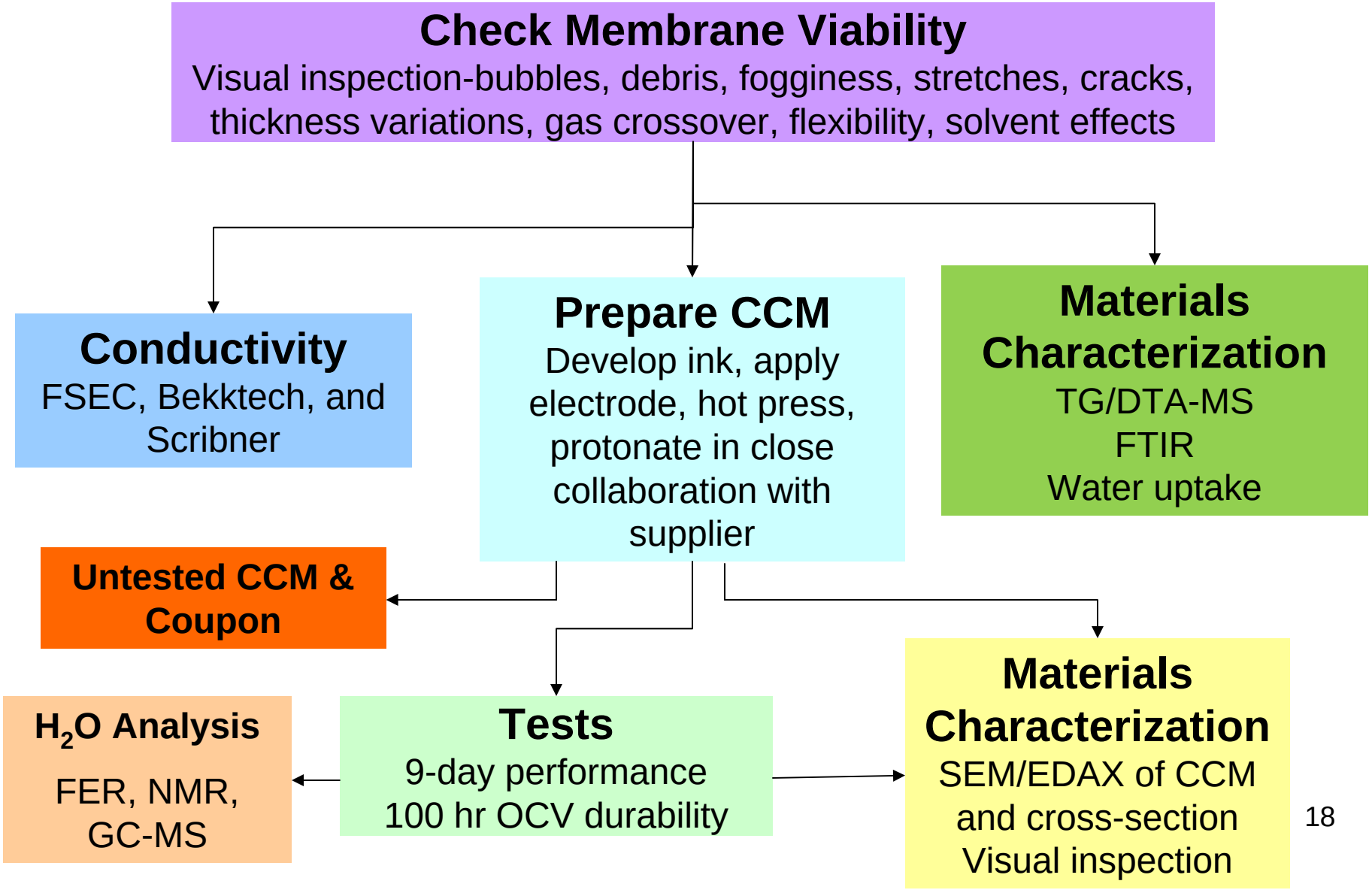
1. End plate
2. Gold coated copper plate
3. Bipolar plate
4. Teflon gaskets to provide pinch
   - Total pinch = 228-254 μm (9-10) mil
5. Gas Diffusion Media
   - 10 BB SGL Carbon (Sigracet™)
6. CCM
7. Bolts

Assembly verification

– Check for electrical short using a multimeter

– Leak check

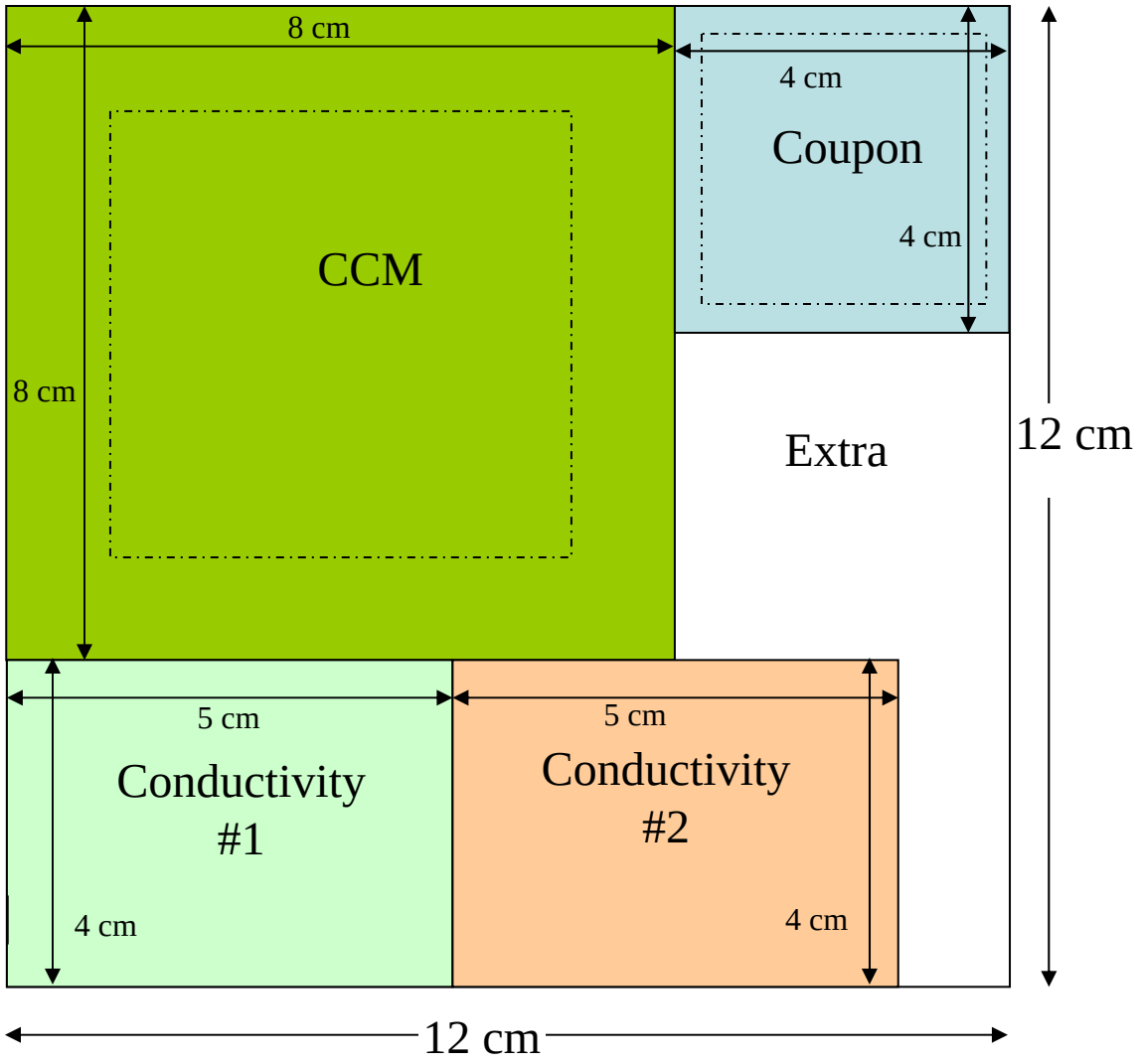
CCM Fabrication & Testing of Your Membranes



Provided to Supplier

- All the data collected
  - MEA manufacturing issues **as they arise**
  - Conductivity, performance and accelerated durability data with analysis
- An untested CCM for your evaluation
- Coupon for *ex situ* testing
  - SEM, FTIR, XPS, etc.

Membrane Sample Size



- CCM piece used for MEA
- Conductivity pieces tested at FSEC Bekktech, and Scribner
- Coupon piece prepared with electrode at same time as CCM
  - Could be used to examine effects of post spray treatment, electrode/membrane interface, electrode surface, etc

Electrode Development In Collaboration With Suppliers

- Solvent in ink mixture
  - Type, ink content
- Ionomer in electrode
  - Type, final electrode loading
- Cure rate of ink on membrane
  - Heat, distance from heat, ink application rate
- Catalyst

How Can You Help Us?

- Membrane temperature limits?
- Membrane solvent tolerance?
- Membrane/ionomer interactions?
- What ionomer do you want in your electrode?
- Additional questions for discussion?