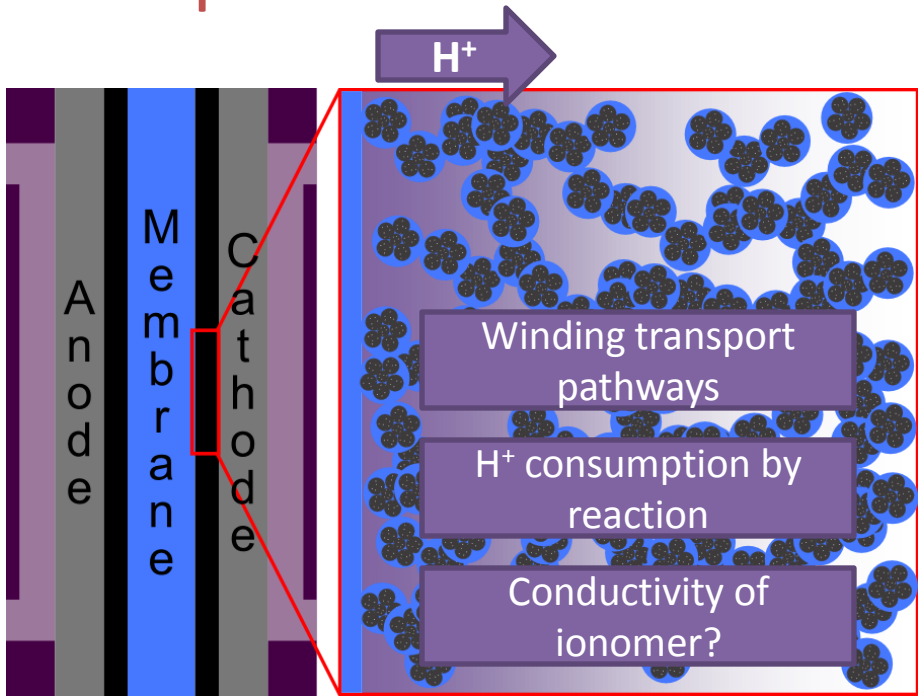
Fuel cell electrodes: Plagued by transport losses

- Porous electrode is very thin
- Still, at high current, transport can be an issue

Ionic potential gradients can be high



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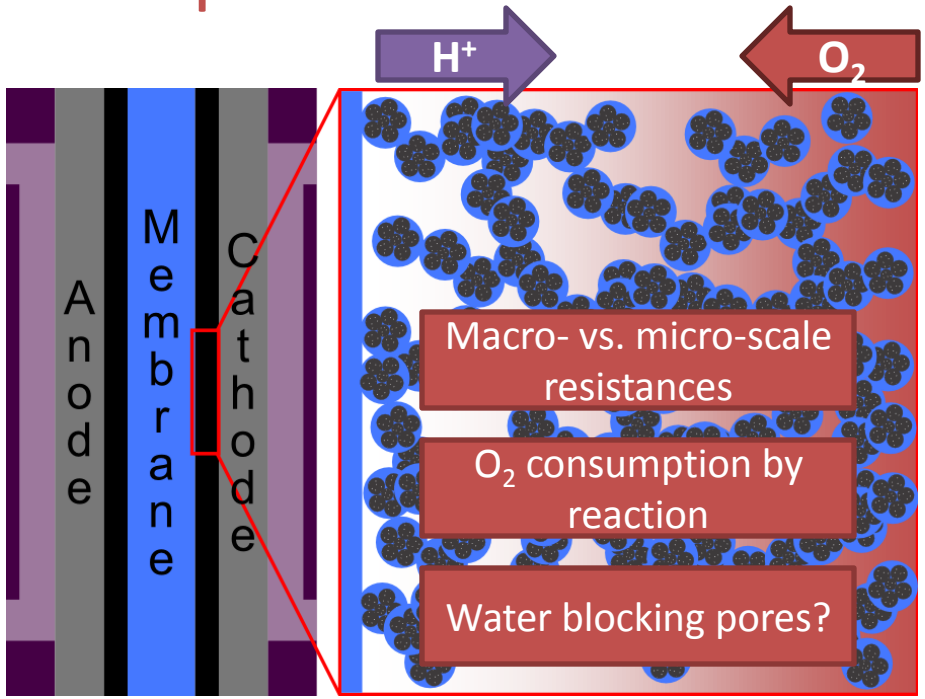


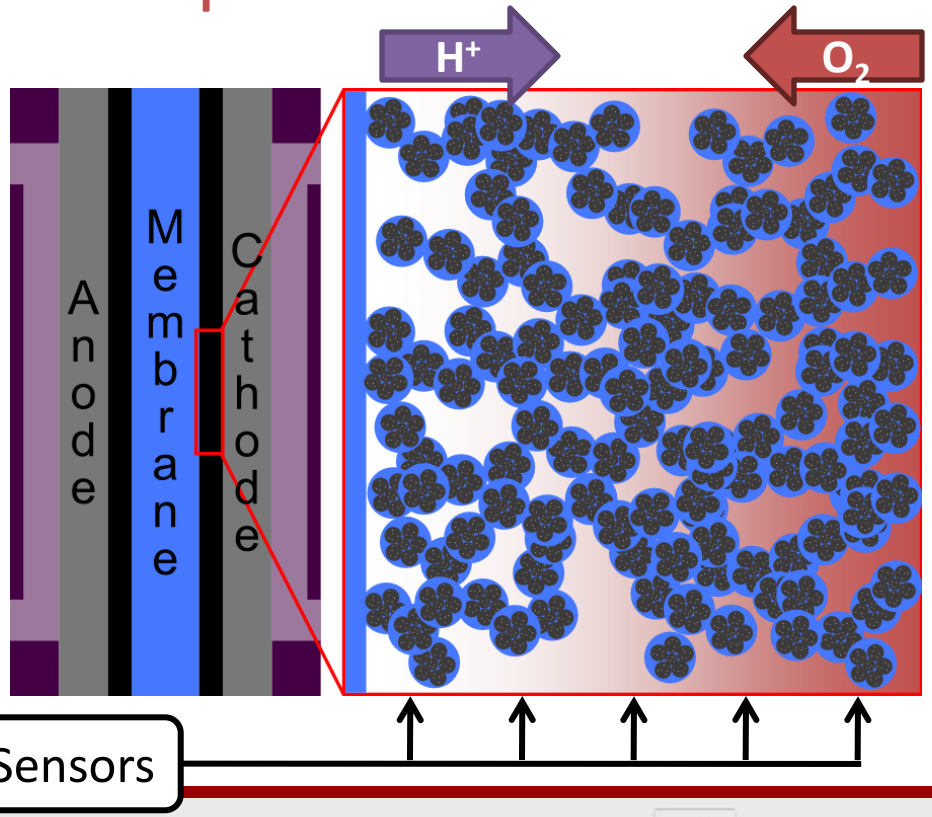
Fuel cell electrodes: Plagued by transport losses

- Porous electrode is very thin
- Still, at high current, transport can be an issue

Ionic potential gradients can be high

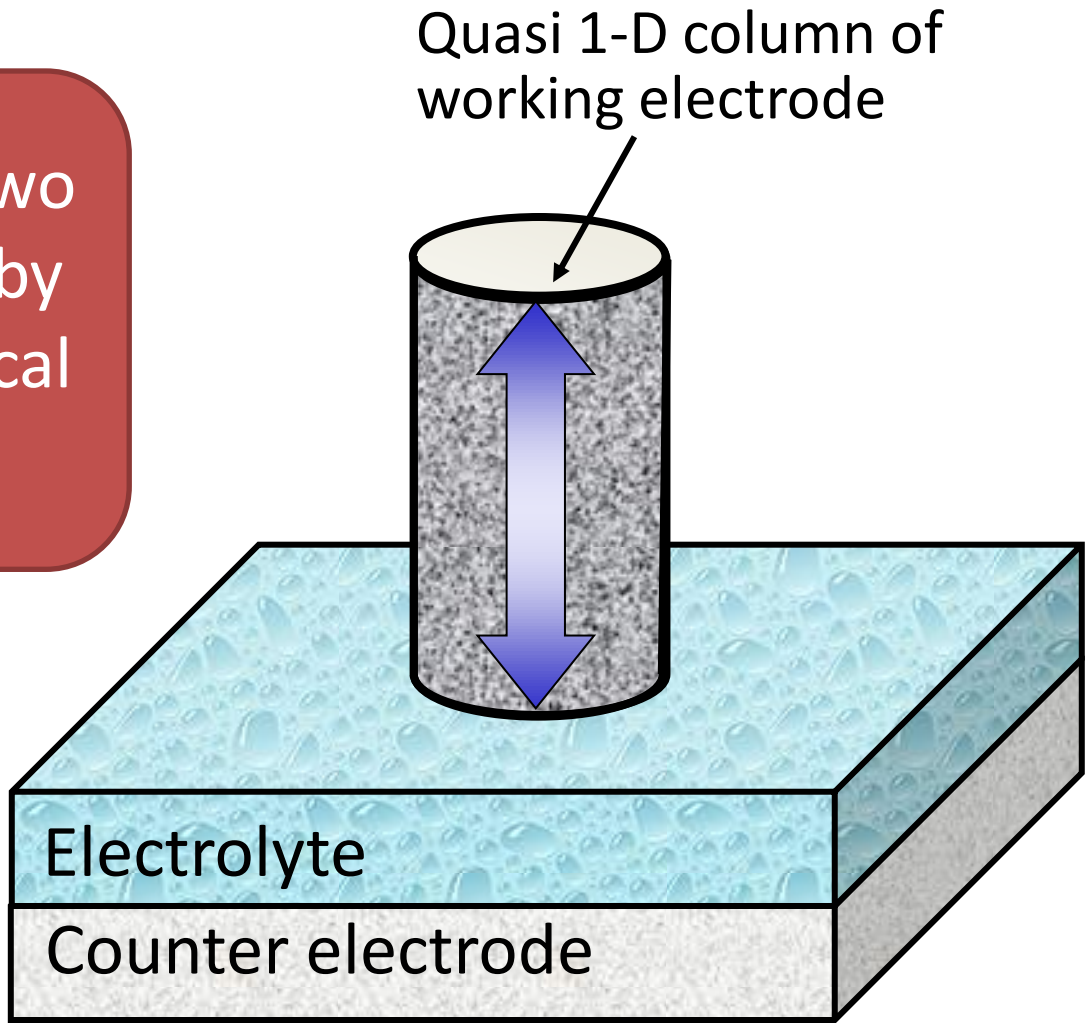
Oxygen gradients can be high

We measure these gradients to understand transport resistance



Microstructured Electrode Scaffold (MES) Diagnostics

Structure consists of two electrodes separated by a PEM just as in a typical fuel cell



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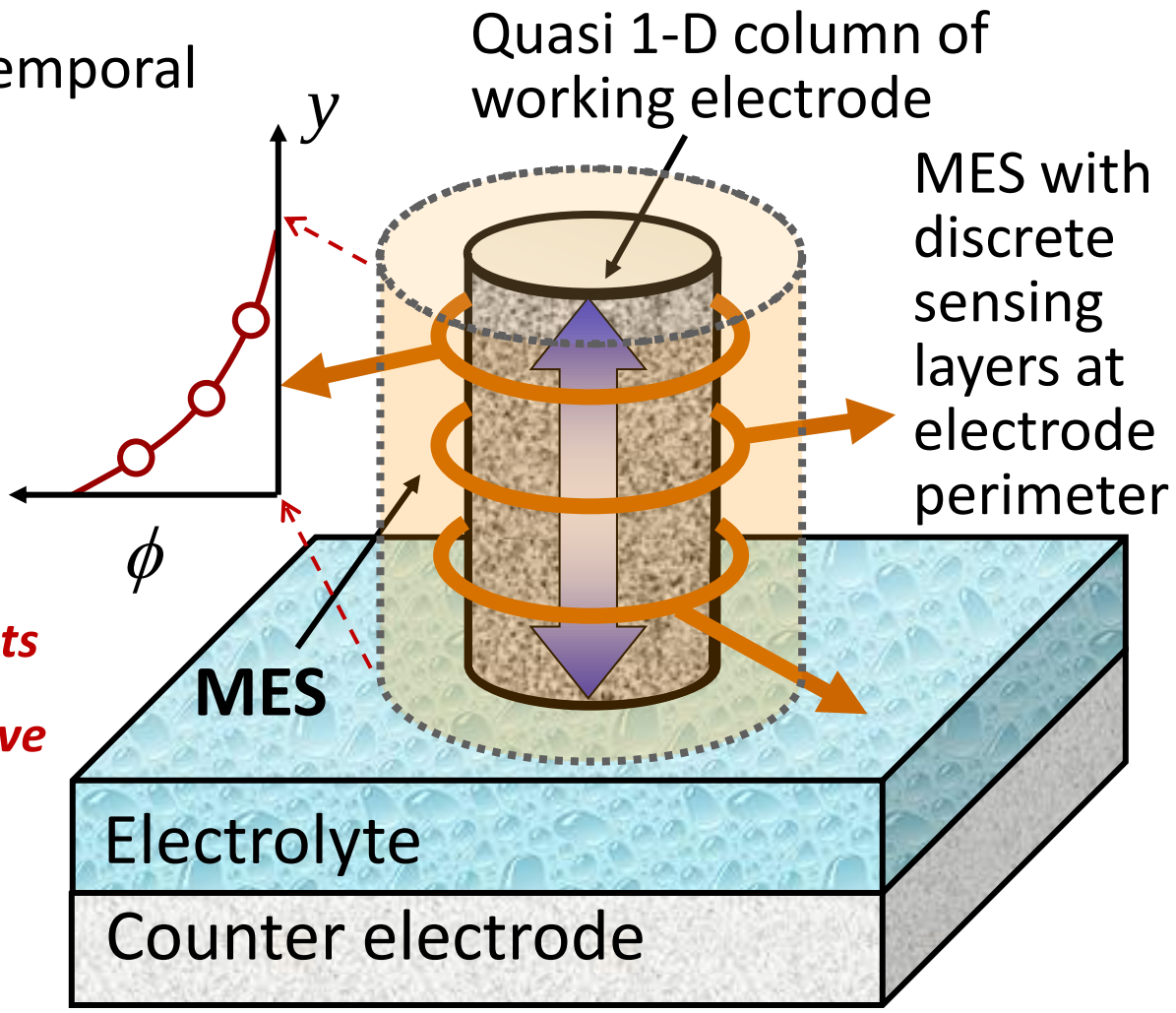
Microstructured Electrode Scaffold (MES) Diagnostics

Use to measure spatio-temporal distributions of:

- Potentials (electric/ionic)
- Conductivities
- Currents
- Local reaction rates
- EDL charging/discharging

Advantages:

- ***Through-plane measurements***
- ***Uninterrupted, representative electrode structure***
- ***Applicable to many porous electrode technologies***



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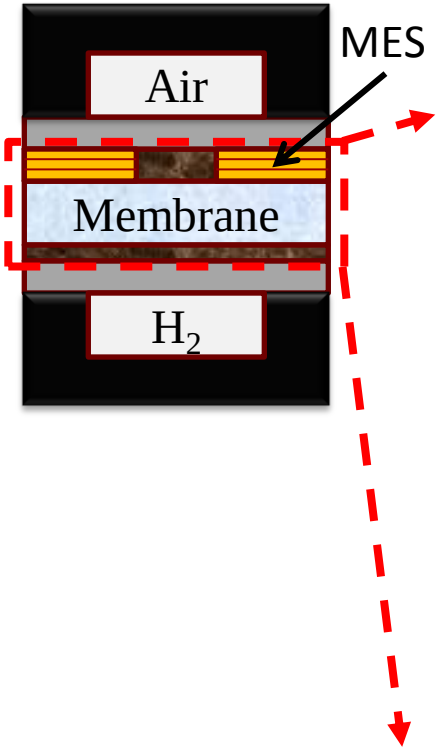
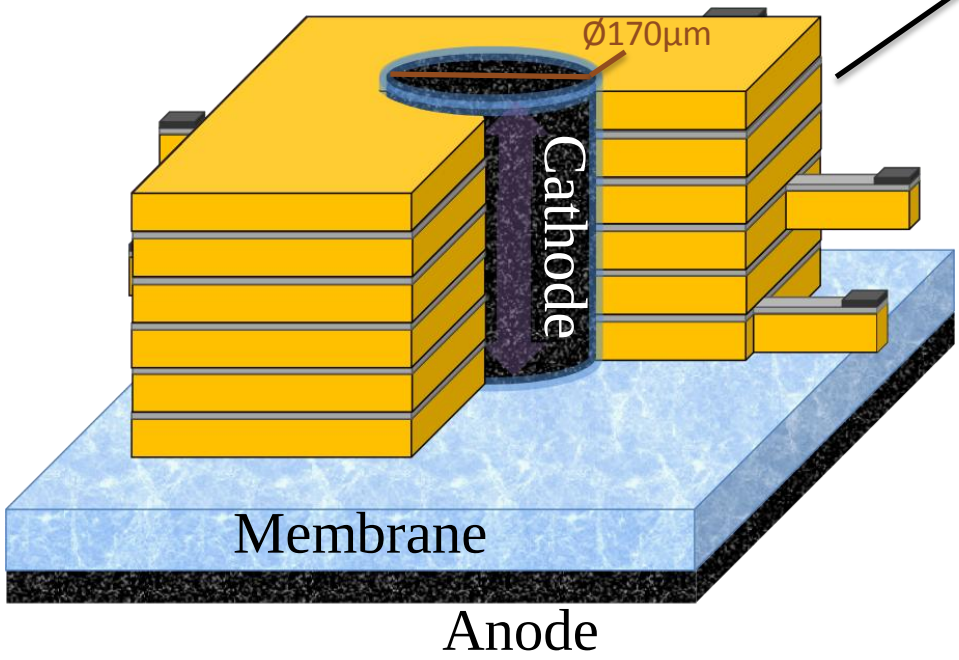
Ionic Potential Sensing MES

Measures ionic potential through electrode's thickness

PEM Fuel Cell



MES surrounding a 170 µm diameter column of catalyst on the cathode side



Laboratory for Transport Phenomena in Energy Systems
Carnegie Mellon

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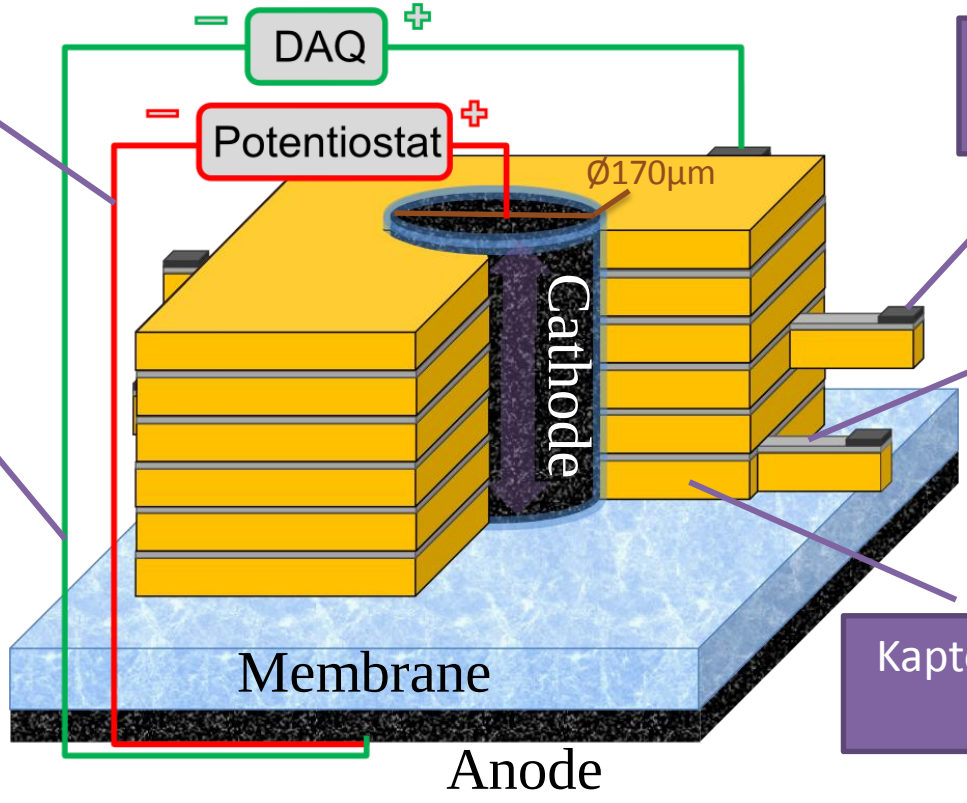
Ionic Potential Sensing MES

Measures ionic potential through electrode's thickness

Apply voltage or current to fuel cell

Measure potential at reference electrodes



Hydrogen reference electrodes

Nafion sensing layers

Kapton insulating layers

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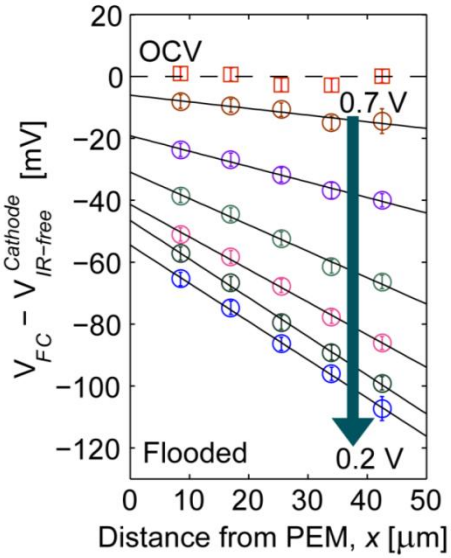
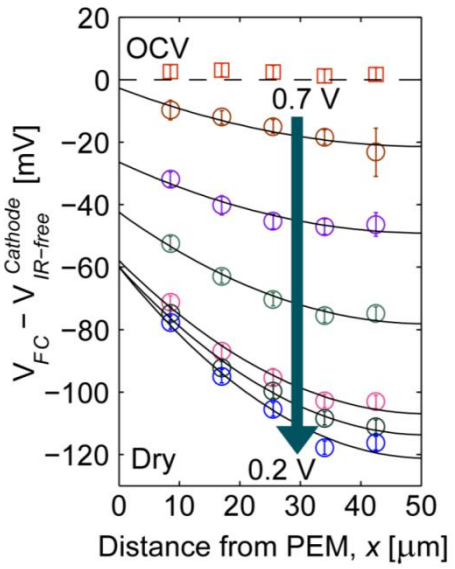
Results from Ionic MES

Distributions measured by MES

MES performance as fuel cell?

Comparable to regular fuel cell





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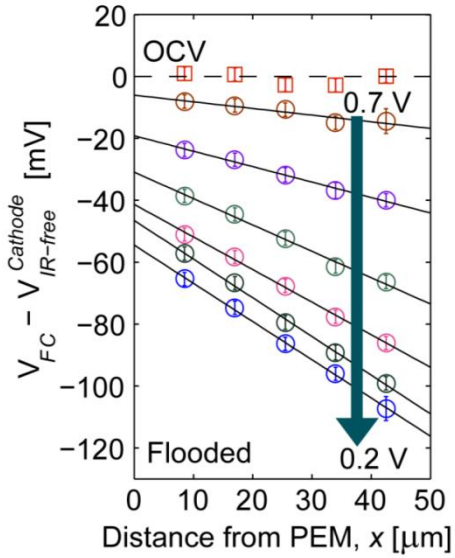
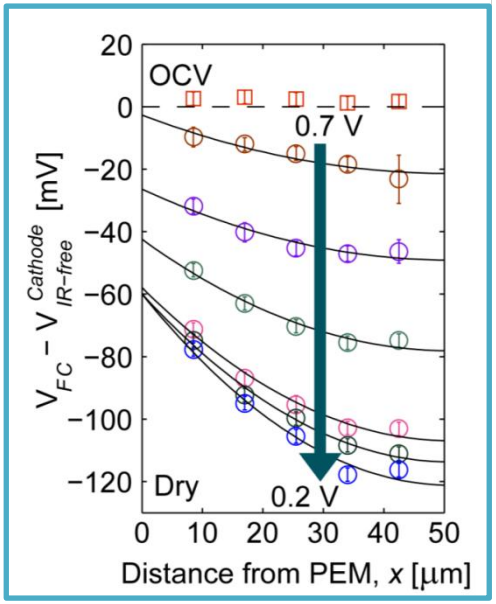
Results from Ionic MES

- Flooded condition (high humidity)
  - Linear distribution profiles
  - Suggests mass transport limitations even at low currents
- Dry condition (less humid)
  - Good match with analytical solution for uniform reaction (solid lines)
  - More linear at highest currents
    - mass transport limitations (expected)





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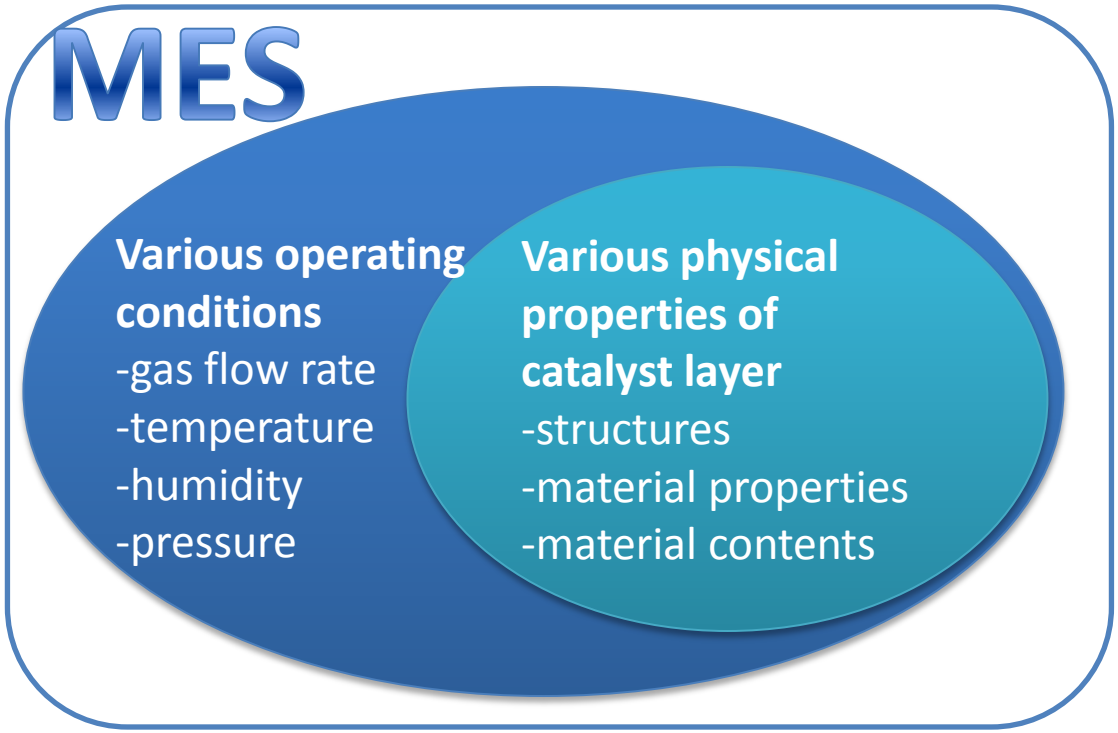
Capability of MES



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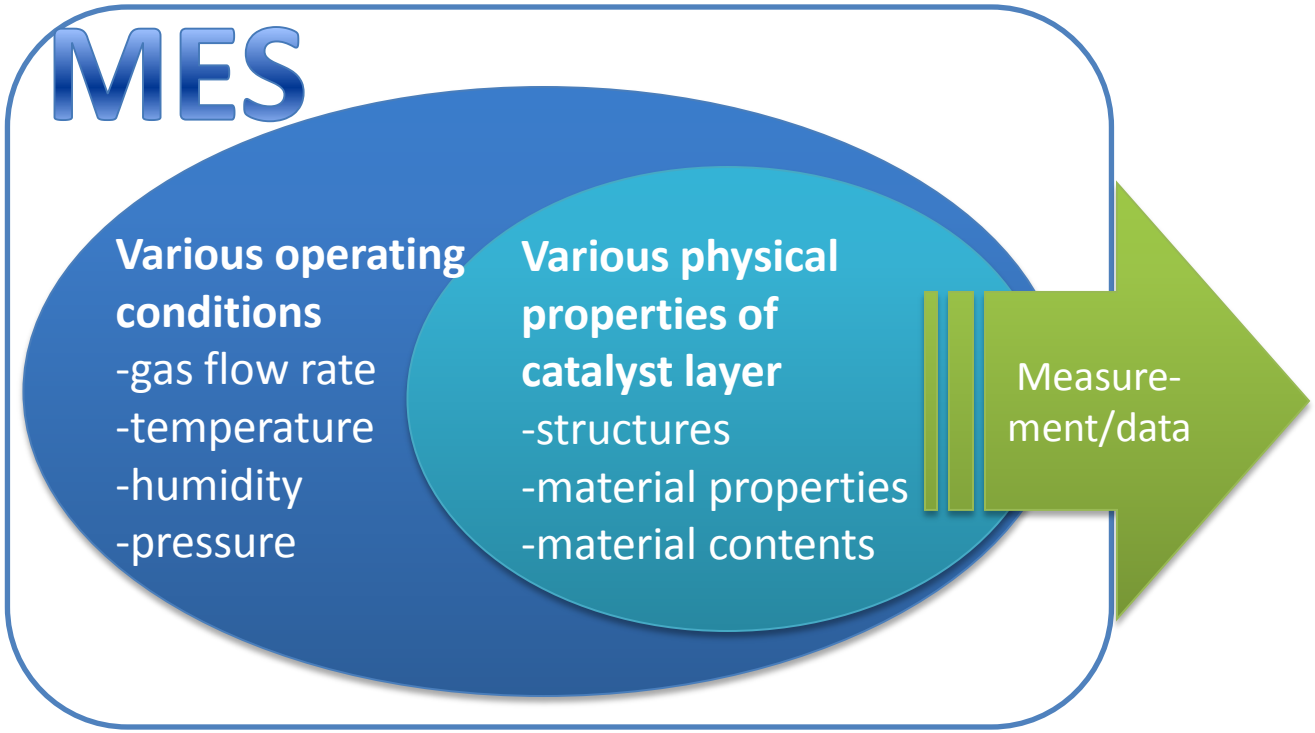
Capability of MES



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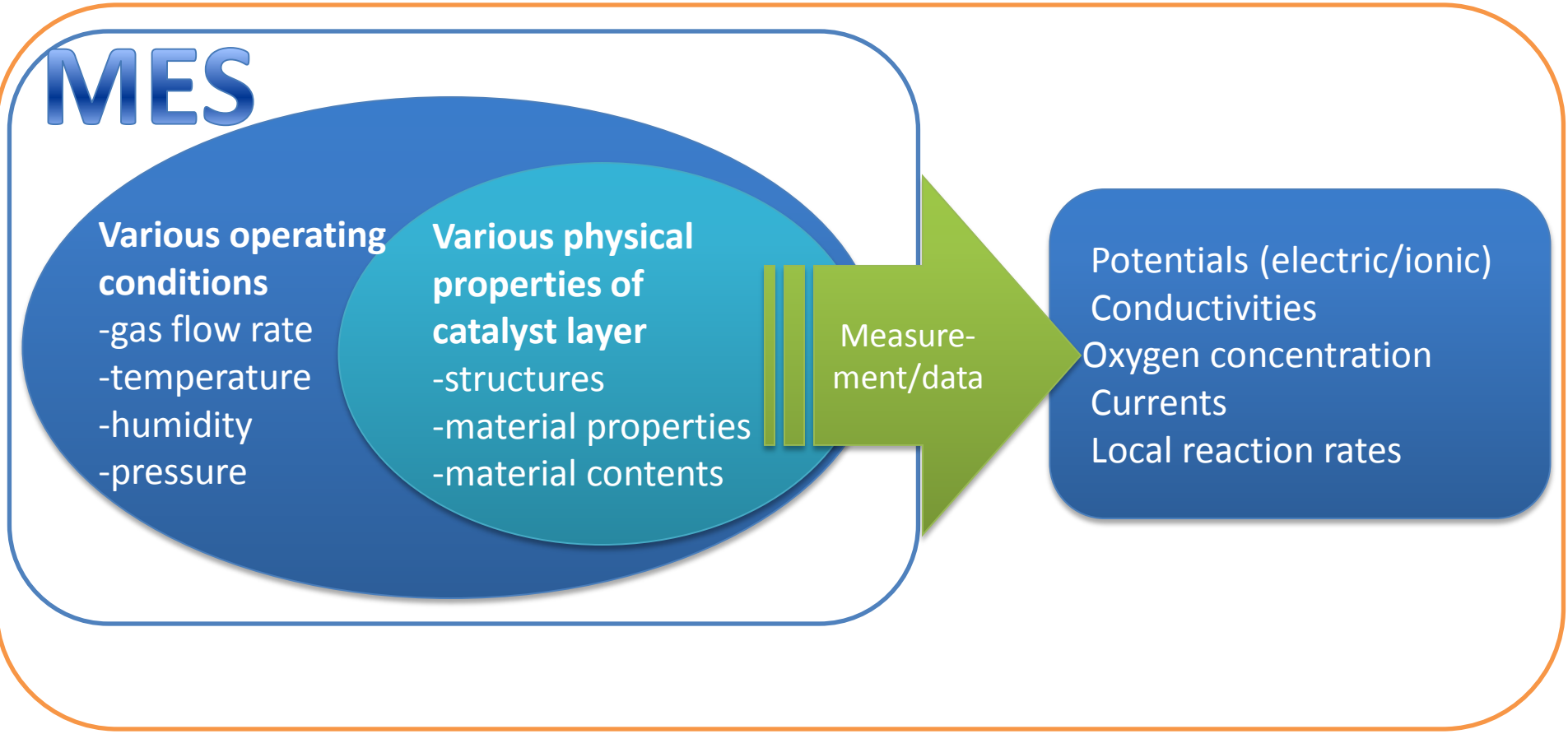
Capability of MES



Understanding *the relation of physical properties of catalyst layer, operating conditions, and fuel cell performance*

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