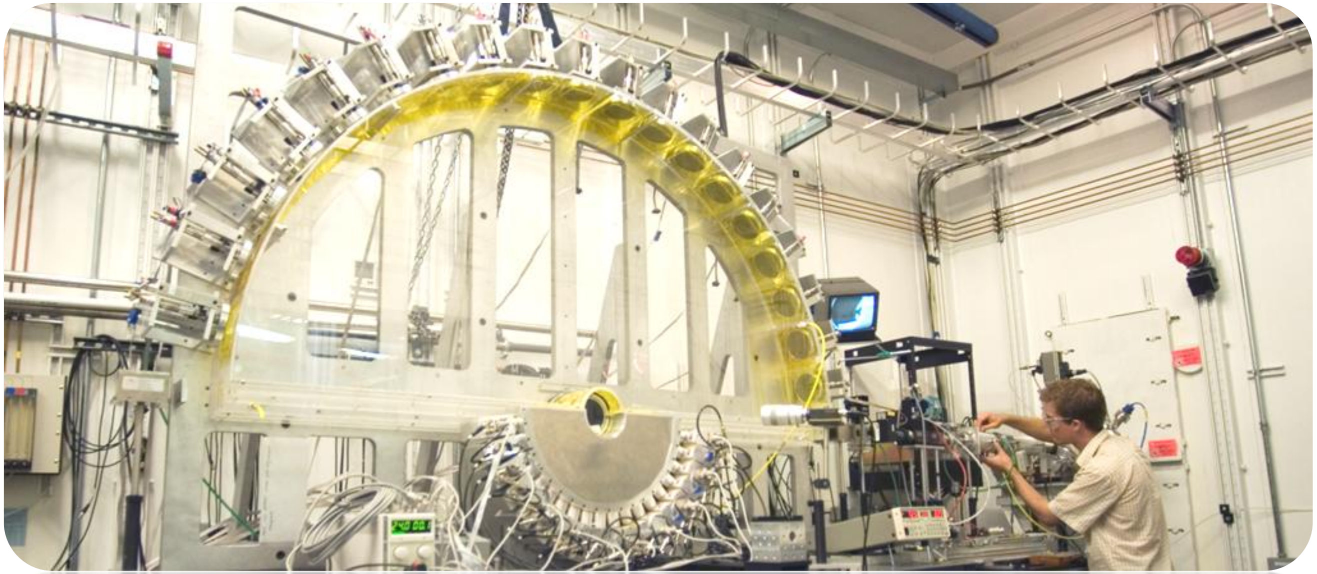

Cathode R&D Introduction

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Project Manager

National Energy Technology Laboratory

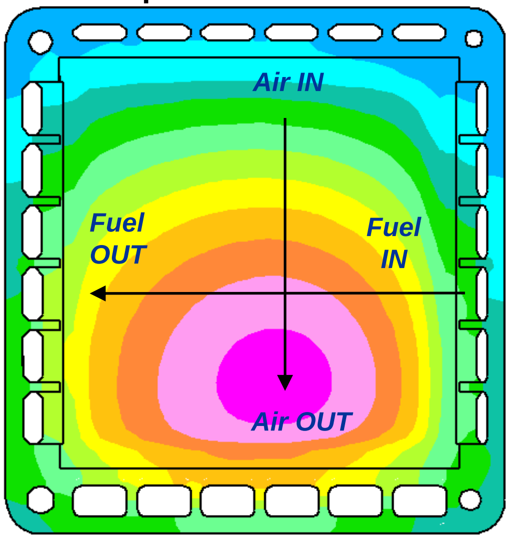
United States Department of Energy

SOFC Operating Conditions for Coal Plants

High system efficiency is a key target

- High performance required over wide design space
  - Temperature, cell potential, fuel utilization

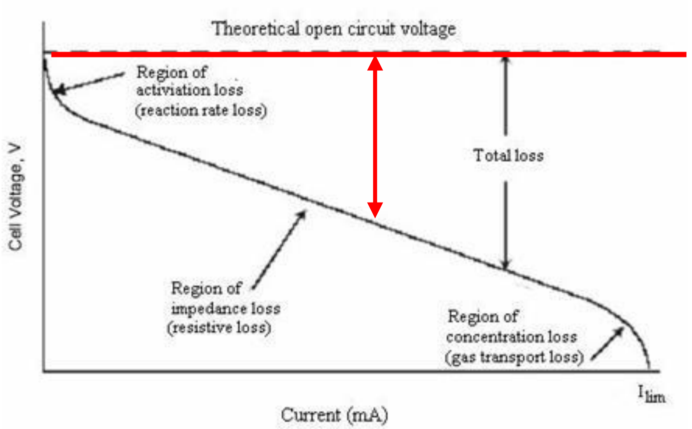
Temperature Model



Stack Operation Parameters

<u>Temperature</u>

- Upper limit - interconnect oxidation
- Lower limit - cathode activity (overpotential)
- Upstream integration - gasification & gas cleaning
- Downstream integration - heat recovery devices & CO_2 capture



<u>Overpotential</u>

- Apparent correlation w/ degradation
- Typically 100-200 mV

Cathode Performance - Status and Objectives

State-Of-The-Art

- Cathode voltage loss substantial
- Industry team progress
  - bulk materials identified
  - microstructures optimized
- Industry cathodes established
- Total degradation 1-2 %/1000 hrs

Technical Objectives

- Cathode overpotential reduction
- Overall degradation 0.2 %/1000 hrs

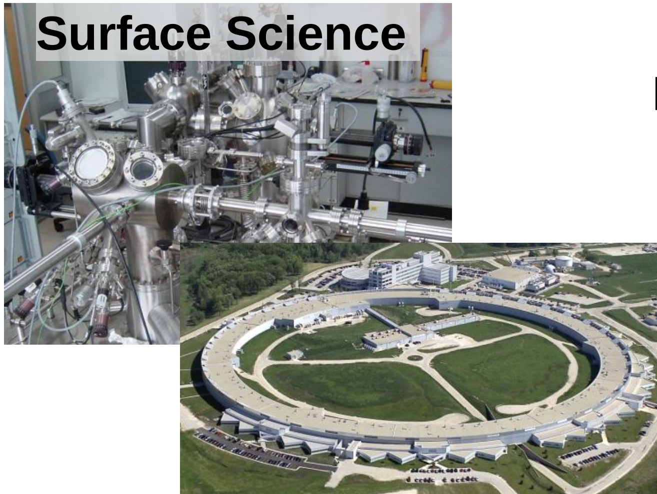
Benefits

- Higher power density = reduced capital cost ($ / kW)
- Higher power block efficiency = higher system efficiency (%)
  - Environmental impact (Coal contaminants, Carbon & H_2O / kW*hr)
- Minimize degradation = longer service lifetime (>40,000 hrs)

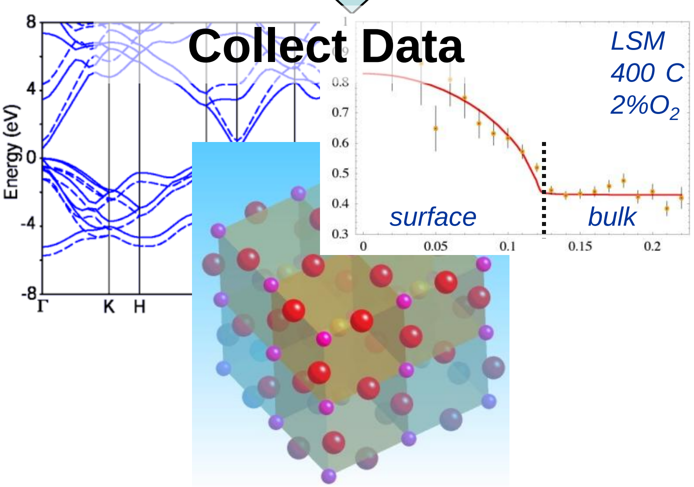
All benefit Cost Of Electricity ($ / MW*hr)

Cathode Catalyst Development

Surface Science



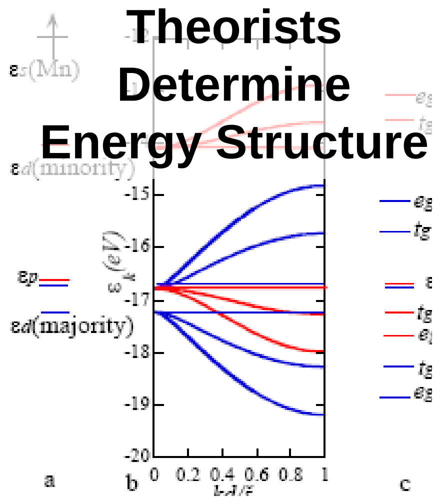
Collect Data



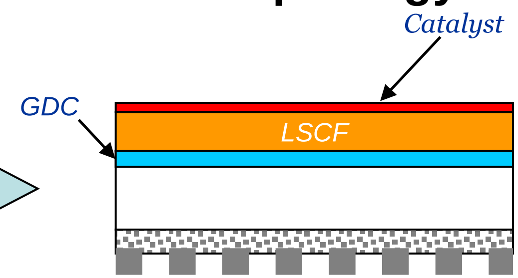
1. Correlate Properties/Performance

2. Generate Ideas

Theorists Determine Energy Structure

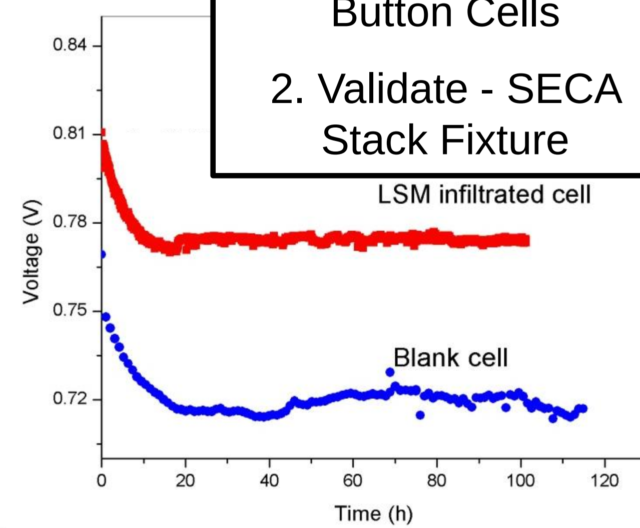


Optimize Catalyst Morphology



1. Infiltrate & Test Button Cells

2. Validate - SECA Stack Fixture



Cathode Catalyst Development Approach

1. Collect data

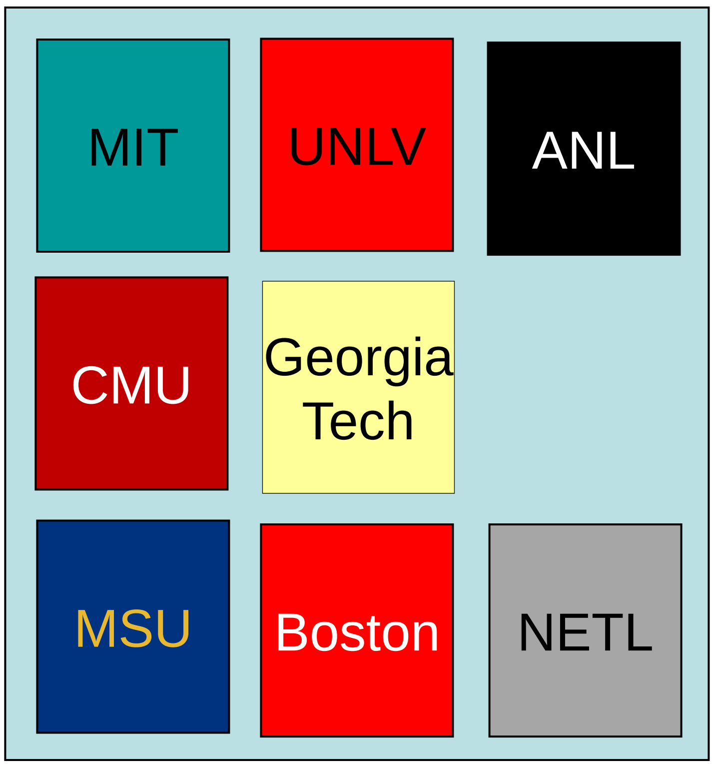
- Generate a database
  - Chemical, crystallographic, and electronic structure data
  - Focused on common compositions: LSM, LSF, LSC, LSCF
- Collect in-situ data relevant to SOFCs
  - At temperature, under overpotentials representing operating voltages of 0.7 V to 0.9 V, in air
- Compare with industrial experience

2. Draw in-situ/ex-situ correlations

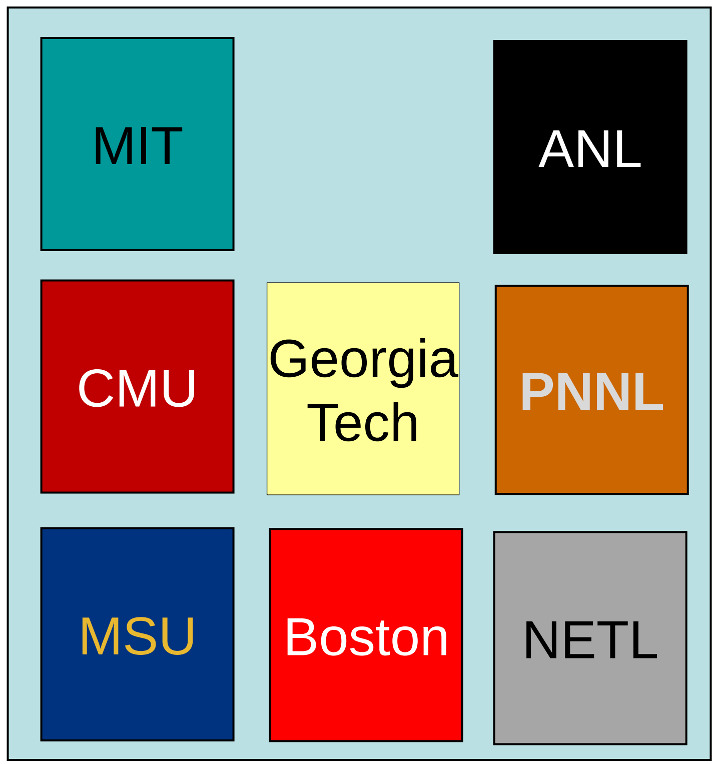
- Enable ex-situ techniques (especially for electronic structure)
- Improve sample throughput
- Validate in-situ measurements

Key Correlations - Surface Characteristics and Performance Properties

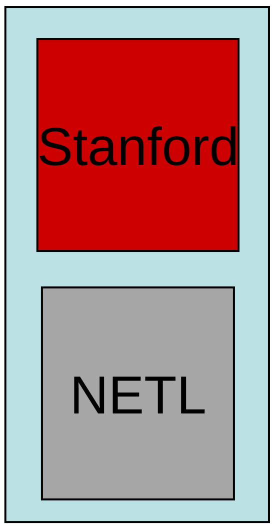
Collecting Surface Characteristics Data



Generating Performance Property Data



Advancing Theory / Interpreting Data



Translating Understanding – model thin-films to infiltrated catalysts

Sample Complexity

Perfect Epitaxial Films

- Boston
- MIT
- ANL
- CMU
- MSU
- UNLV

Imperfect Epitaxial & Sputtered Films

- Boston
- MIT
- Georgia Tech
- ANL
- CMU
- MSU
- UNLV

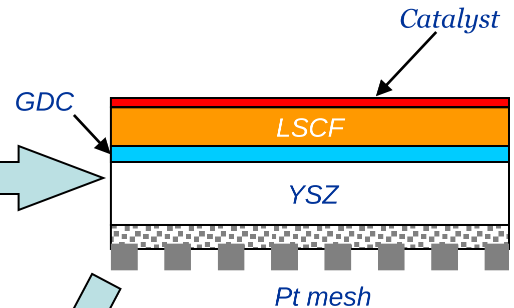
Infiltrated Cell Testing Capability

- Georgia Tech
- NETL
- PNNL

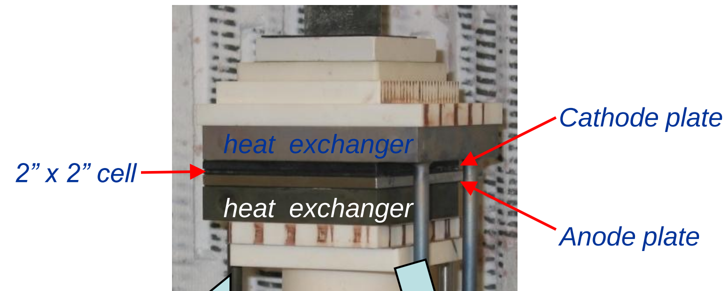
Validation of Candidate Catalysts

Generate
Idea

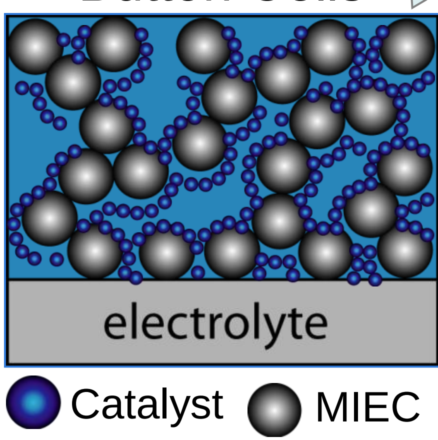
Optimize
Catalyst Morphology



Validate
SECA Stack Fixture

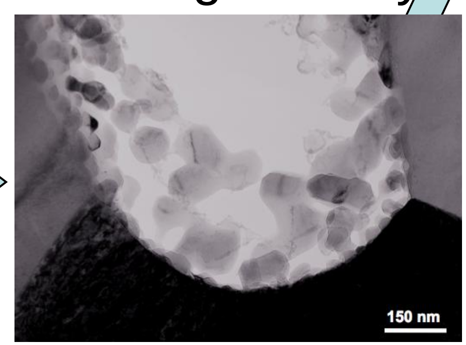


Infiltrate
Button Cells

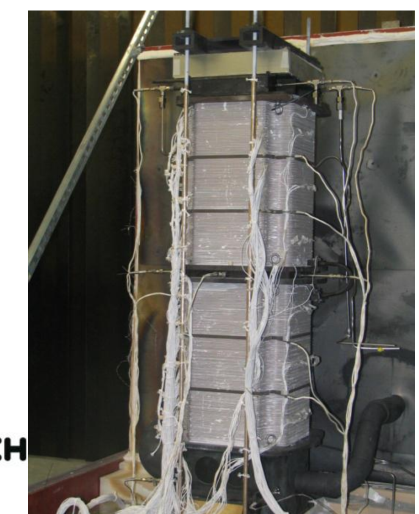


Test Cells

Confirm
Coating Stability



Transfer
to Industry



**Graphics courtesy of LBNL, Georgia Tech, PNNL, and VPS.*