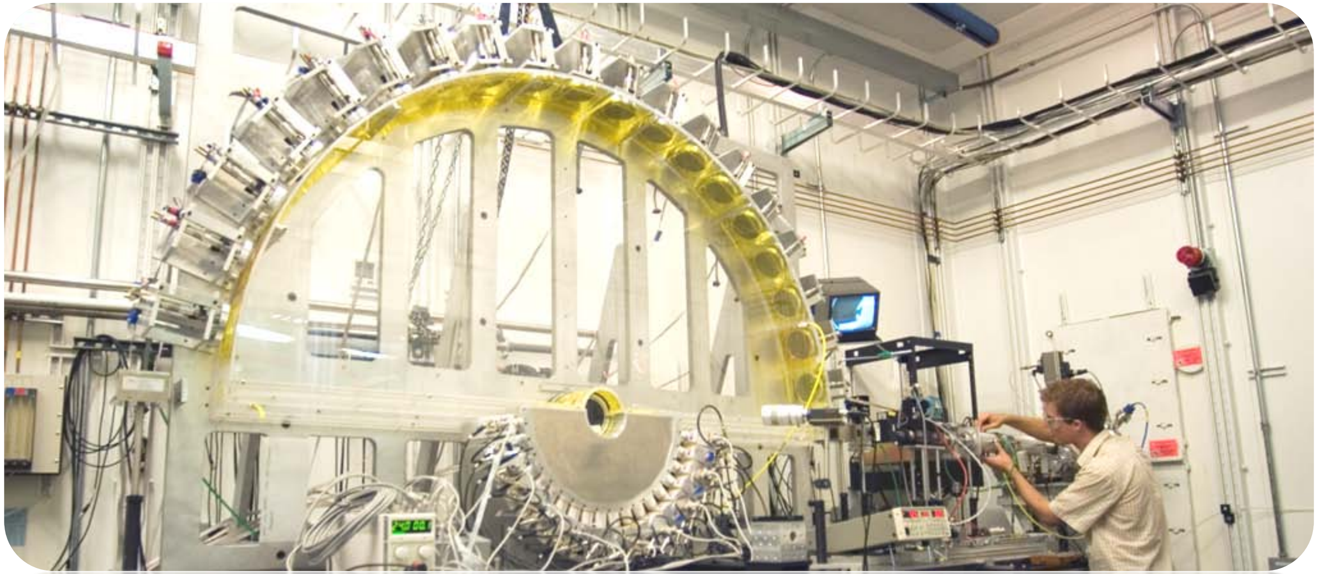
NATIONAL ENERGY TECHNOLOGY LABORATORY



Cathode R&D Introduction

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United States Department of Energy

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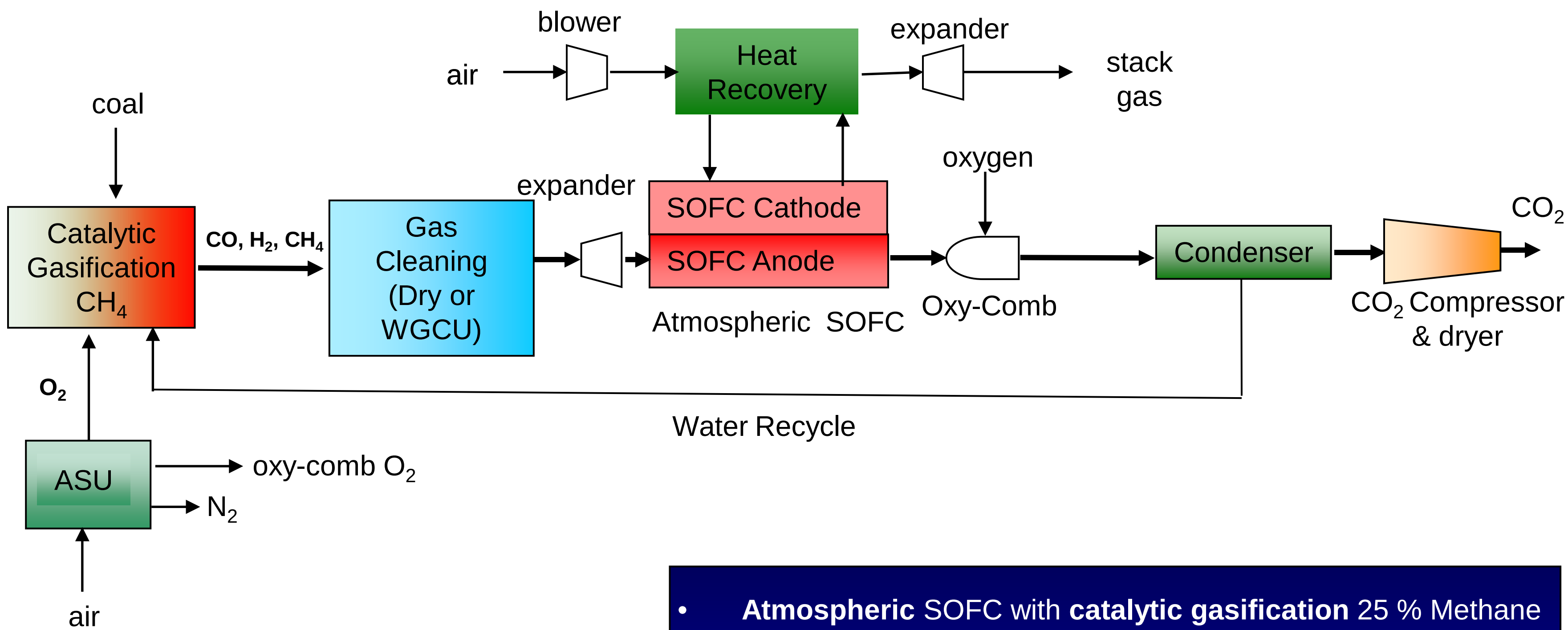
SECA Coal-Based Atmospheric IGFC



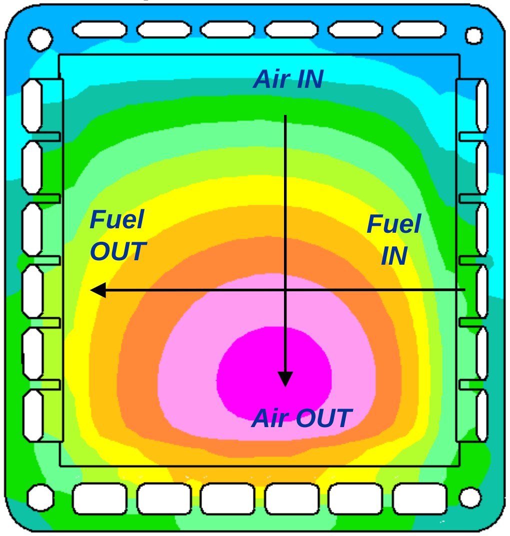
- **Atmospheric** SOFC with **catalytic gasification** 25 % Methane
- **Separate** Fuel and Air Streams**: Oxy Combustion**
- Cycle Efficiency (HHV); **99% Capture**
  - **~51% with CO2 Compression**
  - **~54% w/out CO2 Compression**

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



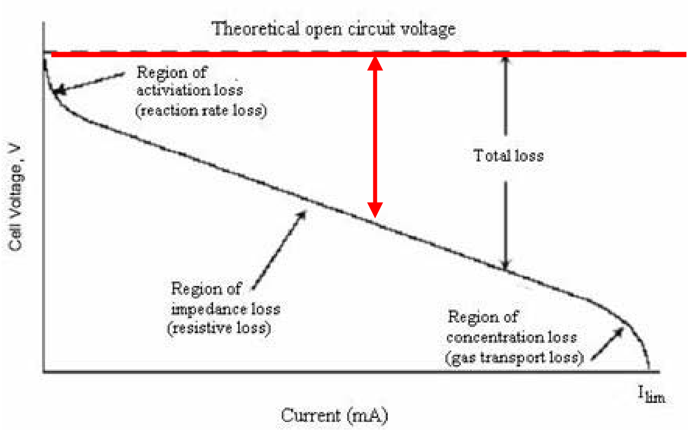
Stack Operation Parameters

Temperature

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

Overpotential

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



Cathode Performance - Status and Objectives

GOAL – Operate at high voltage w/ economical power density

State-Of-The-Art Status

- ~Half of voltage loss occurs on cathode
- Degradation 1-2 %/1000 hrs

Technical Objectives

- Cathode overpotential reduction
- Degradation 0.2 %/1000 hrs

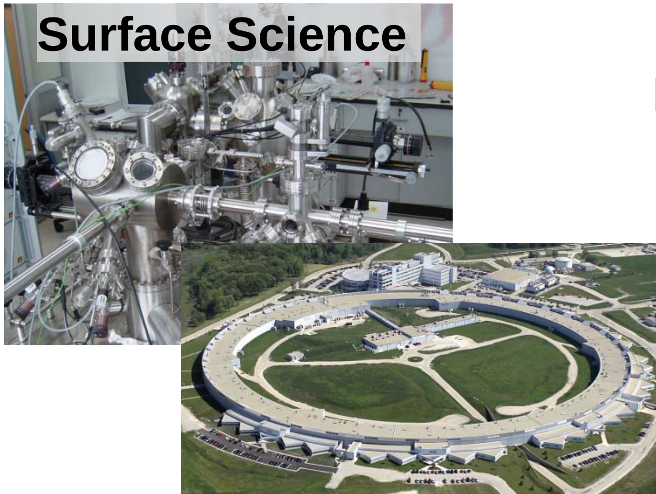
Benefits

- 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

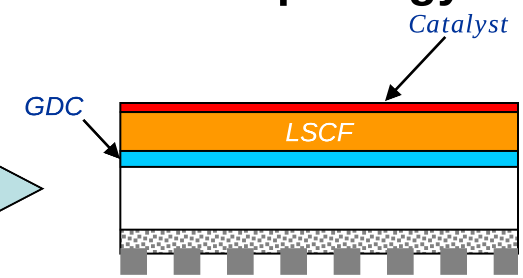
Surface Science



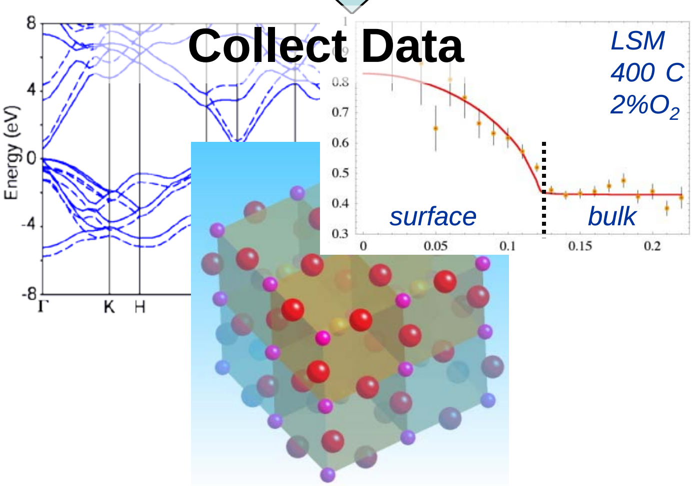
1. Correlate Properties/Performance

2. Generate Ideas

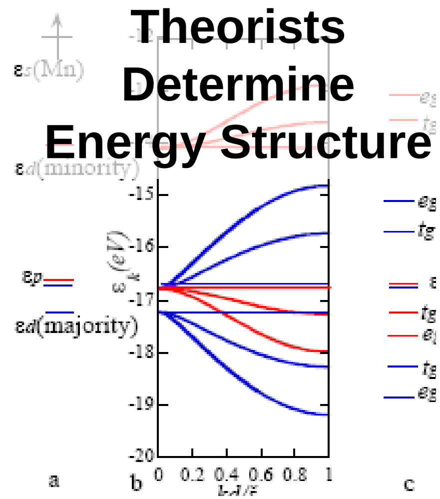
Optimize Catalyst Morphology



Collect Data

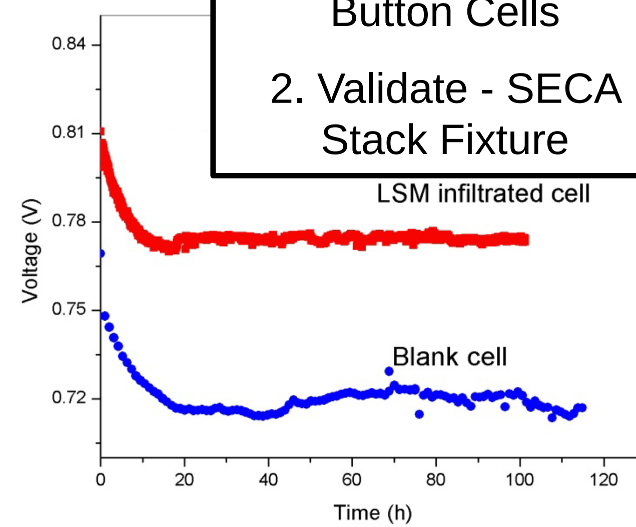


Theorists Determine Energy Structure



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
MIT	MIT	Stanford
UNLV	ANL	
ANL	CMU	
CMU	Georgia Tech	
Georgia Tech	PNNL	
MSU	MSU	
Boston	Boston	
NETL		

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

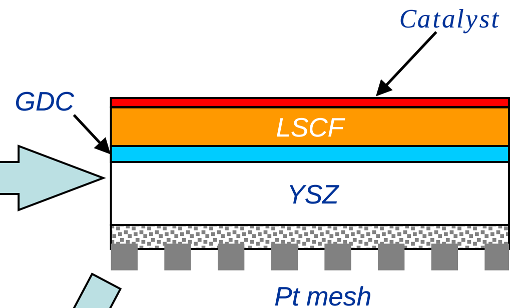
Infiltrated Cell Testing Capability

- Georgia Tech
- LBNL
- NETL
- PNNL

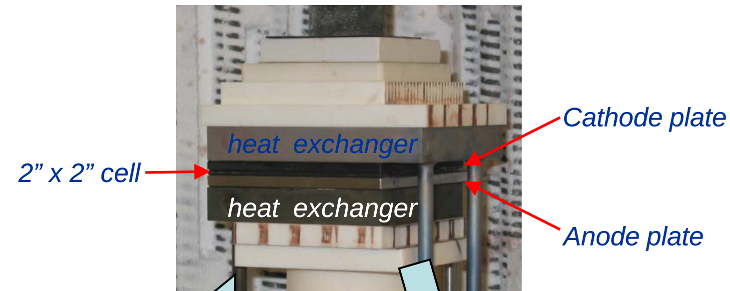
Validation of Candidate Catalysts

Generate
Idea

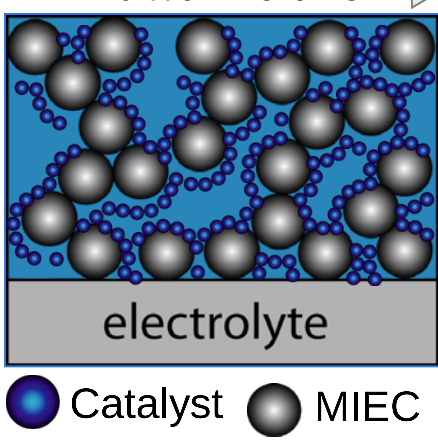
Optimize
Catalyst Morphology



Validate
SECA Stack Fixture

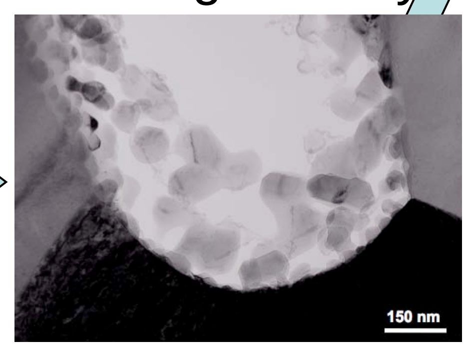


Infiltrate
Button Cells

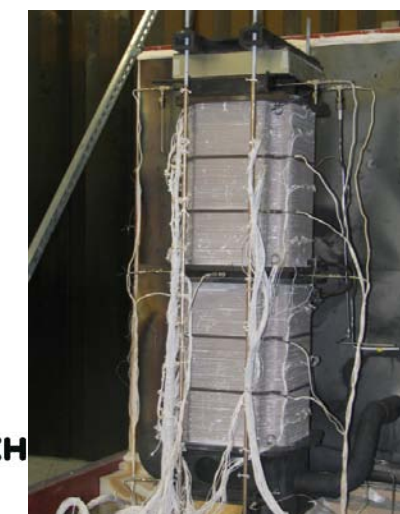


Test Cells

Confirm
Coating Stability



Transfer
to Industry



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