Cathode R&D Introduction

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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

Stack Operation Parameters
Temperature
• Upper limit - interconnect oxidation
• Lower limit - cathode activity (overpotential)
• Upstream integration - gasification & gas cleaning
• Downstream integration - heat recovery devices & CO₂ 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 & H₂O / kW*hr)
■ Minimize degradation = longer service lifetime (>40,000 hrs)

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

1. Correlate Properties/Performance
2. Generate Ideas

Optimize Catalyst Morphology

Surface Science

1. Infiltrate & Test Button Cells
2. Validate - SECA Stack Fixture

Catalyst

Collect Data

Theorists
Determine
Energy Structure

LSM
400 C
2%O₂

Blank cell

LSM infiltrated cell
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

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

Generating Performance Property Data

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

Advancing Theory / Interpreting Data

- Stanford
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
- ANL
- CMU
- MSU
- UNLV
- Georgia Tech

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

Confirm Coating Stability

Transfer to Industry

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