LSGM Based Composite Cathodes for Anode Supported, Intermediate Temperature (600-800 °C) Solid Oxide Fuel Cells

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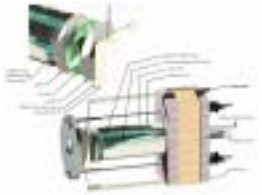
Objectives

- Develop LSGM-based composite cathodes for intermediate temperature solid oxide fuel cells
- Fabricate composite cathodes and cells
  - LSGM with an electrocatalyst
  - Anode supported SOFC with YSZ electrolyte
  - Gd-doped CeO_2 barrier layer
- Optimize cathode composition
  - Determine suitable A and B site doping for perovskites
  - Vary relative amounts of LSGM and electrocatalysts
- Optimize cathode microstructure for optimal performance
  - Composition
  - Firing Temperatures and Times
  - Particle Size and Powder Processing
  - Porosity
  - Cathode Interlayer Thickness
- Cathode Stability
  - Study diffusion between LSGM and electrocatalysts
  - Formation of secondary phases at interfaces

Single Cell Testing



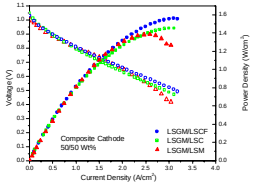
Cell Testing:

Temperatures: 600 to 800 °C
Fuel Utilizations: 40 to 90%
Air Utilizations: 40 to 70%

Fuels:
Hydrogen
Reformed Methane
Direct Internal Reforming (DIR)

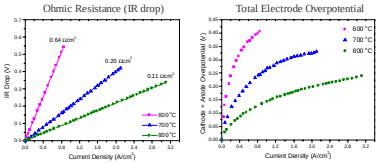
Electrochemical Testing:
Electrode Polarizations
Ohmic Resistance (IR drop)

Performance of Cells with Cathode Interlayers Comprised of LSGM and LSM, LSC, and LSCF



- Tested at 800 °C
- Cathode Interlayers: 50 wt.% LSGM + 50 wt.% Electrocatalyst

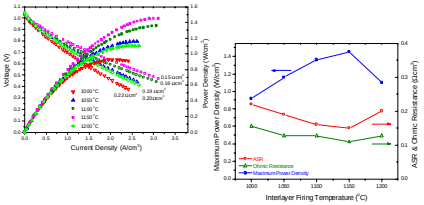
Ohmic Resistance and Electrode Overpotential of Cell with LSGM/LSC Composite Cathode



LSGM Based Cathodes

- LSGM
  - Sr and Mg doped $LaGaO_3$
  - Solid electrolyte (ionic conductor)
  - High oxide ion conductivity ~0.1 S/cm at 800°C
- Electrocatalysts
  - LSC; Sr doped $LaCoO_3$
  - Mixed ionic and electronic conductor (MIEC)
  - Electronic conductivity ~800-1000 S/cm at 800°C
  - Other Perovskites:
    - LSF, Sr doped $LaFeO_3$
    - LSCF, Sr and Co doped $LaFeO_3$
    - LSM, Sr doped $LaMnO_3$
- Composite Cathodes
  - Performance depends on:
    - Three phase boundary length
    - Oxide ion conductivity of ionic conductor (LSGM)
    - Electronic conductivity of electrocatalyst (LSC)
    - Oxygen adsorption on electrocatalyst
    - Degree of sintering and phase contiguity
    - Quality of bond between the cathode and the cell electrolyte

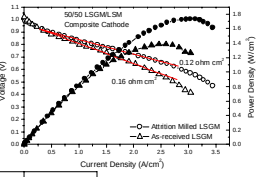
Effect of Cathode Firing Temperature



- Cathode interlayer composition of 50 wt.% LSGM + 50 wt.% LSC.
- Cathode interlayers fired for 2 h.
- Tested at 800 °C

Effect of LSGM Particle Size on Cathode Interlayer Performance

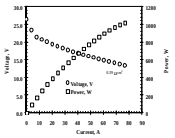
Tested at 800 °C



	Cell Resistance Ωcm²	IR Drop Ωcm²	$R_{p,800}$ Anode+Cathode Ωcm²
Unprocessed LSGM	0.34	0.1	0.24
Attrition Milled LSGM	0.21	0.1	0.11

Stack Testing

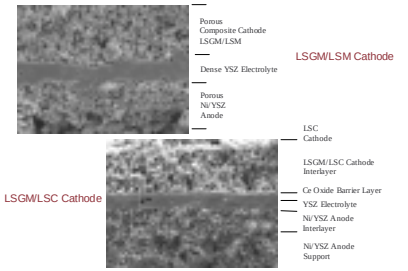
25 Cell Stack
Internally Manifolded
Anode Supported Cells
LSM/YSZ Composite Cathodes



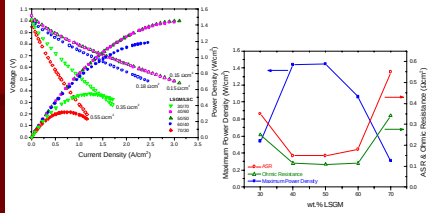
Tested at 800 °C
Fuel: Hydrogen; Oxidant: Air

Anode supported cells with LSGM based composite cathodes will be fabricated and tested in similar stacks.

SEM Micrographs of Cells

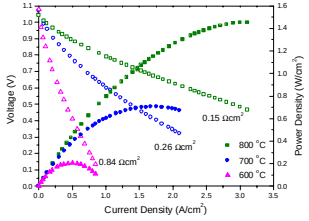


Effect of Cathode Composition



- Weight % of LSGM and LSC in cathode interlayer varied.
- Cathode interlayers fired at 1150 °C for 2 h.
- Tested at 800 °C

Performance of LSGM/LSC Cathode Interlayers at Various Temperatures



Current and Future Work

- Optimization of powder processing and particle size
- Fabrication of submicron and nanosized powders
- Development of low temperature cathode sintering
- Optimization of cathode interlayer microstructure
- Optimization of cathode interlayer composition
- Electrochemical testing of cathodes
- Long term phase stability studies
- Fabrication of larger cell with LSGM based cathodes
- Stack testing of cells with LSGM based cathodes

Acknowledgements

Research Funded by
U.S. Department of Energy, NETL
Under SBIR Contract No. DE-FG03-02ER83489