Materials Development for SOFCs—Novel Cathodes

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NEXTECH MATERIALS

Goals and Technical Approach

Keys to Reducing Cost of SOFCs

- Lower operating temperatures (inexpensive interconnects)
- Increased power densities (Efficient materials utilization)
- Low-cost raw materials
- Increased manufacturing yields
- Efficient materials utilization (advanced stack designs)

Why Focus on Cathodes?

- Critical path to lower operating temperatures
- Critical path to increasing power densities
- Anode-supported cell designs offer flexibility for utilizing new cathode materials

Target Cathode Characteristics:

Performance Attributes

- High electrical conductivity
- Gas permeability (porosity)
- Oxygen mobility (ionic conductivity)
- Catalysis of oxygen reduction reaction

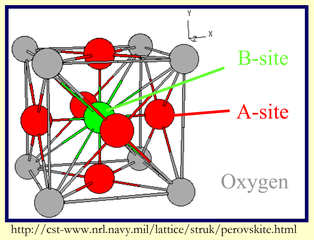
Chemical/Structural Properties

- Thermal expansion match to electrolyte
- Compatibility with electrolyte material
- Long-term stability (>40,000 hours)

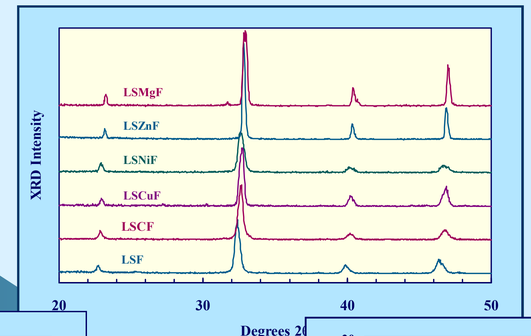
Alternative Cathode Synthesis Studies

- Strategy: Increase Oxygen Vacancies in LSF
  - A-site Doping Effective (Anderson, Steele, Kharton, Kostogloudis)
  - Doping of B-site with Co very effective (Steele, Anderson)
  - Higher Risk/Reward
  - Lack of rapid screening methods
  - Longer evaluation/validation/acceptance timeframes
- Baseline Compositions:
  - $(La_{0.60}Sr_{0.40})FeO_{3-\delta}$ (LSF)
  - $(La_{0.60}Sr_{0.40})(Co_{0.20}Fe_{0.80})O_{3-\delta}$ (LSCF)
- Four B-Site Dopants Evaluated
  - Ni: $(La,Sr)(Ni,Fe)O_{3-\delta}$ (LSNiF)
  - Cu: $(La,Sr)(Cu,Fe)O_{3-\delta}$ (LSCuF)
  - Zn: $(La,Sr)(Zn,Fe)O_{3-\delta}$ (LSZnF)
  - Mg: $(La,Sr)(Mg,Fe)O_{3-\delta}$ (LSMgF)

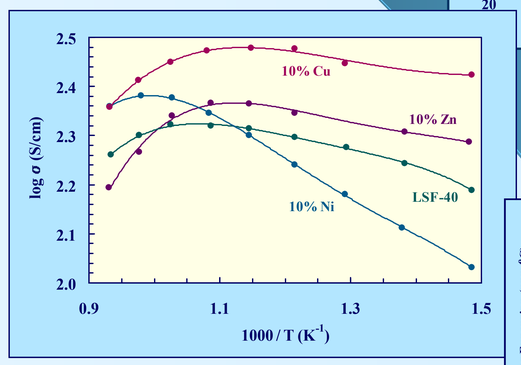
B-site dopant levels ≤ 20 mol%
Dopant preferred valence ≤ 3



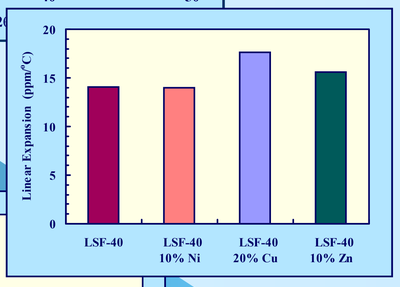
http://cst-www.nrl.navy.mil/lattice/struk/perovskite.html

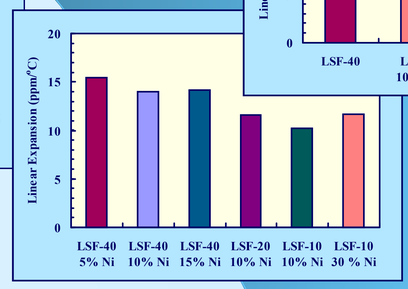


XRD Patterns



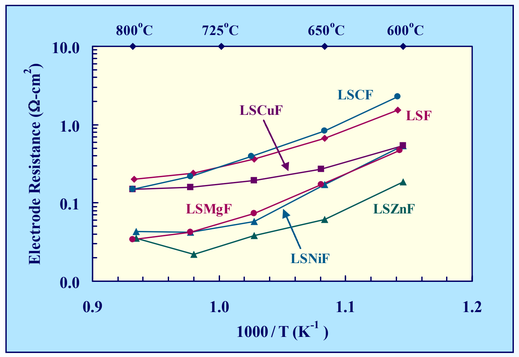
Electrical Conductivity
(Four Point Electrodes)

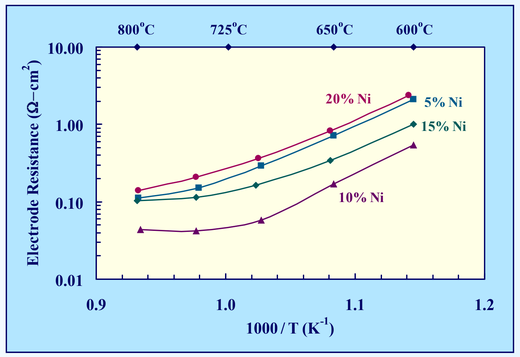




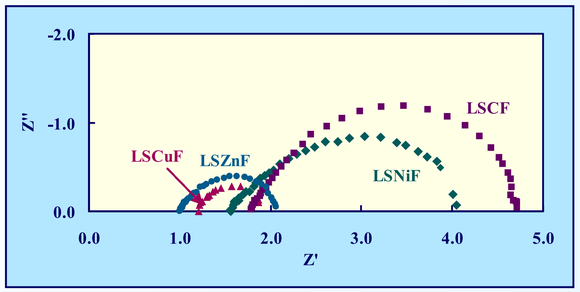
Coefficient of
Thermal Expansion
(RT-1000°C)

Electrochemical Performance of Cathode Materials



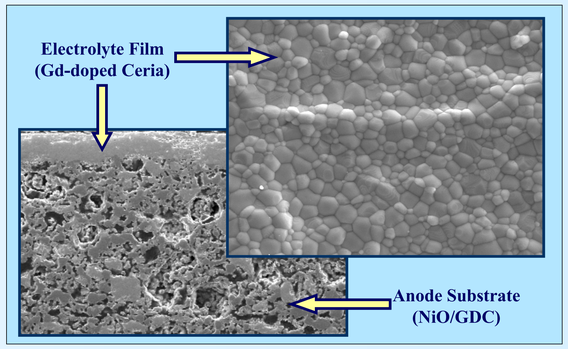


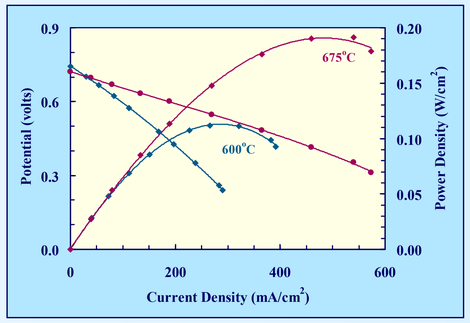
Interfacial Resistance Measured by Direct Current Measurements on Symmetric Electrode/GDC/Electrode Samples

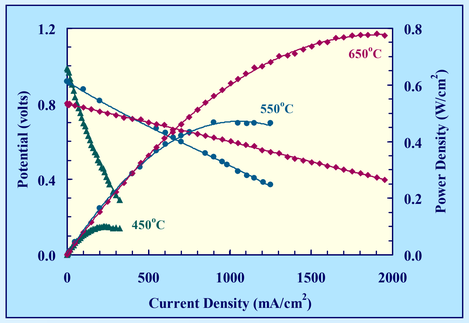


Interfacial Resistance Measured by Impedance Spectroscopy on
Symmetric Electrode/GDC/Electrode Samples

SOFC Performance of Cathode Materials







Fuel Cell Performance for Thin Film GDC Electrolyte SOFC
Cells with LSF (left) and LSNF (10% Ni) Cathodes (right)

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