Solid Oxide Fuel Cell Cathodes Infiltrated with Mesoporous Coatings Using Evaporation-Induced Self-Assembly Methods

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Project Goal

To infiltrate high surface area, mesoporous perovskite electrocatalysts in commercial SOFC cathodes using evaporation-induced self-assembly to reduce electrode polarization resistance

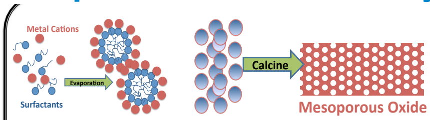
Project Motivation

- **Cathode infiltration** is believed to improve performance by reducing the electrode polarization resistance owing to the increased surface area / reaction sites
- Cathode infiltrations that yield **high specific surface area electrocatalysts** should further enhance the performance of SOFC cathodes
- High surface area, mesoporous $La_{0.8}Sr_{0.2}MnO_3$ (LSM) has been synthesized by us using **evaporation induced self-assembly (EISA)**

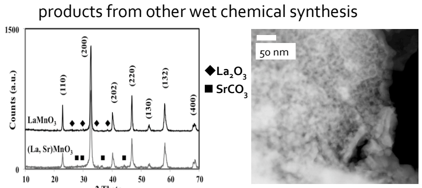
Objectives

- **Form mesoporous coatings** in porous media using EISA process
- Determine the **morphology** of infiltrated catalyst coatings on major SOFC cathode backbone materials
- Determine the **power density and electrode polarization resistance** of commercial button cells infiltrated using EISA process

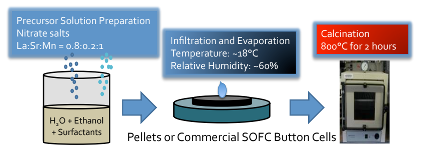
Evaporation-induced Self-assembly



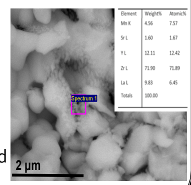
- Induces **surfactant self-assembly** into a soft template by gradual evaporation of solvents
- Decomposition of surfactant micelles leads **to formation of mesopores** in the oxide coating after calcination
- Freestanding LSM particles synthesis in our prior work
  - Crystallized perovskite phase formed
  - The particles are mesoporous
  - Achieved surface areas > **40 m²/g**, or **twice** those of the products from other wet chemical synthesis



LSM Infiltration using EISA Process



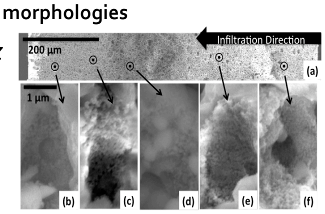
- Infiltrated porous media with heated precursor solution, followed by 8 hours of solvent evaporation, and 2 hours of calcination at 800 °C
- In porous yttria stabilized zirconia pellets, the catalyst coatings formed with **proper cation ratio**



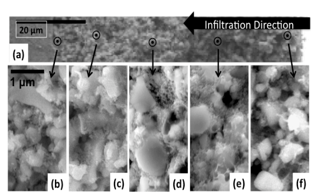
LSM infiltrate using EISA in Different Cathode Materials

- Cathode Materials Tested:
  - Yttria stabilized Zirconia (YSZ)
  - $La_{0.8}Sr_{0.2}MnO_3$ (LSM)
  - $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_3$ (LSCF)
- The precursor solution formed LSM coating through the thickness
- The uniformly coated pore walls implied **good solution wettability**
- Catalyst coating on all tested materials have **similar morphologies**

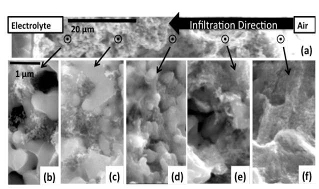
YSZ



LSM

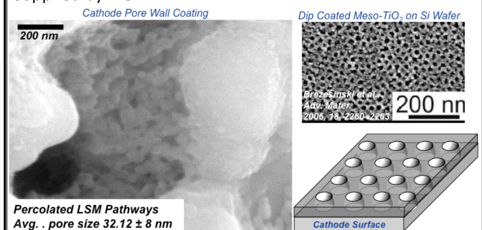


LSCF

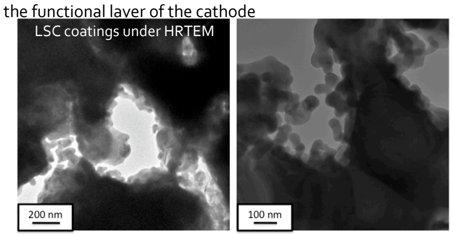


Coating Morphology in Commercial Cathodes

- SOFC button cells with LSCF-based cathodes were supplied by MSRI



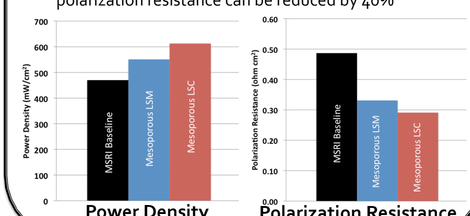
- In **one-step infiltration, 10 wt%** of catalyst coating infiltrated
- The coating showed **inverse-nanoparticle nanostructure** at the functional layer of the cathode



- EISA technology was successfully transferred to infiltrate nanostructured **LSC coating** in LSCF cathodes
- The LSC coatings are also consisted of **mesopores (pore sizes were estimated to be 30-50 nm using ImageJ)**

Performance of Infiltrated cells

- Tested at 750° C, 3% H_2O in H_2 feed at anode and standard air feed at cathode for 200 hours
- Compared to the best baseline cell tested
  - The power density can be enhanced as much as 30%
  - polarization resistance can be reduced by 40%



Conclusions

- EISA process can successfully infiltrate through porous media of **all major cathode materials**
- EISA process **is flexible** to form different catalysts
- Infiltrates commercial LSCF cathodes with 10 wt% of catalysts in **single infiltration step**
- The infiltrated coatings contained **mesopores of 30-50 nm**
- Electrochemical tests show **improved power density** and **reduced polarization resistance**

Future Work

- Continue cell testing to obtain an average performance
- Determine activation mechanism using thin film approach

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