Infiltrated with Mesoporous Coatings Using Evaporation-Induced Self-Assembly Methods

**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$_x$Sr$_y$MnO$_z$ (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 area > 40 m$^2$/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$_{0.8}$Sr$_{0.2}$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

**Performance of Infiltrated cells**
- Tested at 750° C, 3% H$_2$O 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%

**Coating Morphology in Commercial Cathodes**
- SOFC button cells with LSCF-based cathodes were supplied by MSRI
- 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 images)

**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