Additive Manufacturing of Anode-Supported SOFCs through Aerosol Deposition

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Introduction

Objective: Manufacture all components of anode

Benefits of Additive Manufacturing

- Additive lighter mass production of deposition
- Higher resolution
- Customizability

Additive Manufacturing Technologies

- Aerosol Deposition offers advantages over types of technologies such as higher resolution, and customizability
- Pore Former: PMMA, an organic polymer is used to achieve desired pore size within the
- Grain Size: What makes Aerosol Deposition unique to other methods of manufacturing SOFCs?
- Components of SOFC have been developed through Aerosol Deposition
- To demonstrate advantages that Aerosol Deposition has over other additive manufacturing techniques, a cathode with

Aerosol Deposition System

1. Identify SOFC Architecture: Identify desired parameters for specific SOFC component such as material arrangement, pore size, component thickness, microstructure density, etc.
2. Fabricate Suspensions: Utilized within aerosol consist of several different components:
   - Solvent: Ethanol/Water mixture, mixture is predominantly utilized for faster drying time
   - Ceramic Solids: YSZ and electronic conductor depending on desired component
   - Dispersant: Variety of nonconductive and anionic dispersants available to keep solids from agglomerating within suspension
   - Binder: Polyethylene Oxide and Glycol, utilized to give 3-D printed green part strength
   - Porogen: PMMA, an organic polymer is used to achieve desired pore size within the microstructure
3. Synthesize System: Synchronize the time of plug pattern for flexible automation and electrode composition
   - Electrode suspensions are injected through the multi-nozzle generator to form an aerosol cloud that is subsequently deposited on the substrate
4. Load Suspensions: Two peristaltic pumps are utilized to supply acetone and ethanol throughout for manufacturing
5. Start Aerosol Deposition Program: Once suspensions have been loaded, program can be started by clicking "Start" which begins the heating process of the infrared heater to desired temperature for drying deposits. Once heater is brought up to proper temperature, deposition process begins when spray pumps supply suspensions to ultrasonic atomizer and is deposited on substrates
6. Thermal Treatment: Once suspensions are deposited and dried, thermal treatment of deposition is completed to reinforce the 3-D printed SOFC component

Components Development through Aerosol Deposition

Anode Functional Layer

- 0.5/0.75 75/25 ScSZ and 1.3-µm hydroxyl modified PMMA was incorporated within a suspension and deposited onto a YSZ substrate
- Processing deposits were sintered at various temperatures to evaluate thickness, and microstructure density/pore
- Observations: Homogeneous deposits with thicknesses less than 10 mm were observed along with a suitable amount of porosity for the anode

Cathode Functional Layer

- 100% LSCF was incorporated within a suspension and deposited onto YSZ anode supports with varying sintering temperatures
- Sulfur deposits were sintered to 1300 °C to evalue density of microstructure

Electrolyte

- 75/25 ScSZ was incorporated within a suspension and deposited onto YSZ anode supports with varying sintering temperatures
- Sulfur deposits were sintered to 1300 °C to evaluate density of microstructure

Future Work

- Development and printing of multi-functional composite structures with varying degrees of porosity and microstructure
- Demonstrations of the potential of the system to manufacture highly customizable components by changing composition and microstructure in three dimensions was completed

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