Continuous Process for Low-Cost, High-Quality YSZ Powder

S.L. Swartz, M.M. Seabaugh, and M. Beachy
NexTech Materials, Ltd.
Lewis Center, OH

SECA Core Technology Workshop
Philadelphia, Pennsylvania
August 12-14, 2006

Project Details

Contract No.: DE-FC26-02NT41575
Project Monitor: Lane Wilson
Timeline: 10/1/2002 to 6/30/2006

R&D Objectives

Development of a low-cost synthesis process for YSZ electrolyte powder tailored for SOFC fabrication processes

Issues Addressed

- Low-cost scalable powder synthesis and production processes.
- Lower sintering temperatures.
- Effects of dopants and processing on conductivity and mechanical properties.
- Tailoring of YSZ electrolyte powder for different SOFC fabrication processes.
- Batch-to-batch reproducibility.

Process Development

- Homogeneous precipitation
- Low-cost precursors
- Continuous – where possible
- Aqueous
- Agile

Powder Quality Metrics

- Surface area: 10-15 m^2/gram
- Average particle size: <0.5 microns
- Sinterability: ρ > 98% at T_S < 1300°C
- Conductivity: σ > 0.05 S/cm at 800°C

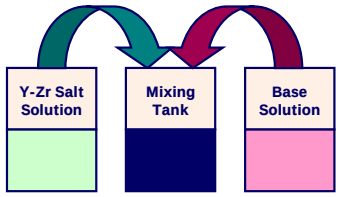
Applicability to SOFC Commercialization

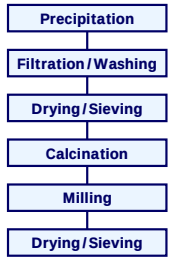
Agile processing allows tailoring of YSZ powder production to the requirements of different SOFC fabrication methods.

- Tape Casting Methods: Tight control of particle size distribution is important; relatively low surface areas needed for high green density.
- Screen Printing Methods: Tight control of surface area and particle size distribution are critical for optimum sintering characteristics.
- Co-Sintering Processes: Lower sintering temperatures are desired; control of sintering shrinkage rates is essential.
- Colloidal Deposition: Dispersion chemistry is critical; higher surface areas can be tolerated; tailored particle size distributions are beneficial.
- Plasma-Spray Methods: Large particle size and spherical morphology are required for optimum flow characteristics.
- Extrusion: Lower surface areas needed for dimensional control; particle size requirements vary by developer.

Homogeneous Precipitation

pH remains constant throughout process

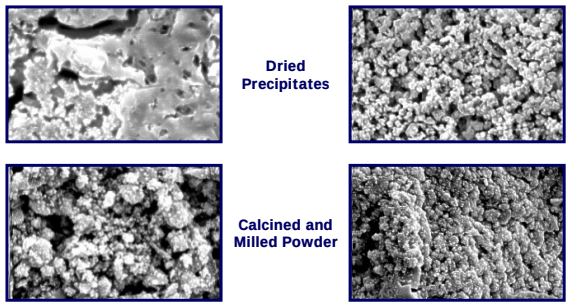




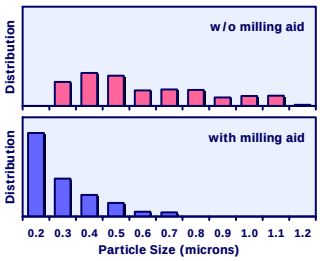
Synthesis Process Variables

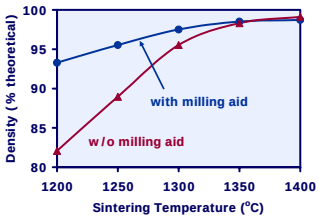
- Batch Size (typically 3-5 kg)
- Precipitation Conditions
- Chemical Purity (e.g., silica content)
- Dopants – sintering aids
- Solvent System (water or alcohol)
- Drying Methods
- Calcination – control of surface area
- Milling Methods – particle size control

Non-Optimized Precipitation Process / Optimized Process

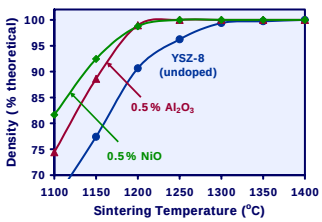


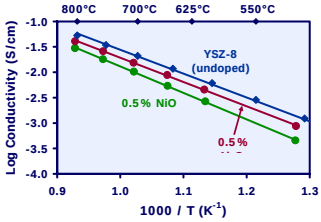
Effects of Milling Aid



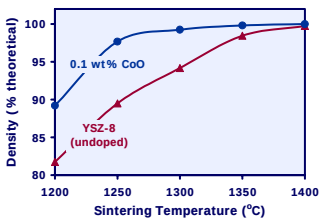


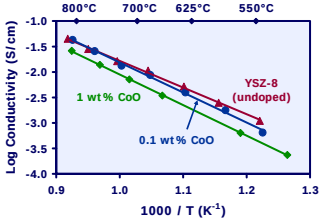
Effects of Alumina and Nickel Dopants





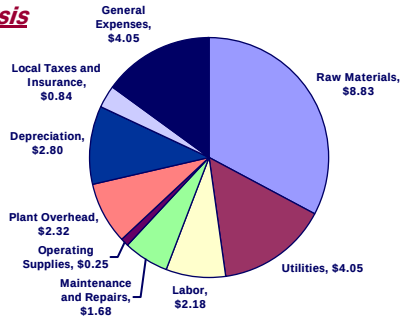
Effects of Cobalt Dopants





Manufacturing Cost Analysis

- Plant Size: 500 MT/year
- Fixed Capital Investment: $11.2 M
- Cost per kilogram: $27.00



Project Accomplishments

- Established homogeneous precipitation process for synthesis of YSZ powders
- Established calcination and milling methods to control surface area and particle size
- Achieved state-of-the-art performance relative to commercially available YSZ
  - Improved low-temperature sinterability
  - Identical ionic conductivity values
- Demonstrated process reproducibility
- Scaled process to 20-kg batch sizes
- Transferred process to ScSZ and doped ceria electrolyte compositions
- Manufacturing analyses suggest a YSZ powder cost of about $27/kg
  - Identified cost drivers for process

Contact Information

(614) 842-6606
swartz@nextechmaterials.com
www.nextechmaterials.com

Acknowledgments

DOE/SECA
Shawna Toth & Don Collins
Ohio Department of Development
Edison Materials Technology Center