Li-S Batteries Based on Ceramic LiSICON Separators

Technology Overview

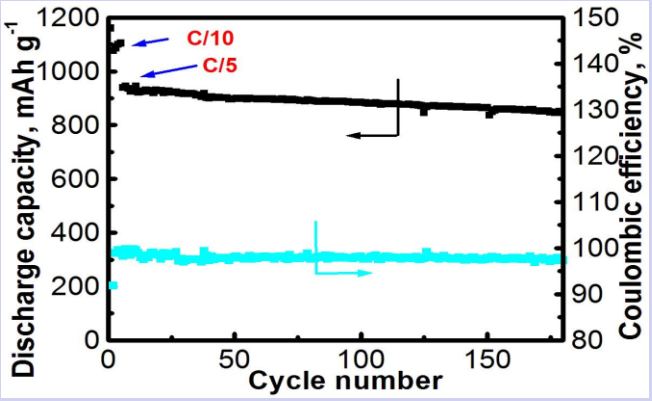
Unique Approach to Program Goal

1. Non-porous planar Li Super Ionic Conducting (LiSICON) ceramic membrane with high conductivity.
2. Sulfur-CNT composite cathode with high specific Capacity
3. Anolyte and anion receptor development

Quantitative value proposition

1. High energy density (> 200 Wh/kg)
2. Long cycle life (>1,000 cycles)
3. Low pack price ($125-150/kWh)

Li-S Battery Using Zr-LiSICON as a Separator



Negligible capacity degradation after 180 cycles (1800 hours)

Team

PI: Dr. Feng Zhao, Ceramatec, Inc.. 801-433-3602, fzhao@ceramatec.com
Prof. Arumugam Manthiram, University of Texas at Austin
Dr. John Zhang, Argonne National Laboratory
Dr. Kenzo Oshihara, Nissan Technical Center North America, Inc.

Current Status

What have proven: (1) stable new LiSICON composition in polysulfide (2) Sulfur electrode optimized and exhibited high specific capacity

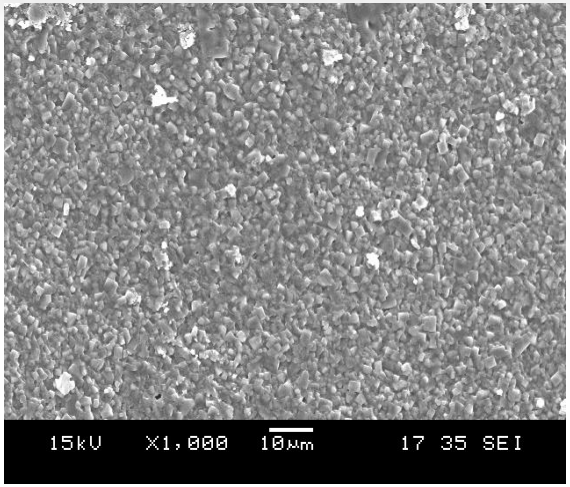
Next step for tech: Development of stable, highly conductive NASICON-type LYZP membranes

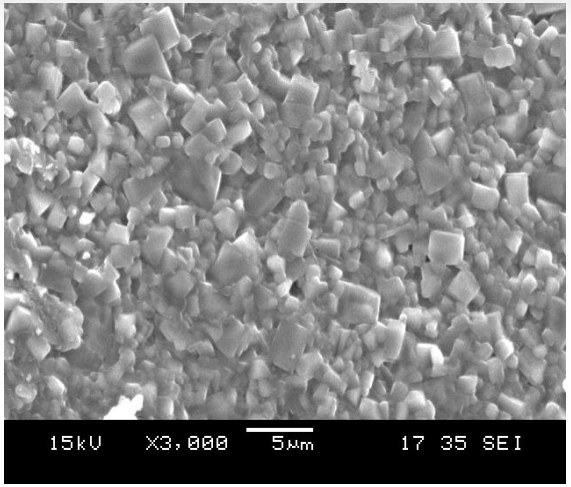
Next commercial steps: Quantitative cost/benefit analysis for the proposed technology; Assess customer requirements and markets ; secure next phase funding.

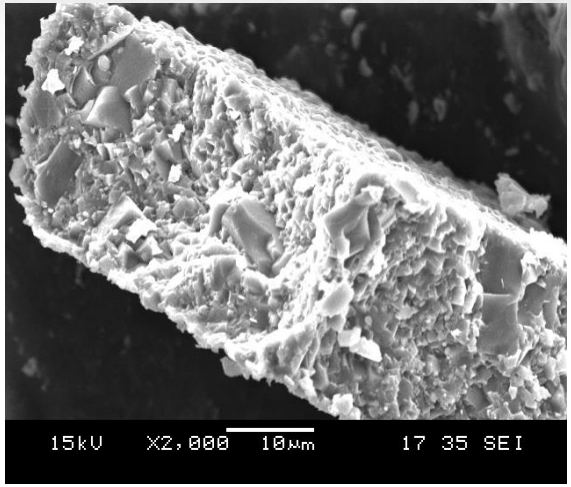
Project Statistics

Award Amount	$3.0M
Award Timeline	January 15, 2014-January 15, 2017
Next Stage Target	Stable membrane with $1*10^{-4}$ S/cm at room temperature
Collaborations Sought	battery manufactures

LiSICON Composition (Ti-LiSICON)





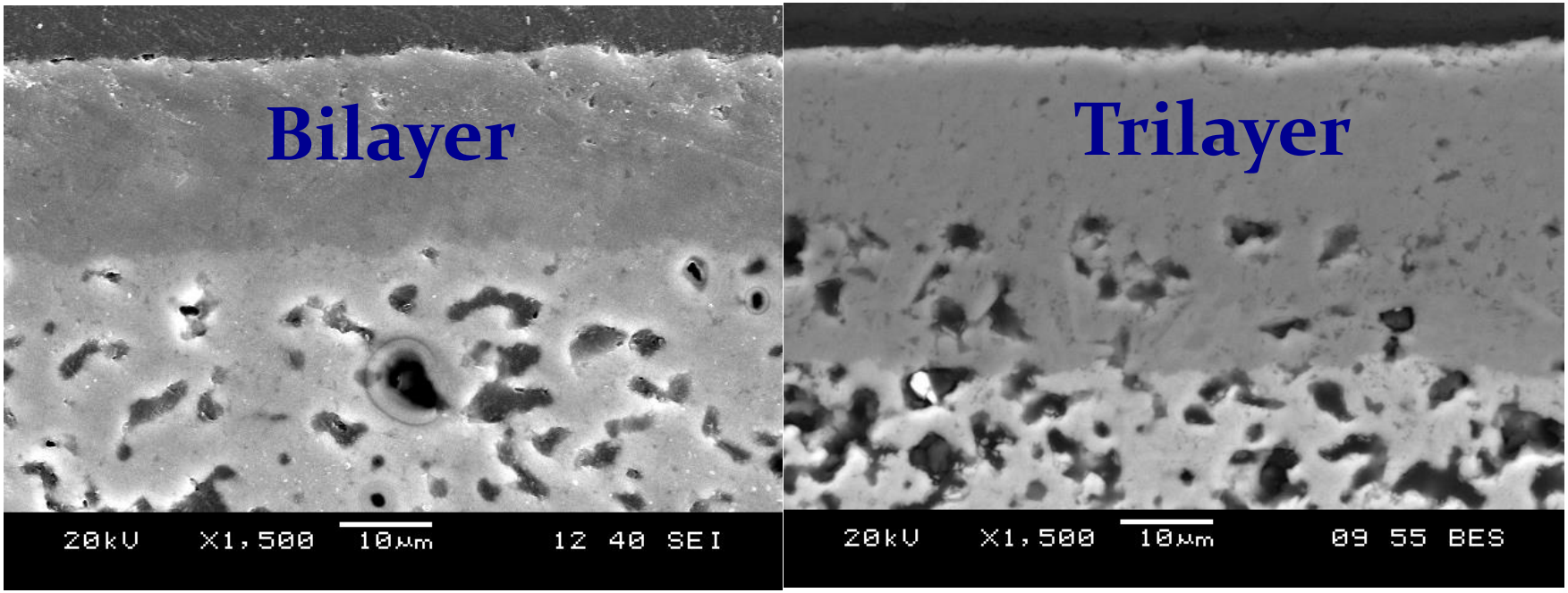


Solid-State Conductivity of LTP-B Compositions			
Temp., ° C	LTP-10B, mS/cm	LTP-10BC, mS/cm	LTP-10BU, mS/cm
27	0.82	0.93	0.95
35	0.85	0.97	1.09
60	0.94	1.15	1.40
71	1.00	1.19	1.54

High conductivity at room temperature!

CERAMATEC®
TOMORROW'S CERAMIC SYSTEMS

Supported LiSICON Membrane

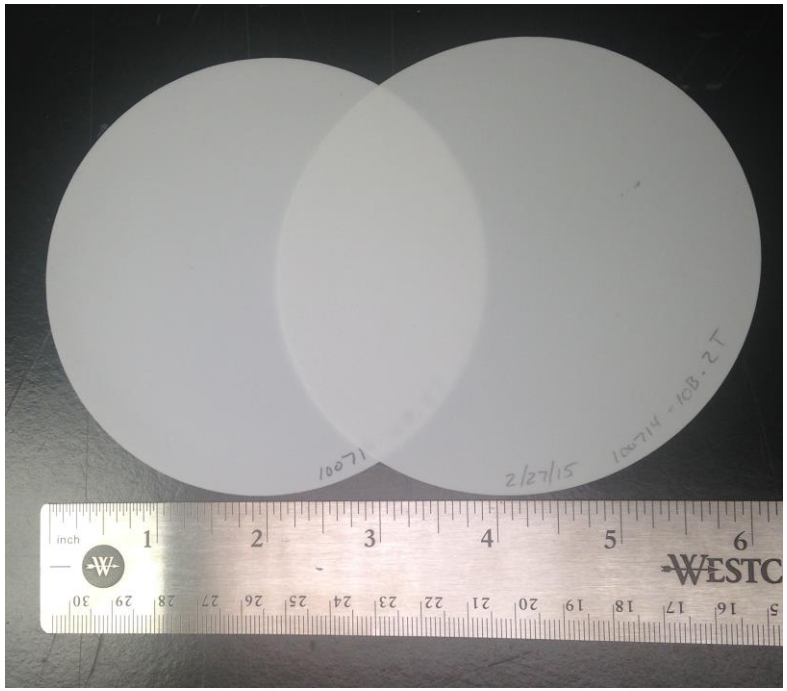


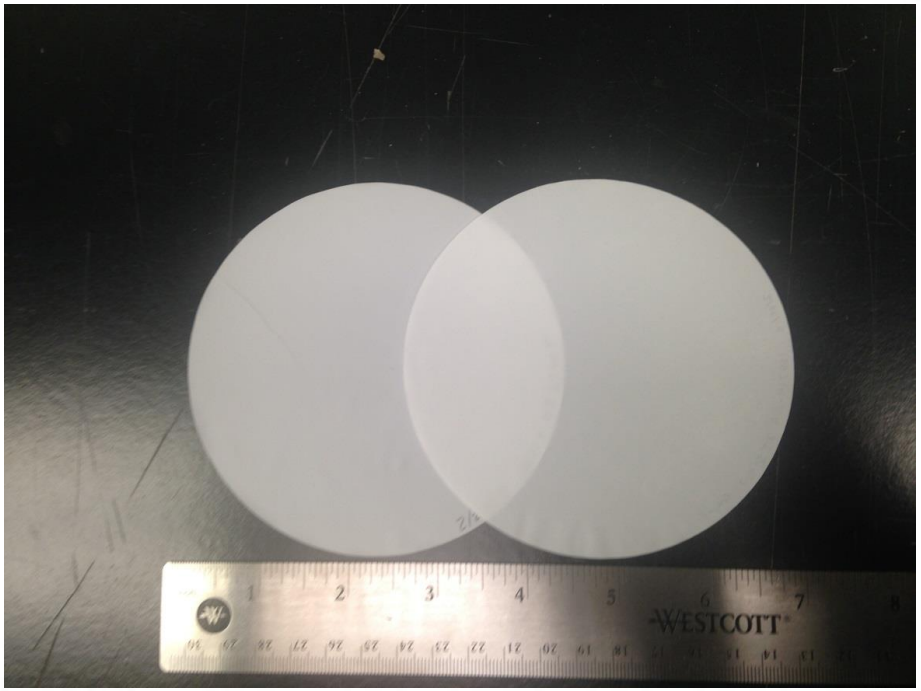
Items	Bilayer	Tri-layer B	Tri-layer C
Conductivity (mS/cm)	0.028	0.1	0.087

20 micron thin dense layer on porous thick support layer

Fabrication of Large Area Membranes

300-µm dense LiSICON membranes

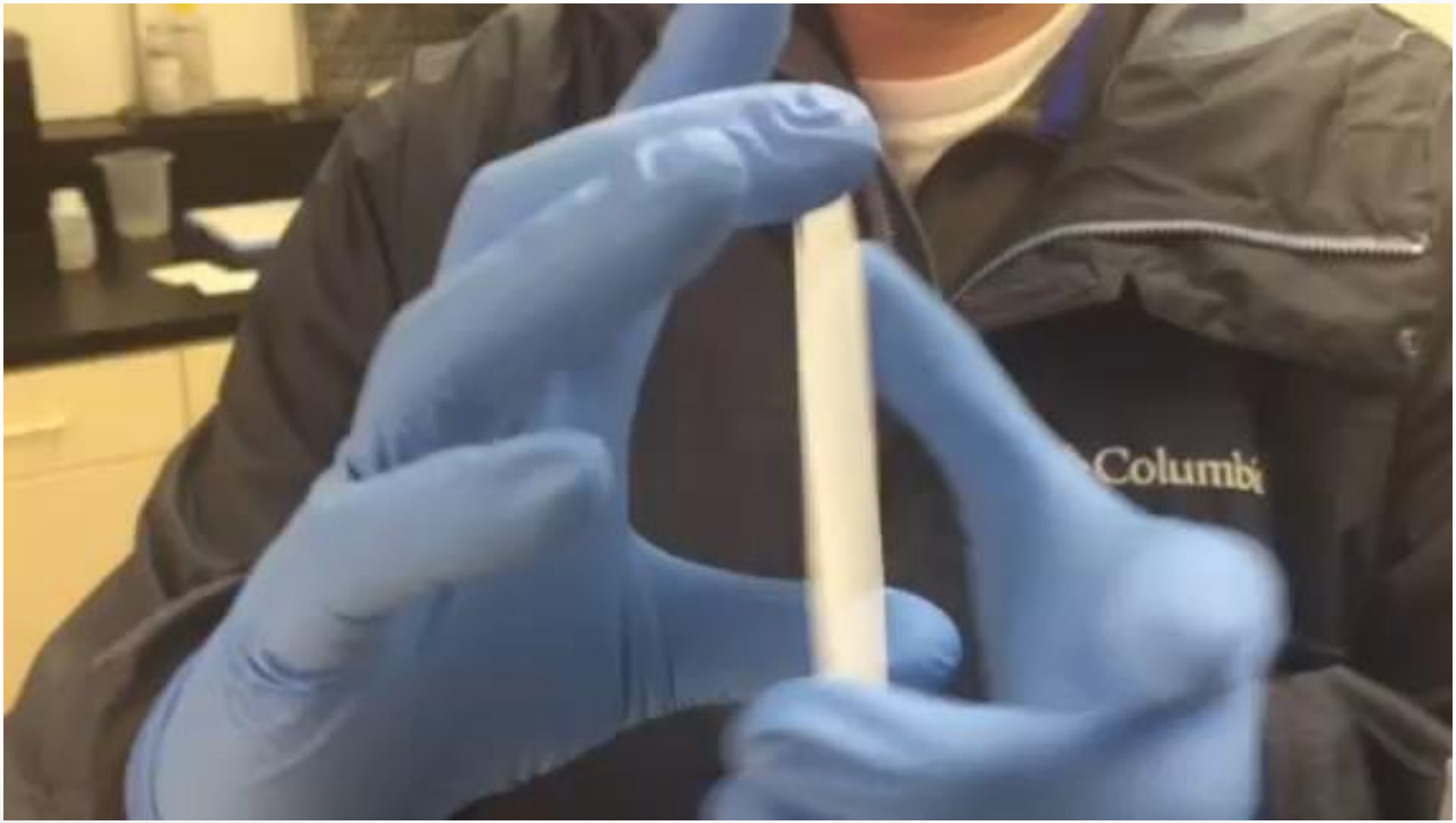




100-µm dense doped membranes

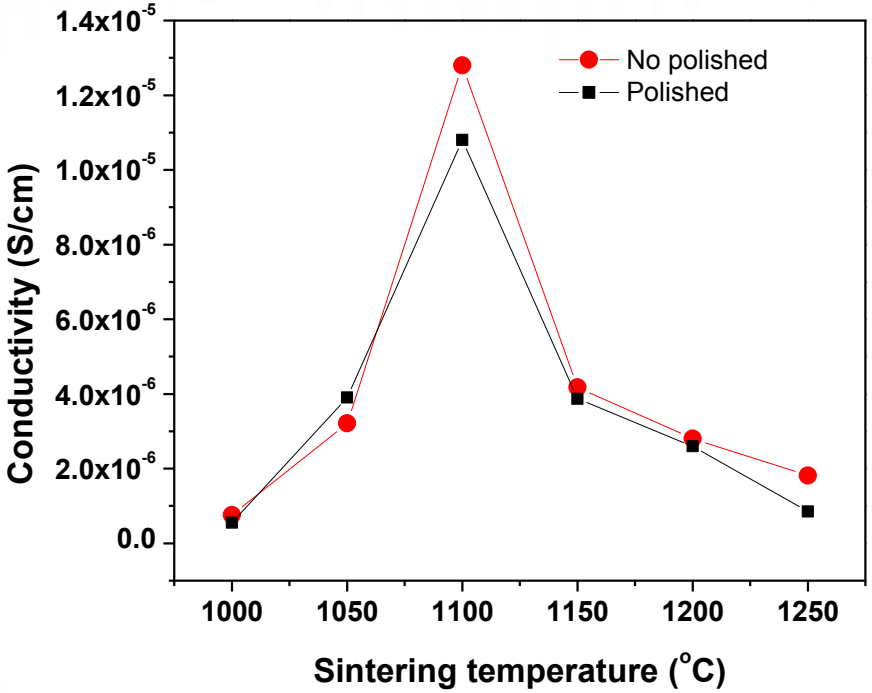
CERAMATEC
TOMORROW'S CERAMIC SYSTEMS

Flexible 150 Micron LiSICON Membrane

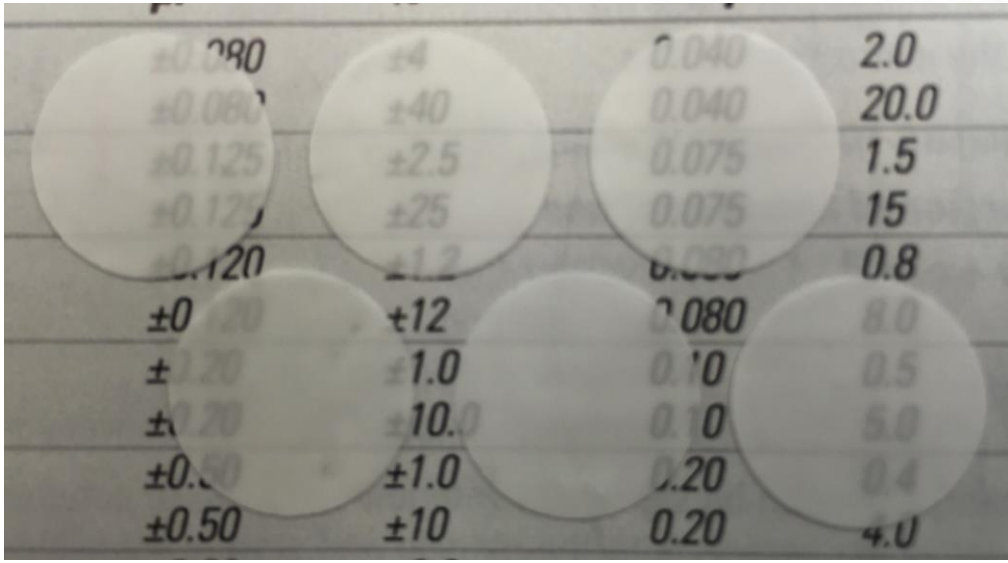


CERAMATEC
TOMORROW'S CERAMIC SYSTEMS

Recently Developed LiSICON Composition (Zr-LiSICON)



150 micron thick, 1 inch in diameter



Conductivity can be improved further by optimizing its composition and fabrication process

CERAMATEC
TOMORROW'S CERAMIC SYSTEMS

Third Year Work Plan

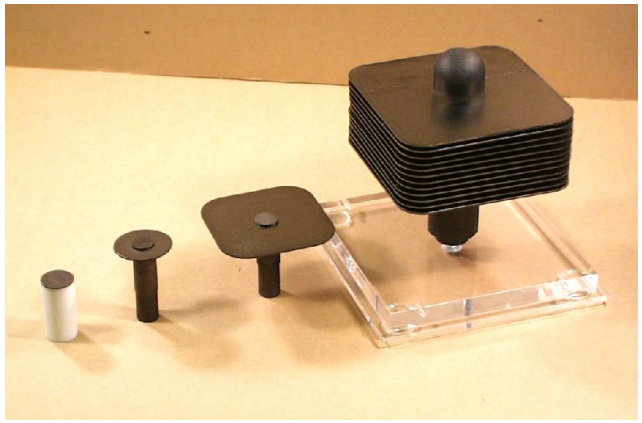
1. Optimize the composition and synthesis conditions of Zr-LiSICON, to improve the lithium-ion conductivity to 10^{-4} S/cm, or greater
2. Evaluate the compatibility of the Zr-LiSICON solid electrolyte with lithium-metal anode
3. Demonstrate the feasibility of lithium rechargeable batteries with the Zr-LiSICON solid electrolyte high-voltage spinel $LiMn_{1.5}Ni_{0.5}O_4$.

Spark Plasma Sintering (SPS) (UT-Austin)

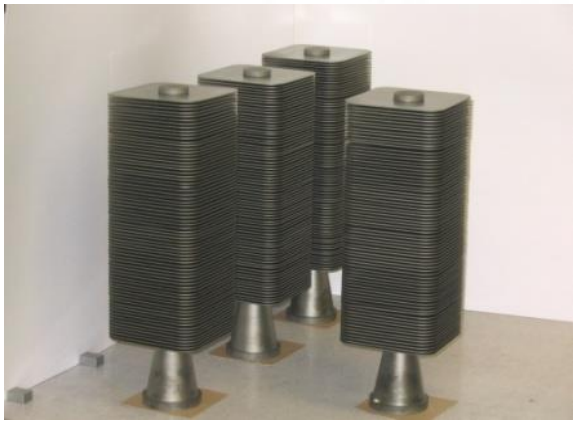
Spark Plasma Sintering (SPS), a fast sintering method, produces the least amount of second phase material due to the reduced time available for phase decomposition and formation.

Ceramatec Overview

Core Competencies: electrochemistry, ionic conducting ceramics and advanced materials, Concept to commercialization



From R&D to Pilot Scale Fabrication



0.5 TPD All Ceramic O_2 Module

17.5 kW Solid Oxide Electrolysis Stack

Tape Casting

Laser Cutting

Thermal Processing

CERAMATEC
TOMORROW'S CERAMIC SYSTEMS

Acknowledgements

- Funding support from ARPA-E RANGE program
- Program Director: Dr. Paul Albertus
- Tech Support: Dr. Aron Newman
- Senior Commercial Advisor: Ms. Susan Babinec

Thank you for your attention.

Please stop by my poster if you have any questions.

CERAMATEC®

TOMORROW'S CERAMIC SYSTEMS