

Comparison of Energy Consumption for  
Microwave Heating of Alumina,  
Zirconia, and Mixtures

Presented by

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Presented at the 105<sup>th</sup> Annual American Ceramic Society National  
Convention in Nashville Tennessee April 28<sup>th</sup> 2003

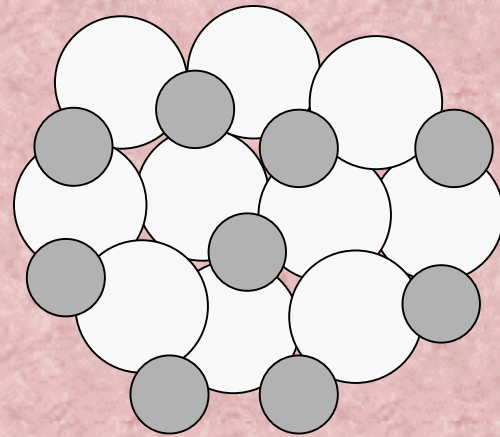
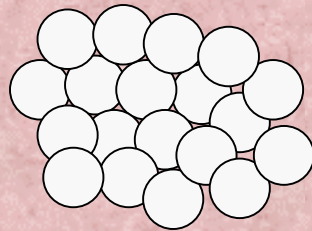
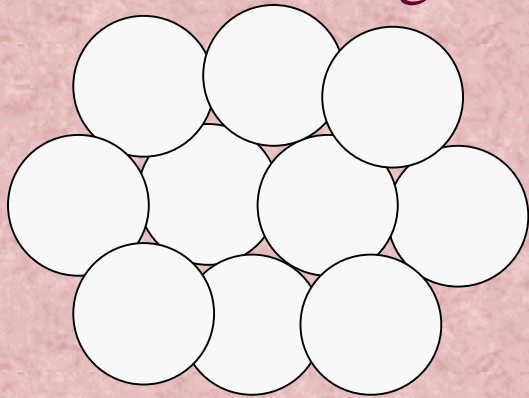
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## Introduction

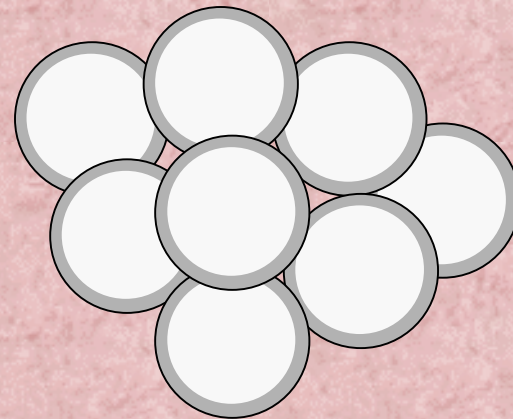
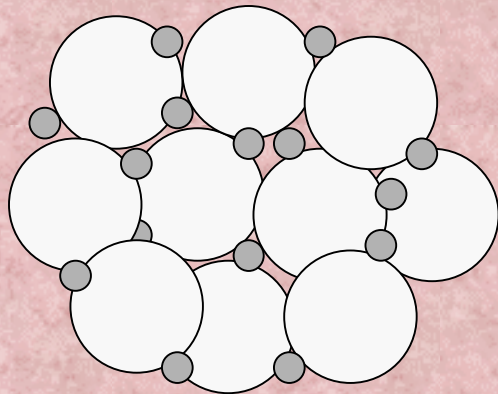
- How Does Heating Rate and Load Size Affect Energy Consumption in a Microwave Furnace?
- Do Mixtures Follow a Rule of Mixtures for Energy Consumption?
- Does Grain Size Effect the Energy Consumption?

# Powder Microstructures

## Single Phase



## Second Phase Distributions



# Experimental Set-up

- Alumina Insulation  
Zircar A1-1700
- Two 50 g SiC Susceptors  
RMS Thermcepts
- 20 g Dry Pressed Discs
  - Zircoa Zirconia
  - Tosoh Zirconia
  - Alcoa A-16 Alumina
- Microwave Heat to 1500°C

Heating Rates	Load Size
10 °/min	60 grams
50 °/min	120 grams
80 °/min	240 gram

# Microwave Furnace

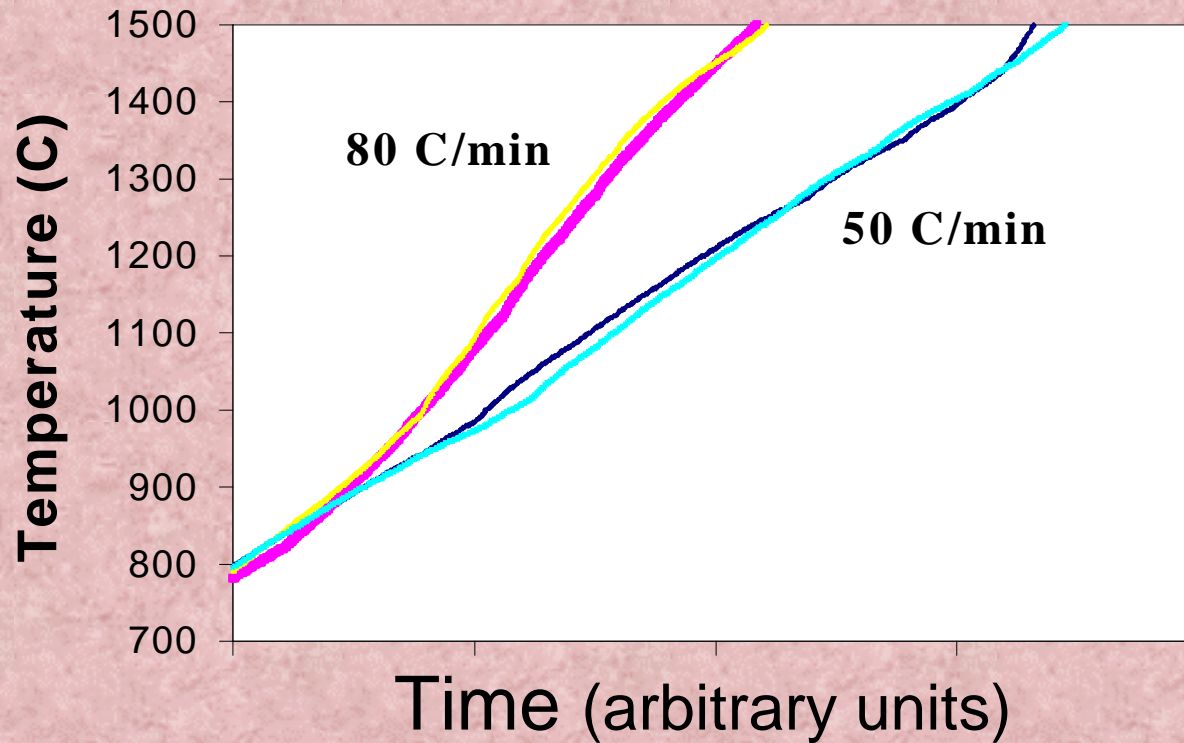
## CPI Autowave

- 3 kW Power
- 2 Color Optical Pyrometer
- Forward and Applicator Power Readings



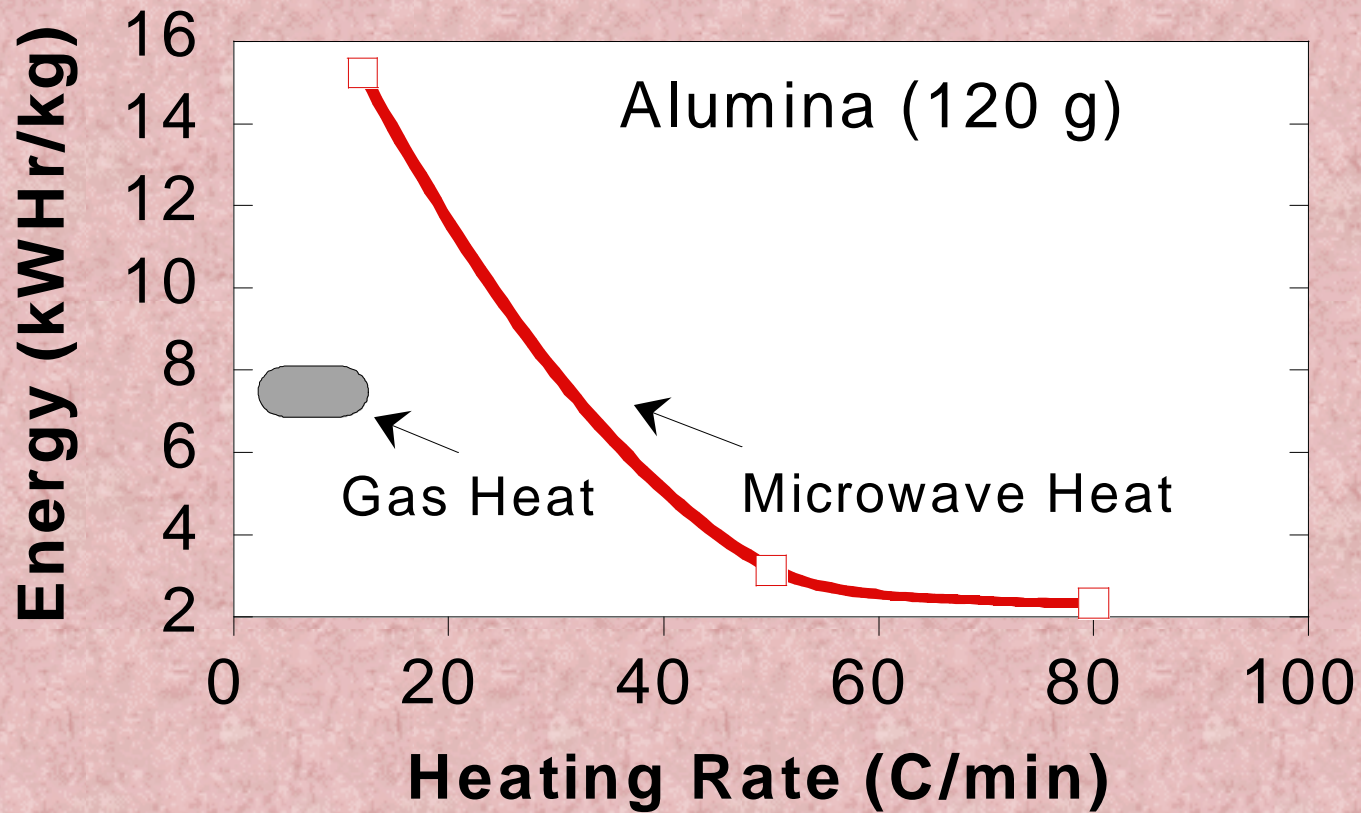
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## Heating Rate

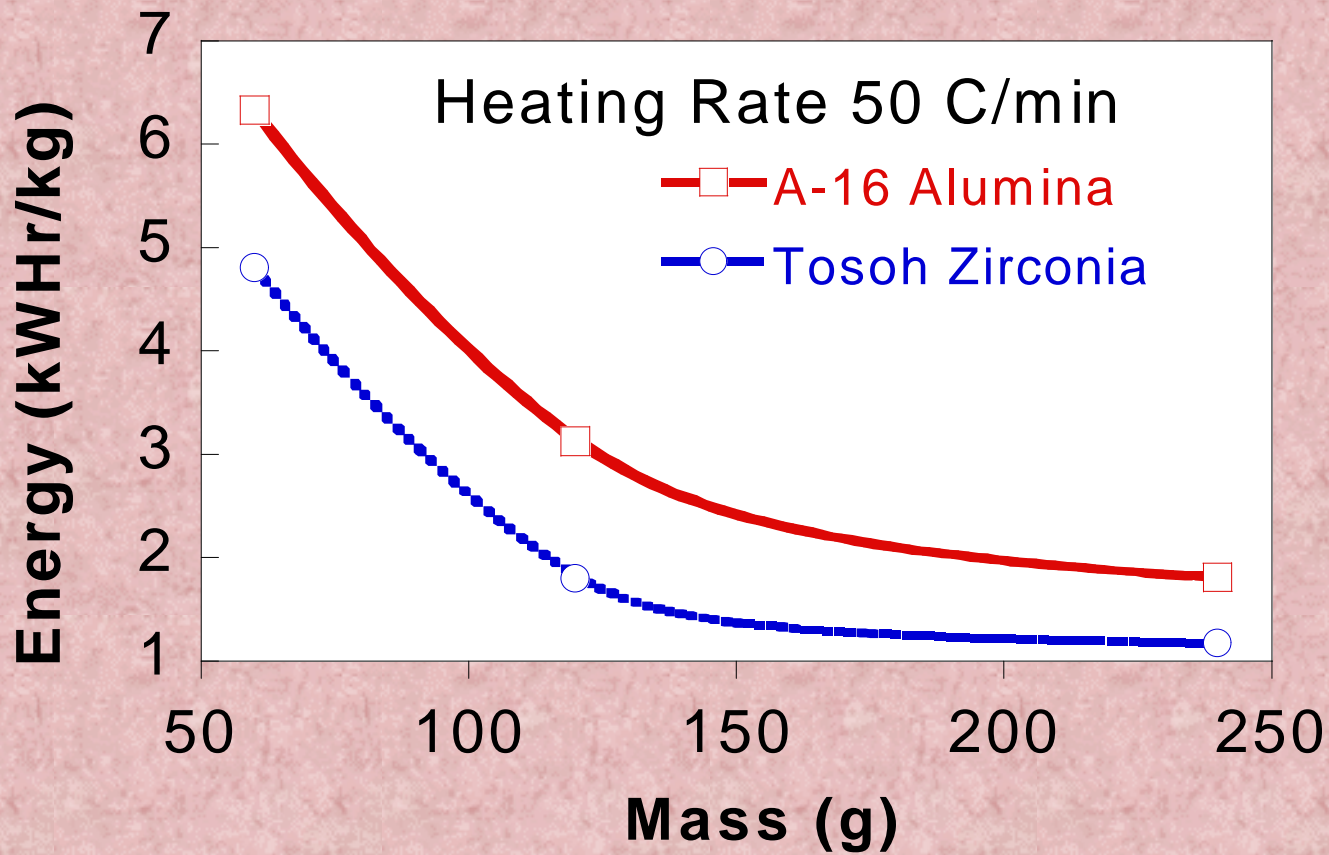


- Different Slopes Reflect Rate
- Reproducible Heating Rate for Different Loads

# Energy Consumption



# Energy Consumption



## Results

- Energy Efficiency Increased with Increasing
  - Load Size
  - Heating Rate
- Less Energy to Heat Zirconia than Alumina with Same
  - Temperature
  - Heating Rate
  - Load Size
  - Thermal Package

# Energy Consumption

**Heating Rate 80 C/min**



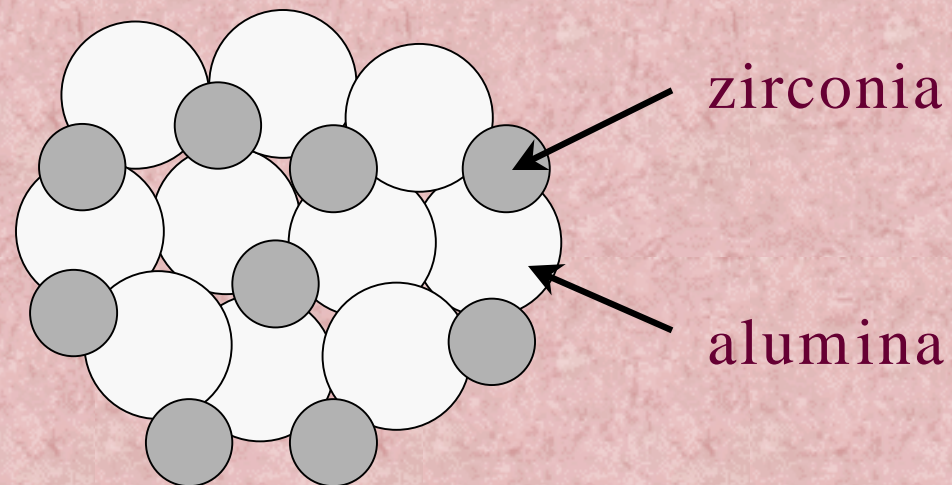
**120 g**

## Results

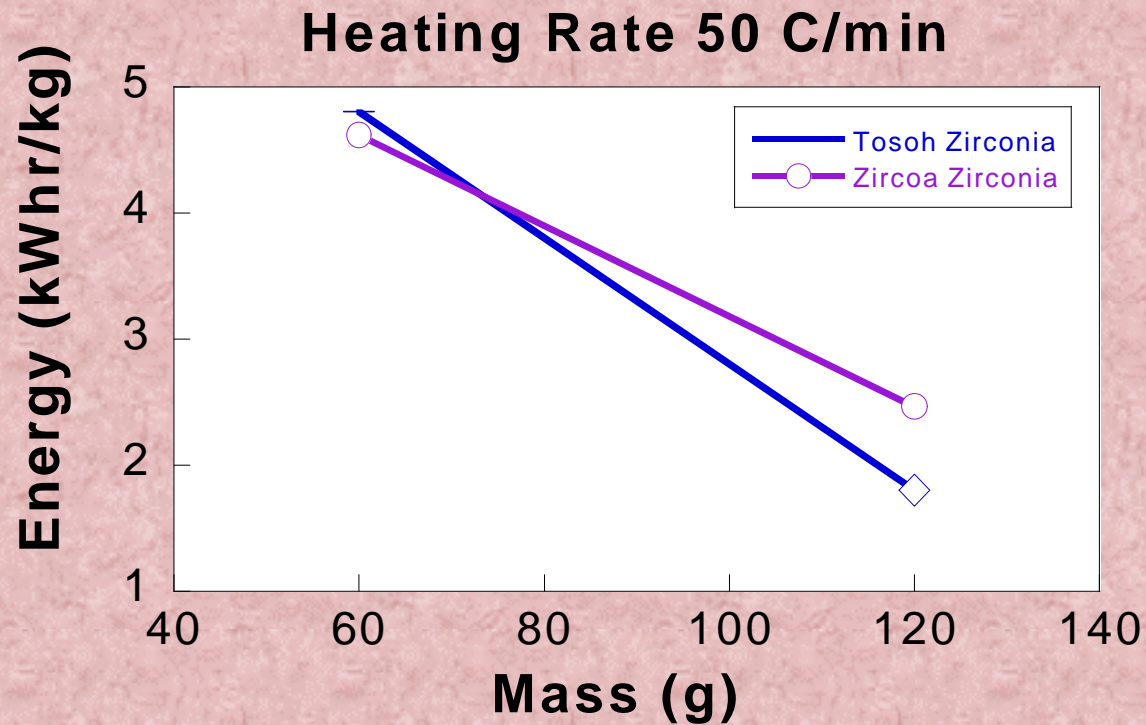
Microwave Heated 30 wt%  $\text{ZrO}_2$  + 70 wt%  $\text{Al}_2\text{O}_3$

→ More Efficient than Rule of Mixtures

→ As if Contained 50 wt% Zirconia



# Energy Consumption



Indication of Grain Size Effect on Energy Consumption  
→ At Larger Load Only

## Conclusions

- Microwave was efficient compared to gas fire
- Efficiency better for larger loads and higher heating rates
- Efficiency depends on material AND thermal package  
→ better for zirconia than alumina
- Mixture of  $\text{ZrO}_2$  and  $\text{Al}_2\text{O}_3$  appears to require less energy than rule of mixtures prediction
- Possibility of using lossy phases to increase energy efficiency in heating non lossy matrix
- Indication of grain size effect at larger loads

## Future Work

- Larger Loads
- Vary amount of zirconia in mixtures
- Grain Size Experiments

# Acknowledgments

Communications and Power Industries

NYSERDA

New York State College of Ceramics  
at Alfred University

Ceralink Inc.