

# **A Comparison of Microwave Furnaces for Sintering Ceramics**

Dr. Holly S. Shulman  
Ceralink Inc.

Dr. William J. Walker, Jr.  
New York State College of Ceramics at Alfred University

**Third World Congress on Microwave and Radio Frequency Applications**  
22-26 September, 2002 Sydney, Australia



C e r a l i n k  
I n c.

A l f r e d , N Y

# Outline

- **Introduction**
- **Microwave Furnaces**
- **Experimental Design**
- **Initial Results**
- **Scale-up Challenges**
- **Conclusions**

# Microwaves **Heat** Ceramics

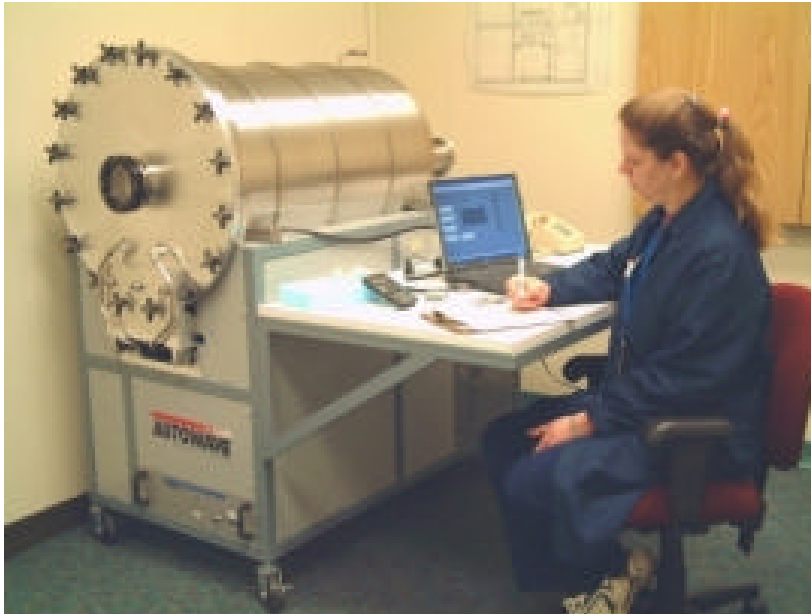
- Fast
- Clean
- Efficient
- New products
- Drying
- Burnout
- Calcination
- Sintering
- Melting

# Ceralink's Microwave Testing Center

- **Snap shot view**
  - Quick, inexpensive feasibility study, control parameters and density
  - Options: microstructure, phases, mech/electrical props.
- **Development work**
  - All levels of product and process development
- **Microwave Resource Center**
  - Showcase MW equipment
  - Specialized, up to date MW library
  - Meeting place for inventors, entrepreneurs, manufacturers, investors, students

# Commercial Microwave Furnaces

Communications and Power Industries



**Autowave**

**2.45 GHz: 3 kW, 5 kW**

# Commercial Microwave Furnaces

Research Microwave Systems



**ThermWAVE**

2.45 GHz: 1.3 kW

# Commercial Microwave Furnaces

Linn High Therm



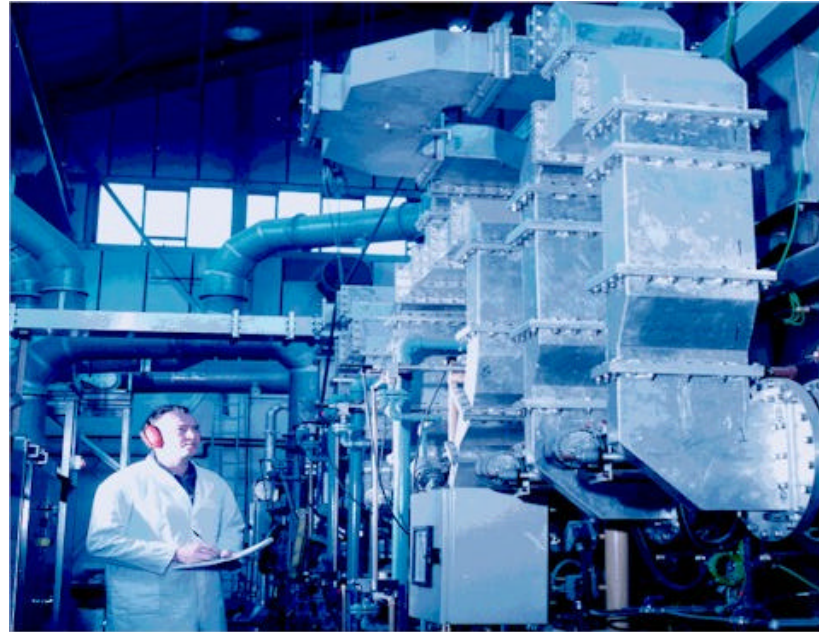
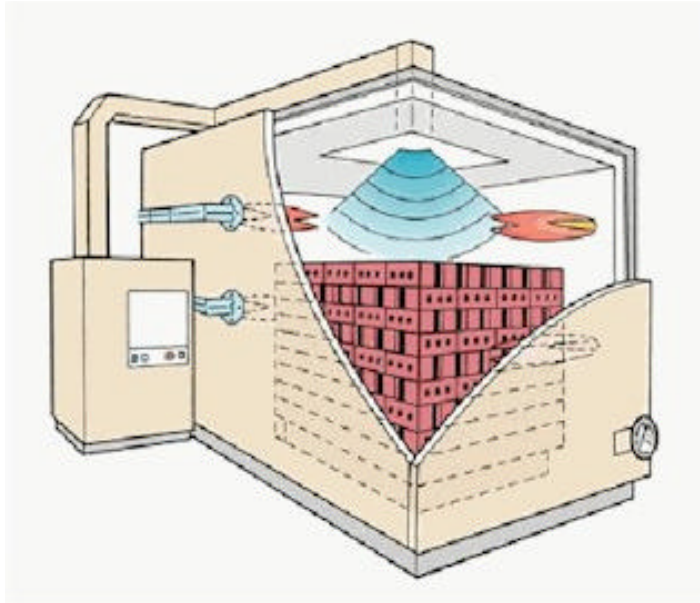
**2.45 GHz, 800 W  
with 5.8 GHz, 500 W**



**2.45 GHz, 1.6 kW  
with 5.8 GHz, 1 kW**

# Commercial Microwave Furnaces

C-Tech Innovation  
(formally part of EA Technology)



**MW Assisted Gas/Electric Firing**  
**2.45 GHz**

# Commercial Microwave Furnaces

- Dennis Tool Company (2.45 GHz, 6 kW)
- Microwave Materials Technology (2.45 GHz)
- CoberMuegge (2.45 GHz)
- InVerTec (2.45 GHz)
- Fuji Denpa (28 GHz)
- Gycom (30 GHz)

# Experimental Design

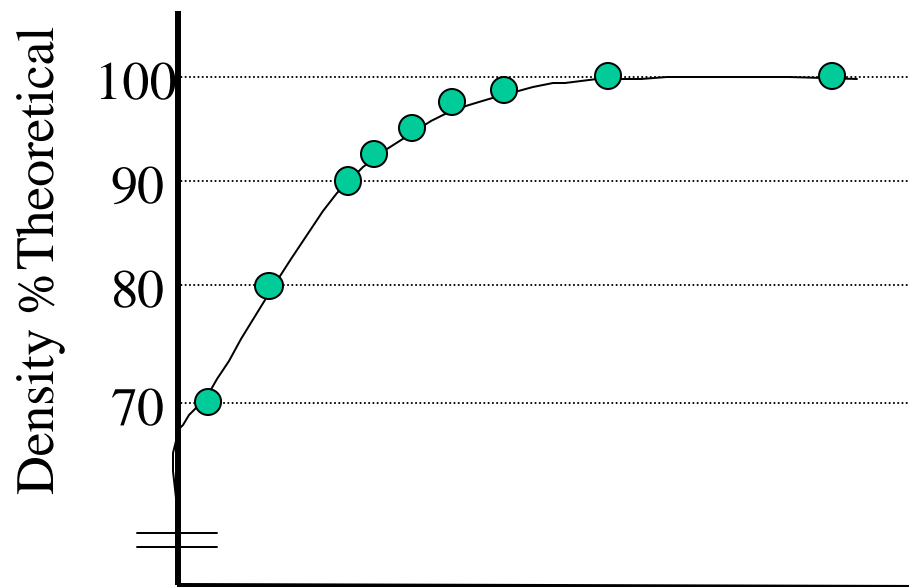
- Applicator Effect?
- Frequency?
- Combined MW?
- Microwave Effect?
- Transfer between MW furnaces?
- Scale-up!

# Experimental Design

## Control Thermal Package

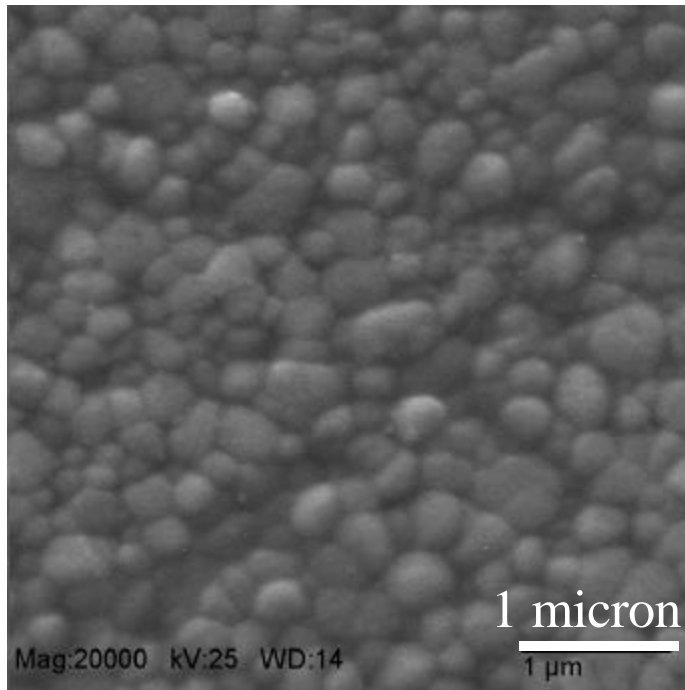
- Refractories: type, volume, shape
- Susceptors: composition, mass, size, shape
- Susceptorless: match load mass
- Load: standard material/process, mass

## Compare Sintering by Density and Microstructure

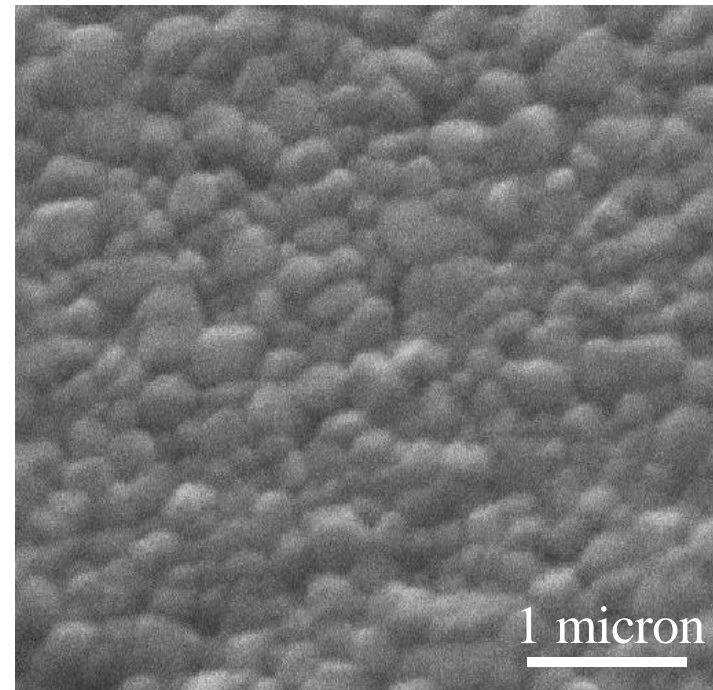


# Initial Results

Tosoh Zirconia 3Y



**ThermWAVE**



**Autowave**

- Same thermal package: refractory, susceptors, load
- Same time/power profile

# Initial Results

Tosoh Zirconia 3Y

	<b>ThermWAVE</b>	<b>Autowave</b>
Density (% theor.)	99.9	99.9
Hardness (GPa)	13.5 (+/- 0.1)	13.5 (+/- 0.1)

- Same thermal package: refractory, susceptors, load
- Same time/power profile

# Conclusions

- Commercial microwave furnaces needed
- Transfer between 2.45 GHz microwave furnaces probably easy
- More studies of microwave furnaces on materials needed
- Scale-up driven by ceramic manufacturers

# Acknowledgements

- New York State Energy Research and Development Affiliation