

# **Breaking Barriers**

## **Commercialization of High Temperature Microwave Processing**

Dr. Holly S. Shulman  
Ceralink Inc.

**Microwellen-Thermoprozesstechnik**  
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Ceralink  
Inc

Alfred, NY

# Outline

- **Introduction**
- **Ceralink Background**
- **Barriers**
- **Microwave Testing Center**
- **Microwave Furnaces**
- **Examples**
- **Conclusions**

# Ceralink Inc.

- Engineers for Hire
- Understand Science
- Focus on Industrial Needs



# Microwaves **Heat** Ceramics

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

# Barriers

- Materials Testing and Scale-up
- Microwave Furnaces

# 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

# Feasibility Studies

	<b>Advantage</b>	<b>Disadvantage</b>
<b>Universities</b>	<ul style="list-style-type: none"><li>• Scientific experts</li><li>• Cost savings?</li></ul>	<ul style="list-style-type: none"><li>• Slow response</li><li>• Education focus</li></ul>
<b>MW Furnace Manufacturer</b>	<ul style="list-style-type: none"><li>• Helpful</li><li>• Low cost</li></ul>	<ul style="list-style-type: none"><li>• Not impartial</li></ul>
<b>Independent Testing Center</b>	<ul style="list-style-type: none"><li>• Fast turnaround</li><li>• Focus on industry</li></ul>	<ul style="list-style-type: none"><li>• Medium cost</li></ul>

# Scale-Up

- Benefits projected from feasibility studies
- Technical expertise combine microwave and materials
- MW Furnace Manufacturers involved in scale-up

# Microwave Furnaces

- Furnace and Kiln specification
- Easy to operate
- Integrated temperature measurement and control
- Testing available
- Show up on an internet search

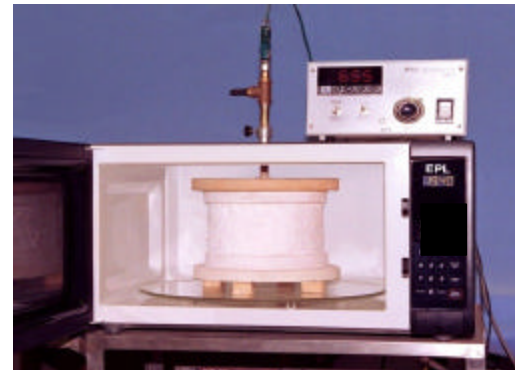
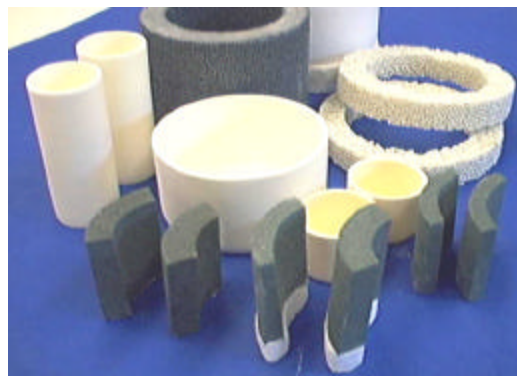
# Microwave Furnace Approach

Method	Advantage	Disadvantage
2.45 GHz low power	Inexpensive	Susceptors
2.45 GHz high power	Large systems	Susceptors, expense
2.45 + 5.8 GHz	Uniformity	Not tested
5.8 GHz	Uniformity	Not tested
2.45 GHz + gas/electric	No susceptors, retrofit	Availability
18, 24, 28, 30 GHz	Good Uniformity No susceptors	Expensive

# Microwave Furnaces

## Research Microwave Systems

- Complete system
- Inexpensive
- Accessories Available



**ThermWAVE**  
**2.45 GHz: 1.3 kW**

# Microwave Furnaces

Communications and Power Industries

- High Power Magnetrons
- Can Build Large Systems



**Autowave**

**2.45 GHz: 3 kW, 5 kW,  
18, 28 GHz: 3 kW, 10 kW**

# Microwave Furnaces

## Linn High Therm

- Inexpensive
- Hybrid



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

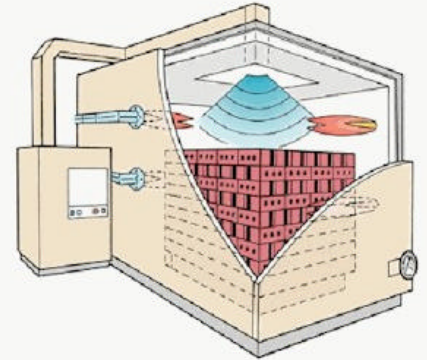
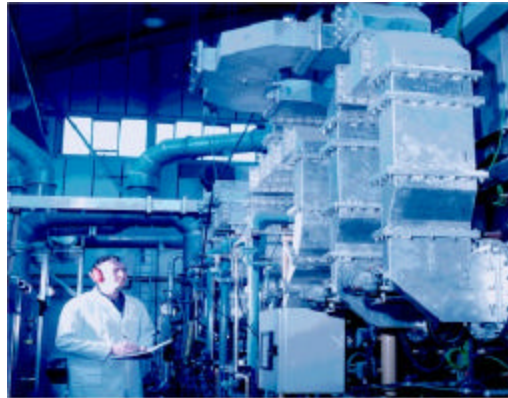


**2.45 GHz, 1.6 kW  
with 5.8 GHz, 1 kW**

# Microwave Furnaces

C-Tech Innovation  
(formally part of EA Technology)

- Retrofit
- Energy efficient
- Hybrid



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

# Examples

- Silicon nitride  
cutting tools
- Tungsten carbide/cobalt  
(cemented carbide or hardmetal)  
cutting tools, mining

Both Examples use 2.45 GHz Microwave Heating

## **Example:** Silicon Nitride

Commercial Microwave Sintered Silicon Nitride Cutting Tools

→ Licensed to **Indexable Cutting Tools**, Canada

Silicon nitride can be used in other wear parts:

e.g. Bearings, Nozzles, Paper processing, Ceramic armor

- 5 years in development
- Excellent properties, competitive price
- Why not used more widely, other applications?

# **Example:** Tungsten Carbide/Cobalt

(Cemented Carbide or hardmetal)

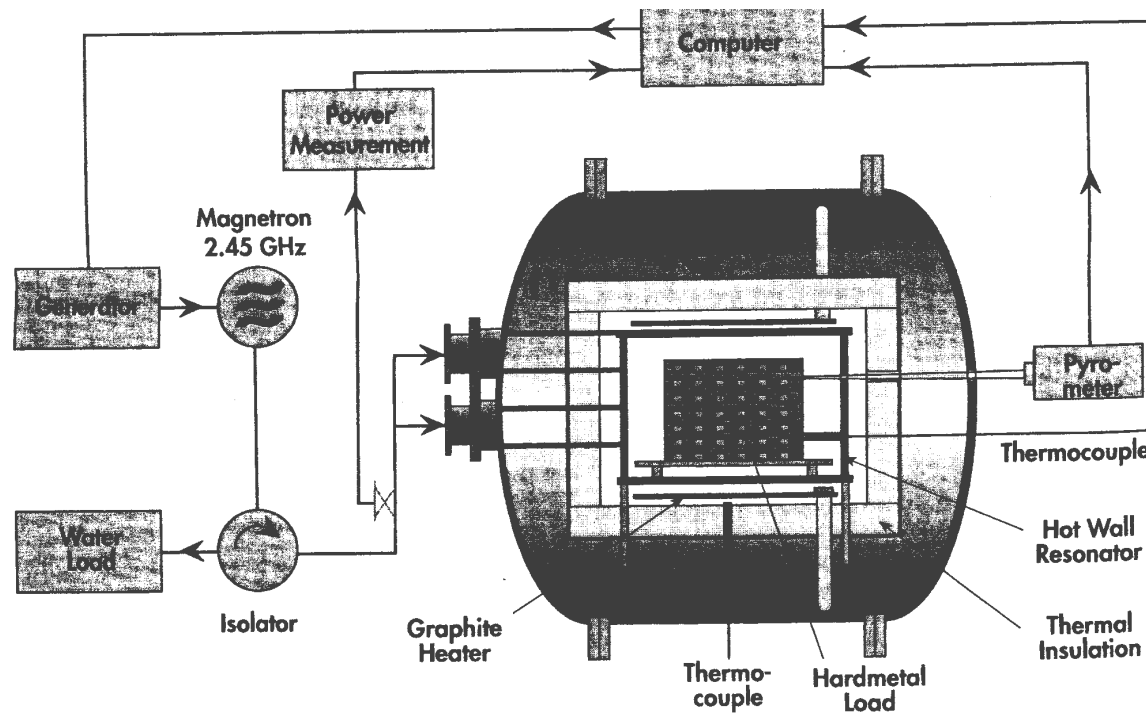
Two companies developed microwave furnace and process for sintering cemented carbides

**1. Widia**, GmgH with Dortmund University

**2. Dennis Tool Company**, USA with Penn State University

→ licenced to **Valenite** (Valenite bought by Widia, now by Sandvik)

# Tungsten Carbide/Cobalt



**Widia** “in house” built microwave sintering furnace  
for cemented carbides

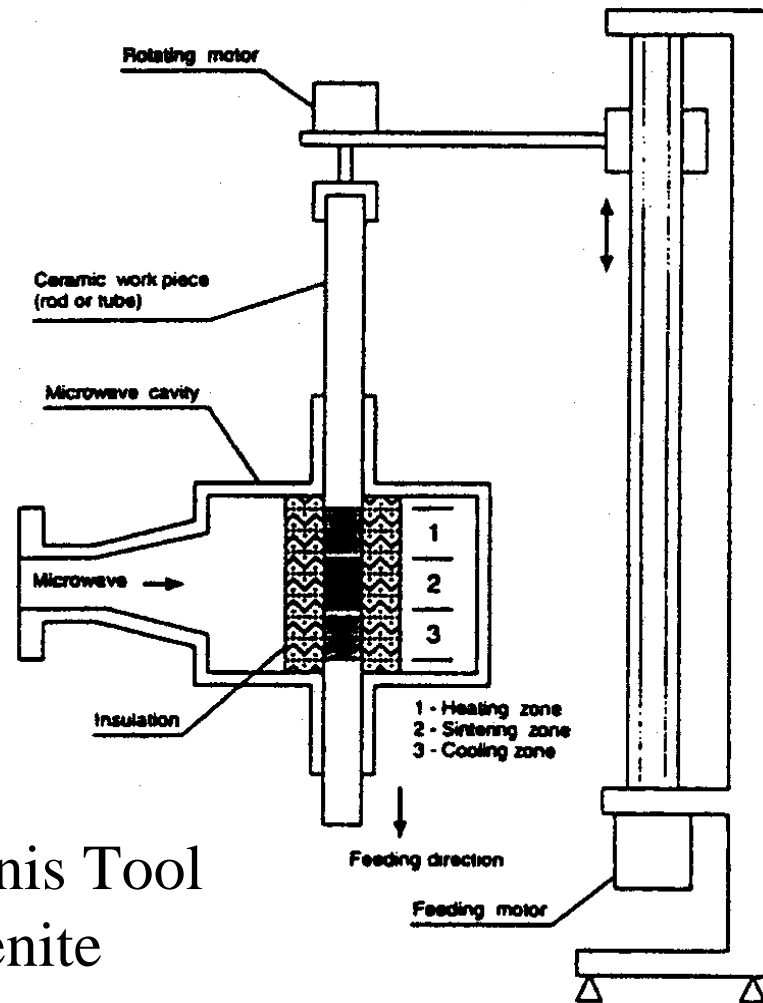
- 8 years in development
- Replaced by Valenite?

# Tungsten Carbide/Cobalt

## Valenite

microwave sintering furnace  
built by Dennis Tool Co.  
for cemented carbides

- 4 years in development at Dennis Tool
- 3 years in development at Valenite
- On market soon?



# Conclusions

## To Overcome Barriers to Commercialization:

- Microwave Testing Center
- Availability of Microwave Furnaces
- Scale-up driven by ceramic manufacturers
  - Need familiarity with standard MW furnaces
  - Need impartial feasibility testing
  - Need technical assistance in materials and collaboration with MW furnace manufacturer

# Acknowledgements

**Mr. Horst Linn**  
Linn High Therm

