

Microwave Technology for Enhanced Binder Removal

Morgana Fall*

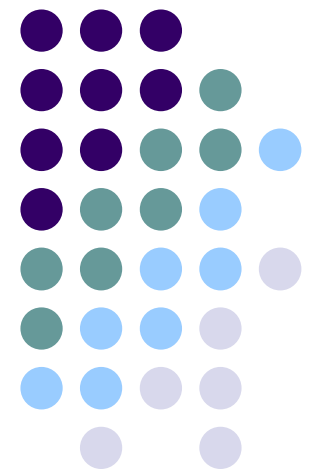
Shawn Allan, Dr. Holly Shulman, Ceralink Inc

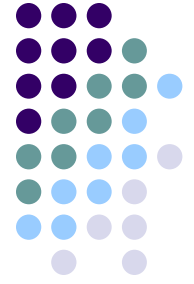
Ceralink Inc.

Rensselaer Technology Park
Troy, New York



Pittsburgh, Pennsylvania
October 7, 2008



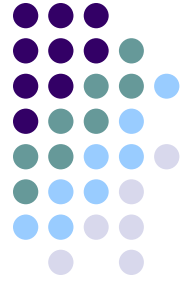


Outline

- Binder Removal Problems
- Microwave Methods
- Proof of Concept Example

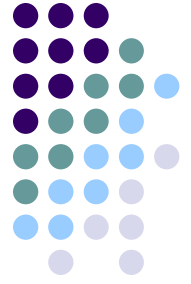
Binder Removal

Example Product Types

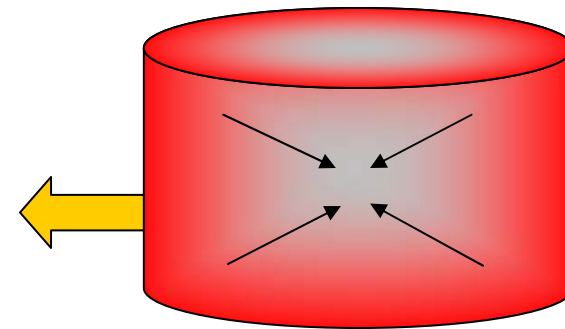


- Ceramics
 - Foams and filters
 - Investment casting molds
 - Refractories
 - Crucibles
- Metals
 - Powder metal compacts
 - Powder injection molded

Binder Removal Challenges

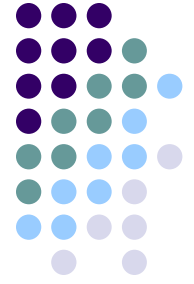


- Problem
 - Slow heating rates
 - Long dwell times
 - Product quality issues
 - Bloating
 - Cracking
 - Incomplete binder removal



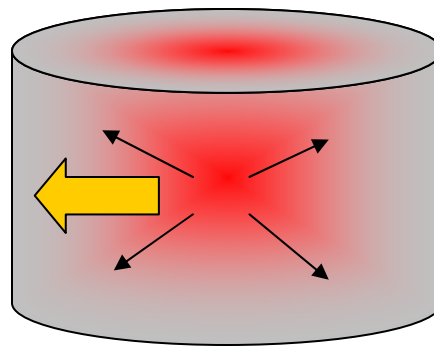
Binder migrates out from **surface**





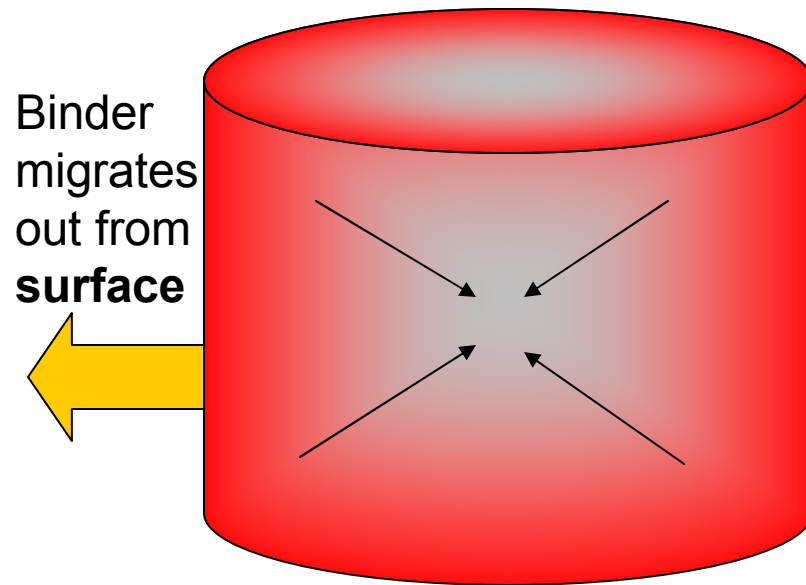
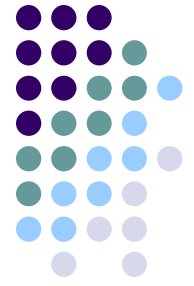
Binder Removal Solution

- Microwave Solution
 - Binders couple directly with microwave energy
 - Increase heating uniformity → faster heating
 - Drive binders from center of part, outward
 - Faster, more complete binder removal



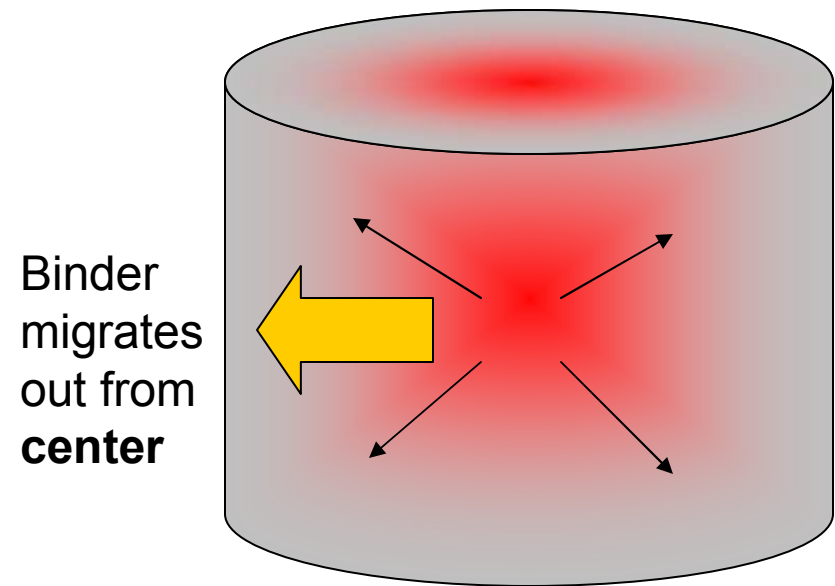
Binder migrates out from **center**

Microwave Technology for Binder Removal



Conventional

Heat transferred from surface to center

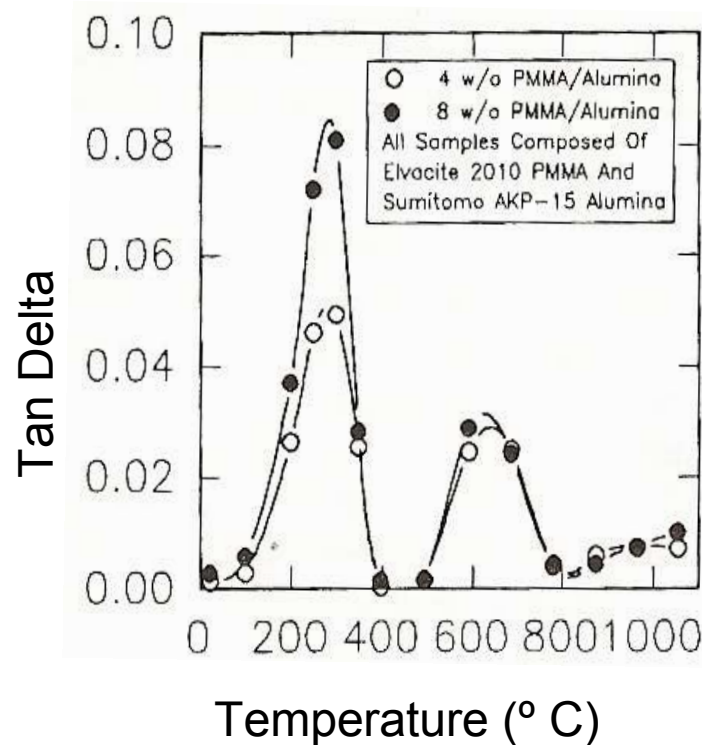
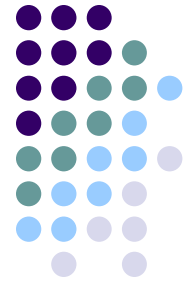


Microwave

Heat generated in center of part

Microwave- Binder Interactions

Microwave Heating and Dielectric Properties

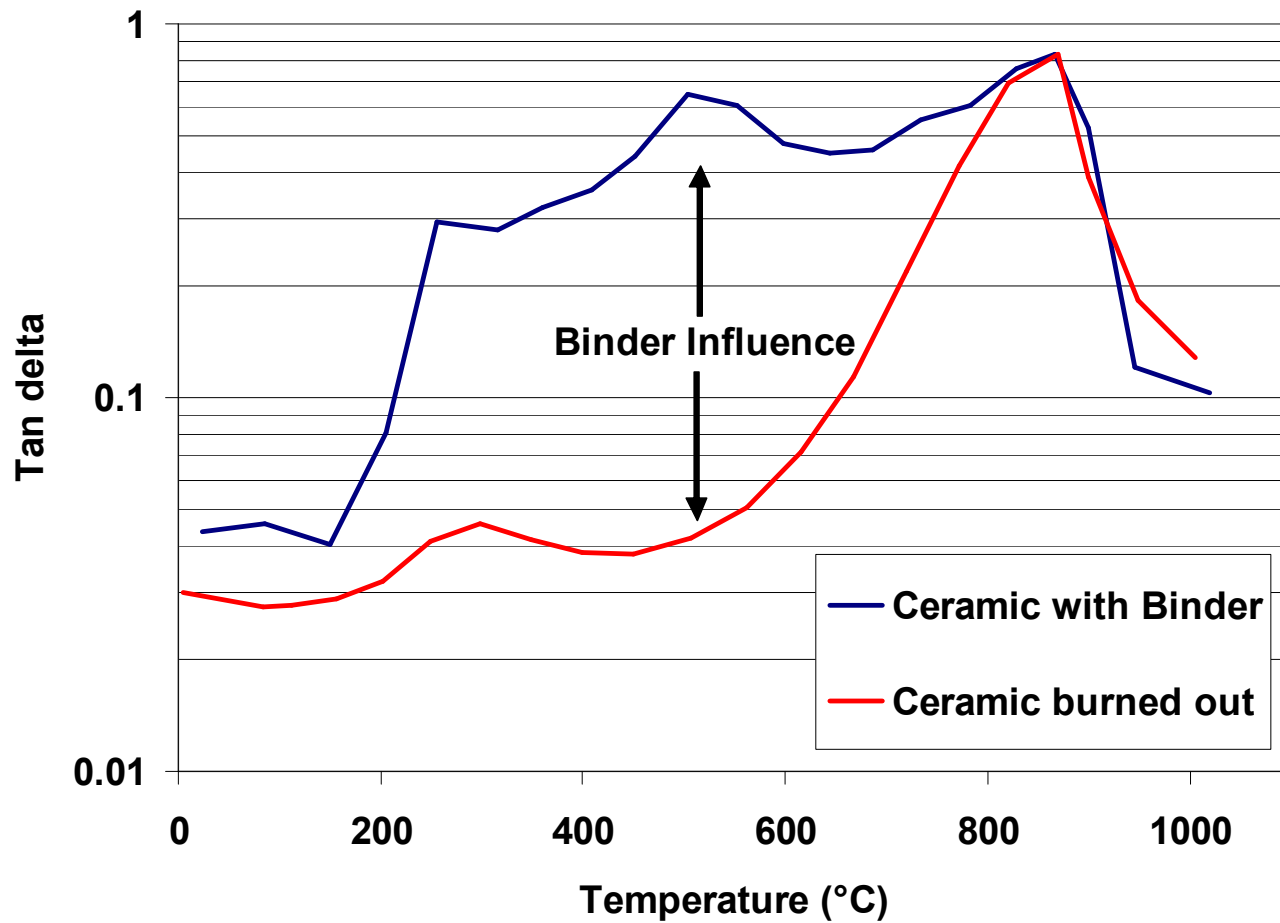
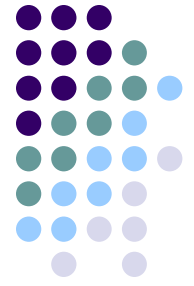


- Dielectric properties
 - Dielectric loss, tan delta
 - Frictional heating process
- First peak:
 - Mostly H and O burning out
- Second peak:
 - Residual carbon burning out



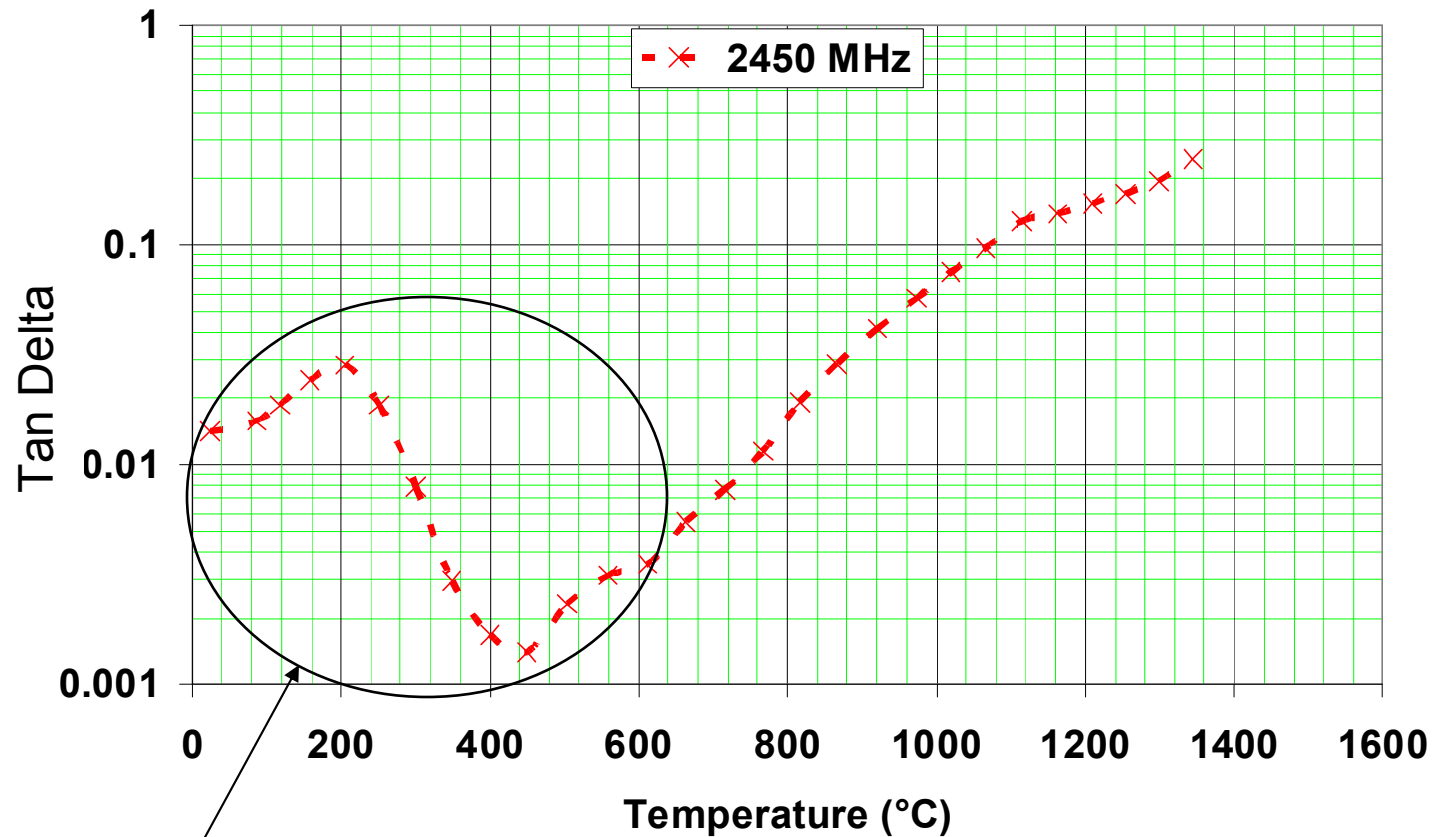
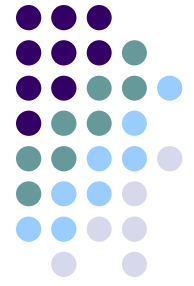
Dielectric Properties

Binder vs. No Binder



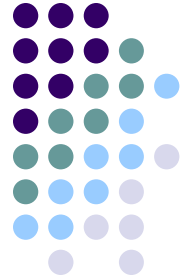
Dielectric Properties

Zirconia Ceramic Filters



Removal of water and binder

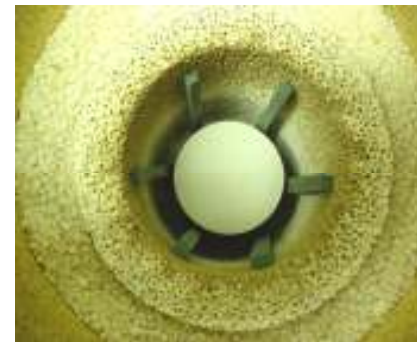
Microwave Binder Burnout Strategies



- Pure Microwave

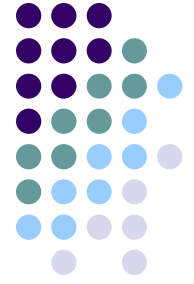


- Microwave + Susceptor



- Microwave Assist Technology





Microwave Binder Removal

Microwave Only

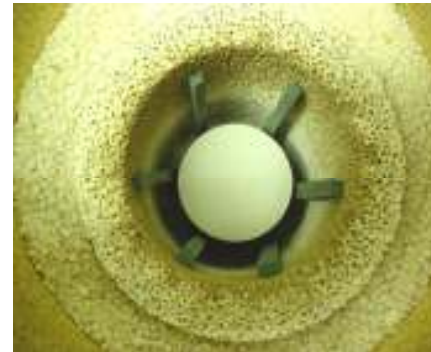


Part Failure

- Overheated in center



Microwave + Susceptor



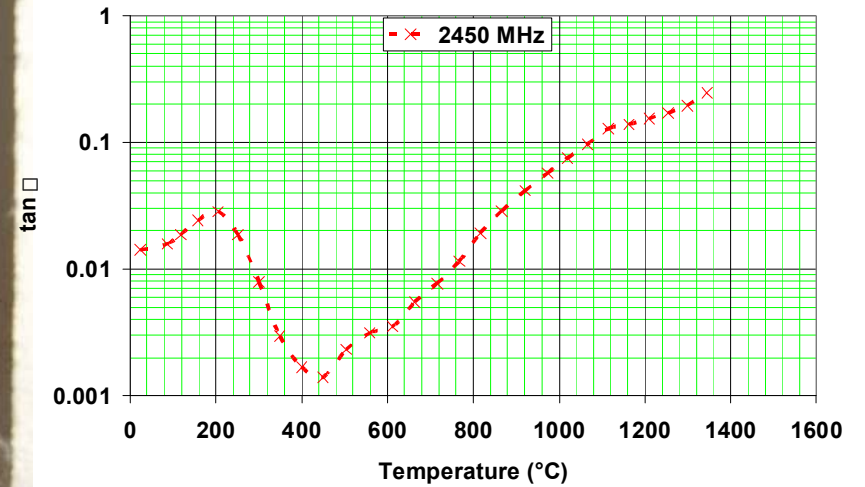
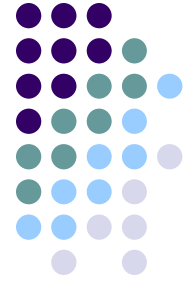
Successful binder removal

- Lower energy usage (99% less)
- 29X faster

Sample	Susceptor	Energy (kWhr/kg)	Time (min)	Weight loss (%)
Microwave	Picket fence	0.3	25	2.7
Conventional	N/A	7.5	720	2.7

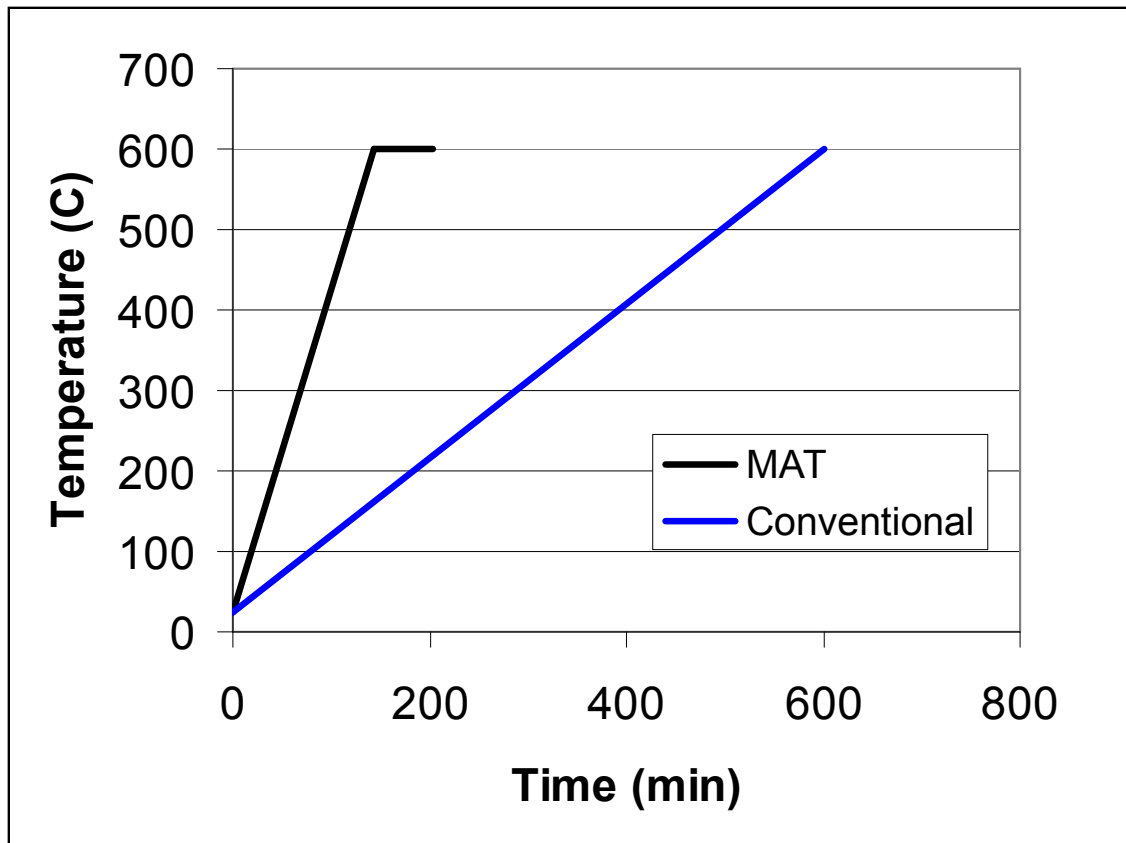
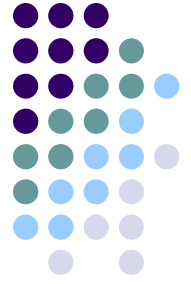
MAT Binder Removal

Reticulated Zirconia

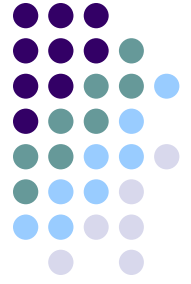


MAT Binder Removal

Reticulated Zirconia



- Successful binder removal
- 3X faster



Summary

- Microwave couples to binders
 - Targets and heats directly
- Proof of concept demonstrated
- Potential for real time and energy savings

- MAT Kiln Example