

Evaluation of SiC Heating in a Microwave Field



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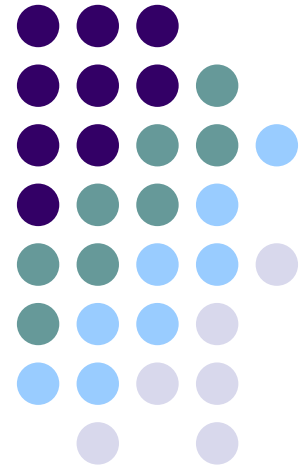
Steven R. Mercurio, Dr. Rich Haber

Rutgers University

David Laughton, James Funk

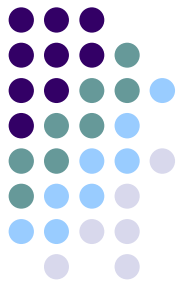
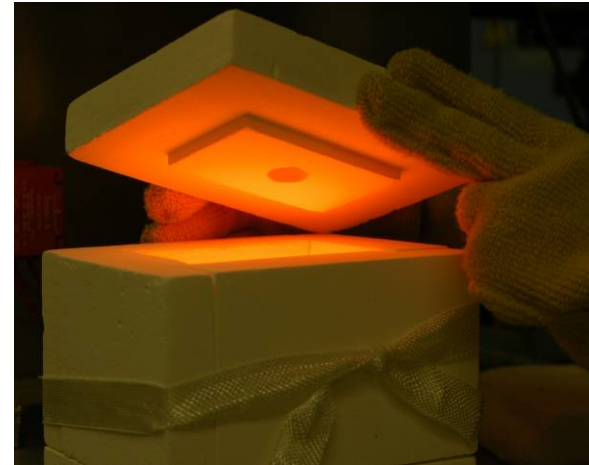
Superior Graphite

January 28, 2010

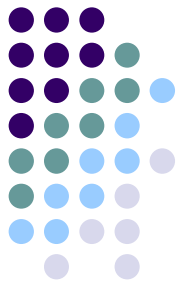


Outline

- Microwave SiC - Goal
- Background Info
- Microwave Study Results
- Conclusions
- Future Work



SiC- Microwave Potential



1) Finer grain size

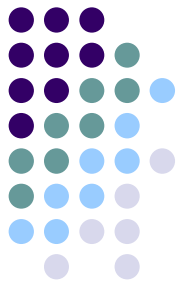
- Property improvements

2) Efficient process

- Low energy, less time, pressure-less
- Allow for complex shapes

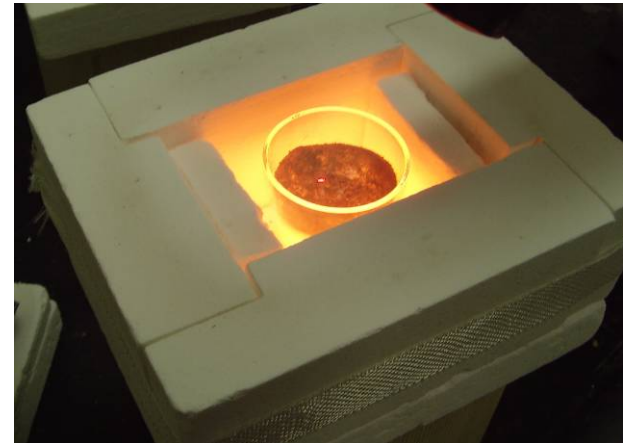
Background

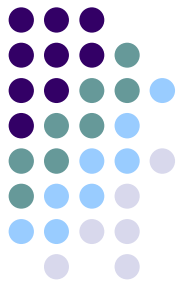
Microwave Sintering SiC



Need:

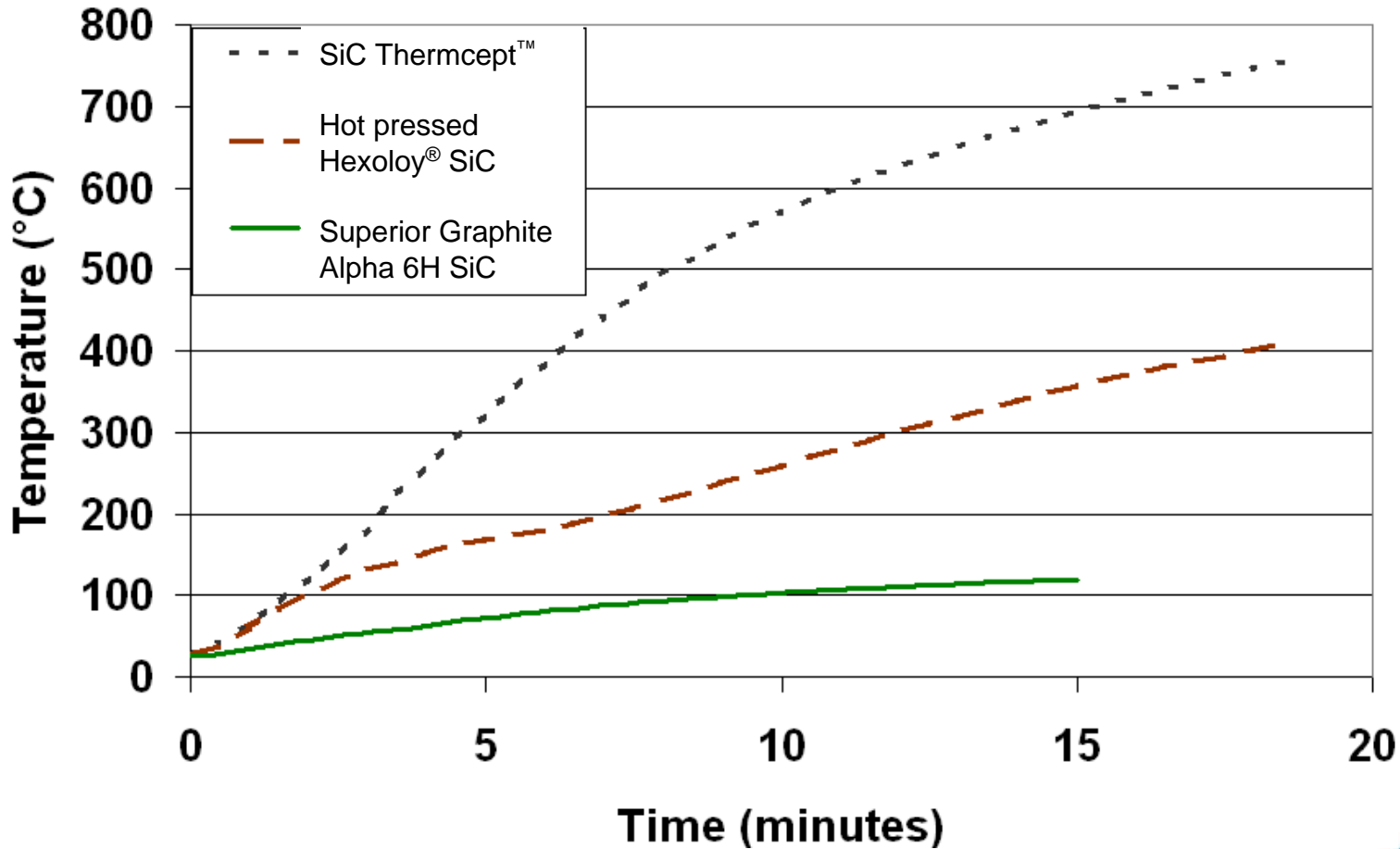
- To understand interactions
 - Systems- additives and polytypes
- Insulation for heat and atmosphere
 - MW transparent, high temperature
- Innovation!

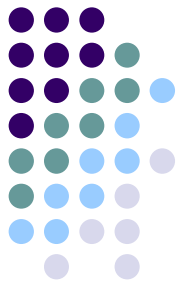




Background

Microwave Self Heating of SiC





Microwaves - Dielectric Heating

$$\text{Tan } \delta = \varepsilon''/\varepsilon'$$

Conductivity increasing* →



Transparent to microwaves
Tan $\delta < 0.01$

Absorb microwave (heats)
Tan $\delta \sim 0.01 - 2$

Reflects microwaves
Tan $\delta > 10$

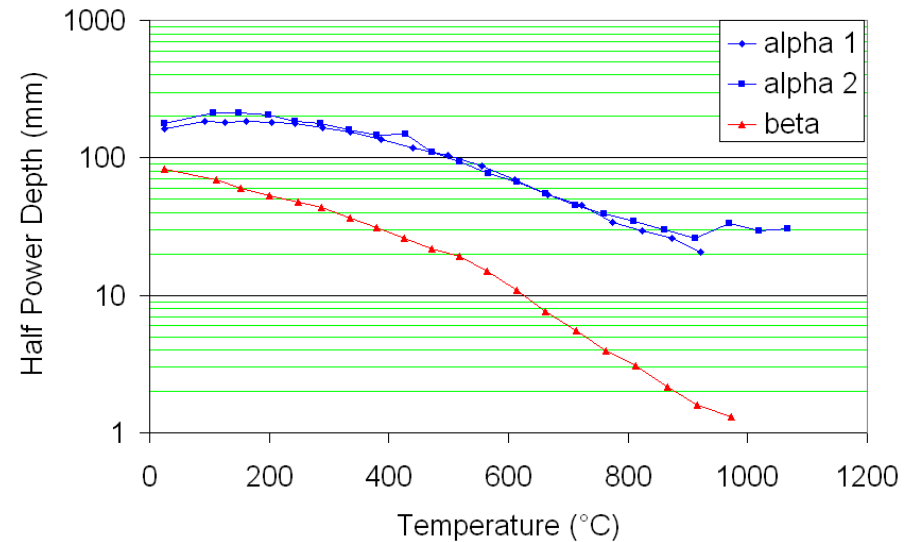
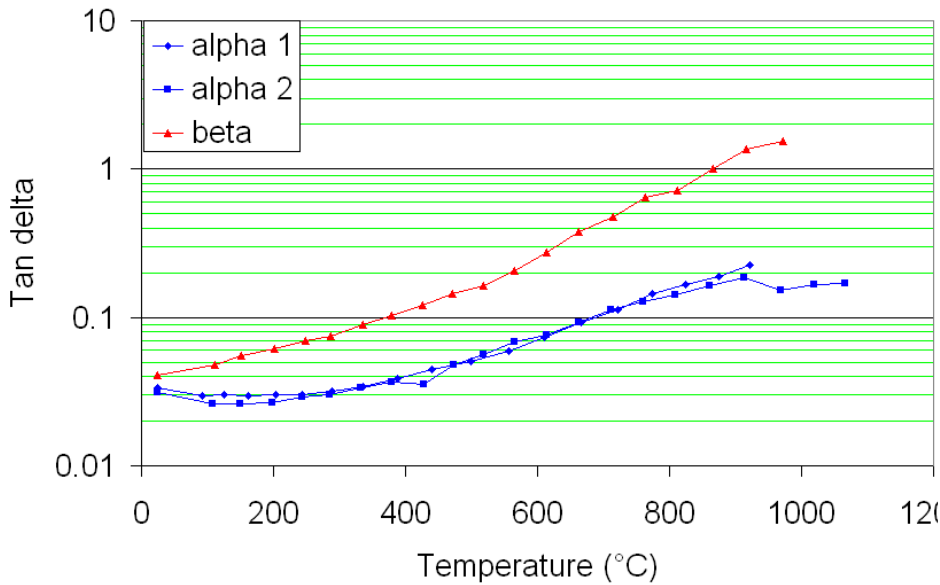
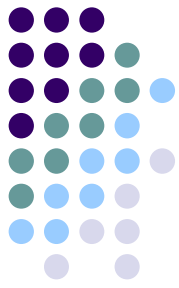
20°C 2.45 GHz	Alumina	Zirconia	Silicon Carbide	Aluminum (bulk**)
Tan δ	0.001	0.015	0.02-1.05	∞
Penetration Depth (m)	12.8	1.0	0.004 - 0.05	0.000001

* Magnetic field may also induce currents leading to heating

** Powder metals have measureable dielectric properties

SiC Dielectric Data

Alpha and Beta Phases



SiC Study Comparisons



- Alpha vs. Beta
 - Superior Graphite SiC powders
- 6H vs. 4H/6H polytypes
 - Different alpha phases from different positions in electrode process
 - Co-precipitated with 10% $Y_2O_3-Al_2O_3$



Experimental Set-up

RT: Heat 15 min at 500 W

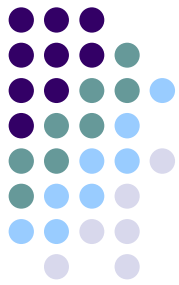
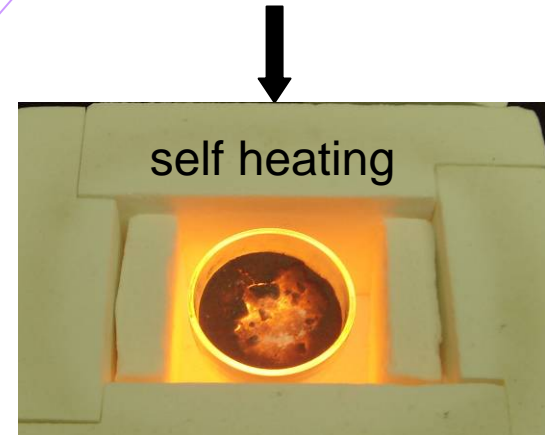
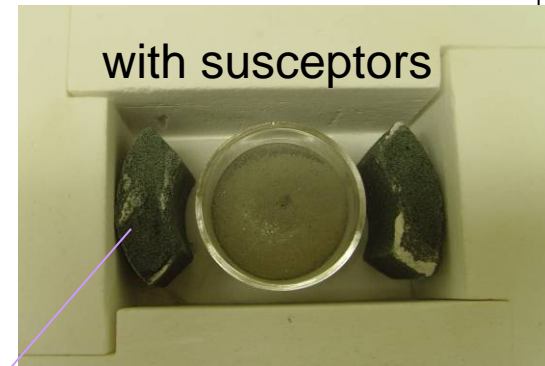
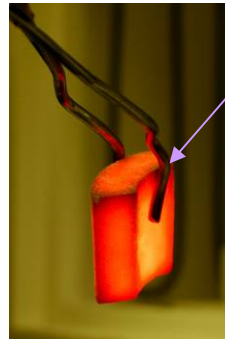
600: Heat to 600 °C w/ susceptors

Hold for 10 min

Remove susceptors

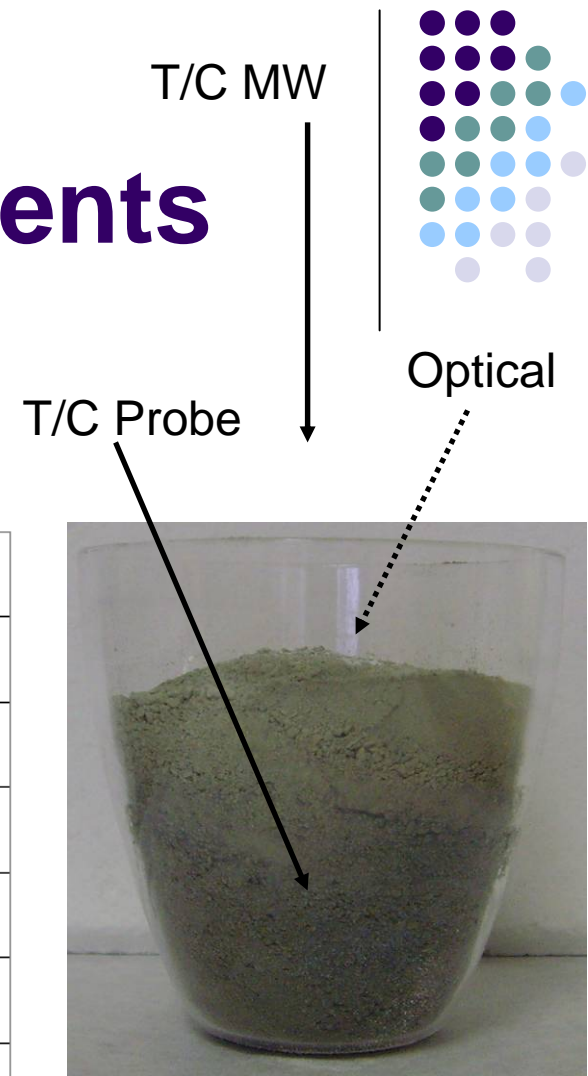
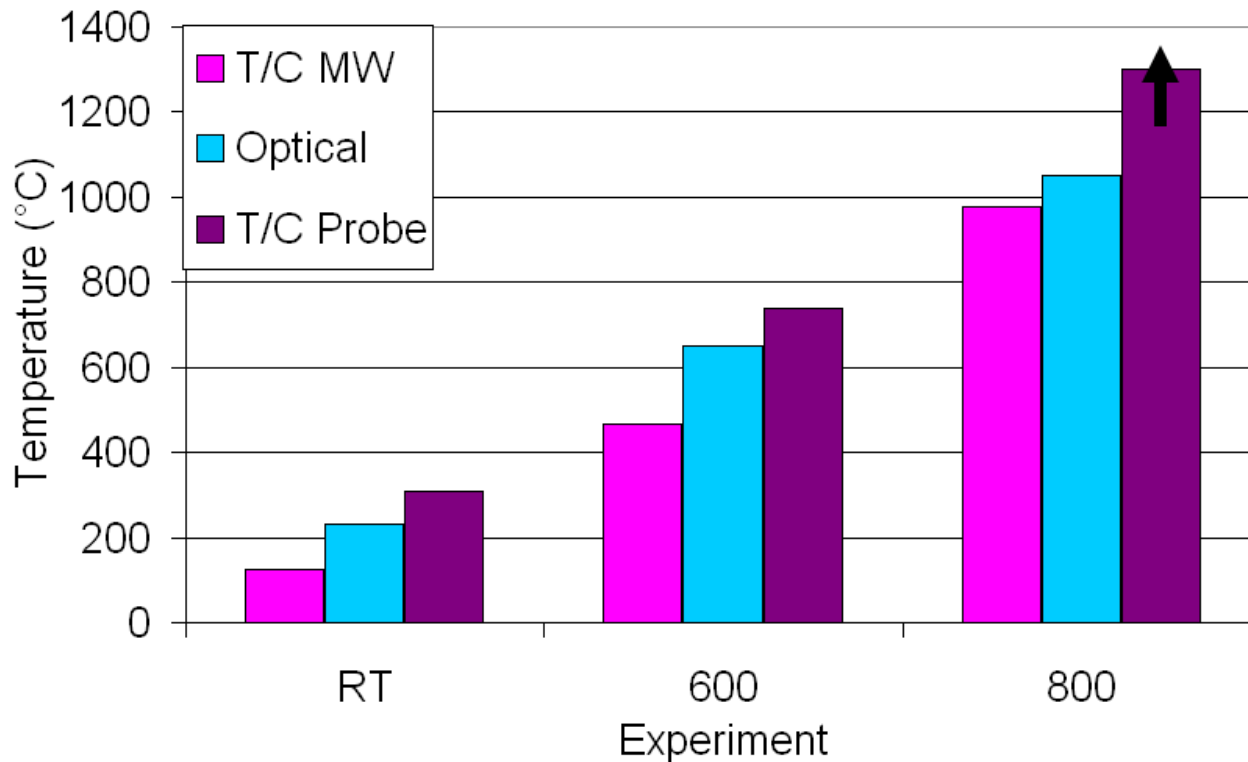
MW at 1000 W

800: same as 600 but to 800 °C



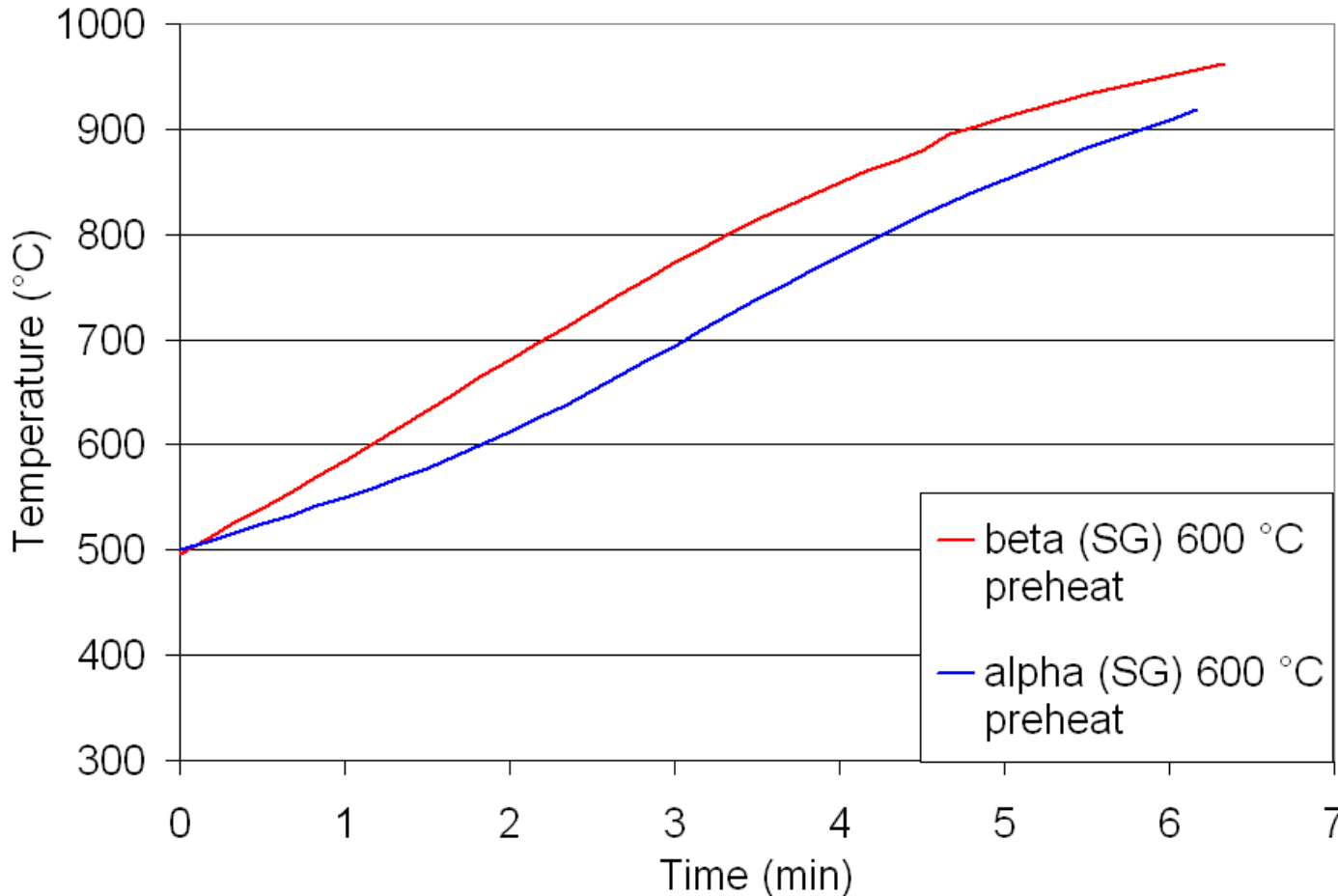
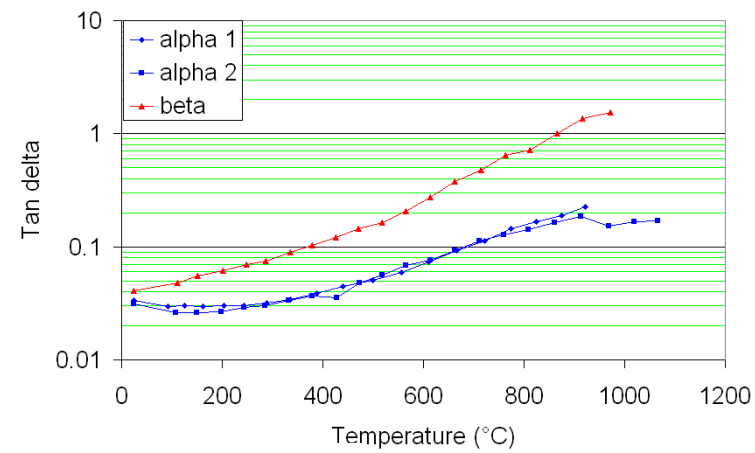
Temperature Measurements

Maximum Temperature Achieved with alpha 6H SiC



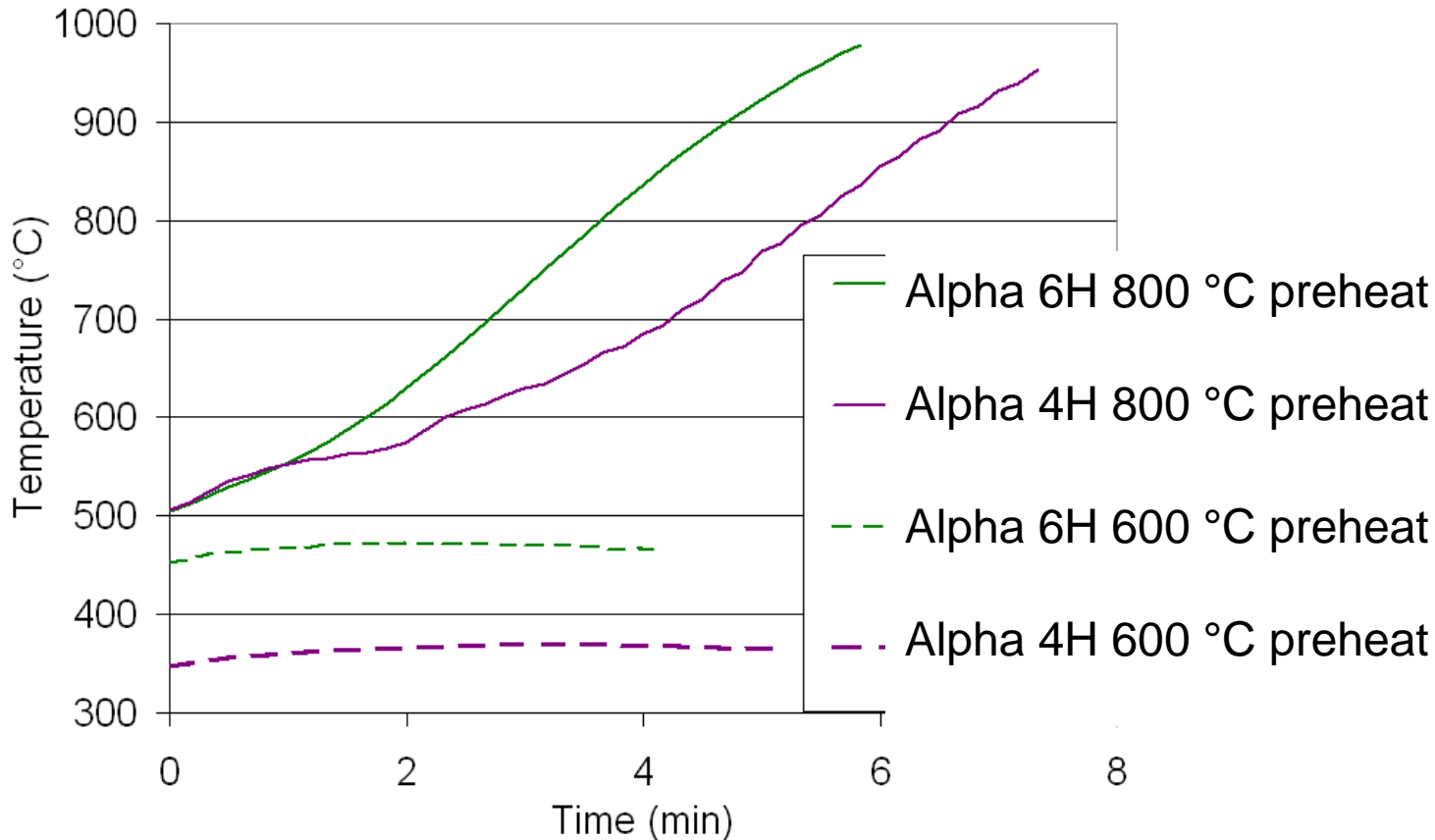
SiC Self Heating

Alpha vs. Beta susceptor pre-heat



SiC Self Heating

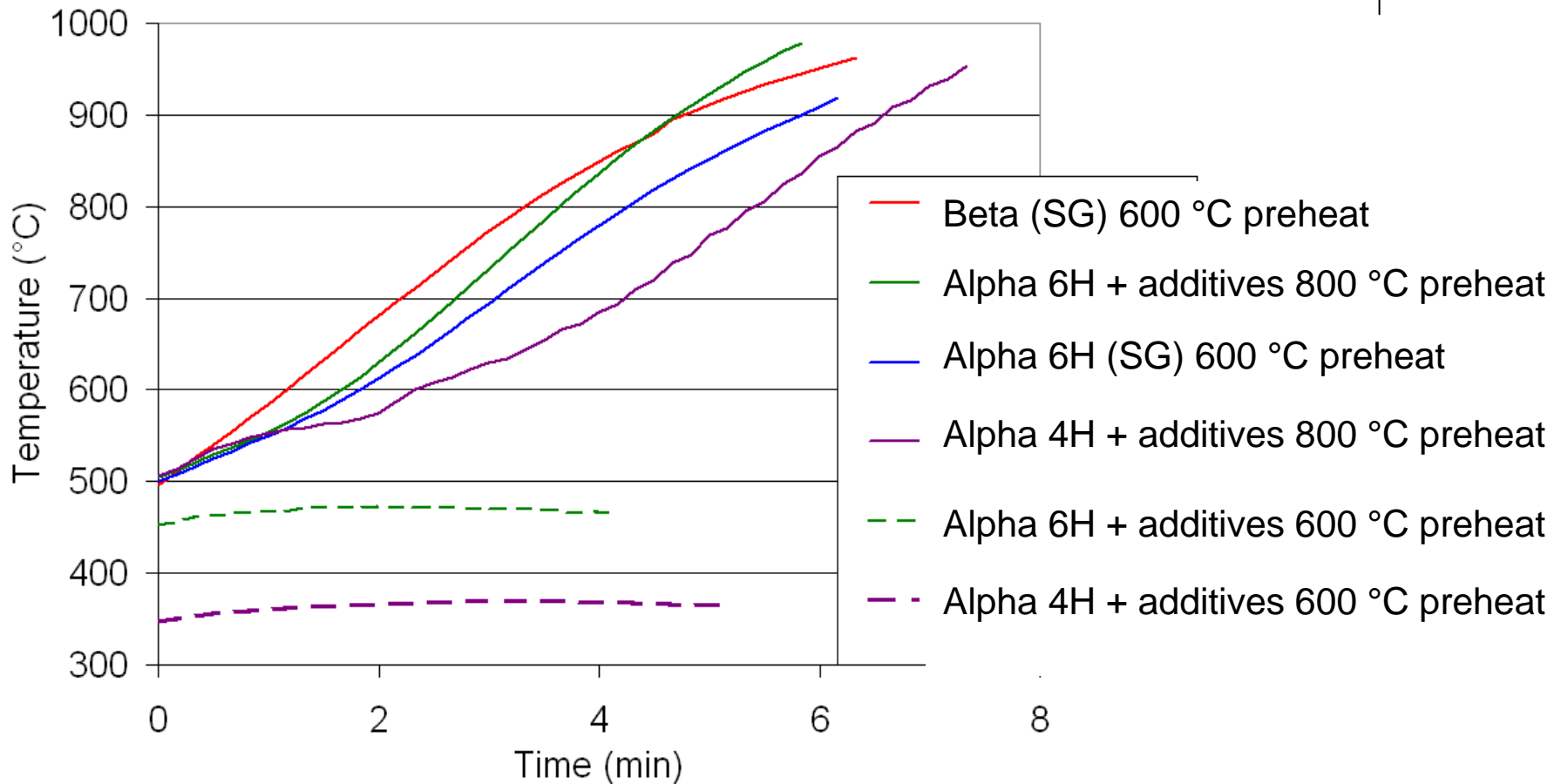
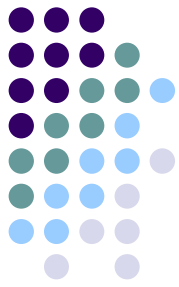
6H vs. 4H w/ susceptor pre-heat



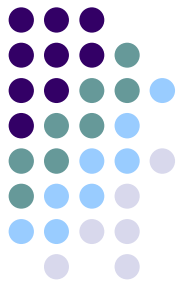
- Powders with co-precipitated additives
- 6H heated better compared to 4H mix

SiC Self Heating Overview

after susceptor pre-heat

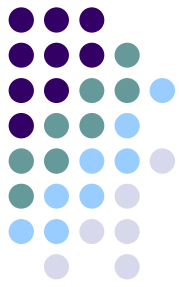


Conclusions and Future Work



- Phase, polytype and additives effect heating
- Need more extensive dielectric testing
- Self heating studies to 1700 °C atmosphere control MAT™ kiln
 - Effect of phases and additives
- Ultra High temperature thermal package design for >1800 °C
 - 2 stage sintering
 - Liquid phase sintering

Acknowledgements



Dr. Ron Hutcheon
Microwave Properties North