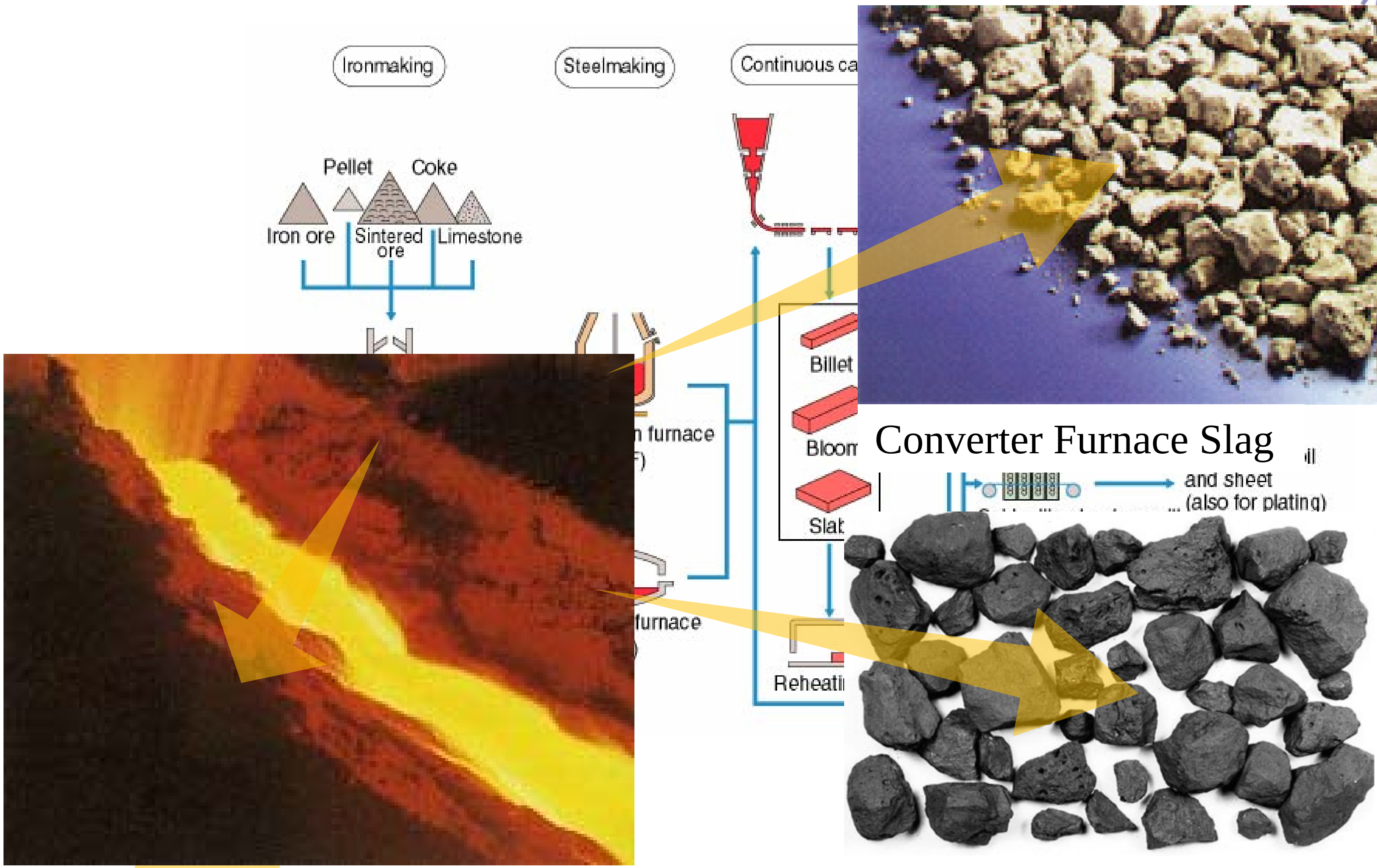
Microwave Treatment of Blast Furnace Slag

The Univ. of Tokyo
Institute of Industrial Science
Morita Lab.

Tomonori KUROKI and Kazuki MORITA

Introduction

Iron- and Steelmaking



Converter Furnace Slag

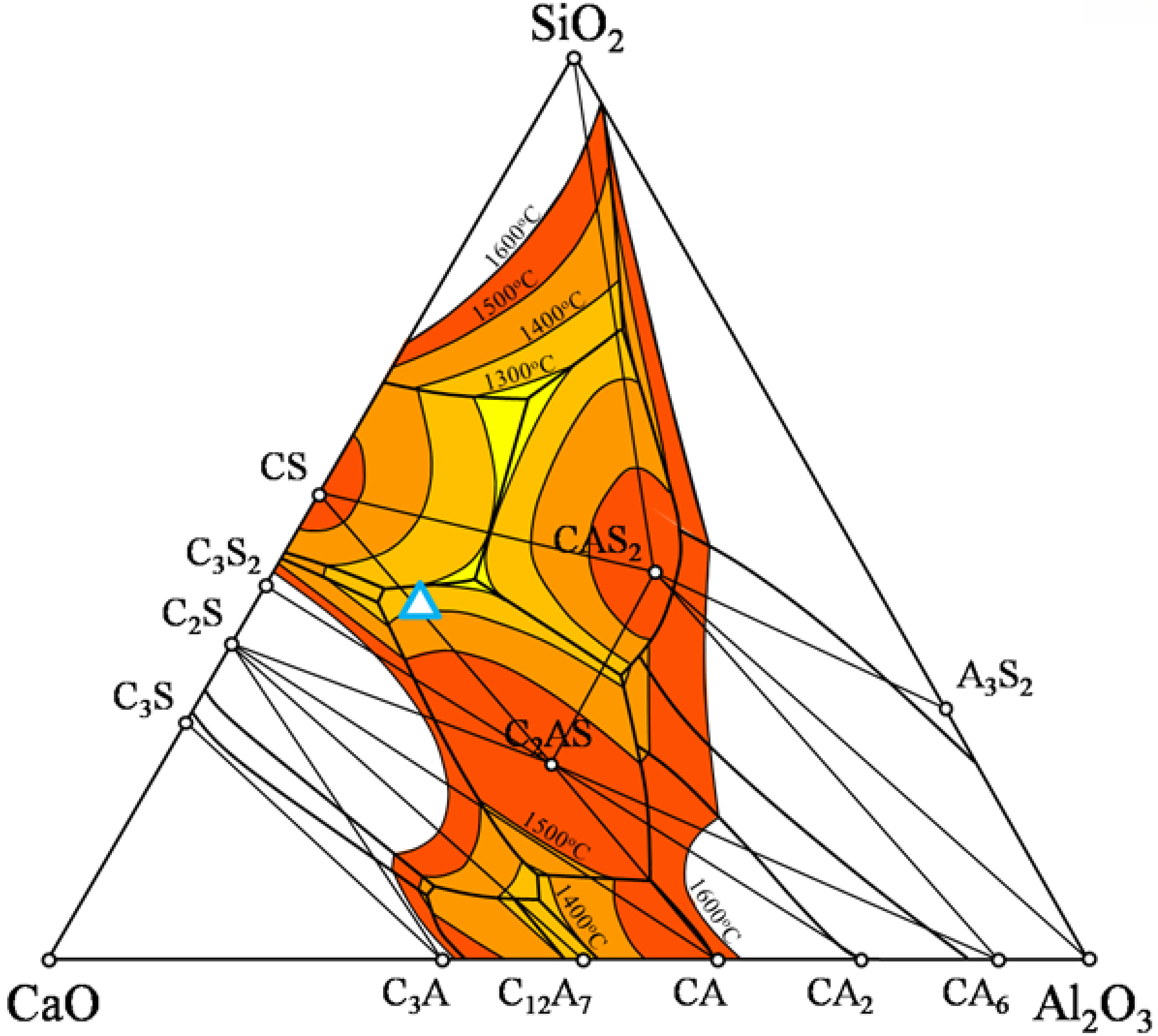
Blast Furnace Slag

Electric Arc Furnace Slag

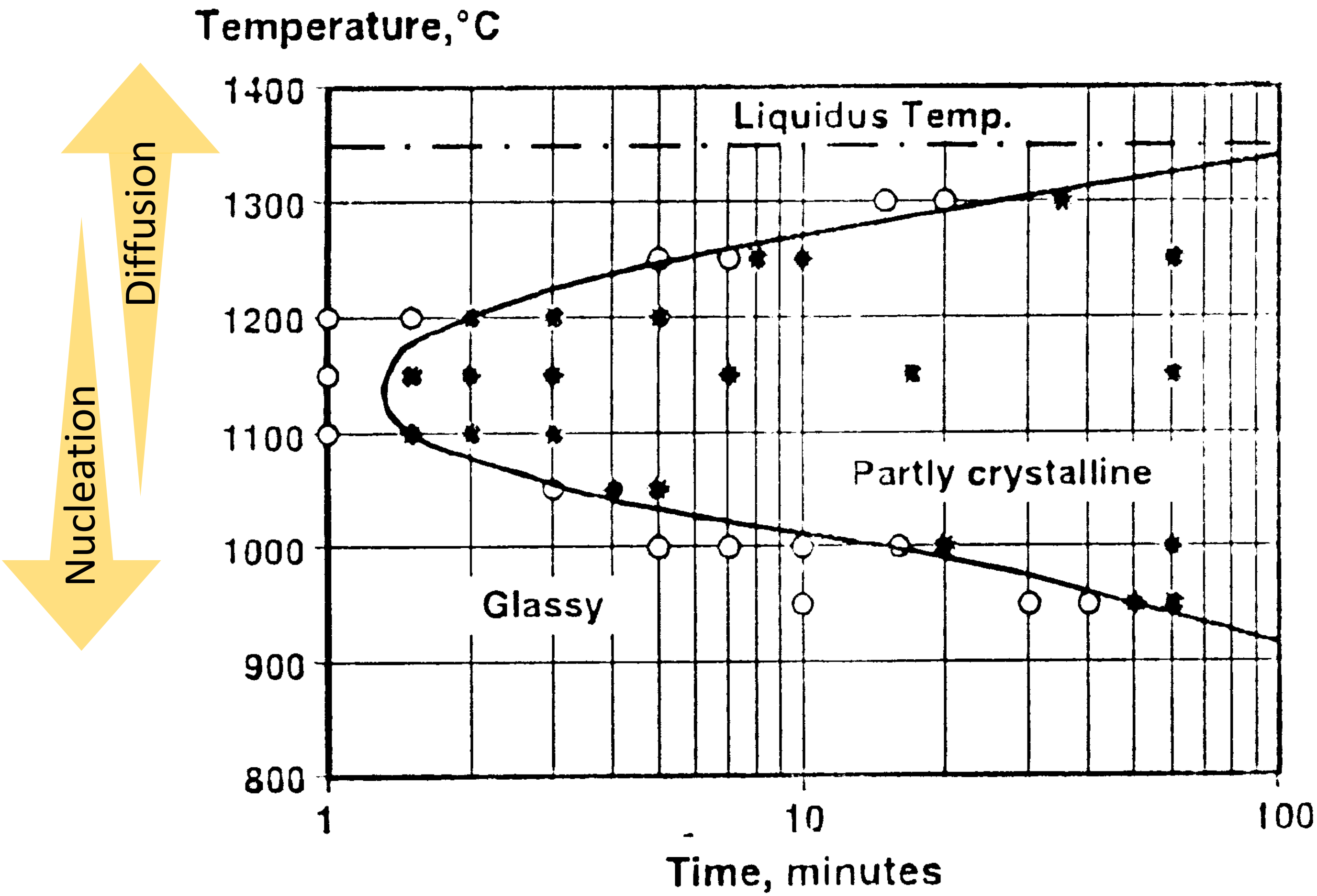
Blast Furnace Slag

- Water-quenched slag
  - Glassy state
  - Hydraulic Material
- Slowly-cooled slag
  - Well-crystallized state
  - High compressive strength

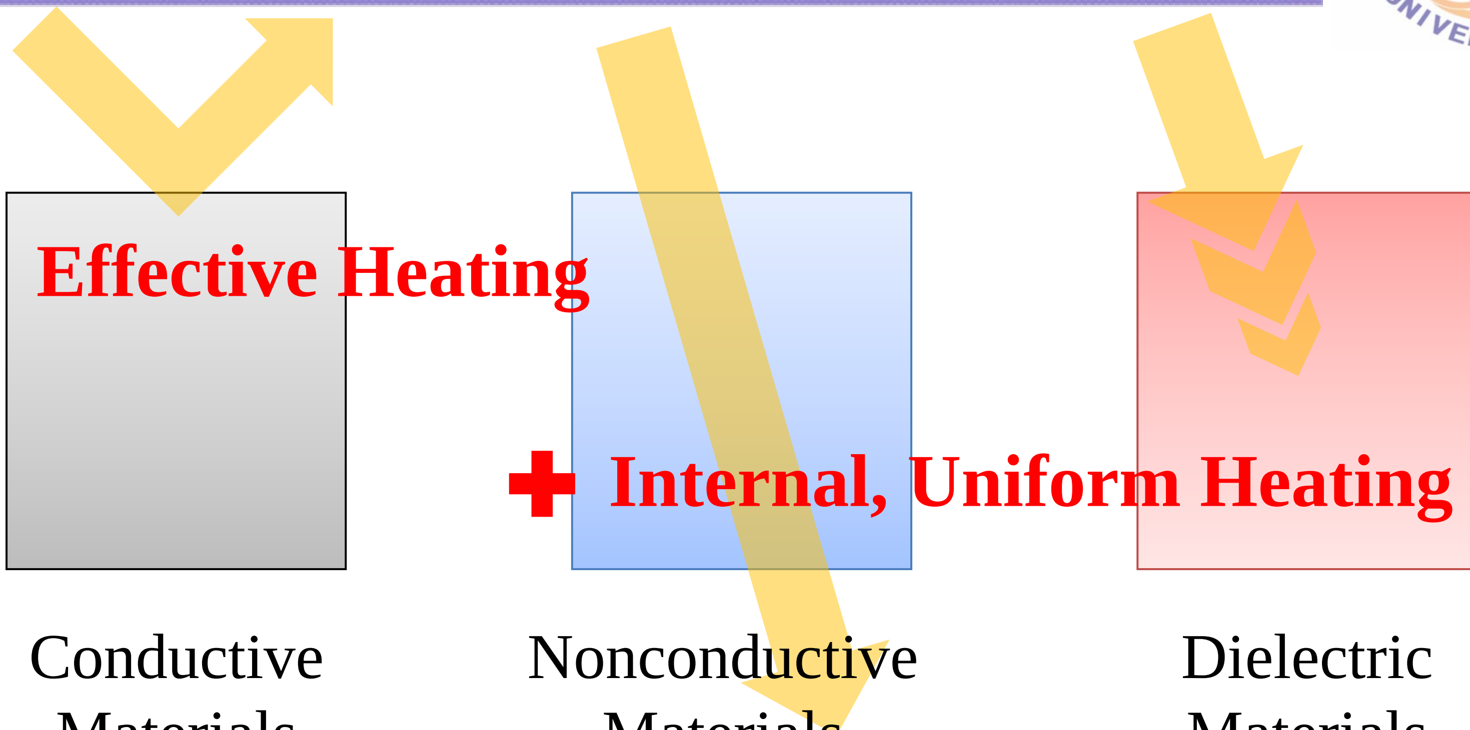
Composition of BF Slag



Crystallization of BF Slag



Microwave Heating



Conductive Materials (Metal)	Nonconductive Materials (Glass, Ceramics)	Dielectric Materials (SiC, Water, etc.)

✚ **Non-thermal Effects**

Millimeter Wave Heating

Compare to 2.45GHz centimeter wave…

- 28 GHz millimeter wave
  - can achieve more uniform heating due to its short wavelength
  - can also heat up metals
  - has stronger non-thermal effects

Objective of This Work

- Can microwaves accelerate the crystallization of BF slag?
- Are there any differences between 28GHz millimeter wave and 2.45GHz?
- Do the impurities and crystalline phases affect the heating behavior of slag?

Experimentals

Slag Samples

Mixing
CaO, SiO_2, Al_2O_3
(+ impurity)

↓

Premelting
1500°C, 20 min

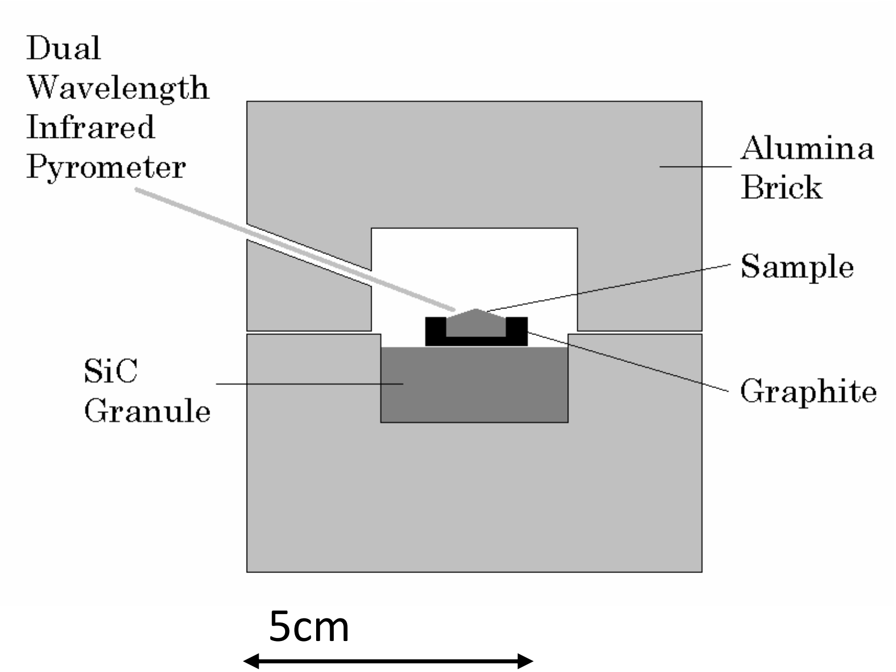
↓

Crushing
74~149 µm

- Synthesized slag
  - 40wt%CaO-40wt%SiO_2-20wt%Al_2O_3
- Actual water-quenched blast furnace slag
  - Composition (wt%)

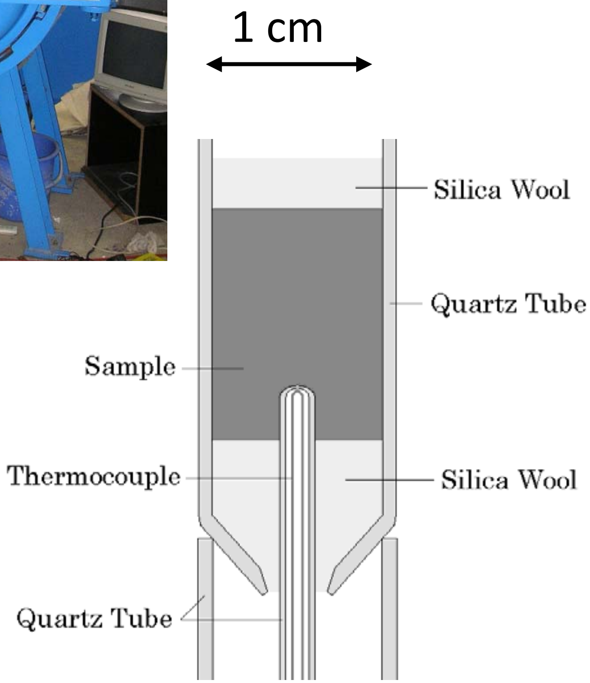
CaO	SiO_2	Al_2O_3	Others
43.2	34.5	14.0	8.3

Experimental Setup (2.45GHz)



- Commercial microwave oven (2.45 GHz, 1.6 kW, Multimode)
- Temperature control by switching of the micro-wave (0 kW/1.6 kW)
- SiC granule
- Dual wavelength pyro-meter

Experimental Setup (28 GHz)

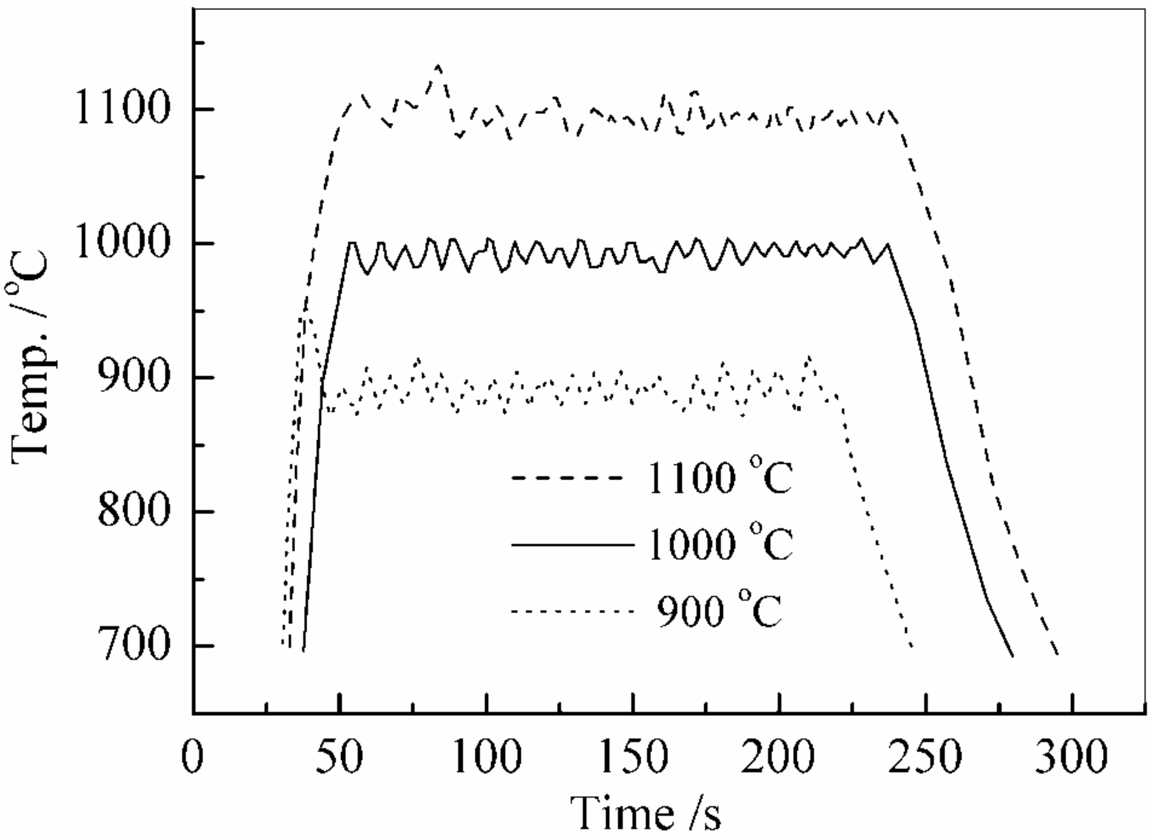


- 28 GHz microwave reactor with Gyrotron (~10 kW, 28 GHz, Multimode)
- Constant microwave power
- Sheathed thermocouple

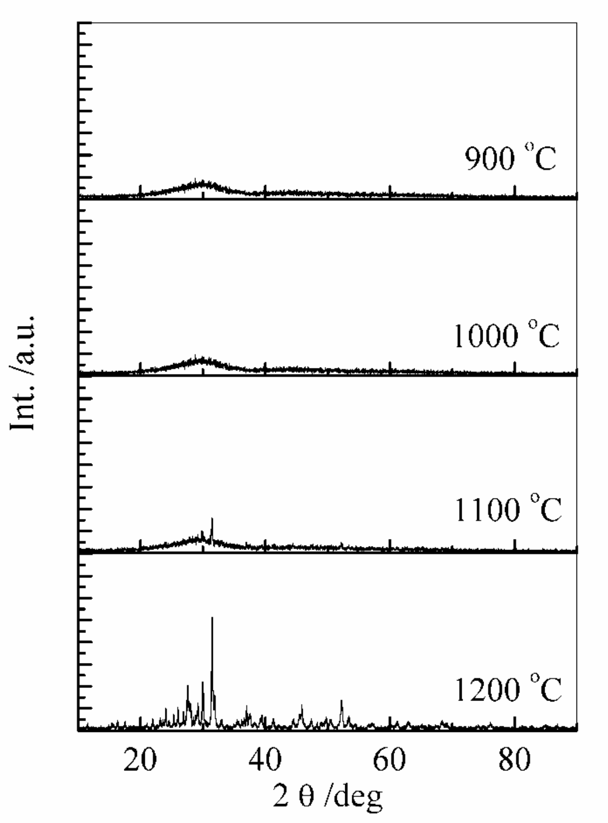
Results and Discussion

Part I - 2.45GHz vs. Conventional Heating
Part II - 28GHz vs. Conventional Heating
Part III - Further Inspection for 28GHz

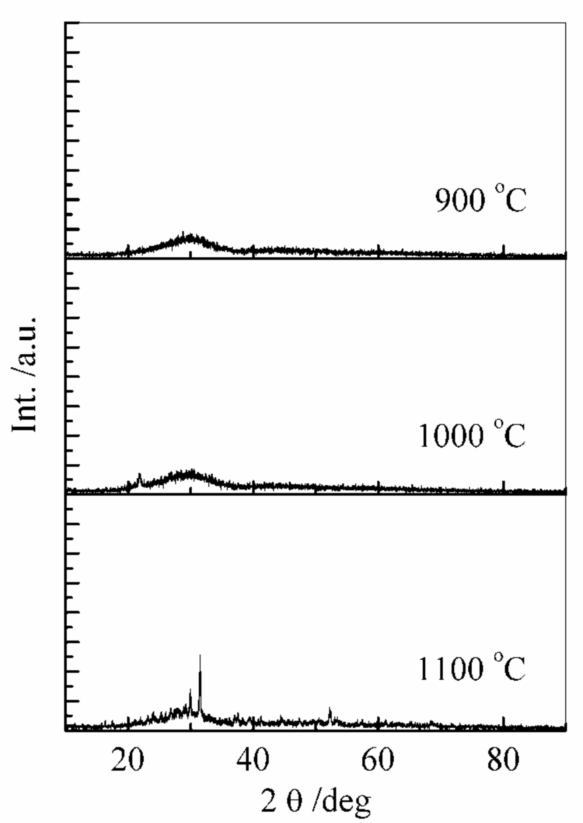
Temperature Behavior



XRD Results



Conventional heating
(Electric resistance furnace)

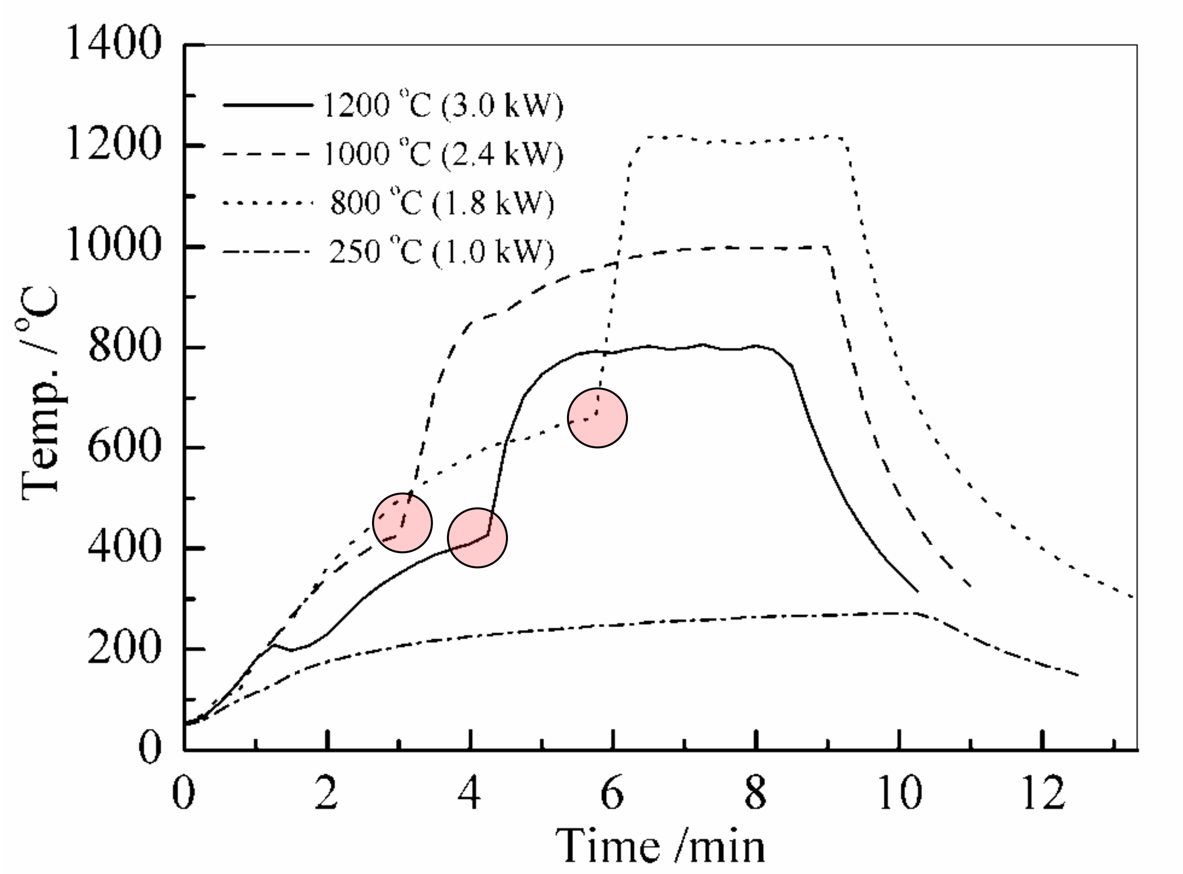


2.45 GHz hybrid heating

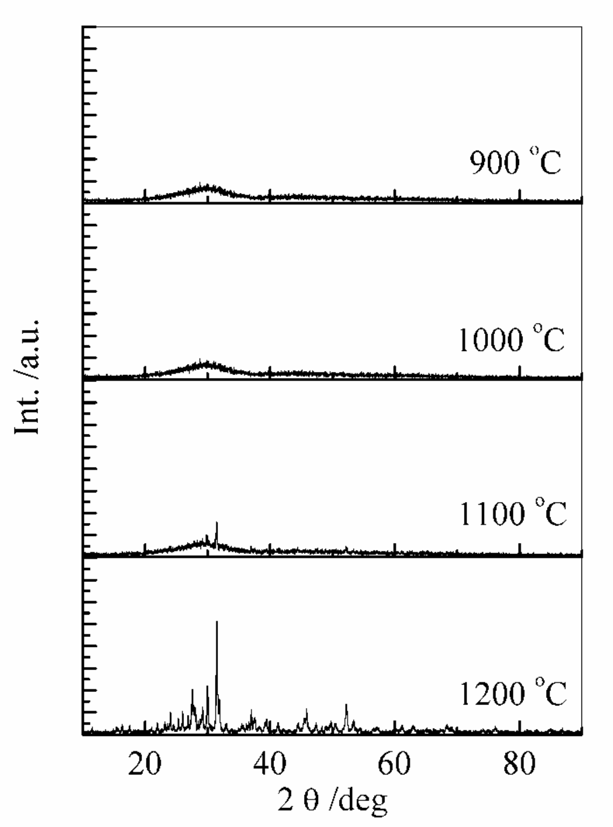
Results and Discussion

Part I - 2.45GHz vs. Conventional Heating
Part II - 28GHz vs. Conventional Heating
Part III - Further Inspection for 28GHz

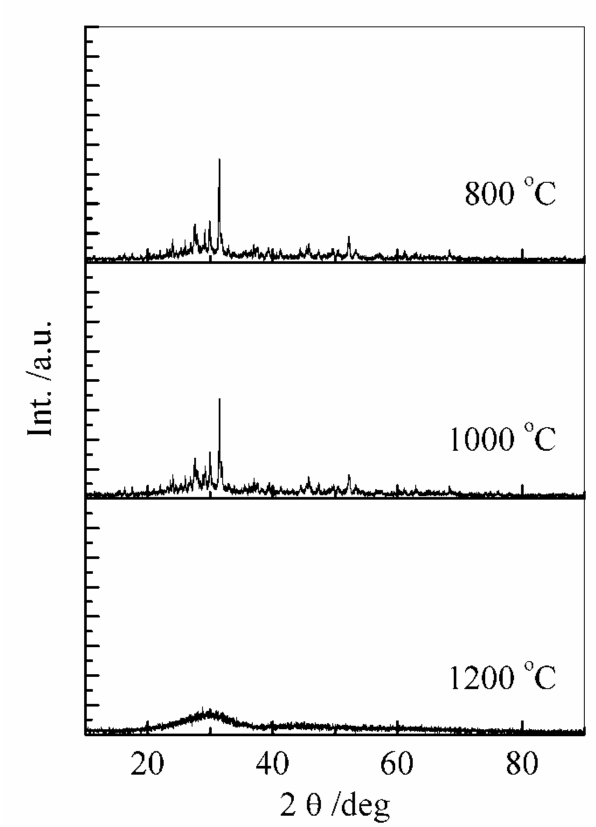
Temperature Behavior



XRD Results



Conventional heating
(Electric resistance furnace)

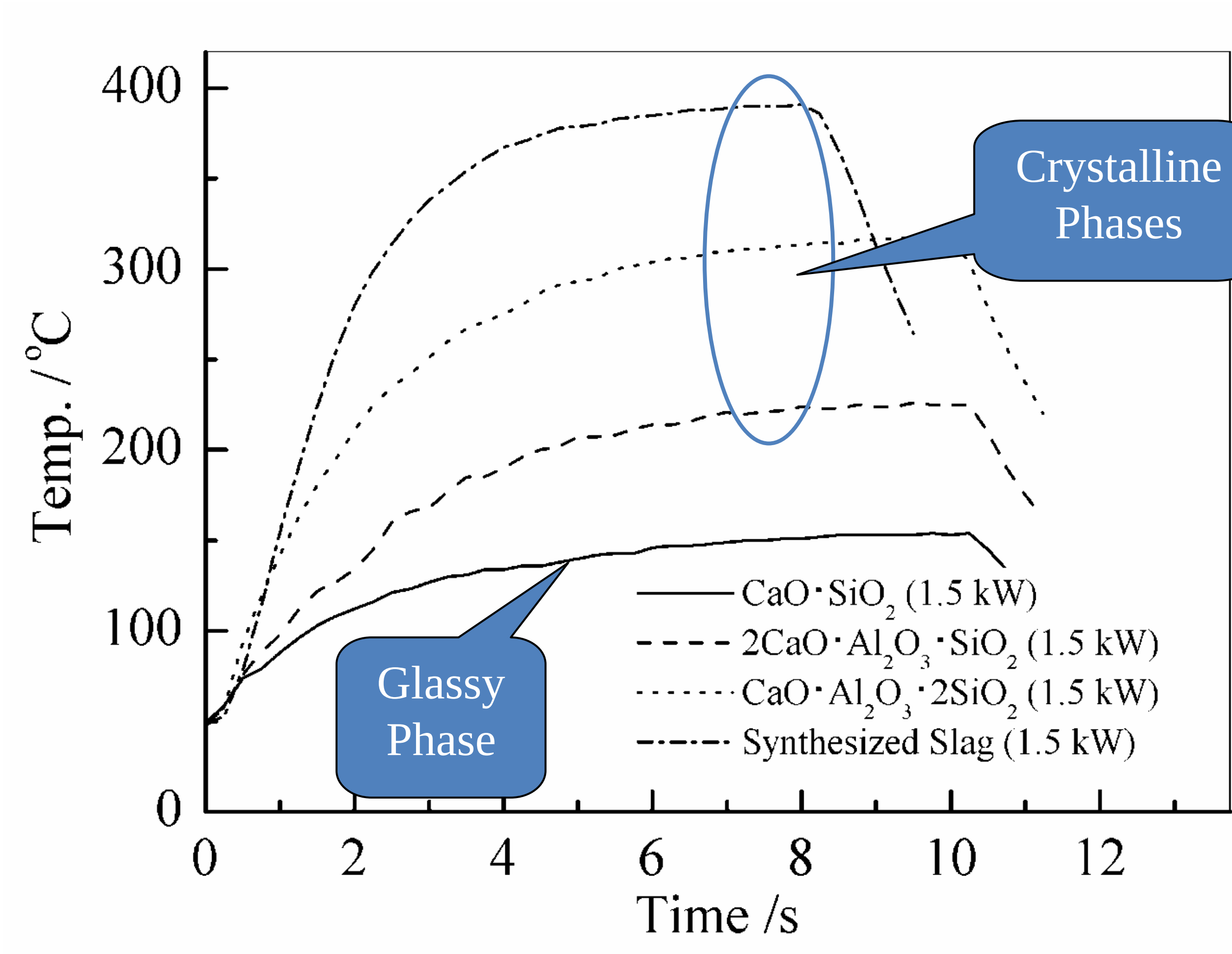


28 GHz microwave heating

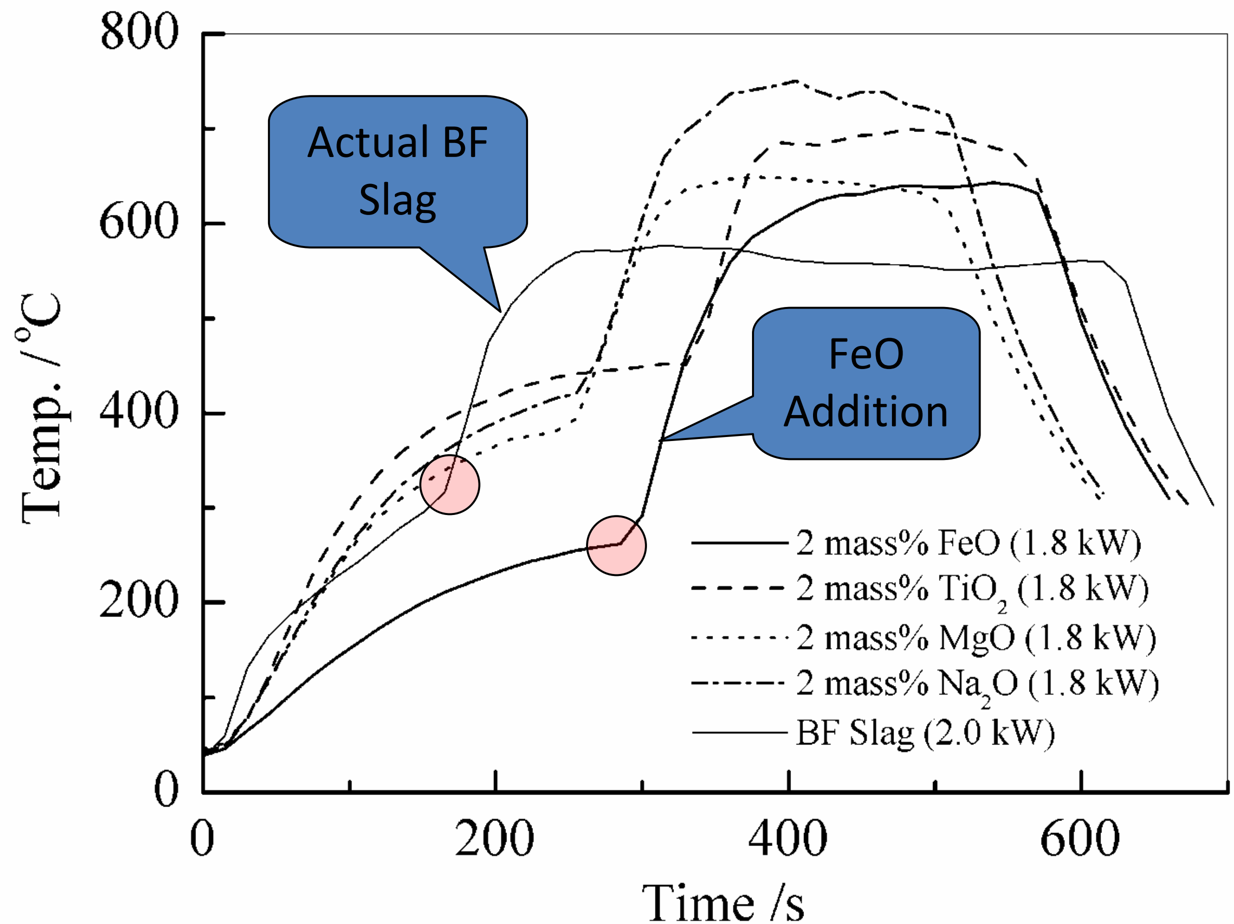
Results and Discussion

Part I - 2.45GHz vs. Conventional Heating
Part II - 28GHz vs. Conventional Heating
Part III - Further Inspection for 28GHz

Heating of Crystalline Phases



Effects of Impurities



Conclusions

Conclusions

- The 28 GHz microwave was able to heat up the $CaO-SiO_2-Al_2O_3$ slag sufficiently, whereas an auxiliary heat source (SiC granule) was required for the 2.45 GHz microwave experiment.
- While the effect of the 2.45 GHz microwave on the crystallization was not observed, the 28 GHz microwave was found to accelerate the crystallization, especially at lower temperatures.
- The temperature increases in the crystalline phases were slower than that in the glassy phase.
- A small amount of impurities caused the acceleration of the microwave heating.