

Mapping Applicator Uniformity: Microwave Sintering of Alumina and Zirconia

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Abstract:

Alumina and zirconia samples are sintered to > 99% theoretical density in less than 1 hour total cycle time.

The study investigates the effects of input power and cycle time on heating rates, microstructure, density and mechanical properties (hardness and MOR). Properties are compared to conventional sintering conditions, which resulted in similar densities. In addition the effects of various sintering conditions, e.g. location of sample within the microwave chamber (hot spots), number of samples within a given insulation box, number, shape and position of various SiC susceptors, and aging effects of the insulation as well as susceptors, are investigated.

Experimental Procedure

Powders: ZrO₂ Tosoh TZ3YS, (Al₂O₃ Alcoa A16, or Malakoff)

Pressing: 5 g powder in 1" diameter floating die at 8000lb \cong 6280 psi = 43.3 MPa; followed by iso-pressing at 60,000 psi = 400 MPa

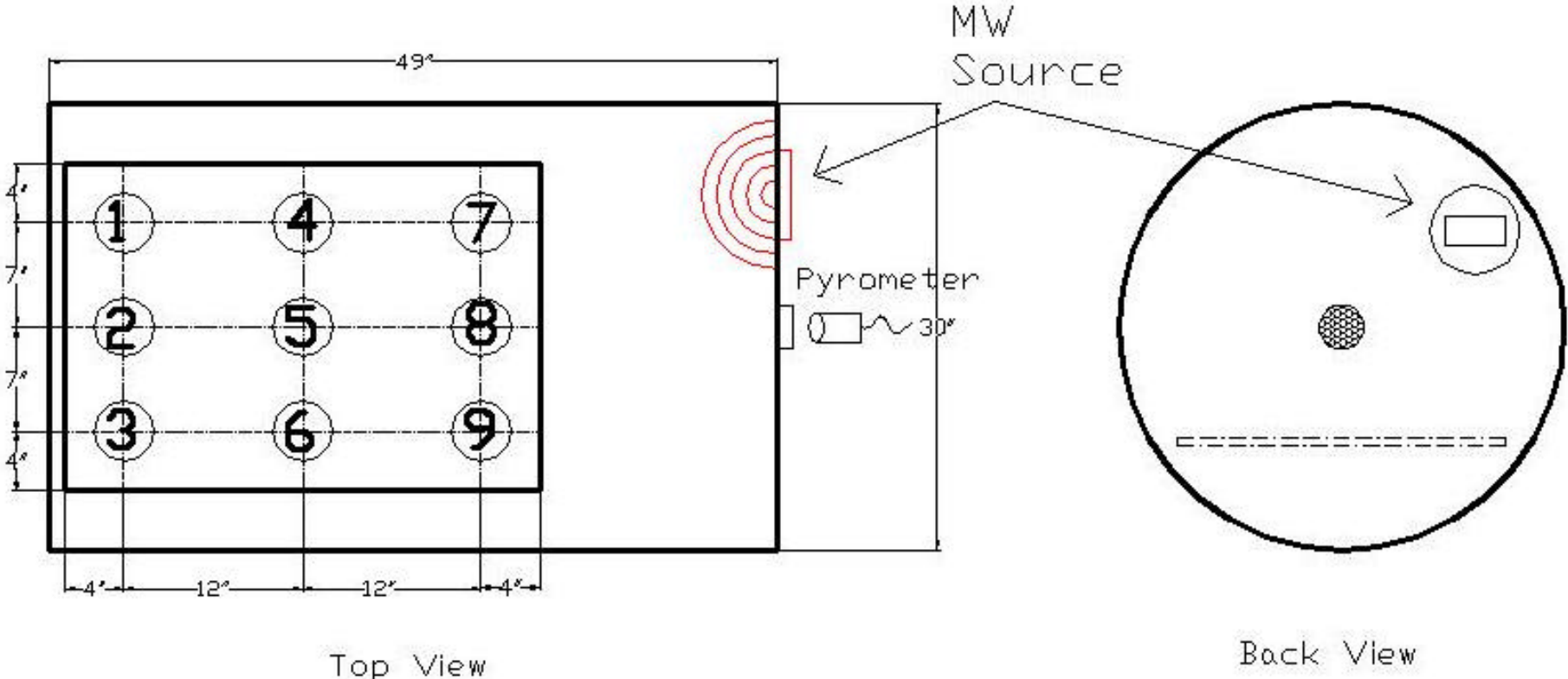
Conventional Firing: in dilatometer at 5°C/min heating and cooling

Microwave Firing: of individual pellets placed inside a 3" ID, 4" OD AL-30 cylinder with Eco-25B top and bottom covers (Zircar) using 2 SiC-35 Thermceptors (RMS). The box was positioned at different places inside the 2' x 4' 2.45 GHz microwave chamber (CPI Autowave), then applying specific power-time profiles.

Sample Temperature: recorded with an optical pyrometer (Raytek MA2S-C-SF, calibrated between 350 and 2000°C)

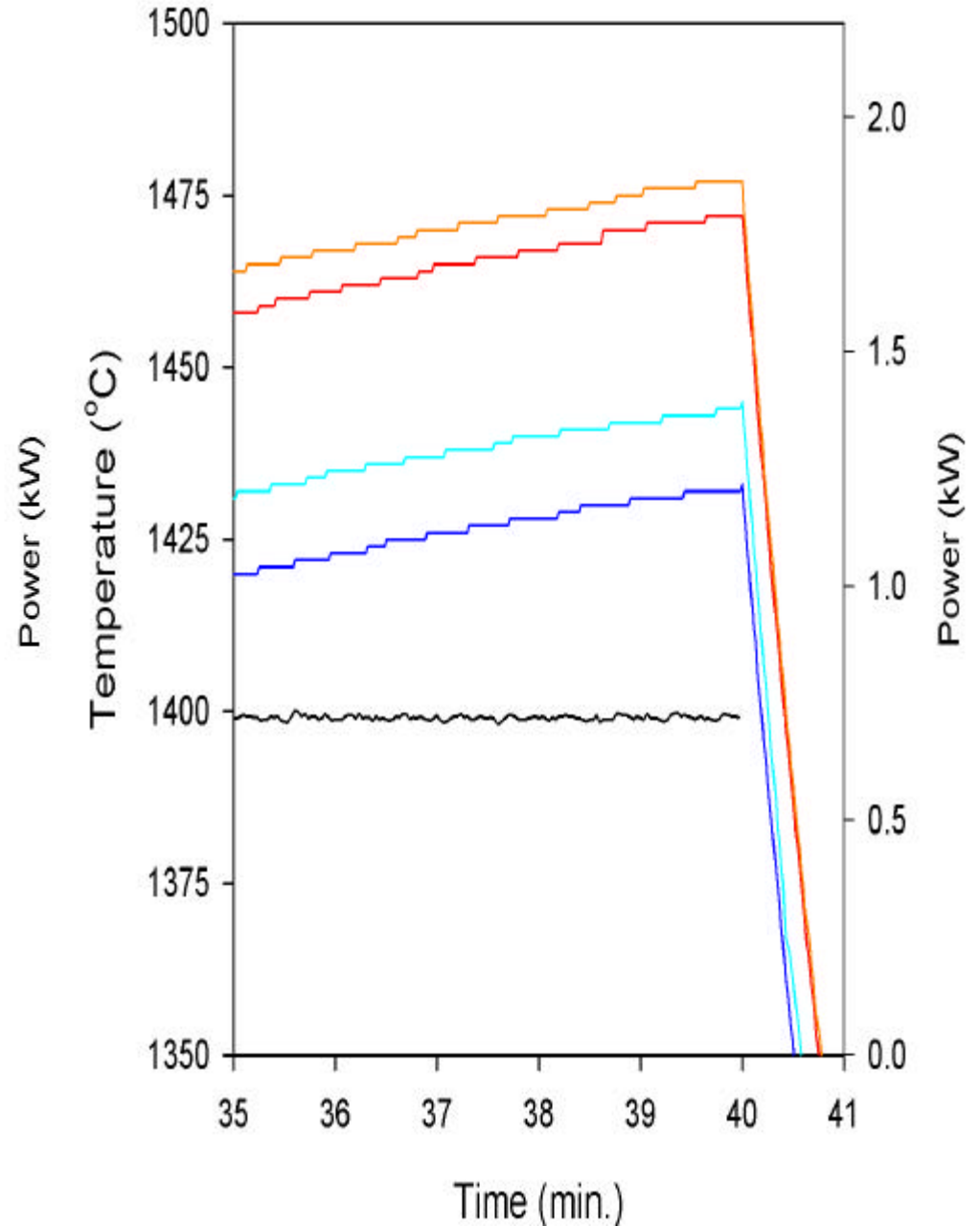
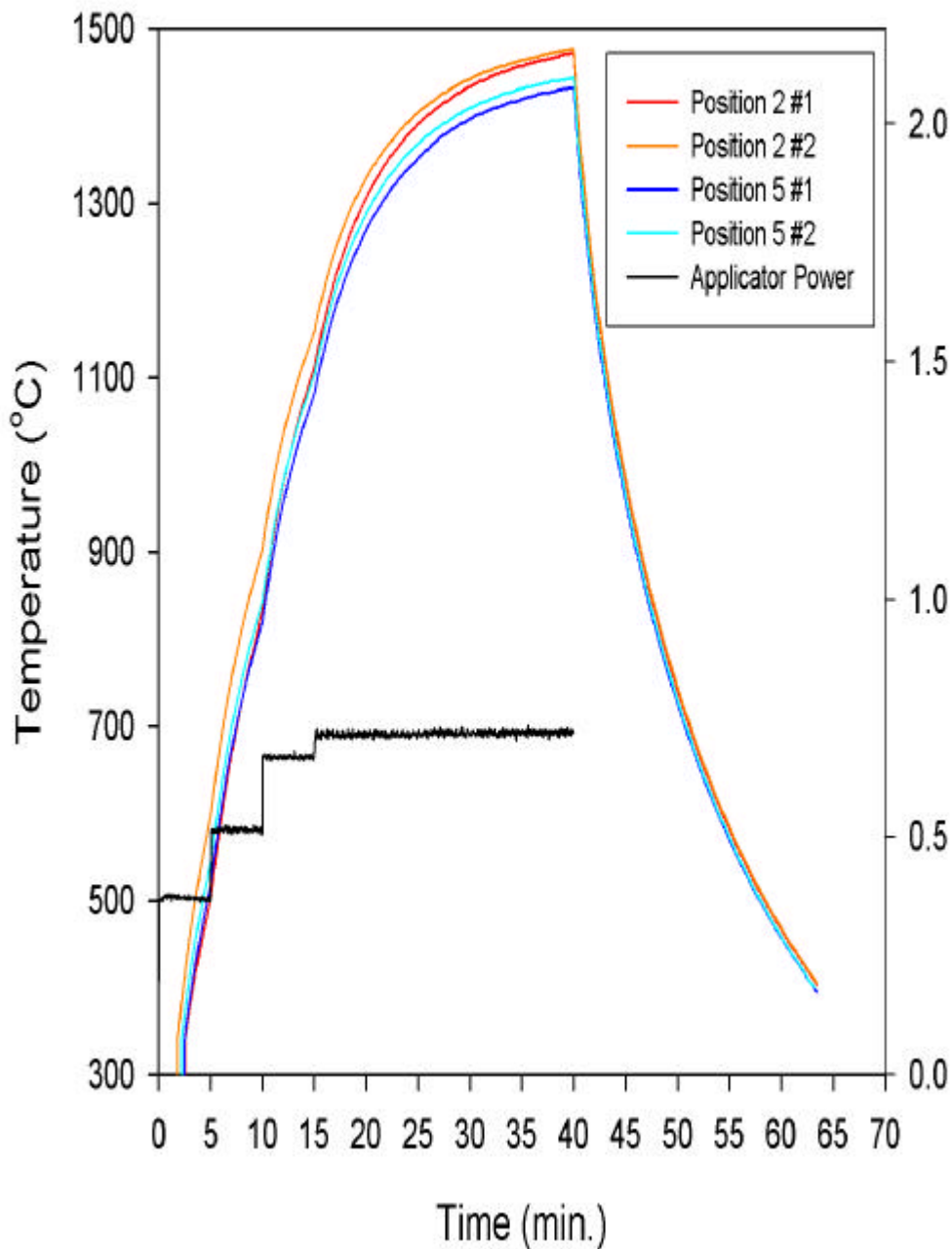
Density: Measured from geometric dimensions as well as using Archimedes technique; assuming 6.06 g/cm³ as theoretical density.

MW-Furnace Dimensions & Test Positions:



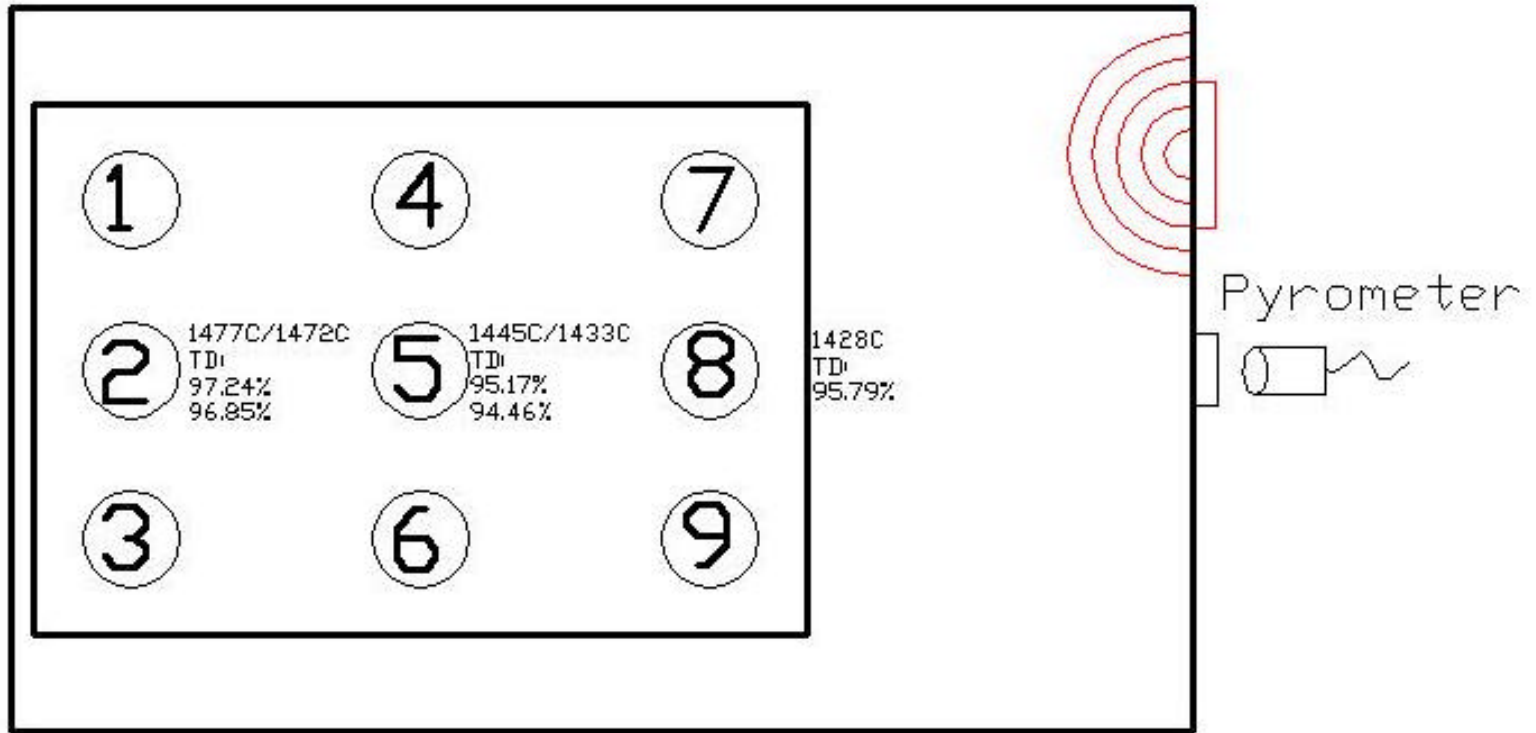
Results: Zirconia Tosoh TZ-3YS

Power – Temperature Profile:



Max. Temperature and Density at constant Power Profile:

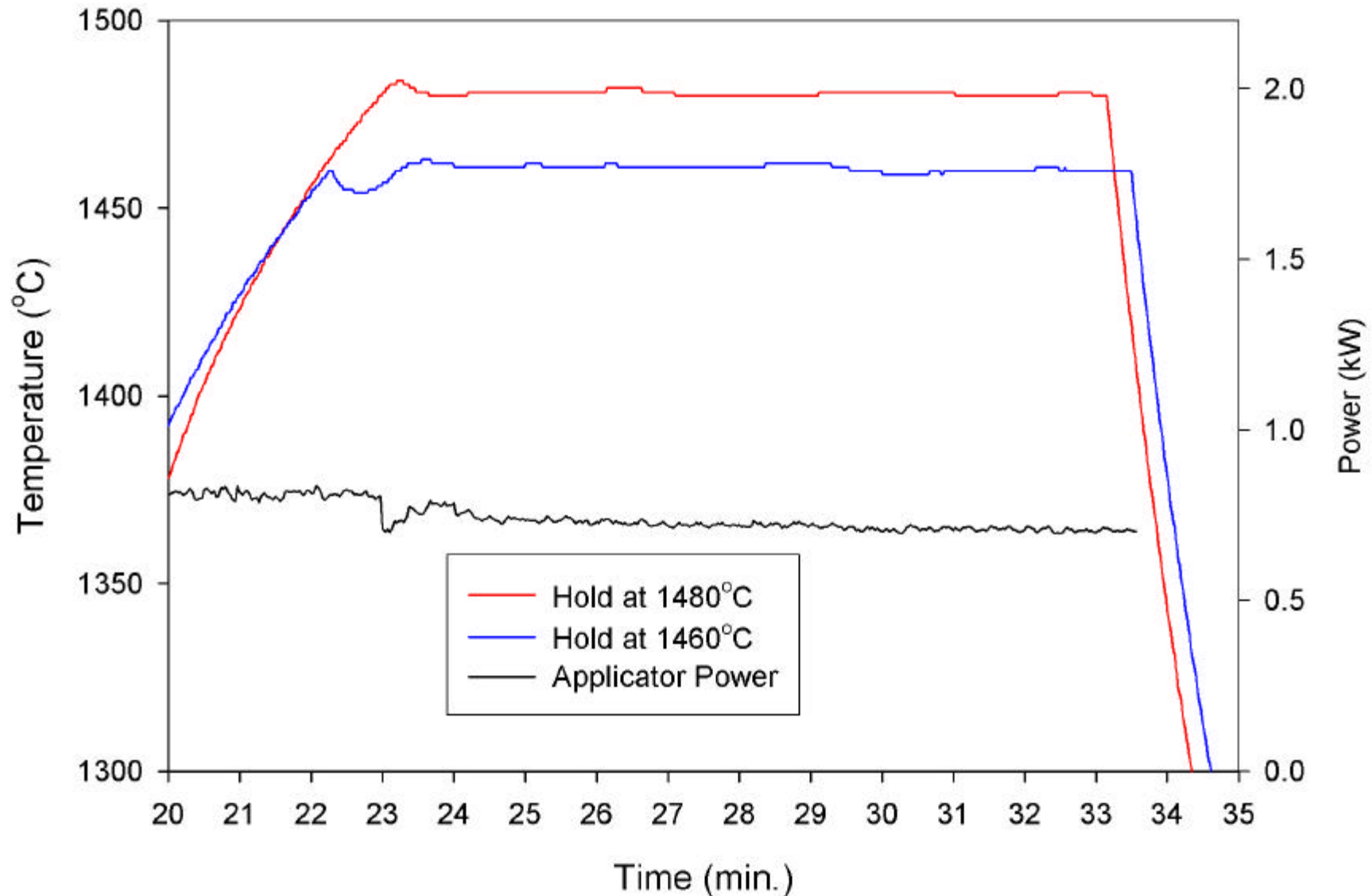
5 min at 20% → 5 min at 25% → 5 min at 30% → 25 min at 33%



Top View

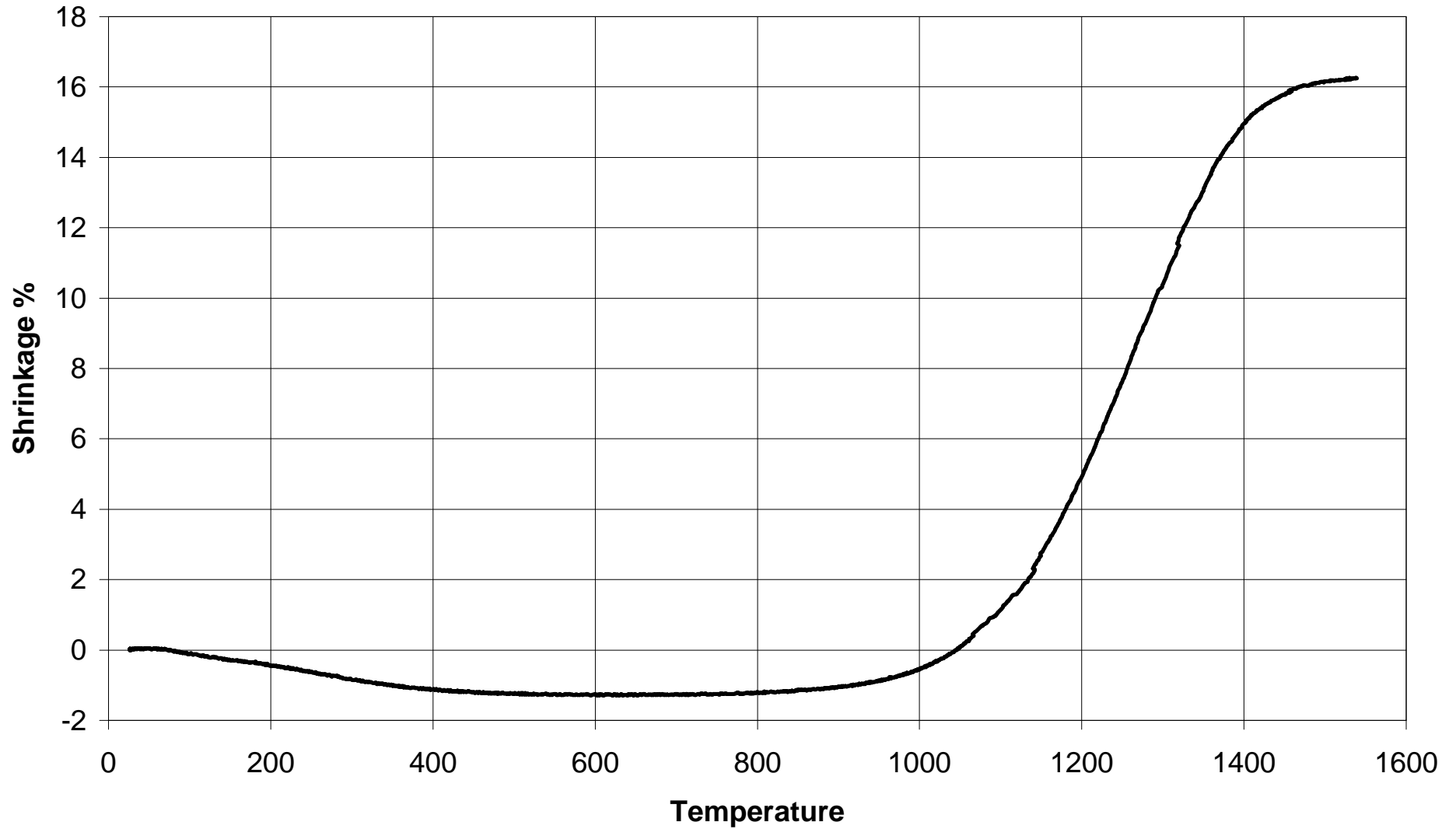
Density variation with max. Temperature in Position 2:

5 min at 20% → 5 min at 25% → 5 min at 30% 5 min at 35% → until 1480°C at 40%
1460°C



Dilatometry:

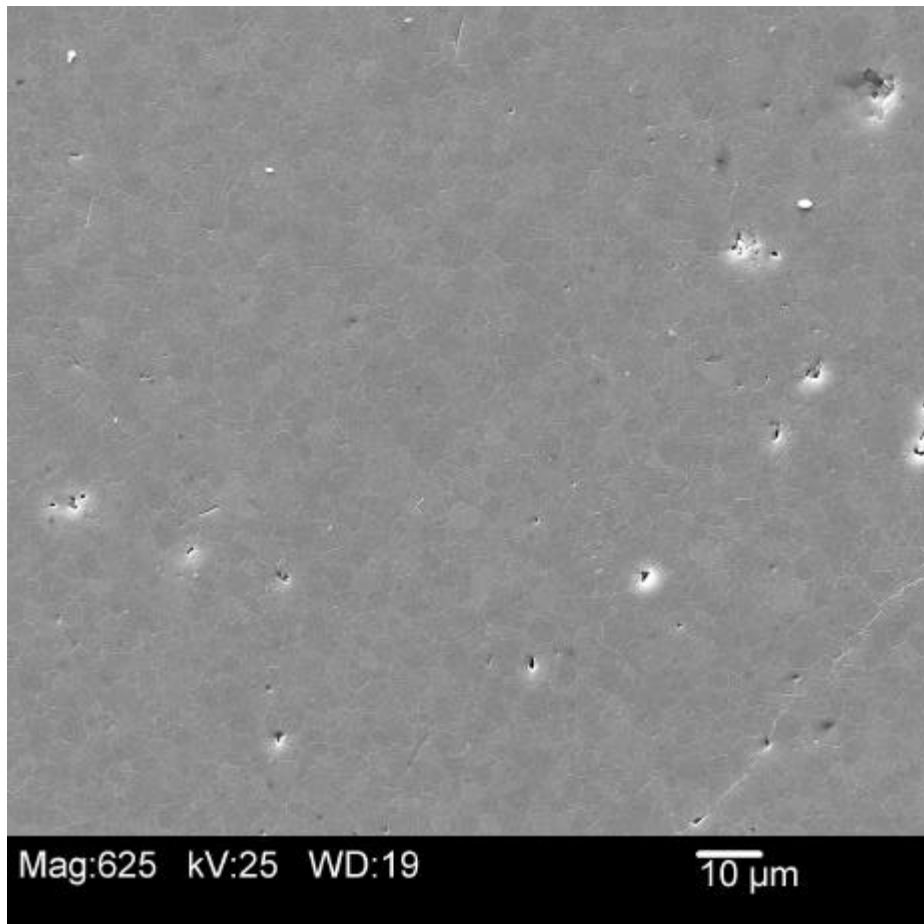
Conventionally sintered Tosoh TZ-3YS at 5°C/min to 1540°C



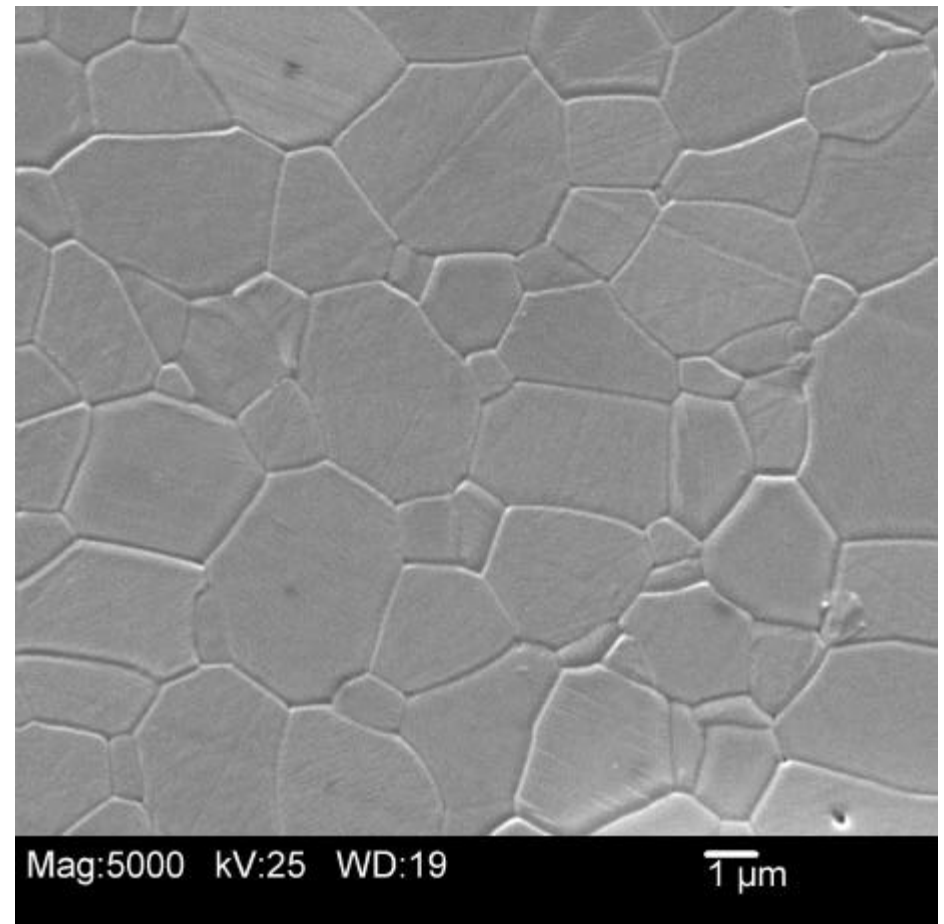
Microstructure: Baikowski Malakoff alumina

Microwave Sintered 5min at 33%, 5 min at 39%, 35 min 43%

Polished



Thermally etched surface



Future / Ongoing Work

- Fully characterize all samples with respect to density, microstructure and mechanical properties.
- Complete position-study with more repeat tests.
- Study effect of number of pellets in one refractory box.
- Study cross influence of having several refractory boxes in the microwave chamber at the same time (position, number).
- Effect of different SiC susceptors (supplier, size, and shape).
- Aging effects of SiC susceptors.
- Aging effects of refractory box.

Acknowledgement

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