

Density Gradient Evolution In Alumina Powder Compacts During Sintering

Denise N. Bencoe, Christopher B. DiAntonio, and Kevin G. Ewsuk
Sandia National Laboratories, Albuquerque, NM 87185-1349
Torsten Rabe

Federal Institute for Materials Research and Testing, Berlin, Germany

Introduction

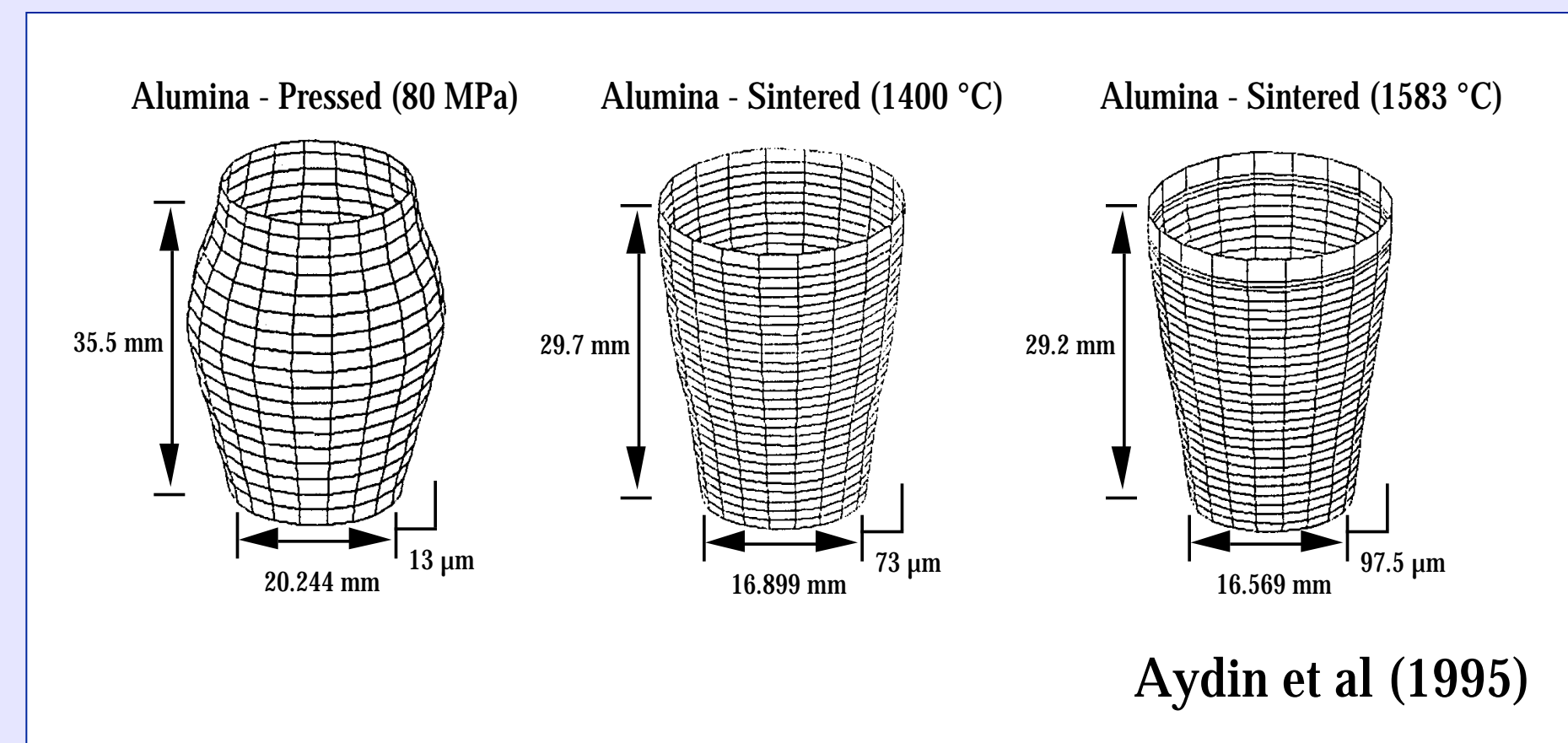
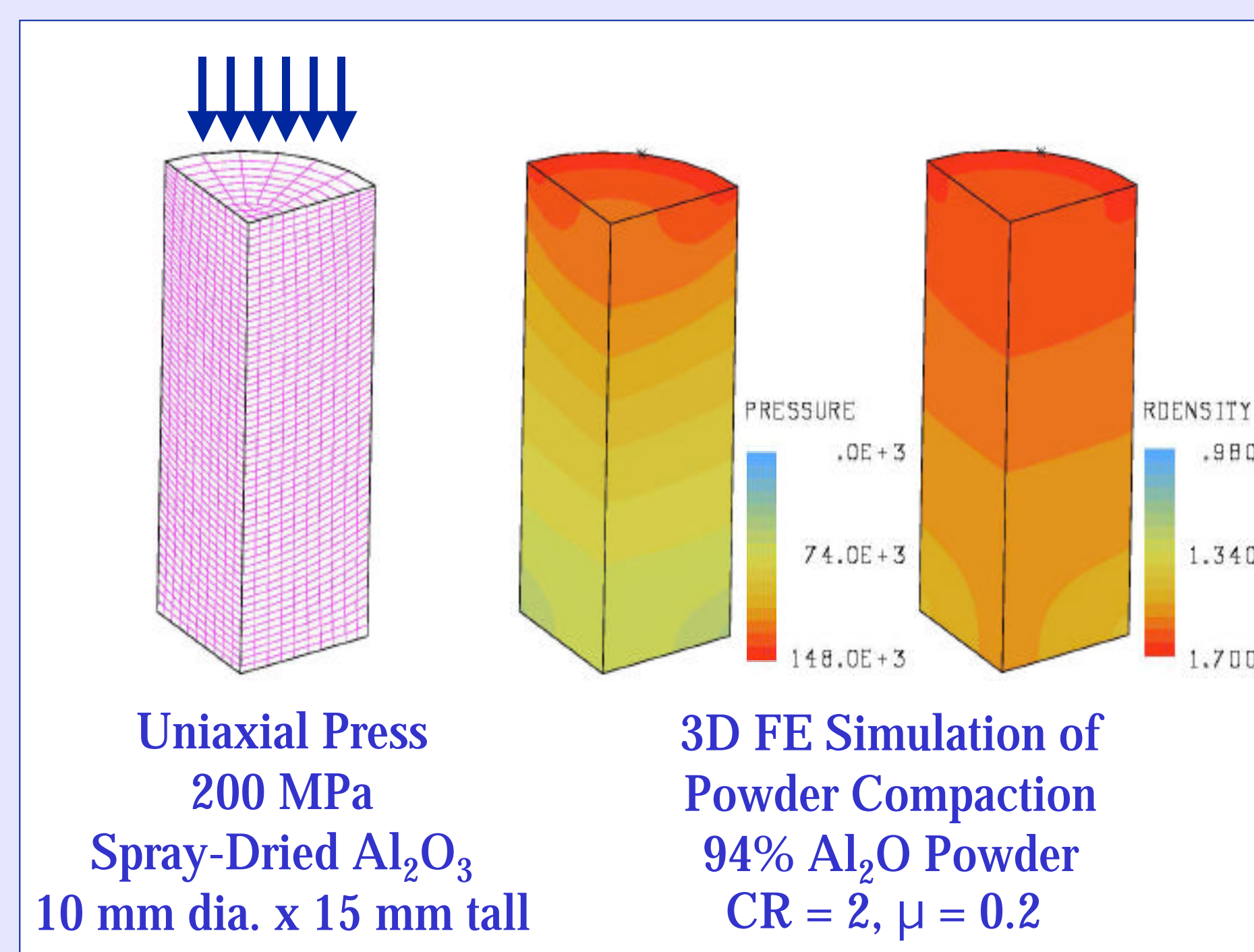
- Pressure gradients produce density gradients in compacts
- Green density gradients result in warping during sintering

Objectives

- Characterize density gradients and evolution during sintering
- Apply sintering theory to predict density evolution

Material

- Spray-dried MgO-doped Al₂O₃



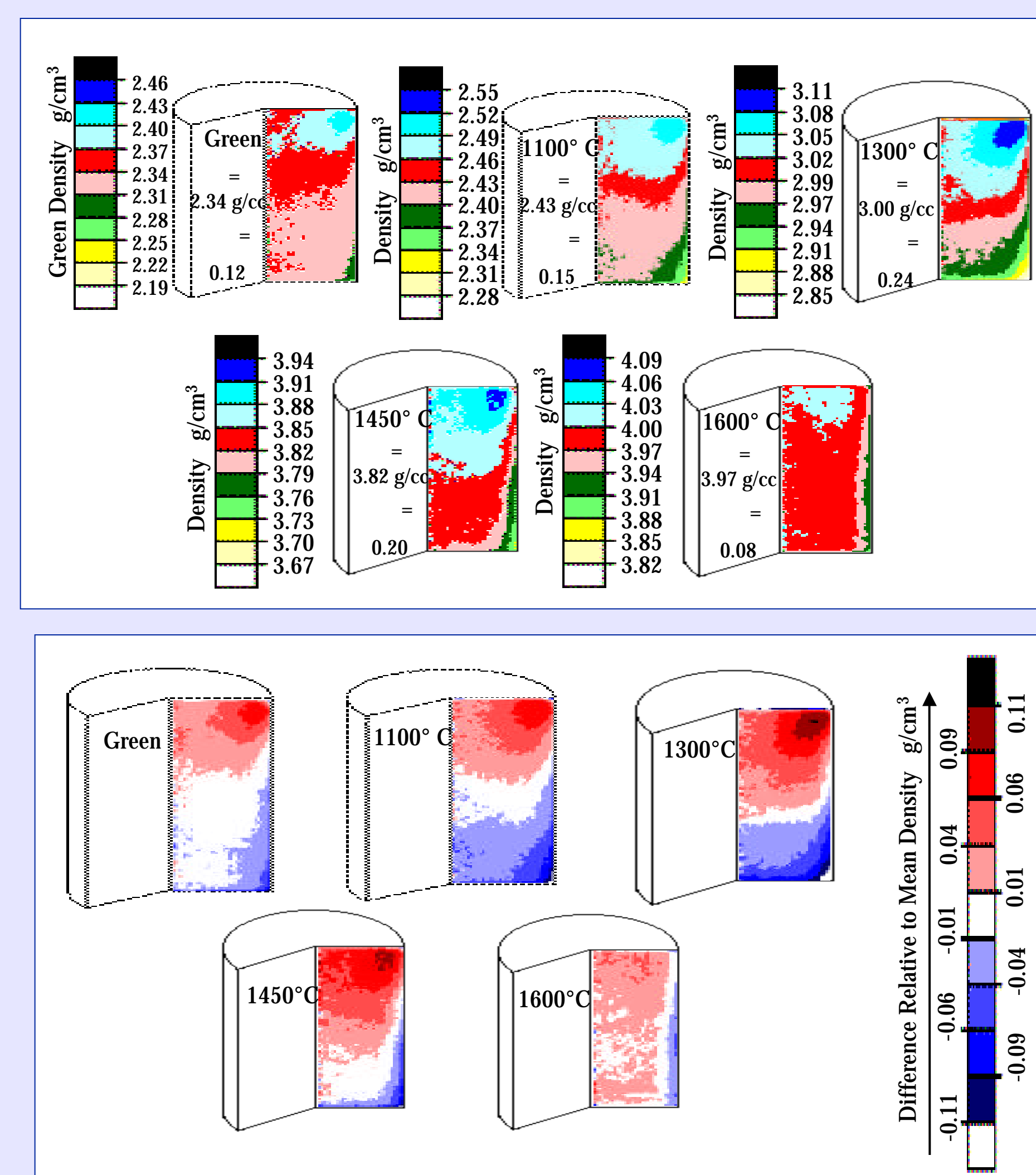
X-Ray Computed Tomography (XRCT)

Experiments

- Uniaxially pressed cylinders
 - Single-action dry pressing
 - 200 MPa and at 85% RH
 - 10 mm dia. x 15 mm tall
- Sintered 1 Hr at 1100, 1300, 1450°C, or 2 Hr at 1600°C

Density Gradients

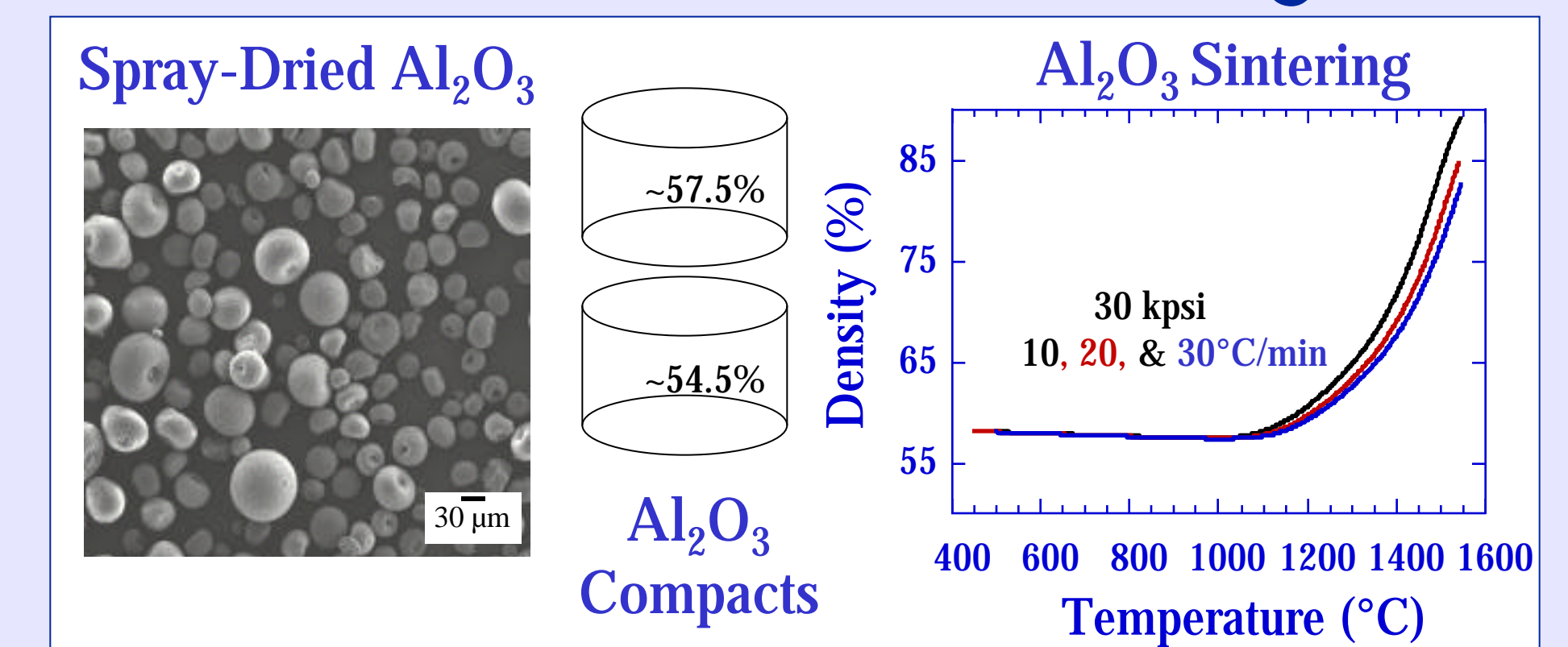
- The density gradient, initially increases during sintering
- Higher green density regions initially densify faster



Master Sintering Curve (MSC) Theory

Green Processing

- Pressed 48 x 6.5 x 4.6 mm bars ~57.5% dense powder compacts
 - 35 MPa uniaxial
 - 207 MPa isostatic
- ~ 54.5% dense powder compacts
 - 28 MPa uniaxial
 - 48 MPa isostatic

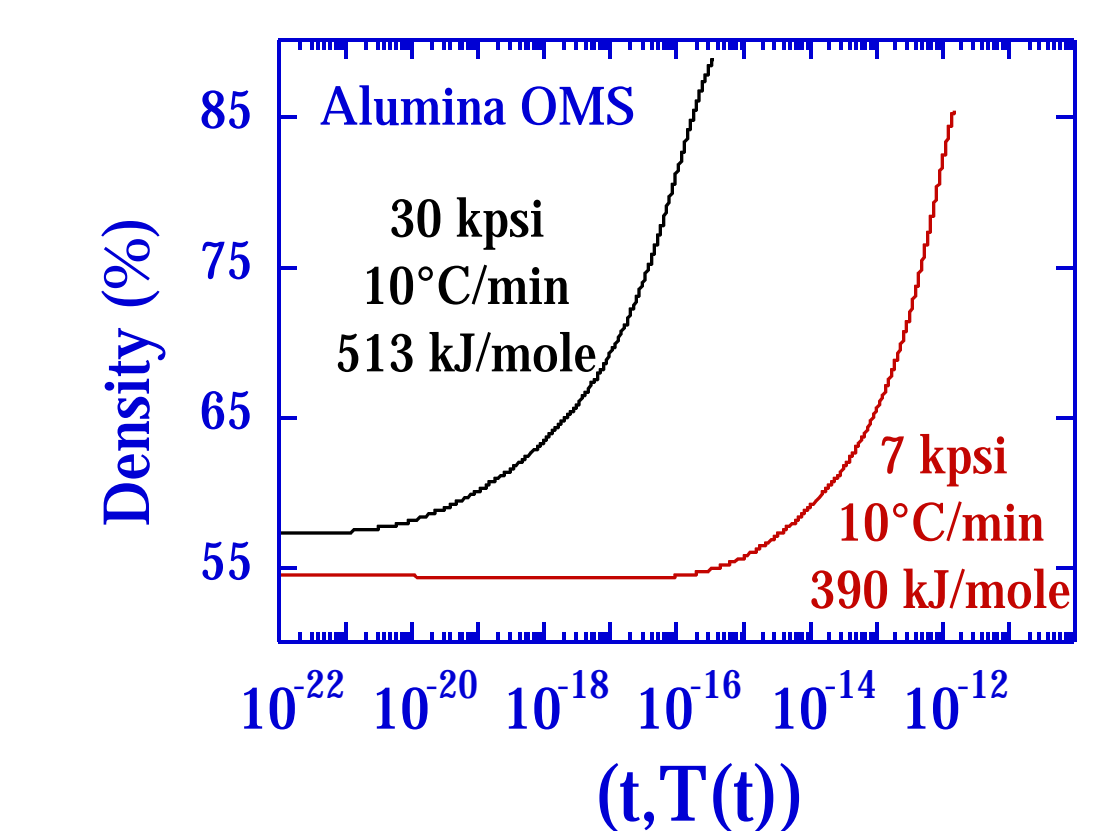


Rearranged Combined-Stage Sintering Model

$$\int_0^t \exp\left(-\frac{Q}{RT}\right) dt = \frac{k}{\gamma D_n} \int_{\rho_0}^{\rho} \frac{(G(\rho))^n}{\rho^n} d\rho$$

Su and Johnson
J. Am. Ceram. Soc.
79 [12] 3211-17 (1996)

Al₂O₃ Master Sintering Curves

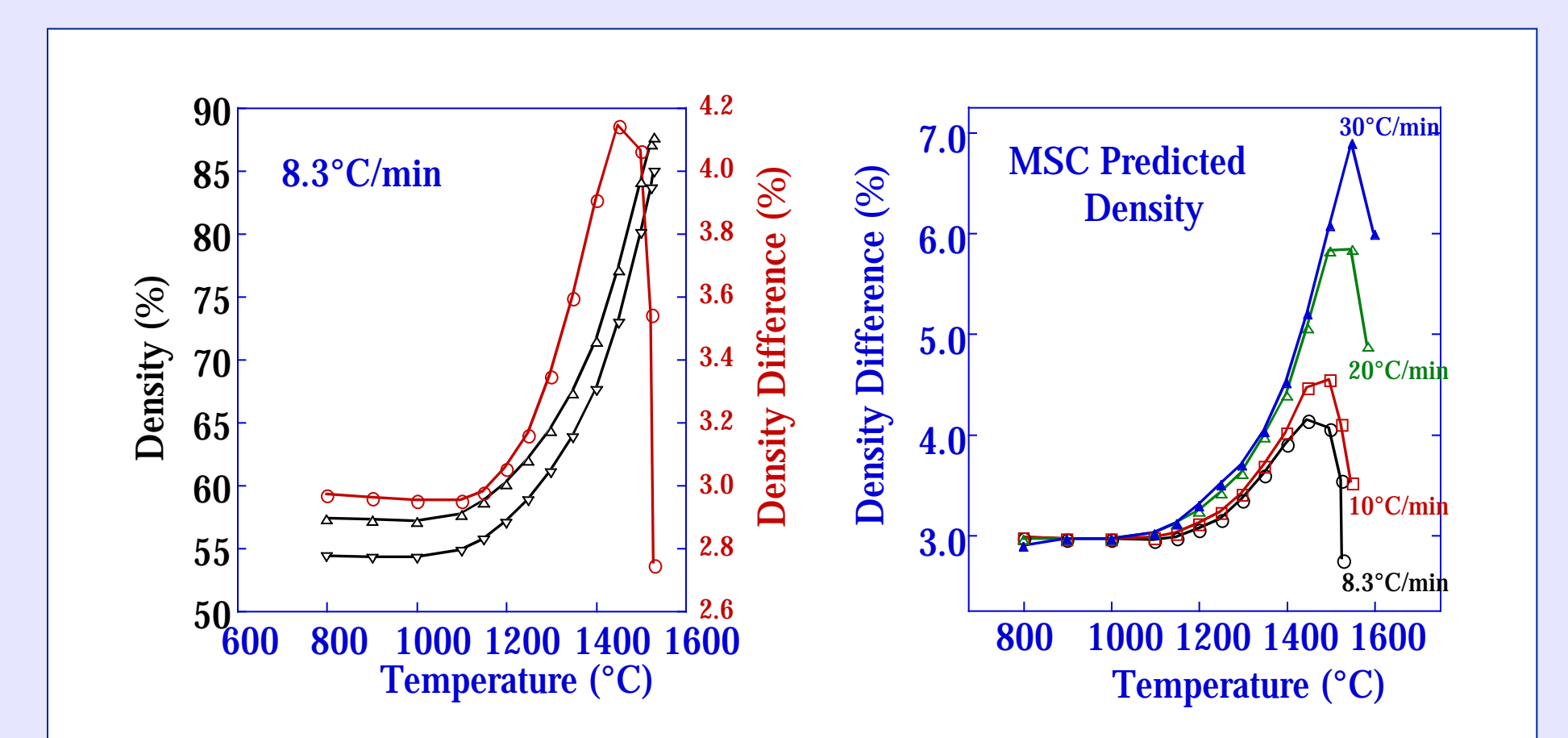


Sintering

- 10, 20, and 30°C/min to 1550°C
- Determined Al₂O₃ Qs and MSCs

Density Predictions

- Density as a function of sintering
 - 8.3, 10, 20, and 30°C/min
- Density gradient as a function of time and temperature
 - initially increases on sintering
 - Max scales with heating rate



Summary

- Density gradients first increase, and then decrease during sintering
 - Confirmed by XRCT & dilatometer sintering studies
 - Higher density regions initially densify faster
- MSC theory predicts density gradient evolution during sintering
 - Faster densification with higher green density
 - Larger maximum density gradients with faster heating rates

