

Challenges toward establishing a benchmark for sintering simulation

Recent advances in synchrotron X-ray tomography have shown that real microstructural evolution during sintering is far more complex than assumed in classical models [1]. To understand these complex phenomena and to move beyond a trial-and-error approach in process design, multiscale modeling and simulation of microstructural evolution are required.

At the particle or mesoscale, various methods—such as the discrete element method (DEM), Monte Carlo method (MC), and phase-field method (PF)—are used to study microstructural evolution and grain growth. However, because many different approaches have been proposed, it is often unclear which is most suitable for a given problem. All these methods involve bold simplifications and approximations, so their validity, range of applicability, and respective advantages and disadvantages must be critically examined and compared [2].

We are currently developing a kinetic model for multiparticle sintering based on rigorous theoretical analysis [3]. By using this model as a benchmark, we aim to facilitate the development of more advanced, large-scale sintering simulation methodologies.

1. G. Okuma, F. Wakai, Synchrotron X-ray multiscale tomography: Visualization of heterogeneous microstructures and defects in ceramics. *J. Am. Ceram. Soc.* 107, 1706-1724 (2024).
2. F. Wakai, *Fundamentals of Sintering* (Springer, 2025)
3. F. Wakai, G. Okuma, Rigid body motion of multiple particles in solid-state sintering. *Acta Mater.* 235, 118092 (2022).

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