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Dopant effects on grain boundary distributions and mechanical response in alumina

Over the past decades, rapid sintering techniques have expanded access to the density-grain size space by promoting densification over grain growth. This has accelerated progress in non-cubic transparent ceramics, where birefringence makes optical properties highly grain-size sensitive. Beyond this paradigm, rapid sintering enables full densification within minutes or seconds and allows tailored heat treatments for advanced microstructural design, particularly grain boundary engineering.

In this study, alumina powders doped with rare-earth elements were spark plasma sintered under controlled conditions. Large-area EBSD maps were acquired to characterize the microstructures. Stereological analysis of grain boundary (GB) distributions revealed temperature- and dopant-dependent changes in boundary structure and habit planes associated with complexion transitions toward lower-energy states. Mechanical spectroscopy was performed on fully dense samples without significant grain growth to analyze GB changes in situ at high temperature. Abnormal grain growth initiated during the measurement, and the associated changes in mechanical response enabled cor-relation between structural changes related to a complexion transition and changes in GB populations.

Given the critical role of grain boundaries in macroscopic properties, this work demonstrates that rapid sintering can be harnessed for advanced materials design and ceramic performance optimization beyond the density-grain size space.

Professional Status of the Speaker

Doctoral or Master Student

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