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ABSTRACT:

Grain Boundary Mediated Strain

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Grain boundary mediated strain can determine high temperature mechanical properties and creep rates in polycrystals and govern the microstructural evolution during sintering. Most traditional treatments of grain boundary strain focus on diffusional transport or point defect emission/absorption. The formation and climb of point defect sources/sinks, however, is also a physical process necessary for grain boundary strain. Indeed, non-Newtonian regimes of the grain boundary creep response are often observed experiments, especial in ceramics, and are not consistent with classical models. We demonstrate that the stress and grain size dependence of creep in these regimes in consistent with nucleation rate limited kinetics in polycrystals. The scaling of in situ transmission electron microscopy (TEM) based bicrystal creep experiments demonstrate this mechanism directly. The same mechanism extends to sintering, which is demonstrated, via in situ TEM, to exhibit discontinuous densification kinetics consistent with nucleation rate limited kinetics and kinetic response consistent with the mechanism.

The nucleation rate limited kinetic model takes an Arrhenius form, which is useful for integrating into a varational model for energy dissipation during creep and sintering that can account for parallel and serial deformation processes effectively. The observations will be discussed in context of predicting materials response in such a framework.