Crystal plasticity–Phase–Field Modeling of Dynamic Recrystallization in Dual Phase Titanium Alloys

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An integrated crystal plasticity finite element–phase–field (CPFE–PF) model has been implemented to study dynamic recrystallization (DRX) in dual phase Ti alloys. In the CPFE module, the statistically stored dislocation (SSD) density at each quadrature point is considered as a state variable and evolves with deformation. The CPFE model is coupled with the Allen–Cahn equation based PF model, which tracks the evolution of grain boundaries by evolving non–conserved order parameters. Nucleation occurs at grain boundaries based on SSD density exceeding a critical value. These nuclei grow due to migration of grain boundaries based on the stored deformation energy. The model is able to address various stages of nucleation and growth for dual-phase Ti-6Al-4V in the α+β region. A driving nucleation force is deemed required to force new nuclei to grow at the expense of pre-existing neighboring grains. A rigorous case study has been conducted to analyze the mechanism of α-globularization and refinement in a synthetic grain structure of equiaxed α grains with β at α-boundaries. We have examined slip level anisotropy in the hcp α phase through parametric studies and mesh convergence analyses. Additionally, validations have been conducted against experiments and good agreement is observed for the flow stress response of single phase alpha-Ti and dual phase Ti6Al4V, grain size distributions before and after DRX, and DRX kinetics.

Keywords: Crystal plasticity, dynamic recrystallization, finite element method, phase–field, titanium alloys.