3D studies of coarsening kinetics of individual grains

Techniques for fast, non-destructive characterization of the microstructure of materials using synchrotron X-ray radiation have in recent years become an important tool in materials science. The non-destructive nature of the techniques allows for time-resolved characterization of three-dimensional microstructures, i.e. direct probing of the evolution of specific microstructural features.

Synchrotron X-ray radiation techniques have in the present work been employed for experimental characterization of microstructural evolution in individual grains during isothermal annealing: For a study of individual grains during recrystallization, where the recrystallization kinetics of individual grains and the temperature dependence of the recrystallization rate is examined, and for a study of grain structure and grain growth, where growth predictions are put forth in terms of the grain size and topology of individual grains, and compared to the observed growth of a small number of grains.

A phase-field model has been developed and implemented efficiently for parallel execution on computer clusters for simulation of a third annealing phenomenon: Coupled grain growth and coarsening in polycrystalline, dual-phase materials, under phase ratio conserving conditions. This is used to investigate the microstructural evolution in a 50/50 volume ratio material and in a 40/60 volume ratio material by large-scale three-dimensional simulations, in both liquid/liquid and polycrystalline/polycrystalline states. These are used to make general predictions of the coarsening kinetics of polycrystalline, dual-phase materials, specifically the coarsening mechanism, steady state distributions of grain size and topology, and interface morphology.