From dendritic and eutectic growth to grain coarsening using a phase-field model

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Phase transformations in multicomponent and multiphase systems play a major role during solidification processes of a variety of alloys. Using a recently developed phase-field model for multicomponent and multiphase systems, we apply our 3D parallel simulator to numerically investigate dendritic and eutectic phase transitions in Ni- and Al- alloys. In our computations, we show both, the solidification processes leading to the formation of a polycrystalline grain structure and the subsequent process of grain growth.

Concerning dendritic growth into untercooled melts, we compare the simulated dynamics and velocity-undercooling relation for pure nickel with recent experimental measurements and theoretical predictions. Further, we consider the binary dendritic phase tranisition in a Ni-Zr alloy and discuss a comparison between molecular dynamics and phase-field simulations on the scale of nanometers. In ternary Ni-Cu-Cr alloys, a morphological transition from dendritic to globular growth is found by varying the alloy composition at a fixed undercooling. The dependence of the growth velocity and of the impurity segregation in the solid phase on the composition is analyzed and indicates a smooth type of transition between the dendritic and globular structures.

The stability of lamellar eutectic structures in Al-Cu alloys is investigated in 2D and 3D. The possible types of the growth structures: Regular lamellae, rod stuctures and oscillatory patterns are discussed depending on the lamellar spacing, the undercooling and the off-eutectic composition of the melt.

On the scale of polycrystals, we present results of grain coarsening and of remelting processes for superheated grain structures.