Influencing Precipitate Morphology, Spatial Correlations and the Anomalous Volume-Fraction Dependence of Coarsening Rates in Binary Ni-Base Alloys

Alan J. Ardell
Department of Materials Science and Engineering
University of California
Los Angeles, CA 90095-1595
USA
aardell@ucla.edu

The kinetics of diffusion-controlled coarsening and the evolution of precipitate microstructure in binary Ni-X alloys (X = Al, Ga, Ge, Si, Ti), including the morphologies of individual particles and their spatial correlations, are currently under investigation. The lattice mismatch, ϵ, between the coherent Ni_3X precipitates (γ'-type, with the $L1_2$, Cu_3Au structure) and the matrix (γ-phase) in these alloys varies by about a factor of five. Elastic energy ($\propto \epsilon^2$) has a profound influence on the evolving precipitate dispersions, as does the volume fraction, f. It has now been established that the rate constant for coarsening decreases with increasing f in all five alloy systems. This anomalous behavior flies in the face of theoretical expectation. In addition to the anomalous dependence on f, Ni_3X precipitates with *concave* interfaces have been seen in all five alloys. These aspects of coarsening behavior, and the spatial correlations in all five alloys, do not correlate simply with the magnitudes of the lattice mismatches, ϵ. Instead, they correlate better, though by no means perfectly, with a length scale parameter:

$$l_o = \frac{\sigma}{\epsilon^2 \overline{\mu}}$$

where σ is the γ'/matrix interfacial free energy and $\overline{\mu}$ is an elastic constant. The anomalous dependence of kinetics on f will be discussed in light of the hydrostatic pressure which arises because of coherent equilibrium in these alloys, and the effect this pressure has on diffusion and the Gibbs-Thomson equation.