

Equilibration of clusters: Ag in Al

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Abstract

In the phase-separating Al-Ag system, intermediate metastable precipitates (Guinier Preston zones) are formed during aging of the supersaturated solid solution of Ag in Al. The metastable miscibility gap is characterized by a large asymmetry [1] with a gap extending to 65 at.% Ag below 175°C and to 30-35 at.% Ag above 220°C. The exact structure of the GP zones (morphology, Ag concentration) is still matter of debate and the experimental studies published on this system have yet to concur. For instance, scattering experiments suggested two possible structures: an inverted shell structure with a Ag-rich core surrounded by an Al-rich shell, or a sphere of uniform Ag concentration [2]. Moreover, recent TEM observations have also indicated that in the initial stages of decomposition, GP zones could form with yet another morphology consisting of a Ag-rich shell surrounding an Al-rich inner core [3]. Clarifying the structures and decomposition pathways in this model Al-Ag system is important to the understanding of alloys phase decompositions. This paper therefore discusses our atom probe tomography results that were performed to elucidate the exact structure of the GP zones.

The miscibility gap for GP zones was first re-assessed taking into account the slow kinetics of the GP zones to reach their equilibrium structure. Indeed, the temporal evolution of GP zones at temperatures below 180°C reveals two regimes: a first stage during which GP zone equilibrates while exhibiting complex morphologies and a second stage of coarsening once the GP zones have reached their equilibrium concentration of 65 at.% Ag.

In order to understand the limiting mechanism for the equilibration of the GP zones, the temporal evolution of zones formed at high temperature and therefore containing only 35 at.% Ag was followed during aging at low temperature where their equilibrium concentration is 65 at.% Ag. The measured Ag concentration profiles in GP zones can be explained by inwards diffusion of Ag within the Ag rich zones. These observations show that diffusion of Ag in the GP zones is more than an order of magnitude slower than diffusion of Ag in the Al matrix. This discrepancy accounts for the slow kinetics of equilibration at early times and the formation of complex structures that led to the original controversy about the exact structure of the GP zones.

To conclude, our work highlights the important role of solute-vacancy interactions controlling the kinetics pathway in phase decomposition.

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