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Phase Separation of Al-Ag Alloys under Slow Deformation

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Introduction

The evolution of microstructures, such as precipitation and / or dissolution of second phase during deformation is quite interesting from the view point of basic research on phase transformations, as well as that of application oriented one. When we look into the process of phase separation under deformation, there are several factors that may lead to the opposite results. Namely, phase separation and coarsening should be suppressed since the GP zones are cut by dislocations, and the process might be described as a simultaneous thermodynamical formation and mechanical destruction of precipitates. Dislocations might serve as a vacancy sink, or even heterogeneous nucleation sites. On the contrary, it is also possible to imagine that dislocation motion might accelerate coarsening by providing excess vacancy, or the destruction of small GP zones provides large GP zones solute atoms to coarsen.

So far, few attempts have been made to give a clear picture how a slow plastic deformation during aging treatment affects phase separation and coarsening[1][2]. In the present experiment, GP zones in Al-Ag binary alloys have been examined, since there is almost no misfit strain between the zone and the matrix, which should simplify the interpretation of the experimental results and the phase diagram has been well studied.

Experimental

Samples used in the present experiment are Al-1.5at%Ag single crystals grown by the Bridgeman method under atmospheric Ar gas flow. The single crystals were then

homogenized at 893 K for 86.4 ks in sealed Pylex glass filled with Ar. The sample was cut into {110} sheet test pieces of about 0.2mm thick. The direction of tension was 5-7 degrees off from [001].

In-situ tensile test machine with a furnace was placed at the sample position of small-angle scattering camera at beam-line 15A. Detailed procedure of the heat treatment is given elsewhere[2]. At a constant aging / deformation temperature of 443 K, the deformation speeds were chosen as 1.2 x 10^{-4} mm / s and 5.0 x 10^{-4} mm / s.

Results and Discussion

At a very slow deformation of 1.2 x 10^{-4} mm/s, no clear anisotropy was observed in the 2-dimensional SAS intensities, and therefore a one-dimensional analysis is sufficient. At higher strain rate, however, the development of the microstructure turned out to be quite different. Figure 1 shows the evolution of two-dimensional SAS profiles during aging at 443 K, and deformation of 5.0x 10^{-4}mm/s. The tensile load was applied to the sample after 900 s of preaging time without deformation. Due to this pre-aging treatment, the effect of heterogeneous precipitation at dislocations is not very strong, while the effect was found to be predominant if the deformation started from the as-quenched state. It is seen that the contours of the scattering intensities are isotropic during preaging as shown in Fig. 1 (a). The contour became anisotropic after deformation starts. As shown in Fig. 1(b), the contours of the scattering intensity deviate from isotropy, and the intensity maximum is clearly seen in the direction shown by the arrows. Difference between the directions of the microstructural anisotropy and the deformation is explained by the mechanism of plastic deformation in crystalline samples. Detailed analysis is now under way.

References

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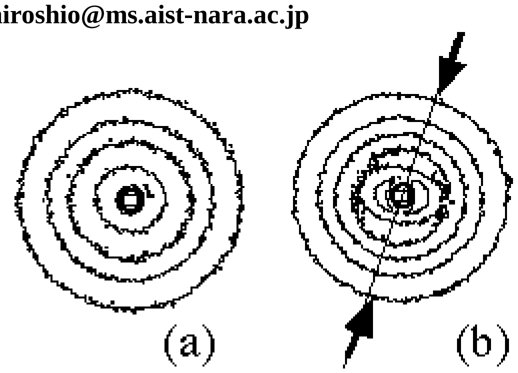

Fig. 1 Two-dimensional SAS patterns during phase separation under deformation at 443 K. (a) before deformation, (b) after deformation, t =1800s.