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NEGATIVE CLIMB OF PRISMATIC DISLOCATION LOOPS IN Al-7.2 At. % Mg ALLOY

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Negative climb (shrinking) of prismatic dislocation loops in thin foils of Al-Mg alloys has been studied using a heating stage in the electron microscope (1). The results are shown in Fig. 1. Prior to thinning, the specimens were quenched from 550°C into an ice-brine solution and aged 100 h at 100°C. Some data are also included from specimens quenched from 550°C into water (~20°C) and subsequently aged at 20°C for ~24 h, or at 120°C for 50 h, however, within the range of initial loop radii chosen there is no real difference between results obtained in each case. The dynamic observations were recorded on 16 mm cine film, and an example of part of a shrinkage sequence is shown in Fig. 2.

From the data in Fig. 1, the activation energy for negative climb in Al-7.2 at. % Mg was found to be, \( E(-G) = 0.68 \text{ eV} \) and the pre-exponential constant, \( A \approx 2.0 \times 10^{-6} \text{ cm}^2/\text{sec} \). This energy is to be compared with the values of 1.3 eV for loop shrinkage in pure Al (2) and 0.95 eV measured for loop growth in Al-5.6 at. % Mg (1). The factors which could contribute to a difference between the growth and shrinkage processes in the alloys studied are complicated, for example (i) the distribution and composition of Mg atom-vacancy clusters (or small precipitates) in the two groups of specimens studied, and (ii) that the contribution of individual steps to the positive
and negative climb processes need not be the same. Positive climb in Al-5.6 at. % Mg requires that some source of vacancies, other than the foil surface, supply a supersaturation sufficient to maintain climb. This source was assumed to be vacancy-Mg clusters (1). The supersaturation was apparently inadequate during the present work so the loops had no choice but to shrink. Even if vacancy diffusion through the lattice dominates both the positive and the negative climb processes, one might not expect the energy to form a vacancy at a cluster (positive climb) to be the same as required to form a vacancy at a loop (negative climb). Although, small, coherent precipitates have been observed in specimens aged 100 h at 100°C (3) and it appears that the conditions necessary for positive climb in thin foils should have been met, for some reason they were not.

The very low activation energy for negative climb indicates that the jog energy must be very small. It may be that shrinkage involves breakdown of the Mg-vacancy association at the loop followed by vacancy migration to the active sinks. Since the binding energy (Mg-vacancy) is ~0.2 eV (1), then in this event the migration energy is about 0.5 eV. Although this result is in agreement with the growth model (1) more data is required over the range of Al-Mg solid solutions before all the dynamic effects can be explained.

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References

Al-7.2 at. % Mg
- Quenched from 550°C, aged 100 hr, 100°C
- " " " " 50 hr, 50°C

\[ E(G) = 0.68 \text{eV} \]

Fig. 1

Fig. 2 (none available)