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SOLUTE-DISLOCATION INTERACTIONS IN Al-Mg ALLOYS AT ELEVATED TEMPERATURES

D. Stone, H. Wilson, R.-C. Kuo, and Che-Yu Li
Department of Materials Science and Engineering,
Cornell University, Ithaca, New York 14853

Current theories for the creep of solid solution alloys are concerned with three regimes of creep behavior, depending upon the level of stress, including conditions of alloy class creep behavior [1]. At low stresses the stress exponent, n , of the steady state-like (SSL) strain rate has a value of about 4-5, similar to that of a pure metal. Within a range of intermediate stresses $n \approx 3$. At high stresses n increases.

Like the creep test, load relaxation and tensile tests can be used to examine the effects of solute-dislocation interactions. These interactions are manifested by the presence of a yield drop and serrated flow in a tensile test and a deviation away from pure metal-like behavior in a load relaxation test [2]. In the present work a comparison has been made between results of the three types of tests performed on Al-Mg alloys at 350°C and 360°C. A load relaxation study of high purity aluminum at 360°C was also performed. The results of this work lead to new insights on the creep of solid solution alloys at elevated temperatures.

Constant displacement rate tensile test data of an Al-4.6% Mg alloy are shown in Figure 1 in the form of true stress-true strain curves. The data demonstrate the presence of yield drops and serrated flow. The possibility that the serrated flow might be caused by jerky motion of the cross-head, especially at low strain rates, has been ruled out.

Load relaxation data, constant displacement rate tensile data and creep data are compared in Figure 2 in the form of log stress-log strain rate curves. The tensile test data are taken from Figure 1 at a strain level of 1%. The load relaxation data correspond to an initial strain level of 6%. The SSL creep data are from a 5.5% Mg alloy tested by Pahutova and Cadek at 350°C and have been shifted slightly to take into account the 10°C difference in temperature [3]. The three types of data show excellent agreement in terms of the stress dependence of the strain rate.

The different power law regimes of the creep data are labelled in Figure 2. We find that the serrations during the tensile tests peak at strain rates for which the power law exponent for creep is 3. This result is consistent with the solute-dislocation interactions having their strongest effects in this regime [1]. At high strain rates the serrations disappear, as would also be expected. At low strain rates, the amplitude of the serrations decreases slightly, but compared to the average stress, the amplitude of the serrations remains large at the low strain rates implying that the effects of the solute-dislocation interactions persist at low strain rates.

At low strain rates the load relaxation data of the Al-4.6% Mg alloy, viewed in form of Figure 2, are concave up. Load relaxation data of the pure aluminum, however, are concave down. Although having an average stress exponent near 5, the pure aluminum data demonstrate a power law exponent of about 3 at the lowest strain rates. The concave up instead of concave down behavior of the Al-4.6% Mg load relaxation data represents a deviation from the pure metal-like behavior at lower strain rates. In general, additional information to the

stress exponent is necessary to delineate the mechanisms involved.

In summary, serrations occur in constant displacement rate tensile tests of a 4.6% Mg alloy in the regime where the solute dislocation interaction is supposed to peak according to current concepts of creep in alloys. These serrations die out at high strain rates as would be expected based on the same concept. The serrations appear to persist to low strain rates, in contrast to the pure metal-like behavior observed for creep. Both the tensile and load relaxation data demonstrate effects of the solute-dislocation interactions at low strain rates.

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Figure 1

Figure 2