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TITLE: FAILURES TO MODEL THE DEVELOPMENT OF A CUBE TEXTURE DURING THE HIGH TEMPERATURE COMPRESSION OF AL-MG ALLOYS

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**FAILURES TO MODEL THE DEVELOPMENT OF A CUBE TEXTURE
DURING THE HIGH TEMPERATURE COMPRESSION OF AL-MG ALLOYS†**

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KEYWORDS: cube texture, Al-Mg, non-octahedral slip, rate sensitivity, climb, dynamic recrystallization

ABSTRACT

A strong (100) fiber texture has been observed under some circumstances after the compression and tension of Al-Mg alloys. It is not due to static recrystallization after the text, but probably connected with some form of dynamic recrystallization. Possibilities that this unusual texture might rise from some unconventional deformation mechanisms were searched for but not found.

INTRODUCTION

At temperatures and strain rates where viscous deformation with a stress exponent $n=3$ is observed, one expects the slip system distribution, and therefore the grain rotations and the development of deformation texture, to be different than when the flow stress is rate insensitive. This effect had been observed during tension of Al-3%Mg single crystals at 360 and 410°C, and qualitatively explained in this way.[1] In addition, glide on non-conventional slip planes and the presence of climb should influence rotations and texture development.[2]

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	$n \gg 4$	$n \approx 4$	$n \approx 3$
Al-2%Mg	$T=25^\circ\text{C}, \dot{\epsilon} = 10^{-2}\text{s}^{-1}$ $T=282^\circ\text{C}, \dot{\epsilon} = 10^{-1}\text{s}^{-1}$	$T=282^\circ\text{C}, \dot{\epsilon} = 10^{-5}\text{s}^{-1}$ $T=380^\circ\text{C}, \dot{\epsilon} = 10^{-3}\text{s}^{-1}$	$T=360^\circ\text{C}, \dot{\epsilon} = 5 \cdot 10^{-5}\text{s}^{-1}$ $T=440^\circ\text{C}, \dot{\epsilon} = 10^{-4}\text{s}^{-1}$
Al-5%Mg	$T=25^\circ\text{C}, \dot{\epsilon} = 10^{-2}\text{s}^{-1}$ $T=300^\circ\text{C}, \dot{\epsilon} = 5 \cdot 10^{-2}\text{s}^{-1}$	$T=473^\circ\text{C}, \dot{\epsilon} = 1\text{s}^{-1}$ $T=380^\circ\text{C}, \dot{\epsilon} = 10^{-3}\text{s}^{-1}$	$T=473^\circ\text{C}, \dot{\epsilon} = 10^{-2}\text{s}^{-1}$ $T=473^\circ\text{C}, \dot{\epsilon} = 10^{-4}\text{s}^{-1}$ (Tension <u>or</u> Compression)

OBSERVATIONS

We undertook a series of compression tests on Al-2%Mg [3] and Al-5%Mg polycrystals in a range of temperatures and strain rates, both where $n=3$ and where it was higher. The observed textures are displayed in figure 1. At low temperatures, the standard compression texture, essentially a {110} fiber, is seen. As the stress exponent approaches 3, a small peak at the cube fiber position develops, along with some general dispersion of the texture, but without losing the {110} fiber. Eventually, at 440°C and 10^{-3}s^{-1} , the texture is a pure cube fiber - broad, but with no intensity left anywhere else.

We now believe, for a number of reasons, and after various supplementary experiments, that this texture is due to some form of dynamic recrystallization. One reason for this conviction is that the *same* texture develops in tension as in compression. Nevertheless, we attempted to model this texture on the basis of deformation only.

SIMULATIONS

We prescribed uniaxial strain, a stress exponent of 3, and a <110> slip direction. The Los Alamos polycrystal plasticity (LApp) simulation code [4] was used, except in case 2. The results are shown in figure 2. Both the rotation paths of a few characteristic crystals during the first 10% strain (arrows) and polycrystal textures after a strain of 1.0 (symbols) were investigated.

1. Slip on {111} plane only - full constraints (upper bound). This Taylor-type simulation was carried out for the rate-insensitive case (figure 2a) and for a stress exponent of 3 (figure 2b). The rotations were very similar in both cases, only slower in the latter; thus, the final texture was similar, only slightly more diffuse. This result had also been obtained by Bacroix et al.[2].

2. Slip on {111} only, lower bound. This case was calculated with a new model that keeps all stress components the same everywhere and finds their magnitude such as to satisfy the imposed average strain rate [5]. The conditions under which this lower bound may be a reasonable approximation include high rate sensitivity. The resulting texture (figure 2c) was similar to the upper-bound texture in that the strongest component was {110}; the tail toward {511} was, however, moved to {311}, i.e. away from {100}.

3. Slip on {111}, plus climb. This was modeled by progressing from single to multiple slip and stopping at the third slip system; the remaining prescribed strain components can then be satisfied by climb, which does not contribute to the rotations [6]. The direction of all rotations is similar, only the rate is faster (figure 2d). Such behavior should be expected when fewer slip systems operate.

4. Slip on {111} and {100}. There are only minor differences to slip on {111} only, and the rotations are somewhat slower (figure 2e).

5. Slip on {100} and {110} planes. In this case (figure 2f), the {100} corner becomes preferred; the maximum is actually near {511}, with a tail toward {510}; and a significant remnant at {110}. This result could be marginally in agreement with the experiments; but we cannot fathom why {111} slip should cease entirely.

Figure 2 - Simulated rotations (arrows) and end textures (symbols) under various assumptions. Taylor model with stress exponent $n=33$ (a) and $n=3$ (b) [4]. Lower bound, $n=3$ (c) [5]. Allowing for climb (d) or for different slip planes (e and f), all with $n=3$.

SUMMARY

In summary, on the basis of deformation simulation only, the appearance of a strong {100} component in compression can be predicted only under unreasonable conditions; the disappearance of the {110} cannot be explained in any way we know.

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