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Strain hardening behaviour and the Taylor factor of pure magnesium

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Abstract

Taylor orientation factors for strain hardening in textured and random polycrystals of magnesium were derived from the ratio of the strain hardening rates of polycrystals to that of single crystals deforming by equivalent polyslip. For polycrystals with textures that inhibit basal and prismatic slip while favouring pyramidal polyslip, the Taylor factor is estimated to be between 2.1 and 2.5, increasing to about 4.5 for randomly textured polycrystals. The micromechanics of strain hardening in polycrystals are discussed.

Keywords:

magnesium | dislocations | forest hardening | Taylor factor | Hall–Petch law

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Notes

Notes

1. Kelley and Hosford 13 showed that the yield surface of textured polycrystals of pure Mg is highly non-equiaxed due to the stress asymmetry of twinning; however, it takes a nearly equiaxed shape after the first 6–8% strain, once twinning is over.

2. Preserving the yield surface's initial shape requires strain hardening proportional to the current flow stress, an assumption which is not easy to justify by dislocation theory 3.

3. The scales in Figures 1 through 4 are related by the Taylor factors $M_{\sigma} = M_{\varepsilon} = 4.5$. A higher or lower M value, respectively, decreases or increases the relative slope of the polycrystal curves.

4. It is noted that Graff et al.'s modelling 17 ignored possible contributions from twinning modes other than . More complex modes of twinning are known to become active at high stresses in Mg, and were indeed observed by Kelley and Hosford in their experiments 13, so the picture presented by Figure 5 is likely to be over-simplistic at very large strains.

5. ⟨c + a⟩ slip is similar to an octahedral slip system, {111}⟨111⟩ in a cubic crystal 47, and contains five independent slip systems.

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Pair interaction of pyramidal dislocations and its contribution to flow stresses in Mg crystals during slip in system
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