Development of Recrystallization Texture in Pure Magnesium during Static Annealing

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The present investigation described about the relation between grain orientations and recrystallization mechanism during static annealing of pure magnesium. Commercially pure magnesium was subjected to cold rolling to reduce 90\% of the thickness. Subsequently rolled samples were subjected to annealing within a range of annealing times starting from 10 s to 3600 s. A strong basal texture was observed in the samples and also the maximum weakening of basal texture was seen during annealing at 300 s. No new orientations were seen during annealing of magnesium. However, the rate of movement of very low angle grain boundary (VLAGB) was the chief controlling step for the formation of the recrystallized grains. The formation of sub-grains from the parent grains was seen during annealing without any relation with the orientation of the grains. However, the rate of formation of sub-grain was faster in the grains whose orientation > 40° from the normal direction (ND) of the sample. There was also seen the reduction in growth rate of orientations/grains with increasing their deviation from ND of the sample.

\textbf{Keywords}: Commercially Pure Magnesium, Annealing, Texture, Microstructure, Low Angle Grain Boundaries.
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Objective

Understanding the recrystallization texture development during static annealing of pure magnesium through EBSD (Electron Backscattered Diffraction) analysis.

Introduction

- Poor formability at room temperature deformation of magnesium (Mg) and its alloys restricts their use in different structural applications such as automobiles and aerospace.
- At room temperature the critical resolved shear stress (CRSS) for basal slip is lower than that of non-basal slip, such as the prismatic and pyramidal slip systems. The basal slip system alone does not provide the required independent slip systems to satisfy the Von Mises criterion of five independent slip systems for homogeneous deformation.
- This means that extension twinning is required to accommodate deformation at room temperature. With increasing temperature, the CRSS value quickly decreases for non-basal slip systems and activation of higher order slip systems is observed.

Experimental Procedures

Cold rolling of pure Mg and then subjected to annealing at 200 °C for different soaking times.
- Metallographically polished followed by electro-polishing.
- X-ray Diffraction (XRD) Bulk Texture
- Electron Backscattered Diffraction (EBSD)

Results and Discussion

Fig. 1. IPF maps of the samples after annealing:
(a) 10 s, (b) 30 s, (c) 120 s, (d) 300 s, (e) 600s, (f) 1800 s and (g) 3600s.

Fig. 2. Average grain size of the samples w.r.t annealing time.

Fig. 3. Average size of the grains wrt ND of the sample for different time of annealing.

Fig. 4. IPF maps superimposed with grain boundaries for different grains w.r.t ND of the sample annealed for 10 s of annealing time: Orientations of (a) 0-10°, (b) 10-20°, (c) 20-30°, (d) 30-40° and (e) > 40° from ND. (ii) Orientation relationship between parent (marked ‘1’) and sub-grain (marked ‘2’) is shown in (c). Red, green, dark red, blue and black color in (c) respectively represent orientations of 0-10°, 10-20°, 20-30°, 30-40° and > 40° from ND.

Fig. 5. VLAGB fraction as a function of annealing time.

Fig. 6. Fraction of CSL boundaries for different grain/orientations with respect to ND of the sample annealed for 600 s of annealing time.

Fig. 7. Orientation of grains from ND.

Conclusions

1. Nucleation of new orientations was observed during annealing of the samples. However, formation of sub-grains from the parent grain was observed during annealing irrespective of the orientation of the grains. The rate of sub-grain formation was fastest in the grains of orientations $\phi_{2}$=40° from ND compared to other orientations.
2. The rate of VLAGB movement was observed to be the rate controlling step for the formation of recrystallized grains.
3. The growth rate of orientations/grains was decreased with increasing their deviation from ND of the sample. Grains with orientations $\phi_{2}$=60-120° and $\phi_{2}$=5-15° along $\phi_{2}$ section had higher stored energy compared to other orientations as these orientations were formed from the parent grain which was favourable for basal slip system only.

References