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IN-SITU EBSD OBSERVATIONS OF RECRYSTALLIZATION AND TEXTURE EVOLUTION IN ROLLED Mg-2Zn-xCe (wt.%)

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Introduction

Wrought magnesium (Mg) alloys are attractive for automotive applications where light-weighting is critical. One of the major challenges with conventional Mg alloys, such as Mg-3Al-1Zn(wt.%), is the strong texture formation after rolling and subsequent annealing, which results in anisotropic mechanical properties and poor cold formability [1]. It was observed that relatively weak texture can be obtained by dilute rare-earth additions such as Ce [2]. However, the mechanisms responsible for the weak texture formation during annealing are not clear. The goal of this study was to investigate recrystallization and texture evolution during annealing in a Ce containing Mg alloy system using in-situ techniques.

Experimental methods

Mg-2Zn-0.2Ce(wt.%) and Mg-2Zn-0.6Ce(wt.%) alloy sheets, ~1mm thick, were studied in the as-rolled condition. For electron backscatter diffraction (EBSD) analysis, ~10mm wide and ~15mm long samples were cut from the sheet material using a diamond saw. One of the sample surfaces was mechanically polished and then electropolished using a mixture of 30% Nitric acid and 70% Methanol as electrolyte. The electrolyte temperature was kept below -25°C and a voltage of ~12V was used.

EBSD analysis was performed while the sample was kept at a desired temperature. The specimen was heated using a 6mm diameter tungsten-based heating element placed beneath the sample. EBSD maps of the same area of ~100µm x ~125µm was collected at 25°C, 150°C, 200°C, 225°C, 250°C, 275°C, 300°C, and 325°C. Each scan took ~45-55 minutes at a 0.5µm stepsize. The specimen temperature was kept constant within ±3°C during the scan. A thermocouple was spot welded to the sample surface to monitor the temperature.

Results

Both as-rolled materials exhibited a basal texture in which the c-axis tends to align perpendicular to the rolling direction. The Mg-2Zn-0.2Ce(wt.%) sheet exhibited a stronger texture, with a maximum intensity of ~10 times random in 0001 pole figure along the normal direction (ND), compared to the Mg-2Zn-0.6Ce(wt.%) sheet, which exhibited a maximum intensity of ~5 times random.

In Mg-2Zn-0.2Ce(wt.%), new grains started to appear at ~200°C (See Figure 1). At ~300°C, a completely recrystallized microstructure was formed. Grain boundaries with orientation relationships corresponding to $\{10\bar{1}2\}$ extension twinning (86° about $<11\bar{2}0>$), $\{10\bar{1}1\}$ contraction twinning (56° about $<11\bar{2}0>$), and $(10\bar{1}2)$-$(01\bar{1}2)$ extension double twin (60° about $<10\bar{1}0>$) were observed. This was expected to be due to the recovery and growth of the twins formed during the rolling process. Among the misorientation relationships observed between the newly formed high angle grain boundaries, rotation axis about $<10\bar{1}0>$, $<11\bar{2}0>$, and $<10\bar{1}1>$ were the most prevalent. It is noted that rotation axes about other <hki0> and <hkil> were also observed.

In the completely recrystallized microstructure, the fraction of high angle grain boundaries with a rotation axis about $<10\bar{1}0>$, $<11\bar{2}0>$, and $<10\bar{1}1>$ in Mg-2Zn-0.2Ce(wt.%) and Mg-2Zn-0.6Ce(wt.%) were similar with ~16% for each case. However, a significantly lower fraction (~6%) of grain boundaries with rotation axis about $<10\bar{1}1>$ was observed in Mg-3Al-1Zn(wt.%).

References

[1] Boehlert, C. J., et al. Acta Materialia 60.4 (2012): 1889-1904.
[2] Yi, Sangbong, et al. Acta Materialia 58.2 (2010): 592-605.

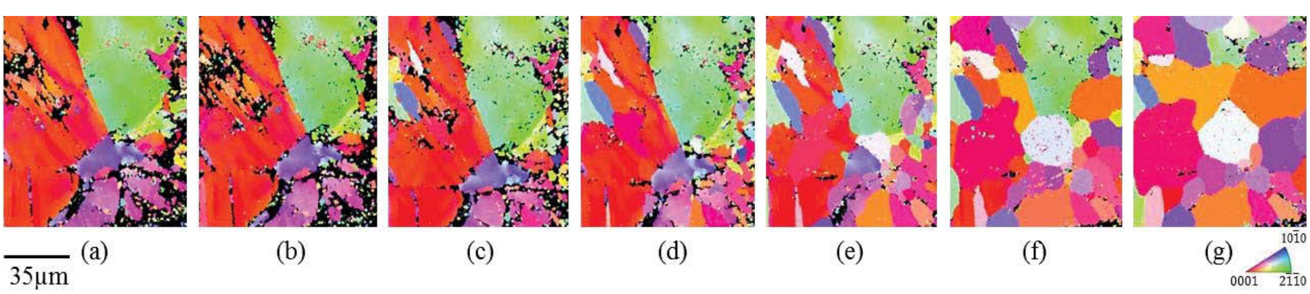

Figure 1. The EBSD IPF map in the normal direction of the same area analyzed for Mg-2Zn-0.2Ce(wt.%) captured at (a) 25°C (b) 150°C (c) 200°C (d) 225°C (e) 250°C (f) 275°C (f) 300°C and (g) 325°C. The rolling direction is horizontal.