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An EBSD Study of Deformation and Recrystallization in Magnesium Alloys

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In the extruded condition some magnesium alloys, such as AZ31 (Mg-3wt%Al-1wt%Mg), exhibit an asymmetry of tensile and compressive properties, while others, such as WE43 (Mg-4wt%Y-2.25wt%Nd-1wt%HRE-0.6wt%Zr) exhibit isotropic behaviour [1]. This difference has been related to the texture produced during extrusion[2] and twinning during compression but not in tension. Recrystallization during thermomechanical processing may alter or reduce the texture and modify the mechanical properties [3]. In the present paper results are presented which were obtained during an investigation of the deformation and recrystallization of alloy ZC71 (Mg-7wt%Zn-1wt%Cu).

Sand cast ZC71 was received from Magnesium Elektron Ltd and homogenized for 24 hours at 435 ^{o}C, hot rolled 15 % at 400 ^{o}C and then re-homogenized for 24 hours at 435 ^{o}C in order to break-up the second phase formed in the cast alloy. The material was then deformed in a channel die to a true strain of 0.4 at a true strain rate of 10^{-4} s^{-1} at temperatures between 250 and 400 ^{o}C. The alloy was homogenized for 24 hours at 435 ^{o}C prior to extrusion at 282 ^{o}C with an extrusion ratio of 17.7 at a speed of 2.05 m min^{-1}. Optical microscopy and electron backscattered diffraction (EBSD) were used to characterize the microstructure of the alloy; EBSD was also used to determine the texture of the as-deformed and annealed material. Tensile and compressive strengths were determined using an Instron.

Twinning and nucleation of new grains occurred during deformation. Fig. 1 is an EBSD map of ZC71 following deformation in a channel die at 250 ^{o}C to a true strain of 0.4 at a true strain rate of 10^{-4} s^{-1}. Dynamic recrystallization of new grains has occurred along a pre-existing boundary. Fig. 2 is an EBSD map showing the partially recrystallized microstructure of as-extruded ZC71. Small recrystallized grains surround unrecrystallized material. In ZC71 deformed in a channel die at 250 ^{o}C and extruded at 270 ^{o}C recrystallization occurred preferentially at pre-existing grain boundaries.

The ZC71 extruded at 270 ^{o}C had a tensile / compressive strength ratio of 1.15. ZC71 extruded and homogenized for 25 hours at 435 ^{o}C had a tensile / compressive strength ratio of 1.26. Fig. 3 shows the texture of ZC71 extruded at 270 ^{o}C. Fig. 4 shows the texture of ZC71 extruded and then homogenized at 435 ^{o}C. The as-extruded ZC71 exhibited a $<10\bar{1}0>$ fibre texture; after annealing the $<10\bar{1}0>$ fibre texture had been replaced by a $<\bar{2}110>$ fibre texture.

In $<10\bar{1}0>$ and $<\bar{2}110>$ fibre textures the basal planes are aligned parallel to the extrusion direction and are unfavourably orientated for slip. Twinning is an important deformation mechanism; twinning during compression occurs at a lower yield stress than slip or twinning during tension, and this is probably responsible for the observed mechanical asymmetry in the extruded and annealed ZC71.

References

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[4] This work was supported by the EPSRC and Magnesium Elektron Ltd. Discussions with Prof. F.J. Humphreys are gratefully acknowledged.

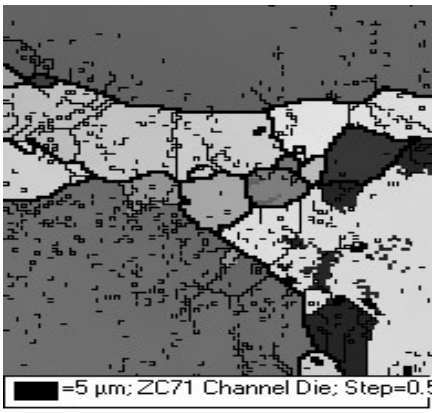

Fig. 1. EBSD map of ZC71 following channel die deformation at 250 ^{o}C to a true strain of 0.4 at a true strain rate of 10^{-4} s^{-1}. Dynamic recrystallization of new grains has occurred along a pre-existing boundary.

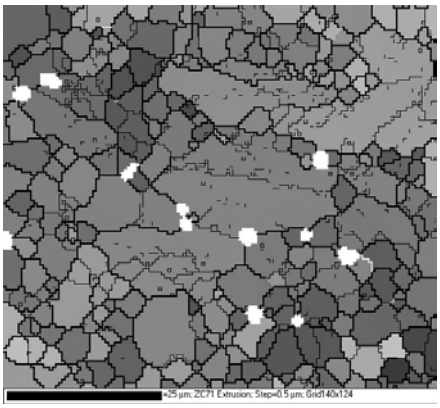

Fig. 2. EBSD map of ZC71 following extrusion at 270 ^{o}C with an extrusion ratio of 17.7 at a speed of 2.05 m min^{-1}. Small recrystallized grains surround unrecrystallized material.

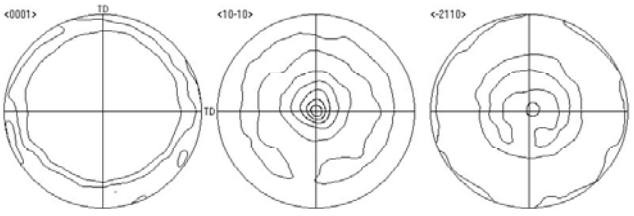

Fig. 3. $<10\bar{1}0>$ fibre texture of ZC71 following extrusion at 270 ^{o}C

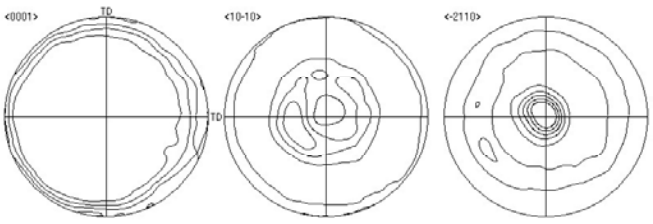

Fig. 4. $<\bar{2}110>$ fibre texture of ZC71 following extrusion and annealing for 24 hours at 435 ^{o}C

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