Formation behavior of basal texture under the high temperature plane strain compression deformation in AZ80 magnesium alloy

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Abstract. The formation behavior of basal texture during high temperature deformation of AZ80 magnesium alloys in single phase was investigated by plane strain compression deformation. Three kinds of specimens with different initial textures were machined out from an extruded bar having a <10\text{\textomicron}0> texture. Plane strain compression tests were conducted at temperatures of 623K and 723K and a strain rate of 5.0 × 10^{-2} s^{-1}, with a strain range of between -0.4 and -1.0. After deformation, the specimens were immediately quenched in oil. Texture measurement was carried out on the compression planes by the Schulz reflection method using nickel filtered Cu Kα radiation. Electron backscatter diffraction (EBSD) measurements were also conducted in order to examine the spatial distribution of orientations. Three kinds of specimens named A, B and C were prepared from the same extruded bar. In the specimens A, B and C, \{0001\} was distributed preferentially parallel to ND, TD, and RD, respectively. After deformation, texture evaluation was conducted on the mid-plane section. At the plane strain compression deformation, peaks appeared in the true stress-true strain curves irrespective of the kinds of specimen used. It was found that the main components and the pole densities of the textures vary depending on deformation condition and initial texture. Six kinds of texture components were observed after deformation. The (0001)<10\text{\textomicron}0> has formed regardless of the initial texture. There are two types of texture components; one exists before the deformation, and the other does not. Either types are considered to have stable orientations for plane strain compression. Also, the basal texture is composed of two crystal orientation components – (0001)<10\text{\textomicron}0> and (0001)<11\text{\textomicron}0>. When (0001) existed before deformation, an extremely sharp (0001) (compression plane) texture is formed.

Introduction

Due to their low density and high specific strength, magnesium alloys have grown interests in various industrial fields such as electronics and vehicle parts. However, magnesium, having a hexagonal close-packed structure, has a poor formability at room temperature due to the limited number of slips and the twinning systems [1]. Texture control is one of the attractive approaches to improve the formability of magnesium alloys [2]. Many researches have conducted to understand the effect of texture on the deformation behavior in magnesium alloys [3].

The authors have previously investigated the deformation behavior and the texture development in AZ80 magnesium alloy [4]. The deformation was conducted at 723K with a strain rate of 5.0 × 10^{-2} s^{-1}. It was found that texture has formed along with the occurrence of DRX (Dynamic recrystallization), and the main texture component and its sharpness varied depending on the deformation conditions. It was reported that the deformation temperature had a strong effect on the texture [5]. However, the types of specimens and deformation conditions were limited in the previous studies [4]. Hence, in this study, the formation
behavior of the AZ80 magnesium alloy was investigated on the specimens, which have different initial textures from the previous study, at 623K and 723K with a strain rate of $5.0 \times 10^{-2}$ s$^{-1}$.

**Experimental Procedure**

AZ80 magnesium alloy bars with a strong $<10\overline{1}0>$ (extrusion direction) texture were used. In order to investigate the characteristics of texture formation under plane strain compression deformation, three kinds of specimens; A, B and C; with different initial texture were machined out in the rectangular shape with a dimension of $10 \times 10 \times 6.7$ mm from the extruded bars. Figure 1 shows the geometry of the three specimens: A, B and C.

RD in the figure represents the elongation direction for plane strain compression deformation, and the hatched areas show the compression planes. The compression direction (ND) of specimen A, the constraint direction (TD) of specimen B, and the elongation direction (RD) of specimen C are the extrusion direction of the base material, respectively. All specimens were annealed at 723K for 1h before compression deformation.

Plane strain compression tests were conducted at 623K and 723K with a strain rate of $5.0 \times 10^{-2}$ s$^{-1}$. The specimens were quenched in oil immediately after compression deformation in order to prevent a change in the microstructure. The mid-plane section of the specimens was taken out by the mechanical polishing for texture measurements. Texture measurements were carried out by the Schulz reflection method using Cu Kα radiation. Based on five pole figures, the crystal orientation distribution function (ODF) was determined using the Dahms and Bunge method [6]. Electron Backscatter Diffraction (EBSD) measurements were performed after the electrolytic polishing. The region of $0.45 \text{mm} \times 1.33 \text{mm}$ was scanned using the beam control option with a step size of 4μm.

**Results and Discussion**

The true stress – true strain curves for the three kinds of specimens are shown in Fig. 2. Deformation temperatures of (1) - (2) and (3) - (4) are 723K and 623K respectively. True strain of Fig. 2 is given by an absolute value. The flow curves of the specimen A indicates that the flow stress decreased with an increase in deformation temperature. At the beginning of the flow curve, work softening was observed in all kinds of specimens.

Figure 3 shows the (0001) pole figures for three kinds of specimens before and after deformation. The deformation was conducted at 623K, up to a strain of -1.0. Pole densities are projected onto the compression plane. Mean pole density is used as a unit to draw the contour lines. In fig. 3, (1) and (4) show the (0001) pole figures for specimen A before and after deformation. The (0001) pole densities are distributed at the periphery of the pole...
figure before deformation. The deformation changes the pole densities at the center, left and right ends, and top and bottom ends of the pole figure after deformation. The change of the pole density is similar to that at 723K [4].

Figure 3 (2) and (5) show the (0001) pole figures for specimen B before and after deformation. The (0001) pole densities are distributed on the great circle 90° away from the TD before deformation. The pole densities at the center, and the top and bottom ends of the pole figure changed with a deformation up to the true strain of -1.0. However, in case of the deformation at 723K, (0001) pole was distributed near TD at a strain of -1.0 similar to specimen A. As shown in Fig. 3 (4) and (5), the formation of basal texture is observed in specimens A and B. It seems that basal texture in (4) develops discontinuously, while it develops continuously in (5). In case of specimen C (Figure 3 (3) and (6)), the formation of basal texture was continuous. However, the maximum pole densities at 623K are different from the deformation at 723K. The maximum pole densities at 723K are 26 times the average level [4], while those of 623K are 7 times. It was indicated that basal texture of specimen C is affected by deformation temperature.

Figure 4 shows the φ2 =0° section for specimens A and B, which deformed at 623K up to -1.0. The preferred orientations are shown below the φ2 sections. It should be noted that the

Fig. 2 True stress-true strain curves for the three kinds of specimens.

Fig. 3 (0001) Pole figure showing the crystallographic characteristics of the specimen before (upper) [4] and after (bottom) deformation - 623K with a strain rate of $5.0 \times 10^{-2}$ s$^{-1}$, up to a true strain of -1.0. (1, 4), (2, 5) and (3, 6) show the specimens of A, B and C, respectively. Pole densities are projected onto the compression. Mean pole density is used as a unit to draw the contour lines.

Levels: 1, 2, 4, 8, 16
The present study uses a coordinate system wherein if $(\varphi_1, \Phi, \varphi_2) = (0^\circ, 0^\circ, 30^\circ)$, then the coordinate system becomes $(0001)<1\bar{0}\bar{1}0>$ [4]. It is observed that the basal texture is composed of $(0001)<1\bar{0}\bar{1}0>$ and $(0001)<1\bar{1}20>$ texture components. The $(0001)<1\bar{0}\bar{1}0>$ component was found in all specimens, and had higher orientation density than other orientation components at 723K. In the specimen A, this texture component was formed by discontinuously, suggesting that the development of basal texture can be attributed to either DRX or twinning [4]. It was also confirmed that a sharp basal texture is formed when $(0001)$ exists before deformation. The texture formation behaviors at 623K and 723K were observed to be similar.

Summary
In order to investigate the formation behaviors of basal texture during high-temperature deformation in AZ80 magnesium alloy, the texture formation by plane strain compression is investigated on the three kinds of specimens with different initial textures. It is found that the texture components vary depending on the initial texture and deformation conditions. Two basal texture components are formed by the continuous or discontinuous process. $(0001)<1\bar{0}\bar{1}0>$ texture component shows higher orientation density than other orientation densities in all specimens.

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