Materials Characterization 129 (2017) 104–113

Contents lists available at ScienceDirect

Materials Characterization

journal homepage: www.elsevier.com/locate/matchar

Effect of initial microstructure on static recrystallization of Mg-3Al-1Zn alloy

Jingjing Shi[a], Kaixuan Cui[a], Bingshu Wang[a,*], Liping Deng[a], Chen Wang[a], Zeren Xu[b], Qiang Li[a]

[a] College of Materials Science and Engineering, Fuzhou University, Fujian 350108, China
[b] Department of Automotive Engineering, Clemson University, Greenville, SC 29607, USA

ARTICLE INFO

Keywords:
Magnesium alloy
Static recrystallization
Microstructure
Twin

ABSTRACT

The effects of twin types on grain nucleation and texture evolution during static recrystallization were investigated. Three kinds of cylindrical samples were cut from an AZ31 magnesium alloy plate with their compression directions aligned 0°, 45°, and 90° to the normal direction (ND), and they were referred as 0ND, 45ND and 90ND samples, respectively. The compression tests were conducted at room temperature with a strain of 16%, followed by an annealing at 250 °C for 3 min, 20 min and 60 min respectively. The effects of twin types in different samples on grain nucleation and texture evolution during static recrystallization were investigated with electron backscattered diffraction (EBSD) technology. The {10 − 11} − {10 − 12} double twinning was found to be the dominant deformation mechanism in 0ND and 90ND samples, while {10–12} tension twins and compression twins can be observed in some grains in 45ND sample. The {10–11} − {10–12} double twins are the preferred sites for new grain nucleation, and the {10–12} tensile twins are unfavorable for nucleation of static recrystallization. It is noteworthy that a tiny fraction of {10–11} and {10 − 13} compression twins can be nucleation sites for new grains. The sequence of recrystallized speed in the samples is: 90ND sample > 0ND sample > 45ND sample. The grain size can be refined effectively and the deformation texture becomes weaken during the static recrystallization. The misorientation angle between recrystallized grains and matrix is fluctuated from 20° to 60°, and this phenomenon is suggested to be related to the {10–11} − {10–12} double twins, {10–11} and {10–13} compression twins.

1. Introduction

As the lightest structural material, magnesium alloy has received increasing interest for aerospace and automotive applications [1–3]. For many advantageous mechanical properties, such as high specific strength, low density and so on. However, due to the hexagonal close packed structure at room temperature, the number of independent slip systems in magnesium alloy is limited [4–10]. In addition, a strong basal texture can be obtained after traditional plastic deformation processes, leading to a poor cold working ability and a strong mechanical anisotropy in magnesium alloys [11–15].

It is well known that shear bands are concentrated on the deformed microstructures in plastic deformed metals and alloys. In others' work, the recrystallized processes have been reported to occur in shear bands in deformed metals [16–18]. Static recrystallization favors the improvement of working abilities for magnesium alloys [19], which not only can promote the softening and grain refinement but also alter the detrimental strong basal texture [20–22]. Through optimizing the grain size and orientation of the deformed microstructure, recrystallization can reach the purpose of improving the plastic properties and strength of the magnesium alloys. In spite of numerous studies of dynamic recrystallization (DRX) about commercial production of wrought magnesium alloys, it is well known that dynamic recrystallization plays an important role in deformation process [23–26]. However, detailed investigation of static recrystallization is less frequently undertaken. Static recrystallization puts forward a new heat treatment process in deformation magnesium alloy. There are only a few reports focusing on the annealing behaviors and microstructure evolution in magnesium alloys. Most of these previous studies concentrate on the annealing time or thickness reduction of hot warm processed magnesium alloys. Li et al. [21] suggested that compression twins are more effective as nucleation sites than tension twins, and the former is the dominant nucleation site of magnesium alloys. Jäger et al. [27] reported that recrystallized new grains usually nucleated at twin lamellas or the mutual crossing places of the twins. The annealing texture after cold deformation in Mg is closed to the deformation texture [28]. In our previous work, the effect of initial texture on dynamic recrystallization during hot rolling was investigated [23]. It was found that {10–12}

* Corresponding author.
E-mail address: bswang@fzu.edu.cn (B. Wang).

http://dx.doi.org/10.1016/j.matchar.2017.04.029
Received 2 January 2017; Received in revised form 25 April 2017; Accepted 26 April 2017
Available online 27 April 2017
1044-5803/

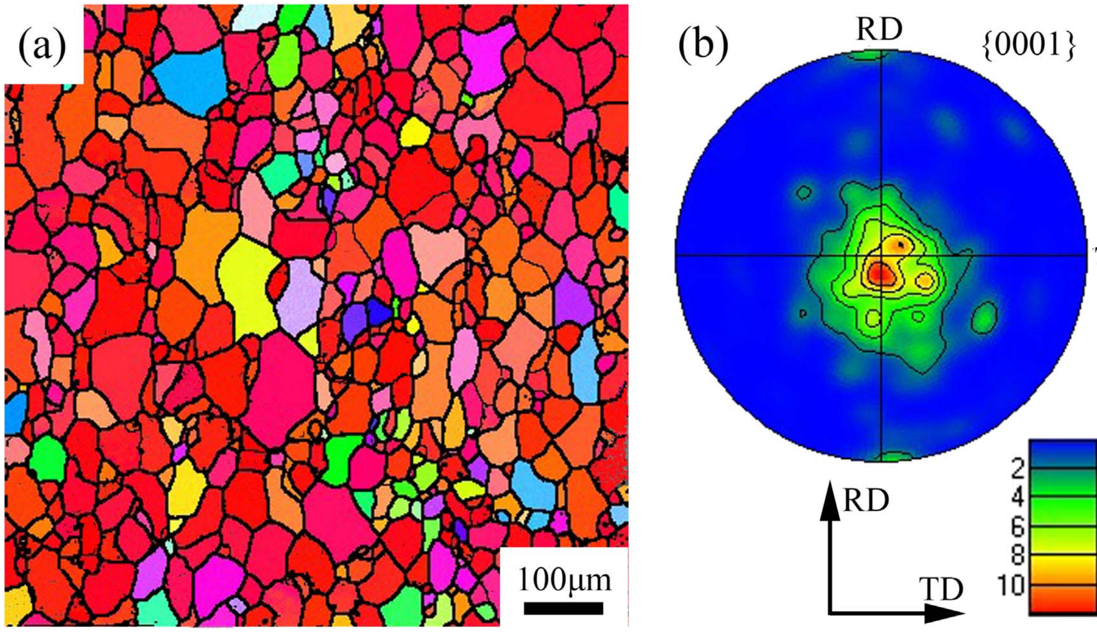

Fig. 1. The as-received AZ31 Mg alloy sheet: (a) Orientation map and (b) {0001} pole figure.

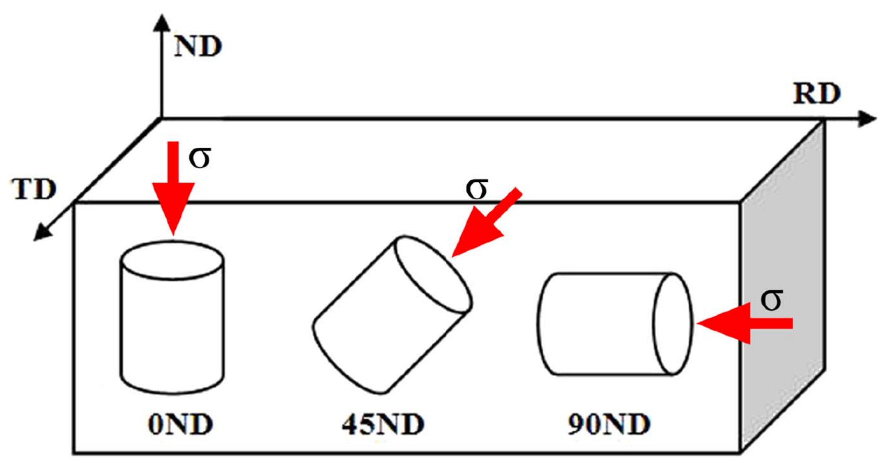

Fig. 2. Schematic illustration of the samples used for compression tests.

tension twins and {10–11} − {10–12} double twins were the dominant deformation mechanism in the plate which was cut with wedge surface approximately perpendicular to normal direction (ND plate). The process of DRX in the plate which was cut with wedge surface approximately perpendicular to transverse direction (TD plate) was retarded compared with that in ND plate.

The primary purpose of this paper is to study the effect of different initial microstructure on static recrystallization during annealing at different time. Based on the metallographic and electron backscattered diffraction (EBSD) results, the microstructure and texture evolution are analyzed in details, allowing the relationship between recrystallized grains and matrix to get discussed.

2. Experimental Materials and Methods

The material used in this study was a commercially available AZ31 Mg alloy (Mg-3%Al-1%Zn) hot rolled plate with a strong {0001} basal plane texture (Fig. 1). Cylindrical samples, with a height of 12 mm and a diameter of 8 mm were cut from the hot rolled plate for uniaxial compression tests, as schematically shown in Fig. 2. The compression directions are along various orientations: ND (0ND sample), 45° from ND to RD (45ND sample), and RD (90ND sample). Compression tests were carried out at room temperature with a strain rate of 1 mm/min. Samples at strains of 0.16 were taken for microstructure examination at room temperature. Then the samples were annealed at 250 °C for 3 min, 20 min and 60 min, respectively. The samples for EBSD orientation mapping were ground with 600 to 4000 grit papers, and then electro-polished with a solution of ACII electrolyte for 120 s at 20 V. EBSD observations were carried out on a Zeiss Supra 55 FEG-SEM equipped with an HKL channel 5 system.

3. Results and Analyses

3.1. Microstructure After Uniaxial Compression

The microstructures of 0ND, 45ND and 90ND samples with the same