Available online at www.sciencedirect.com
ScienceDirect

JOURNAL OF IRON AND STEEL RESEARCH, INTERNATIONAL. 2016, 23(1): 74-77

Twinning Behavior of a Basal Textured Commercially Pure Titanium Alloy TA2 at Ambient and Cryogenic Temperatures

Jin-ru LUO, Xiao SONG, Lin-zhong ZHUANG, Ji-shan ZHANG
(State Key Laboratory for Advanced Metals and Materials, University of Science and Technology Beijing, Beijing 100083, China)

Abstract: Twinning greatly affects the microstructure and mechanical performance of titanium alloys. The twinning behavior of a basal textured commercially pure titanium TA2 plates rolled to 4% reduction at the ambient and cryogenic temperatures has been investigated. Microstructures of the rolled samples were investigated by optical microscope (OM) and the twinning analysis was carried out based on orientation data collected by electron back-scatter diffraction (EBSD). $\{11\bar{2}2\}$ contraction twins, $\{11\bar{2}4\}$ contraction twins and $\{10\bar{1}2\}$ extension twins have been observed. Twinning mode activity varied with rolling temperature. Twinning is considered as the dominant deformation mechanism during rolling at both temperatures for the strain condition. Larger proportion of grains activates twinning during cryorolling, and greater number and more diverse types of twins are observed; manifestly related to the suppression of dislocation slips at the cryogenic temperature. $\{11\bar{2}2\}$ contraction twins are the dominate twin type within samples rolled at both temperatures. Several $\{11\bar{2}4\}$ contraction twins are observed in the cryorolled sample while there are only a few in the sample rolled at room temperature. A few tiny $\{10\bar{1}2\}$ twins have been identified in both samples. $\{11\bar{2}4\}$ contraction twins are preferentially activated at cryogenic deformation temperature and the $\{10\bar{1}2\}$ extension twins may result in local strain accommodation.

Key words: titanium; rolling; twinning; cryogenic temperature

The wrought titanium has the advantages of high strength and good ductility especially at the low temperature comparing with the other light-weight HCP structural metals such as magnesium. As other metals with a HCP crystalline structure, twinning is active in α-titanium[1-4]. Twins can separate grains thus refine grains, improving the mechanical properties[5]. They may also be related to the shear bands[6] contributing to the grain subdivisions[7,8]. And the precipitation strengthening phase in some Ti-based bulk metallic glass has also been considered as twin-related[9]. Twinning plays an important role in affecting the microstructure[10-13], texture[10,14] and mechanical performance[2,15-20] of the material during plastic deformation. Six different types of deformation twins have been reported[1-4] in the α-titanium at different strain conditions: $\{11\bar{2}2\}$, $\{11\bar{2}4\}$, and $\{10\bar{1}1\}$ contraction twins easy to occur during contraction strain of the *c*-axis, and $\{10\bar{1}2\}$, $\{11\bar{2}1\}$, and $\{11\bar{2}3\}$ extension twins easy to occur for extension strain of the *c*-axis. $\{11\bar{2}2\}$ contraction twin and $\{10\bar{1}2\}$ extension twin are the most common twin types[1-3]. Because of the significant influence of twins on the deformed material and the various twin types, a lot of studies[21-25] have been done on discussing the twinning behavior of titanium at different strain conditions. However, seldom works have focused on the twinning behavior for the deformation at cryogenic temperature at a relatively high strain rate such as cryorolling. The present work aims to analyze the twinning behavior of a commercially pure titanium plate during cryogenic and room temperature

Foundation Item: Item Sponsored by National Natural Science Foundation of China (51401019); China Postdoctoral Science Foundation (2014M550612); Fundamental Research Funds for the Central Universities of China (FRF-TP-14-048A1); Common Construction Project from Beijing Municipal Commission of Education of China (FRF-SD-13-005B)

Biography: Jin-ru LUO, Doctor; **E-mail**: luojr@ustb.edu.cn; **Received Date**: August 31, 2015

rolling, and discuss the effect of rolling temperature on the twinning behavior. The rolling reduction was chosen to be as low as 4% to avoid the interaction of over-active dislocation slips at a high strain level.

1 Experimental

The initial material was a commercially provided hot rolled TA2 plate. The initial sheets were annealed at 500 ℃ for 30 min in an air furnace and then air cooled as a homogenization treatment. Before rolling, the sheet for cryorolling was placed in liquid nitrogen for 30 min in order to achieve a uniform temperature. The sheet was then transferred to rolling mill and rolled immediately to a reduction of 4% in one pass, followed by liquid nitrogen cooling. Rolling conditions were chosen to ensure homogenous deformation with a roll gap ratio of $l/d \approx 1$ (l is arc contact length and d is average plate thickness before and after rolling).

The samples being rolled at ambient and cryogenic temperatures are marked as RT and CT, respectively. Then, the samples were cut from the center of the rolled sheet for microstructural investigation. In all cases, the surface used for inspection was the transverse section (normal to the transverse direction). Microstructural observations were carried out using optical microscope (OM) as well as electron back-scatter diffraction (EBSD) mapping on the polished surface. The samples were mechanically polished after standard metallographic grinding, and then electro-polished in a solution of 10 mL perchloric acid and 150 mL methanol at −30 ℃ using a DC (direct current) power supply with the voltage of 30 V. The chemical etchant used on the samples was a solution of 2 mL HF, 6 mL HNO_3, and 97 mL H_2O. The EBSD investigations were carried out using a FEI-field-emission gun scanning electron microscope in order to achieve the spatial resolution required to identify twins using the software package Channel 5.0.9.0.

2 Results and Discussion

Figs. 1 and 2 illustrate the microstructure observed by OM and texture of the initial material calculated from EBSD data, respectively. The material is a completely recrystallized sheet with a strongly basal texture. The initial material is twins free.

Fig. 3 illustrates the microstructures of the rolled samples. Twinning takes place in the grains of the rolled samples at both cryogenic and room tem-

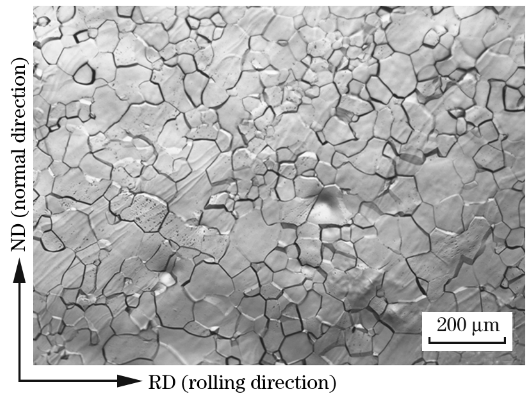

Fig. 1 Microstructure of the initial material

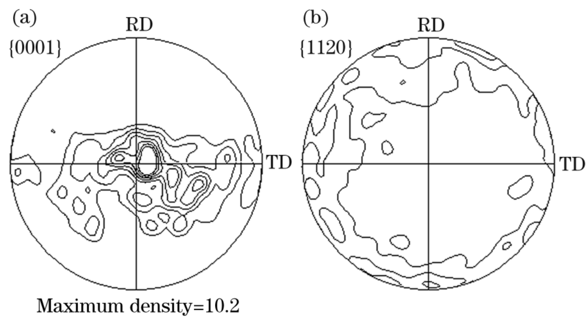

Fig. 2 {0001} (a) and $\{10\bar{1}0\}$ (b) pole figures of the initial material (TD=transverse direction)

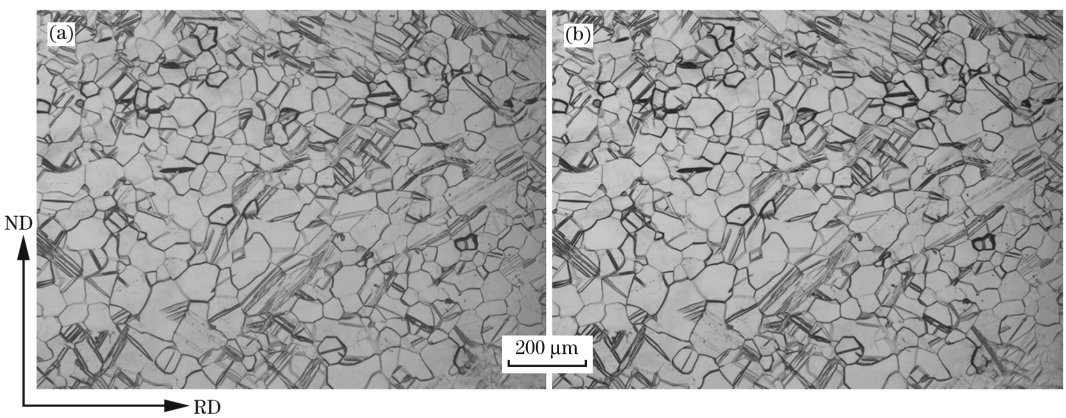

Fig. 3 Microstructure of the samples rolled at room temperature (a) and cryogenic temperature (b)