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Texture development in Al/Al_2O_3 MMCs produced by anodizing and ARB processes

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ABSTRACT

Anodizing and accumulative roll bonding (ARB) processes were used as a new technique for manufacturing aluminum/alumina composites including various Al_2O_3 quantities. Textural evolution during ARB process of composites was evaluated using X-ray diffraction (XRD). The effective parameters in texture evolution were the number of cycles (3, 5, 7 and 8 cycles) and alumina quantity (0.48, 1.13, 2.40 and 3.55 vol.%). The texture evolution demonstrated that the Rotated Cube was a major texture component for all specimens except for the produced composite containing 0.48 vol.% alumina after eight cycles. For subsequent composites, the dominant components were Copper and Dillamore. Also, for almost all specimens (except for the composite with 0.48 vol.% alumina), the intensity of the texture components (except for Rotated Cube) was very weak. All these results are related to the presence of the second phase particles and also size and quantity of them.

1. Introduction

Discontinuously reinforced aluminum metal matrix composites (MMCs) are now recognized as important structural materials. One of the primary advantages of these materials is that they can be processed and shaped by conventional metal working techniques, such as extrusion and rolling [1].

Severe plastic deformation (SPD) is one of the most effective ways to produce ultra fine grained (UFG) materials, with a mean grain size smaller than 1 μm, in bulk macroscopic materials. The UFG materials are expected to perform prominent mechanical properties. Accumulative roll bonding (ARB) process, originally developed by Saito et al. [2,3], is one of the most popular SPD techniques [4–6]. ARB process does not require any special equipment and enables the production of UFG structures in bulk sheet materials. Moreover, continuous rolling mills can be readily used in industry for ARB. For these reasons, ARB is perhaps the most promising SPD process for industrial practices [7].

Accumulative roll bonding process consists of multiple cycles of rolling, cutting, stacking and solid-state deformation bonding, so that a large strain can be accumulated in the metallic sheet during the ARB process without any sheet geometrical changing. Particularly, ARB is a prospective SPD process which can produce bulk material continuously and has a good potential for commercialization [8].

The texture is an important feature for controlling the properties of the ARB-processed sheets because the ARB process basically fabricates sheet materials. There is limited information, however, as to the texture of ARB-processed sheets [9]. In ARB process, evolution of texture is often compared to that of conventional rolling or simple shear deformation and is generally characterized by rolling-type components at the center or the mid-thickness and shear-type components near the surface [10]. Several authors [2,11], based on {1 1 1} pole figures in commercial purity aluminum have shown that the texture developed after ARB process is asymmetric and very weak. Also, for this material, it has been reported by Heason and Prangnell [12] that most of the shear texture is rotated to Copper and S textures when incorporated into the center during ARB process. Kim et al. [13] and Li et al. [10] also observed the presence of ideal Copper and Dillamore orientations at the center during ARB process.

The texture evolution in ARB processed specimens has not been studied as extensively as the microstructural evolution. Furthermore, the texture behavior of metal matrix composites (MMCs) produced by the new technique of anodizing and ARB processes has not yet been investigated. In this work, an investigation was launched to understand the textural changes in the Al/Al_2O_3 composite produced by anodizing and ARB processes. Also, the effects of number of cycles and alumina quantity (due to different anodizing times) on the deformation textures were studied.

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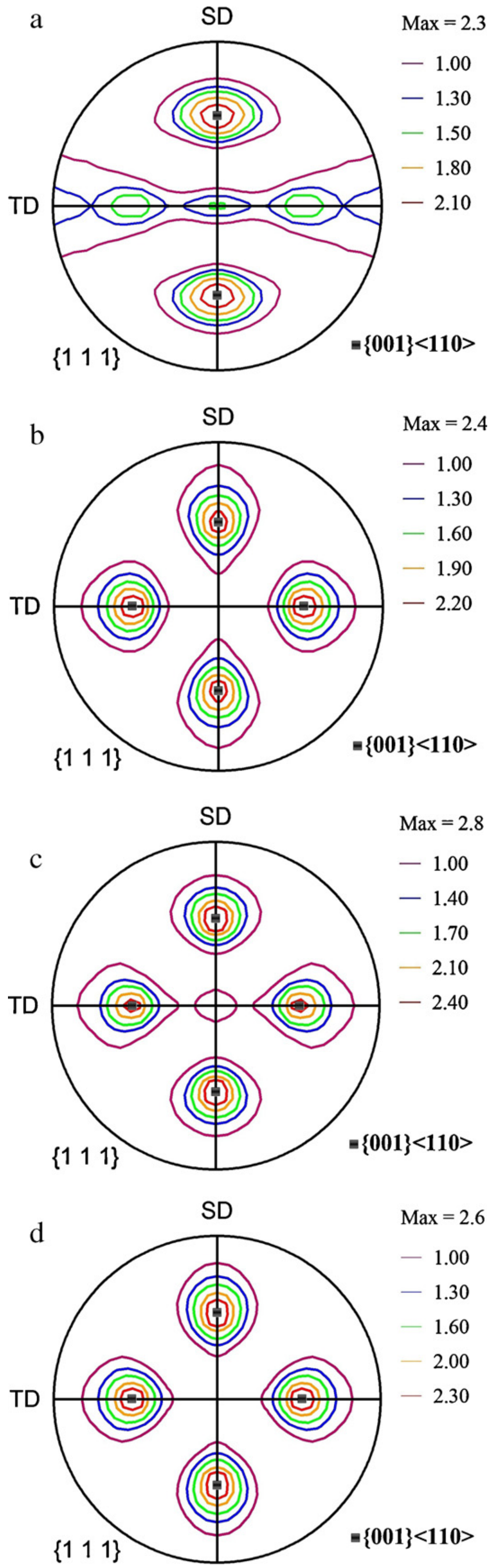

Fig. 1. {1 1 1} pole figures of ARB-processed composites with 2.40 vol.% alumina after (a) three, (b) five, (c) seven and (d) eight ARB cycles.

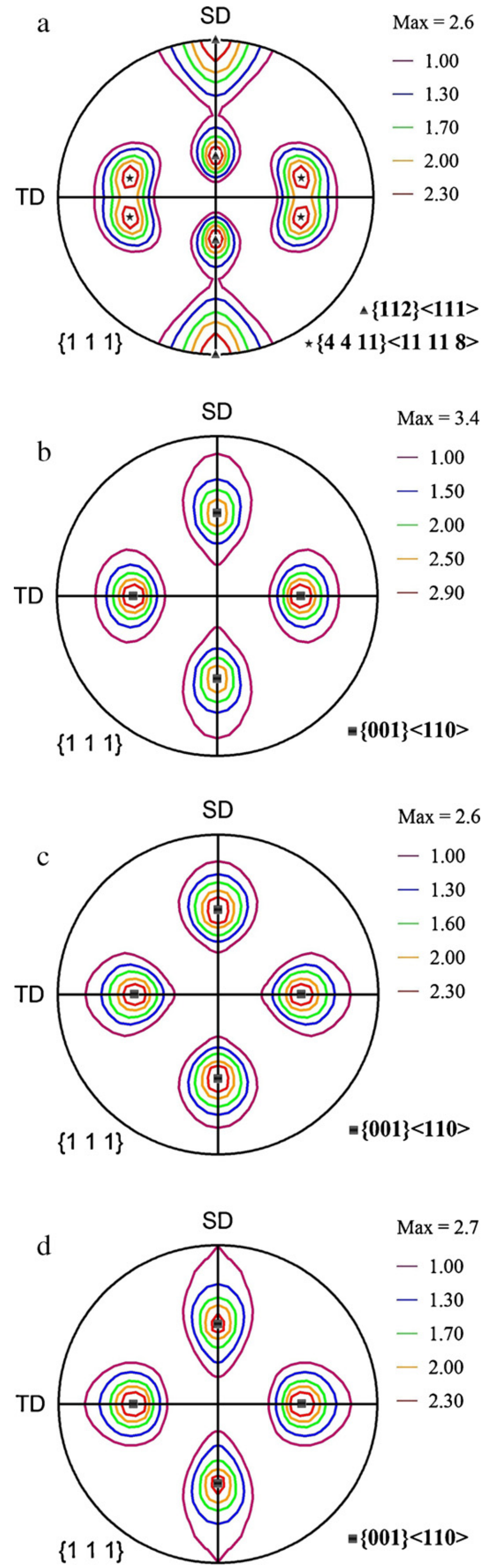

Fig. 2. {1 1 1} pole figures of eight cycle ARB-processed composite with (a) 0.48, (b) 1.13, (d) 2.40 and (e) 3.55 vol.% alumina.