Accepted Manuscript

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PII: S0925-8388(18)32153-4

DOI: 10.1016/j.jallcom.2018.06.043

Reference: JALCOM 46379

To appear in: *Journal of Alloys and Compounds*

Received Date: 25 December 2017

Revised Date: 3 June 2018

Accepted Date: 4 June 2018

Please cite this article as: H. Wei, Y. Cui, H. Cui, C. Zhou, L. Hou, Y.h. Wei, Evolution of grain refinement mechanism in Cu-4wt.%Ti alloy during surface mechanical attrition treatment, *Journal of Alloys and Compounds* (2018), doi: 10.1016/j.jallcom.2018.06.043.

Evolution of grain refinement mechanism in Cu-4wt.%Ti alloy during surface mechanical attrition treatment

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Keywords: Surface mechanical attrition treatment; nanostructured materials, grain refinement; Grain boundary strengthening, mechanical twining

Abstract

This work reveals the grain refinement process of low-stacking fault energy Cu-4wt.%Ti alloy during surface mechanical attrition treatment (SMAT). Without phase transformations, the grain refinement process in Cu-4wt.%Ti alloy with a low stacking fault energy involves formation of planar dislocation arrays and twins in the small strain and low strain rate deformed region adjacent to the coarse grain matrix, twin-twin intersections leading to grain subdivision. The formation of lamellae, polygonal grains, and rotation recrystallization were induced by the large strain and high strain rate deformation near the treated surface. We also observed one distinct layer at the treated surface with the thickness about 15 μm, which is filled with equiaxed nanograins. The hardness of the treated surface was increased by 40% and attributed to the grain refinement according to the grain boundary strengthening mechanism.

1. Introduction

Surface mechanical attrition treatment (SMAT) is a simple and effective severe plastic deformation (SPD) approach to obtain ultra-fine materials, and has been the subject of extensive studies during the past decade years. So far, SMAT has been successfully applied in many materials such as RAFM steel [1], 316 L [2], AISI 304 stainless steels [3], low carbon steel [4], pure Fe [5], Al [6], Ti [7], Co [8], Ni_3Al [9], pure Cu and copper alloys [10-12], AZ91D [13], Mg-Li-Al alloy [14] and Inconel 600 [15]. Porosity-free and contamination-free nanograins are formed on the top