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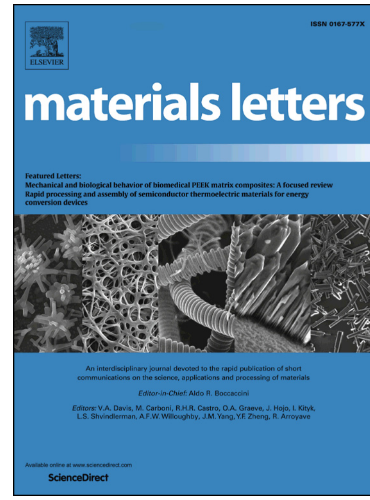

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The impact of ultrasonic vibrations on shear banding in nanocrystalline titanium

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Abstract

The mechanical properties of nanocrystalline titanium of commercial purity were found to be influenced substantially by superimposed ultrasonic vibrations, since by this treatment, dislocation slipping and grain-boundary sliding under plastic deformation are modified. An effective decrease of the grain-boundary strength within the shear band was observed. The impact on the shear banding, on the shear-band morphology, and on its structure was investigated by transmission and scanning electron microscopy.

1. Introduction

Highly localized strain in the form of shear bands is an inherent plastic deformation mode of nanocrystalline titanium (along with dislocation flow and twinning). Shear banding reduces considerably the workability of a material. Shear-bands are often precursors of crack formation and thus deteriorate the mechanical properties. Therefore, the shear-band properties are subject to numerous studies [1-3], not only to understand the plastic-deformation process, but also to control the series of events leading to material failure. Investigations on shear-band microstructures produced in nanocrystalline titanium at quasi-static loading are scarce at present, but with superimposed cyclic stress are, as far as we know, not exist.

Recently, the impact of ultrasonic vibrations (USVs) on the mechanical properties of nanocrystalline titanium of commercial purity has been investigated at uniaxial quasi-static compression [4]. It occurs that USVs decrease the yield stress and initiates the development of shear bands. By definition major shear bands cross the entire sample. It should be noted that the major shear-band initiation and propagation also take place at quasi-stationary deformation without USVs, but at a comparatively large strain value. In the present work, we report the analyses of shear band structure in nanocrystalline titanium after mechanical tests with and without USVs. The results are discussed in terms of mechanisms for the shear band formation.

2. Materials and Methods

Samples of nanocrystalline titanium with an average grain size of about 40 nm were obtained by rolling at a temperature of about 110 K (cryo mechanical treatment) [5]. Quasi-static compression tests up to fracture were carried out at room temperature with a strain rate of 10^{-4} s^{-1}. In addition,