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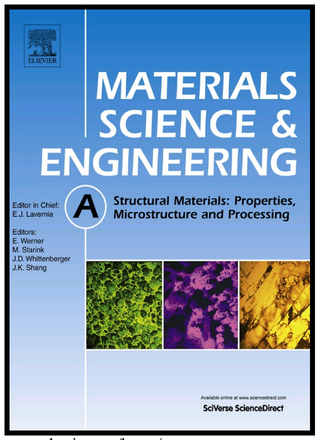

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PII: S0921-5093(17)30958-9
DOI: http://dx.doi.org/10.1016/j.msea.2017.07.063
Reference: MSA35311

To appear in: *Materials Science & Engineering A*

Received date: 11 April 2017
Revised date: 16 June 2017
Accepted date: 19 July 2017

Shear bands as translation-rotation modes of plastic deformation in solids under alternate bending

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Abstract

The paper studies the shear banding developing in corrugated surface layers of commercial titanium, hydrogenated Ti surface layers and high-purity aluminum foils glued onto commercial aluminum A7 plates against elastic deformation of their bulk under alternate bending at room temperature. In surface layers of commercial titanium under alternate bending up to fracture, plastic flow develops through microscale twinning against the background of dislocation substructure and shear banding is absent. Early in the alternate bending (up to $N=10^3$ cycles which corresponds to strain $\varepsilon \sim 55\%–60\%$), shear banding in hydrogenated Ti surface layers and Al foils is also absent. At $N=10^4–10^6$ cycles, severe shear banding is detected in hydrogenated Ti surface layers and Al foils. Two types of meso- and macroscale shear bands are revealed and analyzed: planar shear bands with continuous misorientations in slightly corrugated surface layers and three-dimensional shear bands which propagate in highly corrugated surface layers. The latter shear bands are responsible for submicro- and/or nanofragmentation of material and culminate in plastic collapse and fracture of solids. Shear bands are treated as translation-rotation modes of plastic deformation in solids with high crystal lattice curvature. Shear banding is a multiscale noncrystallographic mechanism of a curved crystal lattice fragmentation that transforms an elastic lattice curvature of a deformed solid to its inelastic rotation.

Keywords: Shear banding, titanium, Al, Cyclic loading, Plastic collapse, Fracture mechanisms.

1. Introduction

The microstructure of shear bands in a deformed solid has been much addressed in research papers, placing the most emphasis on adiabatic shear bands at high strain rates and the mechanisms of shear band nucleation and propagation have been rather thoroughly studied in experiments and simulation [1-16]. However, shear bands developing under dynamic loads are more crucial for materials than it could be expected. These bands cause structural fragmentation in a material, are dependent on its rotational