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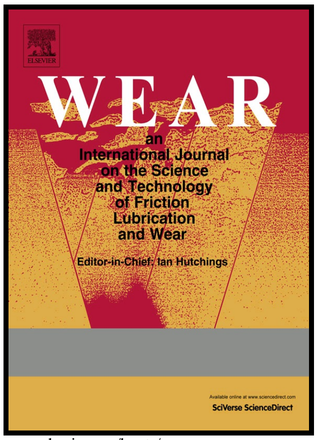

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The effect of crystallographic grain orientation of polycrystalline Ti on ploughing under scratch testing

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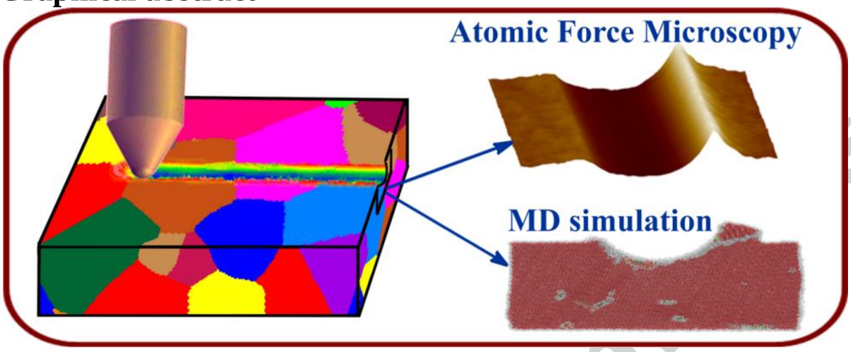
Plastic ploughing of polycrystalline Ti samples subjected to scratching was studied experimentally and using molecular dynamic simulation. Crystallographic orientation of Ti grains is found to substantially affect the formation of pile-ups at scratch flanks and the residual depth of scratch grooves. This effect is concerned with the difference in plasticity of the grains with different orientations in the zone of a tribological contact. It is shown that the most preferred grain orientations in terms of enhancement of their resistance to abrasive wear are those that can favor strain hardening of the material in the scratch groove. The applicability of the H/E and H^3/E^2 ratios for the prediction of resistance of grains with different orientations to abrasive wear is investigated. It is found that the H/E ratio provides better agreement with the residual depth of scratch grooves then the hardness or H^3/E^2 ratio.

Graphical abstract



Keywords: Titanium, Scratch testing, Molecular dynamics, Structure, Plasticity

1. Introduction

Titanium and its alloys are widely used engineering materials within the Aerospace, Automotive, Energy and Chemical industries. Their unique combinations of high strength-to-weight ratio, strong resistance to creep, excellent corrosion resistance, and low heat conductivity make them suitable for a wide range of applications [1]. However, the usage of titanium alloys is partially limited by their poor wear resistance [2, 3]. Detailed studies of the effect of the microstructure of titanium alloys on the mechanisms of their abrasive, adhesive, fatigue and other wear types are necessary to improve their tribological properties.

Scratch testing is a powerful technique to gain insight into abrasive wear, since the wear mechanisms of materials subjected to scratching and abrasion are both very similar [4-6]. Taking into consideration that the mechanical behavior of crystalline materials is substantially determined by their crystallographic orientation, the significant advantage of scratch testing over conventional wear tests consists in the possibility of detailed investigation of defect nucleation and plastic ploughing in individual grains of a polycrystal. It is of crucial importance not only for increasing wear resistance of materials by the directed formation of the preferred grain orientation (texture) but also for studying micro- and nanotribological processes, where even in the case of polycrystalline materials contact interaction occurs within a single grain.

The majority of experimental studies of the mechanical behavior of polycrystalline solids subjected to scratch testing are focused on investigation of plastic ploughing of the materials as well as determination of their hardness and coefficient of friction [7-10]. At the same time, there is a lack