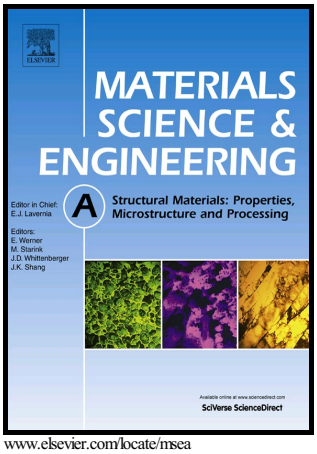
Strain rate sensitivity in commercial pure titanium: the competition between slip and deformation twinning

Qinmeng Luan, T. Benjamin Britton, Tea-Sung Jun



www.elsevier.com/locate/msea

PII: S0921-5093(18)31062-1
DOI: https://doi.org/10.1016/j.msea.2018.08.010
Reference: MSA36781

To appear in: *Materials Science & Engineering A*

Received date: 17 January 2018
Revised date: 29 June 2018
Accepted date: 2 August 2018

Cite this article as: Qinmeng Luan, T. Benjamin Britton and Tea-Sung Jun, Strain rate sensitivity in commercial pure titanium: the competition between slip and deformation twinning, *Materials Science & Engineering A*, https://doi.org/10.1016/j.msea.2018.08.010

Strain rate sensitivity in commercial pure titanium: the competition between slip and deformation twinning

Qinmeng Luan[1,2], T. Benjamin Britton[2], Tea-Sung Jun[2,3,*]

[1]Department of Mechanical Engineering, Imperial College London, London SW7 2AZ, UK

[2]Department of Materials, Royal School of Mines, Imperial College London, London SW7 2AZ, UK

[3]Department of Mechanical Engineering, Incheon National University, Incheon 22012, South Korea

*Corresponding author. Email address: t.jun@inu.ac.kr

Abstract

Titanium alloys are widely used in light weight applications such as jet engine fans, where their mechanical performance under a range of loading regimes is important. Titanium alloys are mechanically anisotropic with respect to crystallographic orientation, and remarkably titanium creeps at room temperature. This means that the strain rate sensitivity (SRS) and stress relaxation performance are critical in predicting component life. In this work, we focus on systematically exploring the macroscopic SRS of Grade 1 commercially pure titanium (CP Ti) with varying grain sizes and texture using uniaxial compression. Briefly, we find that Ti samples had positive SRS and samples compressed along the sheet rolling direction (RD) (i.e. soft grains dominant) were less rate sensitive than bars compressed along the sheet normal direction (ND) (i.e. hard grains dominant). We attribute this rate sensitivity to the relative activity of slip and twinning. Within the grain size range of $\sim 317 \pm 7\ \mu m$, we observe an increase in the rate sensitivity, where volume fraction of $\{10\bar{1}2\} < 10\bar{1}1 >$ T1 tensile twins was low, and the twin width at different strain rates were similar. These observations imply that the macroscopic rate sensitivity is controlled by the ensemble behaviour of local deformation processes: the amount of slips accumulated at grain boundaries affects the SRS, which is grain size and texture dependent. We hope that this experimental study motivates mechanistic modelling studies using crystal plasticity, including strain rate sensitivity and twinning, to predict the performance of titanium alloys.

Keywords

Strain rate sensitivity, pure titanium, macroscopic uniaxial compression, twin, dislocation

1. Introduction

Jet engines are a critical engineering structure in the modern life and in these structure titanium alloys are selected for use in the fan and lower temperature sections due to their excellent specific strength (strength to weight) and fatigue resistance [1,2]. In these applications, the role of strain rate sensitivity is likely important, especially in cold dwell fatigue where time sensitive deformation modes are thought to control fatigue crack