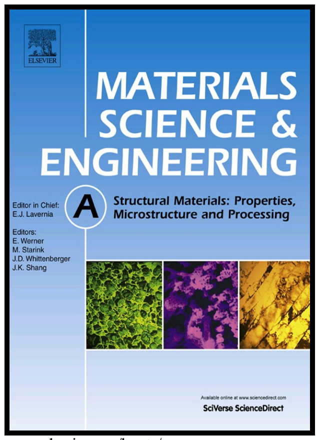
Author's Accepted Manuscript



www.elsevier.com/locate/msea

Identification of anisotropic plasticity properties of materials using spherical indentation imprint mapping

Jianjun Wu, Mingzhi Wang, Yu Hui, Zengkun Zhang, He Fan

PII: S0921-5093(18)30185-0
DOI: https://doi.org/10.1016/j.msea.2018.02.001
Reference: MSA36088

To appear in: *Materials Science & Engineering A*

Received date: 2 January 2018
Revised date: 31 January 2018
Accepted date: 1 February 2018

Cite this article as: Jianjun Wu, Mingzhi Wang, Yu Hui, Zengkun Zhang and He Fan, Identification of anisotropic plasticity properties of materials using spherical indentation imprint mapping, *Materials Science & Engineering A*, https://doi.org/10.1016/j.msea.2018.02.001

Identification of anisotropic plasticity properties of materials using spherical indentation imprint mapping

Jianjun Wu*, Mingzhi Wang, Yu Hui, Zengkun Zhang, He Fan

School of Mechanical Engineering, Northwestern Polytechnical University, Xi'an, China, 710072

Abstract

In this paper, a new inverse method is proposed to identify the anisotropic plasticity properties of materials using solely the residual imprint mapping in spherical indentation. This method does not need the entire load-displacement (P-h) curve in spherical indentation experiment. The stress strain curves along transverse and longitudinal directions of the indented specimens can be simultaneously identified using single spherical indentation test. The new method is based on weighting the average and difference amounts, $\bar{S}$ and ΔS of the residual imprint snapshots along transverse and longitudinal directions. The proper orthogonal decomposition is used to correlate the effective imprint snapshots with material constitutive parameters, and the inverse problem is solved by the "Interior-point" optimization algorithm. We finally applied the new method on the SiCw/A6061. The well-posed solution of material properties is achieved, and the anisotropic plasticity parameters obtained from indentation and uniaxial tests show good agreement. Besides, the influence of weighting factor and experiment error on the numerical results are also investigated. Results indicate the proposed inverse method is very effective and reliable.

Keywords: plastic anisotropy; parameters identification; spherical indentation; residual imprint; inverse analysis

1. Introduction

Indentation test has been widely used as a simple and effective tool to measure various characteristics of materials with small sample volumes, where the conventional uniaxial tests are not applicable [1-3]. The elastic modulus of a material can be directly determined using the well-established "Oliver-Pharr method" [4], while the extraction of the other properties in a relatively complex material system with multiple constitutive parameters is still challenging, e.g. stress strain curves [5-6], wear properties [7-8], residual stresses [9-10], as well as the material anisotropy [11-15].

In the nature and synthetic material systems, anisotropic properties are often observed primarily due to textures, such as the crystallographic orientations of metals [16, 17], thermally sprayed coatings [18, 19], whisker-reinforced metal matrix composites [14, 20] and

* Corresponding author at: Northwestern Polytechnical University, 127 West Youyi Road, Xi'an, Shaanxi 710072, China
Email address: wujj@nwpu.edu.cn (J.J. Wu).