Accepted Manuscript

Title: Deformation Strength of Nanocrystalline Thin Films

Author: W. Blum

PII: S1005-0302(16)30239-0
DOI: http://dx.doi.org/doi: 10.1016/j.jmst.2016.11.025
Reference: JMST 864

To appear in: *Journal of Materials Science & Technology*

Received date: 28-12-2015
Revised date: 15-1-2016
Accepted date: 18-1-2016

Please cite this article as: W. Blum, Deformation Strength of Nanocrystalline Thin Films, *Journal of Materials Science & Technology* (2016), http://dx.doi.org/doi: 10.1016/j.jmst.2016.11.025.

Deformation strength of nanocrystalline thin films

W. Blum
Dept. of Materials Science, Inst. I, University of Erlangen-Nürnberg, Martensstr. 5, D-91058 Erlangen, Germany

*Corresponding author. Tel. +49 9131 63807.
E-mail address: wolfgang.blum@fau.de (W. Blum).
[Received 28 December 2015; received in revised form 15 January 2016; accepted 18 January 2016]

The data of deformation strength and microstructure of thin films of nanocrystalline Pd recently provided by Colla et al. have been analysed. It is shown that the properties of the films with cylindrical grains of 30 nm diameter extending over a significant portion of the film thickness (≈ 90 nm) are quantitatively comparable to what is known from nanocrystalline bulk material. This is explained in terms of boundary-mediated processes governing emission, storage, and recovery of dislocations.
Key words: Stress relaxation; Film; Pd; Strength; Nanocrystalline; In situ; Dislocations; Dynamic recovery; Grain boundaries

1. Introduction

The progress in microstructuring techniques has made it possible to deform Pd-films of 90 nm thickness with columnar grains of 30 nm diameter (Fig. A.4) in tension [1] (see ref. [2] for experimental details). Deformation started under the action of a prestressed actuator when the solid connection of specimen and actuator to the substrate was removed by etching. After removal, the acting force rises from zero to a certain maximum level while the specimen work hardens. Deformation of the specimen then continues at constant total length of specimen and actuator. This leads to relaxation of the stress exerted by the actuator. After 3 h of relaxation the specimens were available for first measurement of stress, strain and microstructure including the dislocation density. According to ref. [1] “the small thickness allows for direct in situ testing by transmission electron microscopy (TEM)”.

The authors reported unusually large strains during stress relaxation and determined an activation volume for thermally activated glide [1]. In the following the results are discussed. It is shown that the behavior of the nanocrystalline (nc) Pd films is in accordance with the known behavior of bulk material indicating that the mechanisms of deformation are the same in both cases.

2. Strength in Stress Relaxation

The crosses in Fig. 1 show the relation between inelastic strain ϵ_{inel}[1] and stress σ of the specimens of nc Pd in stress relaxation after application of the tensile load in tests under four different experimental conditions. The data were evaluated by digitizing the data reported in Fig. 1(b) of