Engineering Conferences International
ECI Digital Archives

Nanomechanical Testing in Materials Research and Development V

Proceedings

Fall 10-5-2015

A comprehensive study on the deformation behavior of ultra-fine grained and ultra-fine porous Au at elevated temperatures

Alexander Leitner
Montanuniversität Leoben, alexander.leitner@unileoben.ac.at

Verena Maier
Institute of Materials Science, Austrian Academy of Sciences

Erich Schmid
Institute of Materials Science, Austrian Academy of Sciences

Peter Hosemann
University of California, Berkeley

Daniel Kiener
Montanuniversität Leoben

A COMPREHENSIVE STUDY ON THE DEFORMATION BEHAVIOR OF ULTRA-FINE GRAINED AND ULTRA-FINE POROUS AU AT ELEVATED TEMPERATURES

Alexander Leitner, Department Materials Physics, Montanuniversität Leoben, Jahnstraße 12, A-8700 Leoben, Austria,
E-mail: alexander.leitner@unileoben.ac.at
Verena Maier, Erich Schmid Institute of Materials Science, Austrian Academy of Sciences, Jahnstraße 12, A-8700 Leoben, Austria
Peter Hosemann, Department of Nuclear Engineering, University of California, Berkeley 4155 Etcheverry Hall, MC 1730, Berkeley, CA 94720-1730, USA
Daniel Kiener, Department Materials Physics, Montanuniversität Leoben, Jahnstraße 12, A-8700 Leoben, Austria

Modern design and engineering of highly efficient devices and machines demand innovative materials to satisfy requirements such as high strength at low density. The purpose of this study was to compare mechanical properties and deformation behavior of ultra-fine grained Au and its ultra-fine porous counterpart, both fabricated from the same base material. Microstructural investigations of the foam surrendered a ligament size of approximately 100 nm consisting of ~60 nm grains in average. The ultra-fine grained Au features a mean grain size of 250 nm.

Nanoindentation is a convenient technique to obtain materials properties at ambient but also at non-ambient conditions and elevated temperatures. In this work, a broad indentation test series was performed in order to determine hardness, Young's modulus, strain-rate sensitivity, and activation volume between room and elevated temperatures up to 300 °C for both materials. Due to the small characteristic dimensions, high hardness values were noted for both materials, which rapidly drop at elevated temperatures. In addition, an enhanced strain-rate sensitivity accompanied by low activation volumes was determined, increasing with elevated temperatures for both states. This can clearly be associated with interactions between dislocations and interphases. Moreover, for ultra-fine porous Au, a considerable increase of hardness was observed after annealing, which potentially can be attributed to starvation of mobile dislocations not occurring in the ultra-fine grained state. Cross-sections of indentations in ultra-fine porous Au combined with quantitative analysis of the resulting porosity maps allow visualizing the occurring deformation of the foam properly, showing distinct differences for tests at varying conditions. While the as-fabricated material exhibits distributed plasticity underneath the indent, this changes to strongly localized failure events in the annealed condition. At increased temperature, the deformation morphology reverts to more distributed deformation favored by the additional thermal activation.