Fall 10-4-2015

A direct comparison of high temperature nanoindentation and tensile creep measurements for aluminum

Warren Oliver
Nanomechanics, USA, warren.oliver@nanomechanicsinc.com

Richard Anthony
Nanomechanics, USA

Sudharshan Pardhasaradhi
Nanomechanics, USA

Recommended Citation

[1]. Luthy et.al., Acta Metallurgica, 28 (1980), 169-178 [2]. Su et.al., JMPS, 61 (2013), 517-536

A DIRECT COMPARISON OF HIGH TEMPERATURE NANOINDENTATION AND TENSILE CREEP MEASUREMENTS FOR ALUMINUM

Warren Oliver, Nanomechanics Inc., 105 Meco Ln, Suite 100, Oak Ridge, TN, 37830
Warren.Oliver@Nanomechanicsinc.com
Richard Anthony, Nanomechanics Inc.
Sudharshan Phani Pardhasaradhi, Nanomechanics Inc.

Scanning electron microscope (SEM) in situ high temperature nanomechanical testing has received a lot of interest in recent times. Performing nanomechanical tests in non-ambient conditions presents several challenges. To meet those challenges a thorough understanding of the instruments' performance both from static as well as dynamic point of view is required. In this regard, data from dynamic nanoindentation testing at temperatures up to 550 C on commercial purity aluminum in the SEM will be presented. The activation energy for creep was found to be 140 KJ/mol/K, matching the value determined with high temperature tensile creep experiments extremely well. The stress exponent for creep at the highest temperatures is determined to be approximately six. This result compares well to the value determined with tensile creep experiments [1]. In addition, the work of Su et.al. [2] can be used for predicting the pre-exponential term and the pile-up/sink-in factor that is appropriate for the stress exponents measured. Thus the indentation results and the tensile results can be directly compared. This comparison is show in the figure bellow. Over at least 15 orders of magnitude, the results are very close. At the lowest temperatures the stresses are under estimated. This is most likely due to the relatively small strains available with the indentation results when compared to the very large strain torsion experiments that were performed to accurately measure steady state creep stresses at low temperatures [1]. New testing and analysis strategies for improving the reliability of the results from high temperature testing will be presented. These results demonstrate that existing models can be used to facilitate accurate comparisons of high temperature tensile creep tests with indentation tests done with a Berkovich indenter over more than ten orders of magnitude in strain rate.

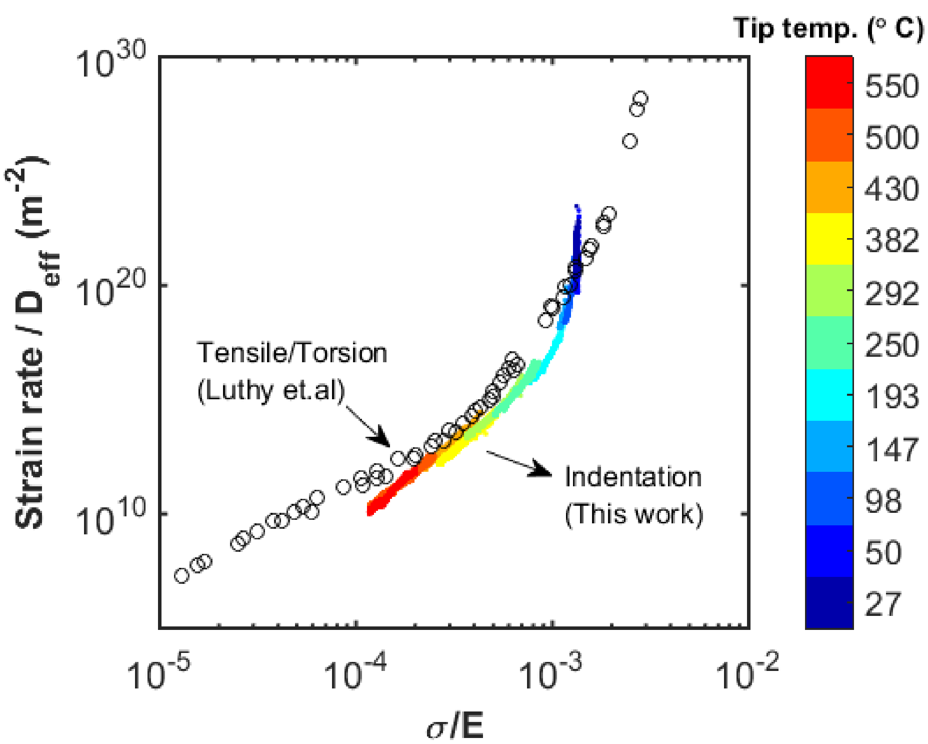

Figure 1 – Normalized strain rate vs. stress determined in two ways: tensile/torsion vs indentation

[1]. Luthy et.al., Acta Metallurgica, 28 (1980), 169-178
[2]. Su et.al., JMPS, 61 (2013), 517-536