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ELEVATED TEMPERATURE MICROCOMPRESSION TRANSIENT TESTING OF NANOCRYSTALLINE MATERIALS: CREEP, STRESS RELAXATION AND STRAIN RATE JUMP TESTS

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Traditionally, time-dependent properties of nanocrystalline metals have been measured on bulk samples. With the advent of thin film deposition techniques like sputtering and electrodeposition for fabricating nanocrystalline materials, it has become necessary to adapt bulk mechanical testing for thin films. Nanoindentation has been extensively applied for this purpose, particularly on thin films where conventional testing is difficult or impossible, and has been demonstrated to successfully extract strain rate exponents [1]. However, the interpretation of the indentation results can be difficult due to the complex stress state, and the nearly instantaneous onset of large-strain plasticity. Microcompression, on the other hand, is advantageous due to the relatively simple, well understood uniaxial stress state.

In this talk, micro-compression creep, stress relaxation and strain rate sensitivity [2] testing performed on nanocrystalline Ni at elevated temperatures (25-125 °C) will be described. All tests were performed on the same sample to remove sample-to-sample variation and allow direct comparison to help understand the correlation between these three time dependent tests. The observed stress relaxation and creep behaviors were found to be significant at stresses even below the 0.2% offset yield strength. Strain rate jump and creep tests yielded strain rate sensitivity and creep stress exponents as a function of temperature. Elevated temperature studies permit the extraction of activation parameters (activation volume and activation energies) that provide an initial estimate of the footprint of the dominant deformation mechanisms. The activation parameters were compared for all the three tests. Based on the results from these studies, possible rate controlling deformation mechanism(s) will be discussed. Overall, this study aims to bridge the gap between the three time-dependent tests and provides useful insights into developing similar indentation based tests, for creep and stress relaxation measurements in particular.

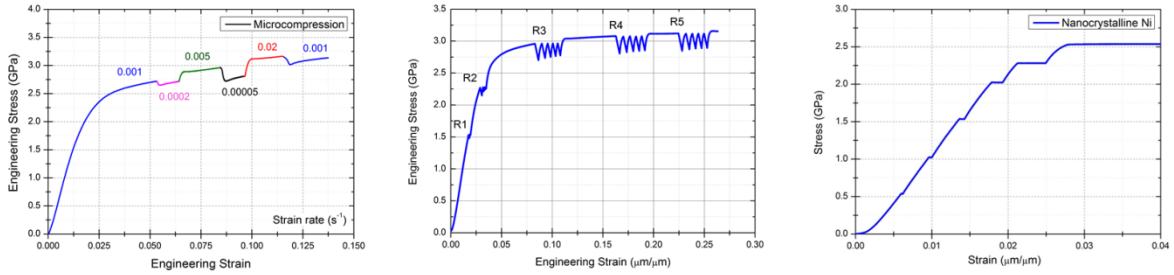

Figure 1. Strain rate jump, stress relaxation and creep tests on nanocrystalline Ni micropillars at room temperature

References:

[1] V. Maier, K. Durst, J. Mueller, B. Backes, H.W. Höppel, M. Göken, Journal of materials research, 26 (2011) 1421-1430.
[2] G. Mohanty, J.M. Wheeler, R. Raghavan, J. Wehrs, M. Hasegawa, S. Mischler, L. Philippe, J. Michler, Philosophical Magazine, (2014) 1-18.