Combinatorial Micromechanics

Jeffrey M. Wheeler

Laboratory for Nanometallurgy, Department of Materials,
ETH Zurich, Vladimir-Prelog-Weg 5, CH-8093 Zurich, Switzerland

Micromechanical testing has made significant progress in the last few decades. Advances in instrumentation and techniques have developed new geometries for measuring uniaxial strength and fracture toughness at very small length scales[1].In addition to increasing the test space envelope in terms of smaller sizes, the development of displacement controlled systems has allowed these properties to be investigated over a wide range of strain rates, even within single samples using strain rate jump and stress relaxation techniques[2]. Using new, high speed actuators, the available test space has also been expanded to reach the high strain rate regime ( >103 s-1). To complete the testing envelope, significant effort has been spent on achieving high temperature testing[3], and recently cryogenic temperature testing has also been achieved[4]. By combining all these capabilities, the micromechanical testing envelope has grown to encompass a significant range of testing temperatures (-100 to 600 °C)and over eight orders of magnitude in strain rates (10-5 to 103 s-1).This creates the opportunity for plastic deformation mechanism mapping of materials at small scales over a wide range of homologous temperatures.

Diffusion couples have long been a fundamental technique in materials science, allowing the exploration of phase diagrams and diffusion constants. With the advent of the Materials Genome Initiative, diffusion couples and multiples are now being used as a high throughput means to investigate a wide range of materials properties[5]. However, so far only the most fundamental micromechanical technique (nanoindentation) has been used to interrogate mechanical properties of diffusion couples. Here, the potential of applying advanced micromechanical techniques to diffusion couples will be demonstrated in the case of the Al-Cu binary system.

**References:**

[1] G.M. Pharr, Current Opinion in Solid State and Materials Science, 19 (2015) 315-316.

[2] J. Wehrs, M.J. Deckarm, J.M. Wheeler, X. Maeder, R. Birringer, S. Mischler, J. Michler, Acta Materialia, 129 (2017) 124-137.

[3] J.M. Wheeler, D.E.J. Armstrong, W. Heinz, R. Schwaiger, Current Opinion in Solid State and Materials Science, 19 (2015) 354-366.

[4] A. Lupinacci, J. Kacher, A. Eilenberg, A.A. Shapiro, P. Hosemann, A.M. Minor, Acta Materialia, 78 (2014) 56-64.

[5] J.-C. Zhao, Chinese science bulletin, 59 (2014) 1652-1661.