Analysis of Thermally Activated Processes via High Temperature Scanning Indentation

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Abstract

Nanoindentation serves as a tool to map mechanical properties of materials not only at room temperature, but also at temperatures at or close to the operating temperature of materials used for high temperature applications. Thermally activated processes can then be characterized via the calculation of strain rate sensitivity and activation volume at different temperatures.
Testing at elevated temperatures, however, presents its own issues in the form of thermal drift due to temperature mismatch and pronounced tip-sample-interactions.

The temperature matching procedure in particular can be time-consuming, which limits the applicability of conventional high temperature nanoindentation to materials with sufficiently stable microstructures at the testing temperature. To overcome some of these limitations, the High Temperature Scanning Indentation (HTSI) technique was introduced by Tiphene et al. (1). It utilizes a large amount of high speed tests (on the order of 1s each) to generate a high density of data points and measure mechanical properties during thermal ramping of a sample. This allows for not only the investigation of dynamic processes like recrystallization, but also for the characterization of brittle-to-ductile or phase transitions with unprecedented data density.

In this contribution, the HTSI technique is applied to investigate the thermal stability of ultrafine-grained copper alloys processed via high pressure torsion (2,3), following different thermal profiles to evaluate hardness and strain rate sensitivity of a function of temperature and time. Fused silica is used as a reference material to show the reliability of the obtained data and the comparability to other testing methods. Additionally, the applicability to brittle-to-ductile transitions is demonstrated on Chromium.

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