
Operando small scale flow behavior – promising applications for spherical nanoindentation

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Abstract

An enticing proposition for materials scientists is to characterize the flow behavior of materials with minimal experimental effort while ensuring highly reliable results. Nanoindentation emerges as a promising technique to achieve this goal. Although it is established as a standard method for extracting hardness and Young's modulus, the technique has not been fully exploited for determining localized flow curves. This gap exists due to the inherent challenges in understanding the correlations between mechanical properties obtained from spherical indentation experiments and uniaxial data.

To address this issue and accurately account for tip imperfections, a calibration procedure based on fundamental geometrical considerations is applied. This procedure lays the groundwork for strain-rate-controlled experiments, enabling the experimental evaluation of the constraint factor while considering mechanical properties and induced strain. Consequently, this approach facilitates the extraction of reliable flow curves.

These protocols are applicable under both ambient and non-ambient conditions, including high temperatures as well as electrochemical scenarios, by employing a novel in-situ electrochemical charging approach known as the side-charging cell. It is evident that electrochemical charging not only increases hardness and flow stress but also results in a reduced constraint factor. This reduction provides further insights, indicating a significant influence on the deformation behavior under electrochemical charging.

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