Mechanical instabilities in metallic glasses: a statistical nanoindentation approach

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Abstract

Bulk metallic glasses (BMGs) are highly promising materials for structural applications due to their exceptional strength and high elastic limits. However, their potential is limited by instabilities in their mechanical behavior under applied loads, often leading to sudden failure due to the formation of shear bands. This study employs a statistical approach to explore the fundamental physical dynamics governing deformation at the elemental level and the temperature-dependent properties, based on over 100 tests per sample under varying structural and thermal conditions. Nanoindentation testing on a Zr-based BMG was used to measure key properties, such as hardness, while also providing insights into deformation behavior. The analysis of nanoindentation data revealed new insights into the deformation dynamics, including the identification of the first serration and a precursor event (1). Further investigations examined how the microstructure of BMGs in different structural states influenced these deformation events. Results indicated that precursor events are linked to unstable regions rather than influenced by the broader microstructure (2). The temperature dependence of mechanical performance, ranging from room temperature to the glass transition and crystallization temperatures, is also explored. BMGs exhibit softening behavior below the glass transition temperature and the activation energy for softening was found to be consistent across different structural states, supporting the idea of a localized mechanism driving deformation (3). These results provide a deeper understanding of the physical processes governing deformation and temperature-dependent properties of BMGs, which could guide their design and application in diverse contexts.

References:

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