Plasticity mechanisms in ZrNi metallic glass thin films with high strength/ductility balance

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Although extensive experimental and simulation researches have been devoted in the past to study the mechanical behaviour of metallic glasses, the elementary deformation mechanisms in these complex systems are not well documented and still a subject of open debates [1-2]. Recent studies have shown that the brittle-like behaviour of bulk metallic glasses (~ 2%) is mitigated when the sample size is reduced down to the sub-micron scale [3-4]. However, the origin of size effects (intrinsic or extrinsic) is not well understood. Also, the threshold size which activates size effects is not well defined. Furthermore, due to the amorphous nature of the microstructure, direct experimental observations of the atomic plasticity events, of their evolution under an external applied stress and of their relationship with the nanoscale structural and chemical heterogeneities often present in these materials are still missing in the literature.

In the present work, the elementary plasticity mechanisms in nanostructured ZrNi thin films metallic glasses (TFMGs) exhibiting outstanding strength/ductility balance are investigated using home-made ''lab-on-chip'' tensile method developed in UCLouvain coupled to advanced X-ray and transmission electron microscopy (TEM) techniques. The films exhibit a very fine glassy nanostructure having well-defined dense Ni-rich regions embedded in Zr-rich regions with lower density with a characteristic length scale of ≈2-3 nm. The results revealed direct correlation between the nanoscale structural and chemical heterogeneities, the evolution of the local atomic order, the generation of free volumes and an unexpected auxetic deformation behaviour. Such features are used explain the delay of catastrophic banding and the remarkable mechanical properties of the films.

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