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On the processing, mechanical and structural characterization of ZrNi amorphous thin films

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The amorphous structure of metallic glasses is at the origin of their high mechanical properties. How- ever, their use in everyday-life products is still limited by their low ductility at low temperatures. Moreover, because of the lack of crystalline long range order, i.e. grains, as well as grain boundaries, these materials are expected not to undergo modification of their mechanical behaviours with down-sizing. Their studies at small scales to understand the underlying deformation mechanisms has arisen more recently thanks to new experimental techniques and their potential applications in sectors where micro- and nano-parts are in demand.
The presentation focuses on the characterization at room temperature of the mechanical properties of self-actuated nanometer-sized ZrNi amorphous thin films processed by magnetron sputtering. These so-called “micro-machines” are produced throughout successive steps of materials depositions and optical lithography etching. This results in dog-bone shaped ZrNi specimens attached to a Si_3N_4 layer containing high internal stresses. When this layer is selectively etched, the ZrNi films are released and deform in traction. The mechanical results show that an expected enhancement of the ductility is observed when the film thickness is decreased [1]. We show how the mapping of the spatial distribution of the local elastic strain can be investigated in such films using nano-beam synchrotron X-ray diffraction in transmission. Such cutting-edges technique sheds light on the local internal modifications of the atomic arrangement of the material under load. It will help us to wider our understanding of amorphous metallic alloys mechanical and structural properties at small scales.

[1] M. Ghidelli, H. Idrissi, S. Gravier, J.-J. Blandin, J.-P. Raskin, D. Schryvers, and T. Pardoen, Acta Materialia 131, 246 (2017)