MEASUREMENT OF THE CREEP BEHAVIOR OF THIN ZRNI METALLIC GLASS FILMS – A COMPARISON BETWEEN NANOINDENTATION RELAXATION, NANOINDENTATION CREEP AND LAB-ON-CHIPS EXPERIMENTS

Guillaume Kermouche, Mines Saint-Etienne, LGF UMR5307, France
Kermouche@emse.fr
Paul Baral, Mines Saint-Etienne, LGF UMR5307, France
Gaylord Guillonneau, Ecole Centrale de Lyon, LTDS UMR5513, France
Jean-Luc Loubet, Ecole Centrale de Lyon, LTDS UMR5513, France
M. Ghidelli, Université catholique de Louvain; Belgium
H. Idrissi, Université catholique de Louvain; Belgium
J.P. Raskin, Université catholique de Louvain; Belgium
T. Pardoen, Université catholique de Louvain; Belgium

Key Words: Time-dependent behavior, Nanoindentation relaxation, Amorphous materials, Finite element modelling.

The characterization of the time-dependent behavior of thin metallic glass films is one of the key-issue for surface engineering. Such a measurement requires loading a constant material volume located in the thin film. Unfortunately, this condition is not fulfilled in the commonly used creep nanoindentation testing, contrary to micro tensile lab-on-chip experiments or micropillar compression testing. In this paper, we show that nanoindentation relaxation is an efficient alternative to nanoindentation creep. For that purpose, an extensive study of ZrNi metallic glasses viscoplastic behavior is performed using several experimental set-up (lab on chips, nanoindentation relaxation, nanoindentation creep, constant strain rate, ...). An innovative nanoindentation methodology is used to perform long-term relaxation tests up to 10 h with excellent reproducibility. It consists in maintaining a constant contact area during the test by controlling the contact stiffness between the tip and the material. Nanoindentation relaxation, constant strain rate loading and lab-on-chips data lead to similar values of apparent activation volume and strain rate sensitivity, whereas nanoindentation creep clearly overestimates the activation volume (Fig 1). Finite element modelling of nanoindentation creep and nanoindentation relaxation also confirms this trend. We evidence, thanks to the long-term indentation relaxation test that the underlying deformation mechanisms remain unchanged on the entire investigated strain rate range.

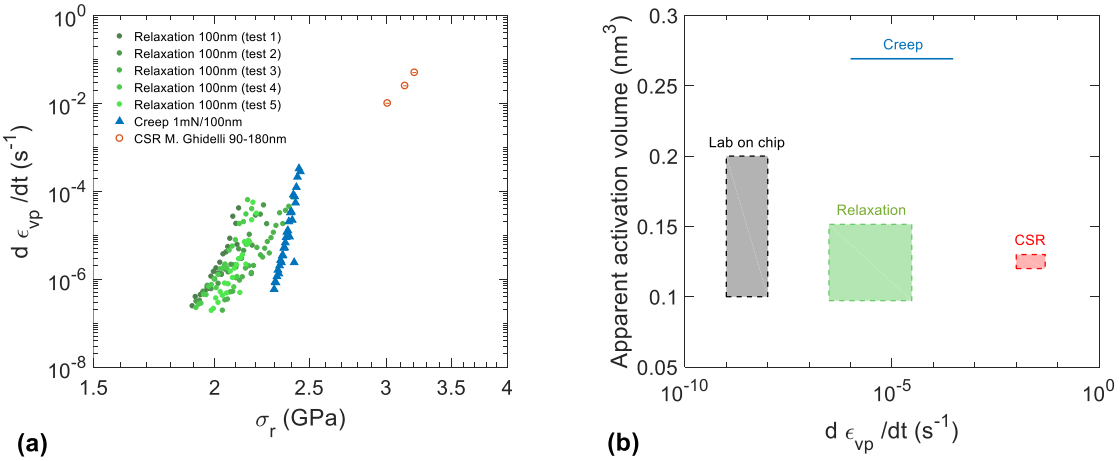

Figure 1 – Viscoplastic behavior of 900~nm layer ZrNi metallic glasses. (a) strain rate versus representative stress as measured by nanoindentation relaxation, creep and constant strain rate experiments. (b) Apparent activation volume from nanoindentation and lab-on-chip experiments as a function of viscoplastic strain rate.