ABOUT THE PLASTIC RESPONSE OF SILICATE GLASSES AT THE MICRONSCALE

G. Kermouche, D. Tumbajoy, P. Ganster, Ecole des Mines de Saint-Etienne, LGF UMR5307 CNRS, Saint-Etienne, France
Email : kermouche@emse.fr
B. Mantisi, G. Molnar, A. Tanguy, Université de Lyon, ILM UMR5306 CNRS, Villeurbannes, France
R. Lacroix, V. Pukhkaya, J. Teisseire, Saint-Gobain Recherche, SVI UMR125 CNRS, Aubervilliers, France
G. Guillonneau, J. Michler, EMPA, LMMN, Thun, Schweiz
E. Barthel, ESPCI ParisTech CNRS UPMC, Soft Matter Science and Engineering, Paris, France

Despite their brittleness, silicate glasses undergo plastic deformation at the micron scale. Mechanical contact and indentation are the most common situations of interest. The plasticity of glasses is characterized not only by shear flow but also by a permanent densification process.

We present novel observations of the deformation and fracture of amorphous silica micropillars of various sizes using In Situ SEM Micro-Compression (Fig 1), that can help better understand the mechanisms occurring prior to its fracture [1]. Exhibiting one of the highest ratios of shear stress on shear modulus, fused silica thus further distinguishes itself from other amorphous materials. Moreover, nanocompression allows successful observations of crack initiation and growth.

In parallel to this experimental investigation, atomistic simulations [2] aiming to investigate the theoretical plastic response of silicate glasses under coupled shear-pressure stress state was run. The results were interpreted in terms of volumetric and shear hardening. A buckling-like behaviour is clearly evidenced at low density (large free-volume) whereas a BMG-like is observed for samples densified until saturation.

Thanks to this rich set of data, it seems now possible to define a constitutive model taking into account both nanomechanical results, i.e. nanopillars, nanoindentation, diamond anvil cell, and molecular dynamics simulation

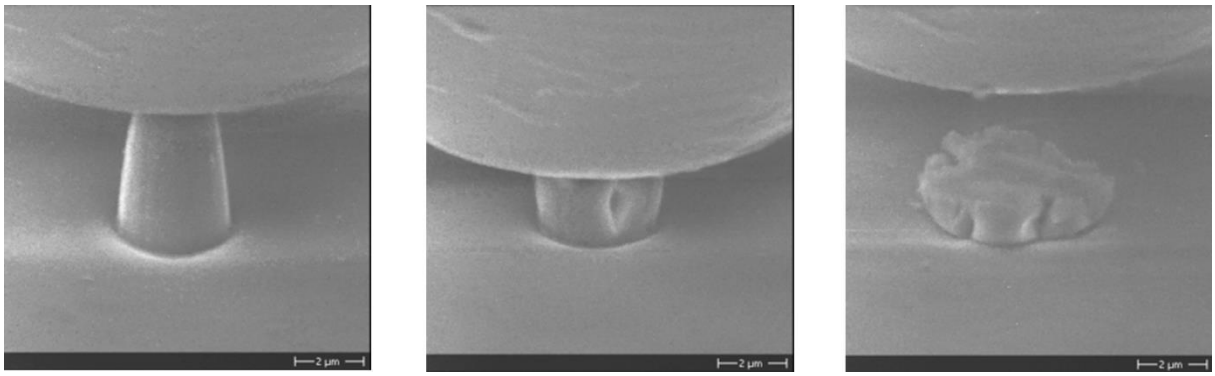

Figure 1 : In Situ SEM compression of a fused silica micropillar

1] R. Lacroix, G. Kermouche, J. Teisseire, E. Barthel, "Plastic deformation and residual stresses in silica pillars under uniaxial loading", Acta Materialia, 60 (15), 2012, pp 5555 -
[2] Mantisi, A. Tanguy, G. Kermouche, E. Barthel, “Detailed study of the Atomistic response of a Model Silica Glass under Shear and Pressure”, European Physical Journal B, 85 (9), 2012, art No 34