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Small scale plastic flow in silica glasses: can we model densification?

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1 Plastic deformation of amorphous silicates

Amorphous silicates (”glasses”) are archetypes of brittle materials. There is a cut-off lengthscale below which plastic deformation occurs, however it is small. For silicate glasses it is of order of 10 microns. Beyond academic interest, understanding these small scale plastic properties is necessary for better control of surface flaw generation and in fine effective device strength.

Yet, in the absence of dislocations, the local rearrangements resulting in irreversible deformation in amorphous silicates are poorly known. There is of course some relation with plasticity mechanisms in Bulk Metallic Glasses but striking differences exist because the geometrical constraints of ionocovalent bonding results in free volume and possible irreversible volumetric deformation (anomalous silicate). In this area, interesting results presently emerge out of MD simulations (see e.g. ref. [1]).

2 Micromechanics experiments and identification of a constitutive equation

In the intermediate lengthscale, there is a need for an accurate description of the plastic response of amorphous silicates at the continuum lengthscale. For that purpose, we have carried out combined indentation/microRaman spectroscopy experiments with micron scale resolution to map the residual indentation strain on both silica (anomalous) or sodo-lime silica (normal) glasses ([2]). Solving the inverse problem by FEM, we have quantitatively specified constitutive equations ([3]) for both materials and detailed their relation to material structure ([4]). We show how the contrast between the known microstructure of these two types of silicates affect the parameters of the constitutive equations. We also illustrate the relation between the constitutive equations and the respective contributions of densification and shear banding in the indentation deformation. Further experiments and implications for the understanding of plastic deformation in amorphous silicates will be discussed.

References

1 M. Tsamados et al. EPJ E 26, (2008) 283-293
2 A. Perriot et al. J. Am. Ceram. Soc. 89 (2006) 596-601
3 G. Kermouche et al. Acta Materialia 56 (2008) 3222-3228
4 D. Vandembroucq et al. J. Phys.: Condens. Matter 20 (2008) 485221