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Probing plastic deformation of glassy polymers with micro-indentation

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Introduction
In our group we developed a model to characterize plastic deformation of glassy polymers. In this model, only one parameter (Sa) is necessary. Sa was defined using a single tensile test [1]. Can we use indentation to determine Sa?

Experiments
Flat punch indentation tests were performed on polycarbonate. This tip’s geometry allows to clearly distinguish the elastic deformation from the plastic deformation on the load-displacement curves.

Results
Rate dependency of the yield stress and sensitivity of the yield stress to thermal-history can be accurately modeled.

Figure 3: Indentation tests (open symbols) compared with the numerical simulation (solid line) for different indentation speeds (left) and for two different thermal-histories (right).

Model validation
Macroscopic tests under different loading geometries and indentation tests were performed on the same samples. Numerical simulations of the macroscopic tests were done using the Sa value defined by indentations. An excellent agreement was found between the simulations and the experiments.

Figure 4: Indentation experiments (open symbols) were fitted to determine Sa (=31.7) (left); Experimental yield stress (open symbols) compared with numerical simulation (solid line) (Sa=31.7) (right).

Conclusions
Indentation combined with numerical simulation can be used to probe plastic deformation. This allows to quantitatively predict the (short and) long-term failure of processed material.

References: