Indentation behaviour of Ge-Se Chalcogenide glasses

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Ge-Se chalcogenide glasses are characterized by relatively low hardness (0.39-2.35 GPa) and fracture toughness (0.1-0.28 MPa$\sqrt{m}$) values. Actually, the hardness (H) is low enough to compensate the lack of fracture toughness (K_c) so that the brittleness parameter, $B=H/K_c$, does not allow to compare this family of glasses with the others. Whereas hardness and Young's modulus increase with rising germanium contents, fracture toughness follows a trend similar to the one of the density and exhibits a maximum for the $Ge_{20}Se_{80}$ composition, which corresponds to the rigidity percolation threshold. Interestingly, glasses in the chalcogen-rich region behave viscoelastic at room temperature. It follows that indentation measurements are time - or rate - dependent. The study of the dependence of hardness on the loading duration for Ge_xSe_{1-x} glasses with x between 0 and 0.4 shows that the penetration displacement is the sum of an elastic component which reaches values as high as 60% of the total displacement, and a creep one, which is strongly non-Newtonian (shear thinning), and leads to a significant decrease of H with an increase of the loading time. The apparent viscosity and activation energy for flow were derived from the H(t) data on the basis of a theoretical analysis of the indentation process, and the results are in good agreement with those obtained from conventional viscosity measurements.

Keywords: chalcogenide glasses / mechanical properties / indentation / fracture toughness / scratch resistance.