The notch fracture toughness of glasses

Eran Bouchbinder[†]*, Manish Vasoya[†] and Chris Rycroft[#]

[†] Chemical Physics Department, Weizmann Institute of Science
Rehovot 7610001, Israel
E-mail: eran.bouchbinder@weizmann.ac.il
Web page: http://www.weizmann.ac.il/chemphys/bouchbinder/

[#] Paulson School of Engineering and Applied Sciences, Harvard University
Cambridge, Massachusetts 02138, USA
E-mail: chr@seas.harvard.edu
Web page: http://people.seas.harvard.edu/~chr/

ABSTRACT

Understanding the fracture toughness of glasses is a fundamental problem of prime theoretical and practical importance. In this talk, its dependence on the loading rate, the age (history) of the glass and the notch radius ρ is discussed [1, 2]. Reduced-dimensionality analysis suggests that the notch fracture toughness results from a competition between the initial, age- and history-dependent, plastic relaxation timescale $\tau_0^{pl}$and an effective loading timescale $\tau^{ext}(\dot{K}_I, \rho)$, where $\dot{K}_I$ is the tensile stress-intensity-factor rate. The toughness is predicted to scale with $\sqrt{\rho}$ independently of $\xi \stackrel{\text{def}}{=} \tau^{ext}/\tau_0^{pl}$ for $\xi \ll 1$, to scale as $T\sqrt{\rho}\log\xi$ for $\xi \gg 1$ (related to thermal activation, where T is the temperature) and to feature a non-monotonic behavior in the crossover region $\xi \sim O(1)$ (related to plastic yielding dynamics). These predictions are verified using computations based on a novel 2D Eulerian projection method for quasi-static elasto-viscoplasticity [3], providing a unified picture of the notch fracture toughness of glasses. The theory highlights the importance of timescales competition and far from steady-state elasto-viscoplastic dynamics for understanding the toughness, and shows that the latter varies quite significantly with the glass age (history) and applied loading rate. Experimental support for bulk metallic glasses will be presented.

REFERENCES

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