Surface Chemistry Effects in the Strength and Fracture of Silicate Glasses

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Abstract

This presentation will focus on chemical effects at silica and silicate surfaces, and their role in strength and fracture. Of particular interest are surface adsorption reactions, in-depth hydration and corrosion reactions. At one extreme are pristine glass surfaces whose strength will be exceedingly sensitive to these surface chemical effects, especially adsorption reaction that open network bonds, hydration reactions that modify surface modulus and ductility, and corrosion reactions which roughen the surface. And of course, all of these effects can influence the sensitivity of fresh pristine surfaces to subsequent damage. At the other extreme are chemical effects at the fracture surfaces which comprise the typical extrinsic flaws on most glass surfaces. Since stresses are concentrated in surface flaws, especially at the crack tip, surface chemical effects which influence crack tip sharpening, blunting and propagation are influenced by the reactivity of these fracture surfaces and its stress dependence. Finally, these effects will be discussed in light of both low and high temperature surface chemical treatments which have been observed to alter the strength and fracture behavior of silicate glasses.

Questions to be answered:

1.) What will be a topic stating an exceptional success to be published in a well known high ranking Research Journal in 2025 concerning your presented R&D field of work? Please think in headlines.

>>>> unbreakable glass... it may be the result of intrinsic improvements in the glass, better understanding of coatings, cost-effective and reliable tempering methods or lamination... but the successful technology will not compromise the characteristics and properties of glass that we already depend upon.

2.) Please name up to 10 future key challenges (till 2025) regarding your presented field of expertise and indicate please the specific year when you expect the topic to become a real bottleneck for the future developments.

- understanding surface chemistry and diffusion under stress (now)
- understanding the evolution of contact damage in the Tg range (now!)
- detecting the formation of subcritcal flaws during heating and cooling (now)
- computer simulation of hydration under stress with the ability to follow concomitant deformation (2015)
- low cost hermetic, hard, lubricious multi-functional coatings (now)
- low Tg glasses with good chemical and mechanical properties (2020)

3.) Concerning the topics, what would be

a) the key breakthrough and when is it likely to occur

b) what must happen concerning the research field if this topic will never be successful

a. A new glass system that “teaches” us... perhaps discovered empirically or by computer simulation
b. “critical mass”.... researchers and funding working across the disciplines of materials and mechanics