Mechanics of Ion-Exchanged Glass

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Abstract

Chemically strengthened cover glasses for portable electronics are based on a ternary alkali aluminosilicate glass system. Glasses within this system can be readily ion-exchanged when immersed in a molten alkali salt bath to produce high surface compressive stress and deep compressive stress layer. The ionic inter-diffusion of monovalent alkali ions within an aluminosilicate glass results in an invading ion concentration profile that has a complementary error function form. Due to the larger size of the invading alkali ion during typical ion-exchange processing, compressive stress is generated along the diffusion profile. The basics of fracture mechanics are reviewed and then used to describe advantages of ion-exchanged glasses, namely imparting high surface strength to allow highly flexible glass sheets and to provide retention of strength following sharp contact damage. A simple model is described that can accurately predict the retained strength as a function of flaw depth for a known stress profile. The sharp contact failure mode for cover glasses is of particular importance since it is the most commonly observed failure type in the field. It is demonstrated that sharp contact damage can be replicated in the lab using diamond indentation. Experimental data show that the resistance to sharp contact flaw generation is improved both with high compressive stress enveloping the deformation region and by utilizing glass compositions that are more resistance to subsurface damage during sharp contact events. The frangibility behavior of ion-exchanged glasses is also described in terms of stored strain energy and cracking responses are shown.

Keywords: Ion, Exchange, Cover Glass, Damage Resistance, Indentation

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