Toughening of Borosilicate Glass by Neutron Irradiation

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Silicate and borosilicate glasses are important materials for many applications; however, their low fracture toughness is detrimental in many situations. An experiment is underway to determine if it is possible to toughen borosilicate glasses by neutron irradiation. Samples of Schott Borofloat 33 were irradiated to thermal neutron fluences of up to $3*10^{15}$ n/cm^2 in the Maryland University Training Reactor. Following the irradiation, the fracture toughness of the samples was determined by the indentation method.

Preliminary results indicate that the toughness of the glass was increased by approximately 40% while hardness slightly increased as well. There are several plausible mechanisms that may contribute to this. Firstly, radiation decreases the average coordination of boron in the glass lattice. This increases the plasticity of the glass and thereby increases its resistance to cracking. Secondly, the reaction of boron 10 with a thermal neutron can introduce small defects into the glass. These defects may form a network of preferred sites between which cracks will propagate; this will force the cracks to take a longer, more torturous path which dissipates its energy quickly, thereby halting crack growth and increasing the toughness.

Work will continue to further characterize and understand the effects of irradiation on borosilicate glass. More samples will be tested to refine the results, and irradiation times will be increased to see if toughness continues to increase with higher neutron fluences. Irradiations will also be performed in a pure gamma environment to attempt to determine the role which the possible toughening mechanisms play.