Increasing the Strength of Silica Glass

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Abstract

Of the most commonly used technical materials, silicate glasses are among the most brittle, with measured fracture toughnesses ranging from approximately 0.6 MPa·m$^{1/2}$ to 0.9 MPa·m$^{1/2}$, compared to metals ranging from about 10 MPa·m$^{1/2}$ for a brittle cast iron to 200 MPa·m$^{1/2}$ for structural steels. It is for this reason that glass cannot be used as a primary structural material and must be supported by metals to be used structurally, with some noted recent exceptions. In this lecture, we discuss the commercial techniques used to strengthen glass. These include the minimization of surface damage, the use of thermal tempering to place the surface structure under a compressive stress to retard the motion of surface cracks, and the use of ion exchange for similar purposes. We conclude the lecture with a discussion of water reaction with silica glass and show that this reaction can also place the surface of silicate glasses under compressive stresses and can be used to strengthen glasses that are not amenable to strengthening by thermal tempering or ion exchange. The technique may be of value to glasses having low thermal expansion coefficients and which do not contain mobile ions.