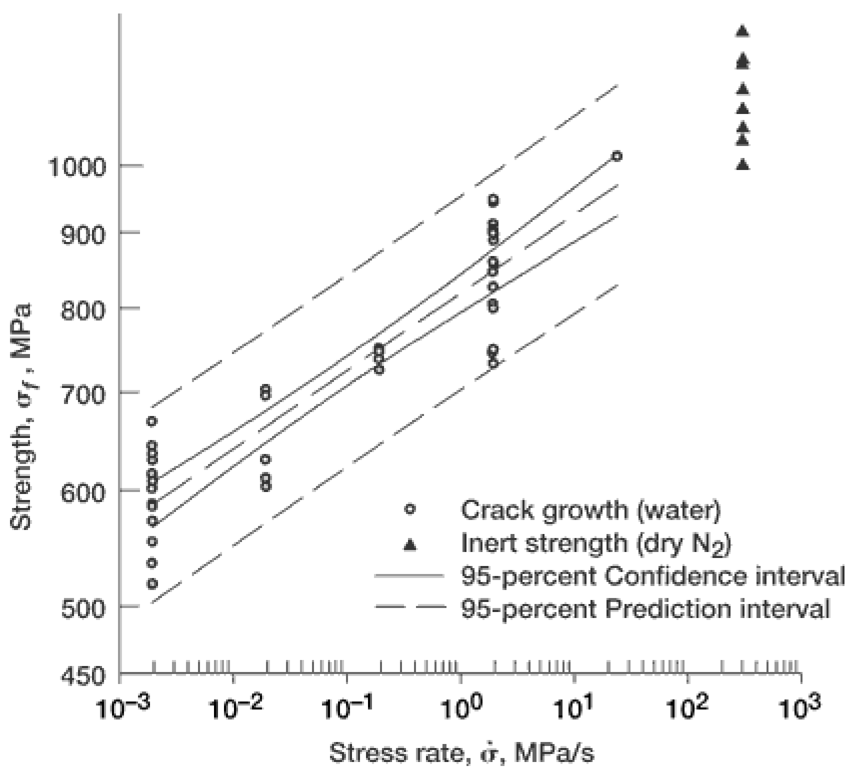
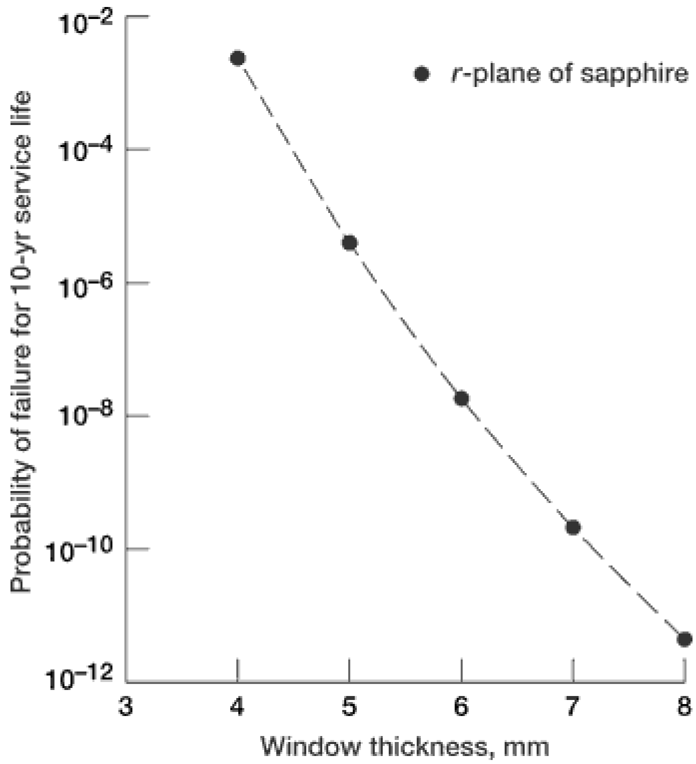
Life-Prediction Parameters of Sapphire Determined for the Design of a Space Station Combustion Facility Window

To characterize the stress corrosion parameters and predict the life of a sapphire window being considered for use in the International Space Station's Fluids and Combustion Facility, researchers at the NASA Glenn Research Center conducted stress corrosion tests, fracture toughness tests, and reliability analyses, as shown in the figures. Standardized test methods, developed and updated by the author under the auspices of American Society for Testing and Materials, were employed. One interesting finding is that sapphire exhibits a susceptibility to stress corrosion in water similar to that of glass. In addition to generating the stress corrosion parameters and fracture toughness data, closed-form expressions for the variances of the crack growth parameters were derived. The expressions allow confidence bands to be easily placed on life predictions of ceramic components.



Fracture stress as a function of stress rate for sapphire tested in distilled water and dry nitrogen in accordance with the American Society for Testing and Materials standard test method C1368-01. The decreasing fracture strength with decreasing stress rate indicates time-dependent material degradation due to stress corrosion.



Probability of failure for a sapphire window as a function of the window thickness. The analysis was performed for a 10-yr service life.

Brittle materials such as sapphire and quartz are required for windows in a variety of applications such as the Fluids and Combustion Facility. To minimize the launch weight of such facilities, researchers must design the windows to be as lightweight as possible. The safe use of lightweight, brittle windows in structural applications is limited by two factors: low fracture toughness and slow crack growth, or stress corrosion. Stress corrosion of these and other optical materials can occur in relatively common environments, such as humid air.

Access to the data has been requested by designers for use in the life prediction of a Northrop Grumman F16 instrument window and a Jet Propulsion Laboratory instrument window. One Space Act Agreement has been formed. Future work includes the measurement of the life of subscale windows.

Glenn contacts: Dr. Jonathan Salem, 216-433-3313, Jonathan.A.Salem@nasa.gov; and Dr. Anthony Calomino, 216-433-3311, Anthony.M.Calomino@nasa.gov
Author: Dr. Jonathan Salem
Headquarters program office: OBPR
Programs/Projects: Microgravity Science, ISS
Special recognition: ASTM Award of Appreciation