Investigation of sapphire strength across the scales

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Abstract

In the absence of a pre-existing crack or notch, the fracture stress parameter is commonly used to describe the failure process in brittle materials. However, this parameter is subject to a significant size effect: the larger the specimen, the lower the apparent stress at fracture. First, we highlight the effect of size on the strength of monocrystalline alumina (sapphire) through multi-scale bending tests ranging from characteristic dimensions of just a few microns to several millimeters. We then investigate the fracture of the sapphire on the μcantilever bending tests. Different types of specimen are prepared by FIB and then tested in flexion. We vary the dimensions of the specimens, the way in which they are prepared and the crystalline orientation, but we also deliberately introduce defects, all with the aim of studying the variation that this induces in the levels of measured fracture strength.

The aim of this work is to generate data on this effect of size on brittle fracture, and also to study the applicability of a model to describe it. These phenomena are often described by a probabilistic law of the Weibull type (1), *i.e.* the larger the volume probed, the greater the probability of finding a defect leading to failure. We are evaluating the effectiveness of such a model, and are also investigating the possibility of using a deterministic law to describe this fracture size effect (2).

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(2) A. Doitrand, R. Henry, J. Chevalier, and S. Meille, "Revisiting the strength of micron-scale ceramic platelets," *J. Am. Ceram. Soc.*, no. February, pp. 1–10, 2020, doi: 10.1111/jace.17148.

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