Scaling poperties of fracture surfaces

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Abstract:

The quantitative study of fracture surfaces has revealed interesting scale invariance properties. Two and sometimes even three self-affine regimes characterized by universal exponents and material-dependent length scales can be observed on these surfaces.

At large length scales, i.e. at scales much larger than the size of the Process Zone (PZ), where energy dissipation occurs, the material can be considered as linear elastic. We show that a stochastic model derived from Linear Elastic Fracture Mechanics can actually predict what is observed. In this model, the material microstructure is described as an array of randomly distributed obstacles likely to induce local shear.

At length scales smaller than the PZ size, a different regime arises, characterized by two different roughness exponents, one along the direction of crack propagation, and one in the direction perpendicular to it. Although no model is able to predict these observations, we argue that in this regime, any kind of damage (plasticity, cavity or micro-cracks nucleation and growth, according to the material) has the neat effect to screen out long range elastic interactions.

This domain was also observed on several silicate glasses. By studying its extension as a function of the humidity rate and the applied stress intensity factor, one can then infer the influence of these parameters on the PZ size.