Measuring in-situ 3D deformation of stepped cracks

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Abstract

The post-fracture surfaces of brittle solids commonly feature step-like structures. These step-like structures consists of discontinuous crack segments that are bridged by a thin material ligament. The ligament of material is the key topological feature that differentiates a "stepped crack" from a simple crack. What happens inside this material ligament? To probe this question requires in-situ 3D measurements of the deformation state near the crack steps. Here, we directly measure the in-situ kinematics at the tip of a stepped crack in 3D. Material displacements in the bulk of a brittle polyacrylamide hydrogel are measured by tracking the motion of embedded polystyrene particles. To obtain the kinematics in three dimensions, we scan a laser sheet through the sample and image the scattered intensity onto our camera sensor.The particle trajectories are used to calculate the local kinematic tensors, and thus to characterize the deformation in the ligament and the surroundings of the stepped crack. Our measurements of deformation state in stepped cracks may help to explain the propagation of the steps in a dynamic setting, and provide insights into out-of-plane brittle failure.

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