An integrative model for the impact response of ceramics and geomaterials

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ABSTRACT

Many rock-like materials such as ceramics and geomaterials exhibit complex mechanical response under dynamic multiaxial loading conditions. In particular, the statistics of pre-existing flaws, identifiable through sophisticated microstructural characterization techniques, play a crucial role in damage initiation, evolution, and post-failure behaviors of materials. On the other hand, contrasting deformation and failure mechanisms can be triggered under different multiaxial stress states. We present a new mechanism-based materials-by-design approach for such brittle solids, motivated by the need for understanding materials under extreme dynamic environments.

We address the questions of dynamic strength and dynamic failure through fundamental high-strain-rate experiments, high-speed visualization, theoretical and computational modeling of failure processes, and simulations. Based on these results and analytical models for dynamically interacting cracks, we construct a mechanism-based integrative model that accounts for dislocation plasticity, amorphization, fracture, fragmentation, and granular flow, using separately validated subscale models for each mechanism. We compare the model to available experimental data, and explore the implications of this approach for advanced ceramics.

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