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Mesoscale modeling of dynamic compressibility, shear strength, and fracture of ceramic polycrystals

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Fundamental understanding of dynamic behavior of polycrystalline ceramics is advanced via constitutive theory development and computational modeling. At the mesoscale, microstructures of silicon carbide grains (hexagonal polytypes) or aluminum oxynitride grains (cubic structure) are subjected to high rates of deformation with varying magnitudes of confining pressure. Each grain is resolved by numerous three-dimensional finite elements, and behavior of each grain is modeled using nonlinear anisotropic thermoelasticity. Cohesive fracture models and post-fracture contact are included. Failure statistics from many simulations are collected and analyzed. Results demonstrate possible effects of load directionality, confinement, dilatation, elastic anisotropy and elastic nonlinearity, and grain boundary strength on average (i.e., macroscopic) failure envelopes in stress space for loading conditions in the ballistic regime. Methods for informing macroscopic constitutive models of brittle and quasi-brittle material behavior incorporating microstructure- and size-dependent strength distributions are developed.