Physically Consistent Phase-Field Fracture for Anisotropic Multiphase Solids

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A physically consistent phase-field framework is presented for anisotropic brittle fracture in multiphase solids, achieved by embedding anisotropy coherently in both the gradient and potential parts of the crack surface energy to ensure orientation-invariant regularization and a uniform interface width across phases [1]. A graphical construction grounded in a generalized maximum energy release rate criterion provides quantitative relations between anisotropy strength and crystal orientation and the onset of crack kinking and effective fracture resistance. Two-dimensional benchmarks across a wide parameter space validate these relations, demonstrate robust mesh convergence, and reproduce distinct deflection regimes: for strong anisotropy, cracks align toward the crystal direction, while for weak anisotropy they deflect away, with clear signatures in the global stress–displacement response depending on orientation. A comparison with gradient-only formulations shows elimination of artificial direction-dependent interface effects, improved prediction of crack paths and energy dissipation, and consistent extraction of critical parameters via near-tip displacement extrapolation. The framework is directly applicable to three dimensions, polycrystalline microstructures with arbitrary grain orientations, and heterogeneous composites, offering a scalable and predictive basis for phase-field modeling of anisotropic fracture.

References

[1] N. Prajapati, L. Schöller, M. Reder, D. Schneider, B. Nestler, A Physically Consistent and Quantitative Phase-Field Model for Anisotropic Fracture in Brittle Multiphase Solids, *Computer Methods in Applied Mechanics and Engineering*, accepted

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