Phase field modeling of damage and fracture in polycristalline materials

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KEYWORD: Phase-field method; Crack propagation; Anisotropic elasticity; Finite elements methods

RESUME

The prediction of failure due to crack initiation and propagation through computational models is an important challenge in materials science and solid state physics. The theoretical foundation of brittle fracture is based on the work of Griffith (Griffith, 1921) and Irwin (Irwin, 1958), which relies on the transformation of elastic strain energy into fracture surface energy. Indeed, they postulated that the propagation of an existing crack begins when the energy release rate at the crack tip becomes equal or greater than the energy required for the creation of new surfaces. They share a conceptual resemblance to Ginzburg-Landau formulations (Karma, 2004) (Karma, 2001) of phase transitions and can also be interpreted as non-local damage models (Sicsic, 2013) in which the dissipation source contains a damage gradient term associated with a regularizing internal length scale.

In the present work, a stress-based damage gradient model is developed to address the numerical simulation of brittle fracture. This model succeeds in capturing some important aspects of crack propagation including crack branching and bifurcation. Also, the proposed phase field model has been developed in the general framework of anisotropic elasticity. It can thus be used for the simulation of brittle fracture in polycrystalline materials, for which crack propagation is impacted by crystallographic orientation because of the anisotropic character of stiffness properties.

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