Phase-Field Modeling of Fracture in Strain Gradient Elasticity

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ABSTRACT

The conventional phase-field crack propagation models utilize the classical Cauchy continuum theory to approximate the elastic energy contribution to the total potential energy. The existence of singular stress fields in front of the crack tip in the linear elastic fracture mechanics has been shown analytically in the literature [1, 2]. In reality, however, there is no stress singularity at the crack tip as confirmed by atomistic simulations [3]. The inherent purpose of the current contribution is to demonstrate that the solution of fracture problems on the basis of a phase-field approach is not sufficient to overcome the problem of stress singularities. On the contrary, it is shown that the underlying continuum theory needs to be adapted. To this end, the problems associated with the use of the classical continuum theory in the context of fracture analysis is investigated in a first step. Thereafter, two different phase-field fracture models based on the theory of strain gradient elasticity are introduced. It is shown that the proposed gradient models using the second- and the fourth-oder phase-field formulations, respectively, improve the performance of the classical models by removing the singular response.

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