Investigating new regimes in interaction of fracture and phase transformation: A phase field model

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ABSTRACT

A phase field model for interaction between crack propagation and phase transformation is developed. An advanced phase field approach to fracture is utilized, which allows for flexibility in the description of the stress-strain curves, and includes impossibility of crack propagation under closing compressive stresses and healing [1]. Phase transformation is described with an advanced model developed in [2], which satisfies some additional conditions to describe some conceptually important features of known experimental stress-strain curves for shape-memory alloys, steel, and ceramics. Change in surface energy during the phase transformation from its value for austenite to that for martensite is explicitly included in the formulation. The coupled system of nonlinear elasticity and Ginzburg-Landau equations for fracture and phase transformation is derived. The finite element method is utilized to solve the complete system of equations. Various problems such as surface induced phase transformation at the crack tip, pseudoplastic behaviour at the crack tip, and crack nucleation and propagation within the interface are discussed. The role of the ratio of the free surface width to the phase interface widths on phase transformation at the crack tip and crack propagation is studied. Our modeling leads to the revealing new regimes and effects in interaction between phase transformation and cracks e.g. tranformation toughening at small scales.

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