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Phase-Field Modeling of Interfacial Fracture in Quasicrystal Composites

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ABSTRACT

Quasicrystals (QCs) are a new class of functional and structural materials with unusual properties, which have quasi-periodic translational symmetry and non-crystallographic rotational symmetry. Due to the special arrangement of atoms, compared with traditional materials, QCs have high strength, high hardness, and high wear resistance, and can be used as a particle reinforcement phase of polymer or metal matrix composites to improve the performance of materials. QC composites are a special type of composites in which the high strength and hardness of QCs can effectively enhance the mechanical properties of the composites while maintaining the lightweight properties of the composites. In the fields of aerospace, automotive manufacturing and high-end equipment manufacturing, QC composites have a wide range of application prospects, and can meet the requirements of material strength, hardness and corrosion resistance. In this paper, a phase-field fracture model is proposed to predict crack propagation and interfacial debonding in QC composites. Two phase-field variables are introduced to regularize the cracks and interfaces in composites, respectively. An equivalent critical energy release rate is introduced to characterize the influence of the interface on crack propagation. Furthermore, a new numerical implementation approach for the present phase-field fracture model is presented based on the Weak Form PDE module in Comsol. Several numerical examples are simulated to demonstrate the ability of the proposed model to predict crack propagation and interfacial failure of QC composites and to analyze the influence of QC reinforcement phase on fracture behavior of QC composites. Numerical results indicate that the interface significantly influences the crack propagation paths, and the phason field has a remarkable influence on the peak force and failure displacement in the tensile test of QC composites. The developed phase-field model and numeral implementation approach provide a convenient tool for predicting interfacial failure and assessing the safety of QC composites in engineering practice.

KEYWORDS

Phase-field model; interfacial fracture; crack propagation; quasicrystal composites

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