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A Thermo-Chemo-Mechanically Coupled Peridynamic Model for Investigating the Crack Behaviors of Deformable Solids with Heat Conduction, Species Diffusion, and Chemical Reactions

Yu Xiang[1], Bao Qin[2], Zheng Zhong[1,*] and Zhenjun Jiao[1,*]

[1]School of Science, Harbin Institute of Technology (Shenzhen), Shenzhen 518055, China
[2]School of Materials Science and Engineering, Harbin Institute of Technology (Shenzhen), Shenzhen 518055, China
[*]Corresponding Author: Zheng Zhong, Zhenjun Jiao. Email: zhongzheng@hit.edu.cn, jiaozhenjun@hit.edu.cn

ABSTRACT

A thermo-chemo-mechanically (TCM) coupled peridynamic (PD) model is proposed to analyze the crack behavior in solids considering heat conduction, species diffusion, and chemical reactions. A PD theoretical framework is established based on non-equilibrium thermodynamics. The influences of species diffusion and chemical reactions on the Helmholtz free energy density and the subsequent formation and propagation of cracks are distinguished by introducing the concentration of diffusive species and the extent of the chemical reaction. Furthermore, inter-physics coupling coefficients are calibrated by equating the corresponding field in the PD model to the continuum mechanics under the same condition. The cases of vacancy redistribution in ceramic and embrittlement in metals are carried out to demonstrate the potential of the model in forecasting the cracks behaviors in solids under multi-physics coupling with limited deformation and constant density.

KEYWORDS

Thermo-chemo-mechanical fully coupled; peridynamic; crack; chemical reaction

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