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A PHASE FIELD METHOD FOR SIMULATING BRITTLE FRACTURE IN FUNCTIONALLY GRADED MATERIALS UNDER THERMAL SHOCK

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ABSTRACT

Functionally graded materials represent an innovative class of composite materials characterized by a spatial gradation in structure and composition, resulting in tailored properties suitable for specific applications and operational environments. Initially introduced for thermal barrier applications in space shuttles, these materials have found widespread use in diverse sectors such as aerospace, automotive, defense, and biomedical fields. While extensive research has explored the fracture behavior of these materials under mechanical loading, there remains a noticeable gap in understanding crack formation and propagation under intense thermal loads. In this presentation, we unveil a computational framework designed for the numerical simulation of dynamic crack propagation in functionally graded materials subjected to thermal shocks. Our approach employs a coupled thermal-mechanical phase field model of brittle fracture, incorporating a temperature-dependent elastic energy density function. We provide comprehensive insights into the mathematical formulation and implementation details, validating our framework against alternative computational methods and experimental findings. Furthermore, we apply our proposed approach to challenging thermal shock scenarios, demonstrating its efficacy in capturing the intricate physics governing the coupled thermal-mechanical-fracture behavior of functionally graded materials in extreme environments.