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# Two-scale Modeling of Thermal Shock Failure in Heterogenous Solids

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## ABSTRACT

Under severe thermal conditions, the failure of heterogeneous materials originates from thermal expansion anisotropy, non-uniformity and/or mismatches between the constituents at the meso or micro level. Therefore a comprehensive understanding of the thermal and mechanical fields and their interaction at all relevant levels of observation is essential for the prediction of failure.

To investigate the interaction of mechanical and thermal fields from a microstructural perspective and to enhance the understanding of the microstructural influence on the damage evolution, a multi-scale analysis approach for thermo-mechanical problems is proposed within the framework of computational homogenization. The existing procedure operational for a purely mechanical analysis [1], is enhanced with a computational homogenization algorithm for heat conduction [2] and extended to perform a thermomechanical analysis of heterogeneous solids [3]. The flexibility of the method permits one to take into account local microstructural heterogeneities and thermal and mechanical anisotropy, including nonlinearities which might arise at some stage of the loading history. After an analysis at the meso level, the resulting complex microstructural response is transferred back to the macro level in a consistent manner. Furthermore, the characteristic failure mechanisms such as debonding along interfaces and diffuse thermomechanical damage evolving in each phase are incorporated within the meso-level model in the form of thermomechanical interface elements and an implicit gradient damage formulation, respectively. Within a well defined numerical quenching test set-up, the two-scale model is used to investigate the relations between the microstructure and the macroscopic properties by tuning the meso level model parameters such as interface strength, fracture energy and microstructural morphology.

The present contribution focuses on the computational thermomechanical homogenization with meso level damage mechanisms and addresses the theoretical basis, algorithmic scheme, implementation details and illustrative examples.

## REFERENCES

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