Reduced order modeling of multiscale materials with coupled dissipative bulk and interface effects

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ABSTRACT

Imperfect interfaces in multiscale materials can have a notable influence on the effective mechanical properties and usually induce special constitutive features such as, e.g., tension–compression asymmetry. For microstructures with dissipative interfaces and dissipative constitutive models for the bulk, the coupling of bulk and interface effects leads to complex overall properties, which are also complex to compute. Hence, full-field simulations (e.g., with the finite element method) are computationally too costly for many applications.

A reduced order model is presented which provides the nonlinear mechanical response of such dissipative microstructures at significantly reduced computational cost (cf. [4]). The technique extends and combines results from [2] for viscoplastic composite materials with an approach for the treatment of imperfect interfaces proposed first in [3]. The key idea is to use reduced bases to parameterize the fields of internal variables and the displacement jump field on the interface. Thereby, not only the number of degrees of freedom is reduced drastically, but also the solution of partial differential equations in online computations is avoided. The reduced basis concept was first proposed in the context of homogenization in [1], but is equipped with a more general, rigorous derivation of the reduced state variables in [2, 3, 4]. A variational, potential-based description of the underlying constitutive models (known from the framework of *generalized standard materials*) is assumed and exploited to that end.

A numerical example is presented which illustrates the interaction of interface mechanics and bulk (visco-)plasticity within a composite material. The predictivity of the reduced order model for loading conditions and constitutive parameters that have not been considered in the training is demonstrated. These capabilities make the reduced model useful for applications such as FE^2-like multiscale simulations or parameter identification studies.

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