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## Modeling damage in strongly heterogeneous materials with phase field: construction of meso models and topology optimization

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In a first part, we present a multiscale framework [1] to model damage due to microcracking in highly heterogeneous materials. The approach uses preliminary calculations based on phase field [2] including initiation and coalescence of microcracks in periodic microstructures such as found in 3D printed lattice materials. At the macroscale where the material is assumed to be homogeneous, an anisotropic phase field model taking into account preferential crack directions induced by the microstructure is identified. The technique uses an inverse approach based in the preliminary calculations. Once identified, we show that the macroscopic model can be used with satisfying accuracy on other configurations at lower cost than using fully meshed model or multilevel methods such as FE2.

In a second part, We propose a topology optimization framework for optimizing the fracture resistance of two-phase composites through a redistribution of the inclusion phases [3,4]. The phase field method for fracture capable initiation, propagation and interactions of complex microcracks networks is adopted here again, as it avoids the burden of remeshing problems during crack propagation and is thus well adapted to topology optimization purpose. An efficient design sensitivity analysis is performed by using the adjoint method, and the optimization problem is solved by an extended bi-directional evolutionary structural optimization (BESO) method. The sensitivity formulation accounts for the whole fracturing process involving cracks nucleation, propagation and interaction, either from the interfaces and then through the solid phases, or the opposite. The spatial distribution of material phases are optimally designed using the extended BESO method to improve the fractural resistance. We demonstrate through several examples that the fracture resistance of the composite can be significantly increased at constant volume fraction of inclusions by the topology optimization process.



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