A Regularized Model for Ductile Damage by Micromorphic Homogenization

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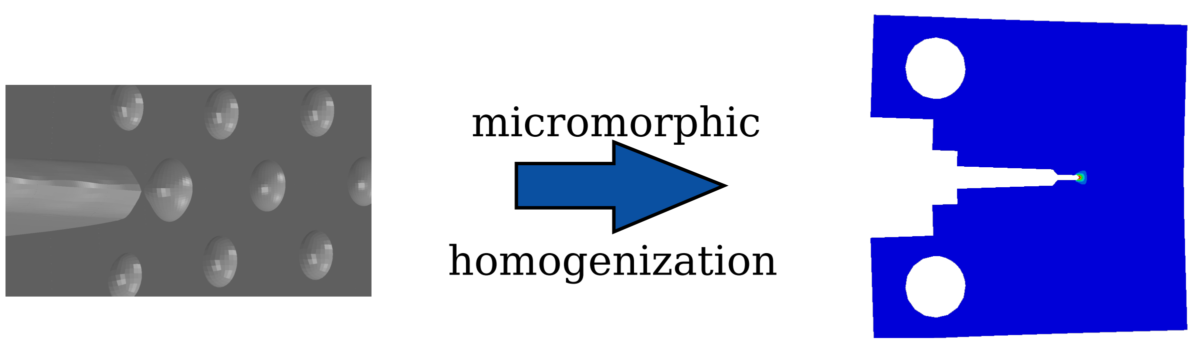
ABSTRACT

Ductile failure of metals is a consequence of nucleation, growth and coalescence of voids. Due to its relevance in engineering applications, a large number of constitutive models were developed to describe this mechanism. Among them, the models of Gurson and Rousselier and its numerous modifications are the most prominent ones. However, both models are formulated within the theory of simple materials and thus do not contain an intrinsic length scale. That is why, corresponding FEM simulations exhibit a spurious mesh dependency in the softening regime. Nonlocal and gradient-enriched extensions of these damage models were proposed to overcome this problem. Unfortunately, most of these extensions are purely heuristical and the additional terms and constitutive parameters lack a distinct micromechanical basis. In contrast, the model of Gologanu, Leblond, Perrin and Devaux (GLPD model) [1] was derived analytically from homogenization within the theory of strain-gradient media so that the mean distance of voids as intrinsic length enters naturally. However, the FEM implementation of strain-gradient theories raises certain difficulties and is expensive.

Both, implcitely gradient-enriched nonlocal theories and strain-gradient theories are special cases of the micromorphic theory. It would be desirable to combine the advantages of both approaches, i. e., to have a model of ductile damage which combines a sound micromechanical basis, including the intrinsic length, with an efficient numerical implementation. For this purpose, the theory of micromorphic homogenization [2] is confined to microdilatational media. An adaption of Gurson's limit load analysis of a unit cell with void to the microdilatational framework allows to derive an extended damage model of Gurson-type whose yield condition contains the intrinsic length and non-classical stress measures naturally [3]. The model is implemented into a multi-purpose FEM code in order to demonstrate its capabilities for uni-axial loading as well as for a fracture specimen.



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