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A mechanically consistent damage model based on the representation theory of invariant tensor functions

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Ceramic matrix composites (CMCs) combine the outstanding high temperature properties of monolithic ceramics with a quasi-ductile, non-brittle mechanical behavior. Microcracks are bridged by fibres such that damage does not directly lead to overall brittle failure. Looking at the effective properties, this microstructural damage leads to a stiffness degradation on the macroscopic scale. Describing this stiffness degradation by a macroscopic material model is a challenging task and involves many effects such as the anisotropic damage initiation and evolution, transverse damage effects, damage deactivation under compression as well as residual (plastic) strains. On the other side, in view of an industrial application, a material model needs to be as simple as possible in order to enable an efficient numerical implementation as well as a straightforward and unique experimental parameter determination.

In this talk, we will present a damage model for CMCs with a special focus on the formulation of the so-called damage effect. In the literature this damage effect is either derived by applying the idea of effective stress together with some equivalence requirements between damaged and undamaged materials [1], but sometimes the motivation also remains unclear [2]. Here we will follow a more rigorous way to formulate the damage effect by making use of the representation theory of invariant tensor functions [3]. Starting from a very general damage effect equation, we reduce the number of material parameters by applying some general mechanical requirements as well as some special material symmetry conditions. In the very end, we will validate the resulting model and give a physical interpretation of the material parameters.

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