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PROCEEDINGS

A Novel Damage Model for Face-Centered Cubic Crystal Materials Incorporating Microscopic Crystal Cleavage and Slip Failure Mechanisms

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ABSTRACT

The occurrence of crystal cleavage and slip at the microscopic level in single crystal materials serves as the fundamental underlying factors leading to their macroscopic failures. Therefore, investigating the failure mechanisms and damage processes at the scale of slip systems significantly enhances our comprehension of the degradation and failure patterns exhibited by crystal materials.

In this study, based on the theory of crystal plasticity, we examine the effects of microscopic damage on the slip systems concerning the failure of face-centered cubic (FCC) crystal materials. Additionally, we develop a novel damage model for FCC crystal materials, incorporating both crystal cleavage and slip as key failure modes. This framework offers an innovative approach to elucidating the underlying physical mechanisms behind the failure of FCC crystal materials and characterizing their failure behavior.

First, we introduce the concept of the damage deformation gradient tensor and establish a constitutive model that couples damage by incorporating microscopic failure mechanisms. Second, we deduce the damage evolution equation based on a thermodynamic framework and numerically calculate the associated material damage processes. Subsequently, we investigate the effects of the two primary failure mechanisms, crystal cleavage, and slip, on the damage process, while also exploring the interactions and competition mechanisms between them. At last, we present a method for describing the constitutive relationship coupled with damage under cyclic strain, aiming to capture both plastic flow and the evolution of damage, thereby achieving a comprehensive description of the damage processes in FCC crystal materials.

KEYWORDS

Crystal plasticity; FCC crystal materials; damage model; microscopic failure mechanisms

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