Effect of strain induced crystallization on the fracture behavior of rubber-like materials

Christian Linder, Prajwal Arunachala and Reza Rastak

Stanford University
Department of Civil and Environmental Engineering
Stanford, CA 94305
e-mail: linder@stanford.edu, web page: http://www.stanford.edu/∼linder

ABSTRACT

The enhanced fracture resistance in rubber-like materials has often been attributed to the phenomenon of strain induced crystallization. For this study, a multi-scale polymer network model of the phenomenon coupled with phase field fracture is proposed. At the microscopic scale, a new polymer chain model accounting for the thermodynamics of the polymer chain and its crystallization under stretch is presented along with a rate-dependent evolution law. This evolution law is constructed such that it ensures that the second law of thermodynamics is satisfied. The contribution of the deformation of the molecular bonds to the internal energy is also accounted for in this non-Gaussian statistical mechanics model. The recently developed maximal advanced path constraint [1] in addition to the principle of minimum free energy is utilized to connect the deformation in the microscale to the macroscale, thus resulting in a non-affine model. At the macroscale, a continuous crystallinity distribution is considered which describes the crystallization along all polymeric orientations with only a few parameters [2]. A chain scission criterion based on the internal energy contribution by the stretch of the atomic bonds is incorporated for fracture initiation. This model is then combined with a phase field approach to study the fracture behavior. The aspects of the model like stress response, crystallinity evolution and distribution, and fracture initiation and behavior have been validated by existing experimental results.

REFERENCES

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