

Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

A micromechanical damage and fracture model for polymers based on fractional strain-gradient elasticity

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ABSTRACT

We formulate a simple one-parameter macroscopic model of distributed damage and fracture of polymers that is amenable to a straightforward and efficient numerical implementation. We show that the macroscopic model can be rigorously derived, in the sense of optimal scaling, from a micromechanical model of chain elasticity and failure regularized by means of fractional strain-gradient elasticity. In particular, we derive optimal scaling laws that supply a link between the single parameter of the macroscopic model, namely, the critical energy-release rate of the material, and micromechanical parameters pertaining to the elasticity and strength of the polymer chains and to the strain-gradient elasticity regularization. We show how the critical energy-release rate of specific materials can be determined from test data. Finally, we demonstrate the scope and fidelity of the model by means of an example of application, namely, Taylor-impact experiments of polyurea 1000 rods.