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Deformation and Failure in Stochastic Fibrous Networks: Scale, Dimension and Application

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Abstract

Simulating local deformation and failure in stochastic fibrous materials is of interest in a number of key materials technologies, including papers and filters, electrochemical substrates, and biomaterials. The local initiators of both deformation and damage are of key technological interest as they govern the properties of networks, and allow rational design of networks once variance in global properties is reasonable predicted.

Here, we examine several key microphenomena associated with failure of these networks, and further, map loading and environmental conditions under which each dominate. These mechanisms include tensile and bending failures, failures due to stress risers resulting from the way in which particles are bonded, and failures due to morphological changes (such as corrosion processes in batteries).

We also describe stochastic approaches for particle/fiber network generation, including the tracking of key geometric features. We show that single-parameter distribution functions rarely capture the real morphological variability seen in engineered microstructures, and suggest a methodology for more robust descriptions. We also present results of both large and small scale simulations of failure progression, and describe the importance of scale effect in numerical methods.