

Uncertainty in the context of materials by design: key roles for stochastic mechanics

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The vision for the development of new structural materials is that models, experiments, characterization, and processing will come together to enable rapid design of new materials with unprecedented capabilities. Closure of this so called materials-by-design loop requires closing communication gaps that exist between the various participants in the process. For example, the modeler can identify which constitutive parameters have a significant effect on the predicted response of a material within a given structural application; however, the materials processor can rarely control these constitutive parameters directly. Therefore, it is of greater value to use a model that explicitly includes parameters, such as microstructural features, that the materials processor might be able to control. Materials-by-design is further challenged by the many uncertainties that pervade this process, from the random microstructure that drives localization of failure, to the errors introduced by inexact measurements in characterization and testing, to the environmental uncertainties that affect the formation of the material during processing. Both of these challenges present significant opportunities for the stochastic mechanics community. Probabilistic evaluation of materials characterization data highlights characteristics of the microstructure that can inform the model. Novel stochastic simulation tools for generating sample microstructures from this data enable micromechanically-based assessment of the degree to which localized material behavior varies within the structure. Surrogate models allow randomness in the microstructure to be efficiently upscaled into a macro-scale structural model with appropriate underlying stochastic spatial variations of the physically based parameters that directly relate to materials processing. This talk will discuss all of these tools in the particular context of brittle materials under high-rate compression, with a brief discussion of other applications in composite materials and polycrystalline metals.