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MULTIRESOLUTION MECHANICS: LINKING MATERIAL PROPERTIES TO EVOLVING MICROSTRUCTURE

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ABSTRACT

In the not too distant future, we wish to use an integrated multiscale software analysis system to design an engineering structure that can perform its prescribed functions under harsh environmental conditions within a predetermined lifetime. A materials scientist starts with a prototype materials sample and uses advanced experimental and imaging techniques to create digital data sets of material microstructure evolutions. Using the developing *"Multiresolution Data Sets Mechanics"*, the "*predictive science based governing laws of the materials microstructure evolutions"* are derived and melted into a "Stochastic Multiresolution Design Framework." We predict that the **future integrated multiscale software analysis system** will be constructed based on a Probabilistic Computational Science-Based Mathematical Framework of which its verification and validation are done through carefully designed experiments, and the Life-Cycled Materials Design for products design and manufacturing is performed through the use of Petascale Computing.

The multiresolution mechanics starts with linking spatial scales for continuous resolution of a microstructure. We wish to be able to zoom into a microstructure in the same way that modern satellite technology allows us to zoom into images anywhere, anytime, and with any resolution. Hence, the separation of data by scales is done through the use of computer imaging and materials science knowledge. We then have refined data in order of scale, which is a variable material length scale theory with gradients. We then use the above refined multiresolution data sets to extract the missing information that would otherwise remain hidden in the results of the carefully designed experiments. This is achieved by linking the missing science with existing single scale governing laws via the introduction of microstructure fluxes and its couples and the identification of microstructure transition events. We apply the multiresolution mechanics to a number of functional materials

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