Low-dimensional models for microstructure representation: A data-driven approach

Zheng Li[1] and Nicholas Zabaras[2] and Baskar Ganapathysubramanian[3]

1.PhD Student, Sibley School of Mechanical and Aerospace Engineering,
Cornell University, Ithaca, NY, USA.
e-mail: zl237@cornell.edu

2.Professor, Sibley School of Mechanical and Aerospace Engineering,
Cornell University, Ithaca, NY, USA.
e-mail: zabaras@cornell.edu

3. Assistant Professor, Mechanical Engineering, Iowa State University,
Ames, IA, USA.
e-mail: baskarg@iastate.edu

Many areas of material science involve analyzing, linking and designing the materials internal structure (microstructure) with macro-scale properties and the processing history. The huge size of the microstructural data set precludes any straighforward analysis, particularly in the areas of stochastic analysis, process-property-structure mapping and accelerated insertion of materials. Constructing low-dimensional representations of microstructure variations would greatly simplify and accelerate such design and analysis tasks. We develop a mathematical strategy for the data-driven generation of low-dimensional models that represents the variability in polycrystal microstructures while maintaining the statistical properties that these microstructures satisfy. This strategy is based on a non-linear dimension reduction strategy to map the space of viable microstructures (M) to a low dimensional region (A). The use of Fourier and/or Radon transform allows for a straightforward method to enforce the statistical constraints. A number of examples will be presented to demonstrate these techniques and their applications.