

Topology optimization is a systemic design that requires simulation and optimization of a system for a single or multiple physics coupling processes. However, it is short of the engineering sense regarding the absence of uncertainties and limitations on applied monophase material.

The foundation of this dissertation is to combine homogenization and stochastic processing into topology optimization to formulate a robust multiscale topology optimization approach. Accordingly, this Ph.D. dissertation concerns (1) the multiscale and multiphysics performance of heterogeneous materials/structures embedded with microstructures material, taking into account the uncertainties, (2) for further optimizing the heterogeneous structure at different scales to satisfy target performance.

These microstructures may arise from the processing of biological materials, or from dedicated engineered materials, e.g., aerogels, foams, composites, acoustics metamaterials, etc. We parametrize architecture material; study the performances of the microstructure at the macroscopic scale by homogenization method. Then, the homogenization model can be considered a stochastic model with presented uncertainties exhibited in the unit cell. It can be built from a polynomial chaos development. In addition, these parametrized micro geometry features can be mapped into homogenized properties space, which can be utilized as design variables to control the macrostructure performance.

Afterward, we combined the topology optimization, homogenization, and uncertainties qualification to (1) design macro topology and micro material distribution to maximum structure stiffness (2) reduce the structure sensitivity to presented uncertainties (e.g., loading and material properties). This proposed general framework has the advance and compatibility ability in solving optimization problems considering the (1) multiple parametrized architectures cells, (2) complex loading problem, (3) hybrid uncertified, etc., with an affordable computation manner.

Key words: paramterilized architecture material, homogenization, uncertainty qualification, multiscale topology optimization, robust opimitization