Concurrent design of structures and materials with nonuniform microstructures

***Hao Li[1], †Liang Gao[1], Zhen Luo[2], and Junjian Fu[1]**

[1] State Key Lab of Digital Manufacturing Equipment and Technology, Huazhong University of Science and Technology, China.
[2] School of Electrical, Mechanical and Mechatronic Systems, University of Technology, Sydney, Australia.

*Presenting author: lihao2009@hust.edu.cn
†Corresponding author: gaoliang@mail.hust.edu.cn

Abstract

This study develops a novel NUMDV (nonuniform unique microstructures with discrete volumes) approach for the multiscale concurrent design of stiff cellular composites. It assumes that the macrostructure is composed of an adjustable number of nonuniformly-distributed unique microstructures, in order to expand the multiscale design space and meanwhile control the costs in both the optimization and fabrication. At the macroscale, a discrete element density based approach is presented to generate the macrostructural layout with a given set of elementary densities. At the microscale, the macro elements with discrete densities are regarded as the unique microstructures with the corresponding densities (or volume fractions), which are to be further tailored by incorporating the numerical homogenization approach into a parametric level set method. A unique microstructure is devised as a representative for all the microstructures with the same volume fractions. The proposed multiscale concurrent design method integrates the discrete element density based approach and the parametric level set method into a uniform optimization formulation, where the layout of macrostructure as well as the distributions and configurations of all unique microstructures are optimized in an interactive manner. Numerical examples verify that, comparing to the single-scale design methods and the multiscale design method with uniform microstructures, the proposed method can remarkably improve the structural performance with the affordable computation and manufacturing costs.

Keywords: **Topology optimization; Multiscale concurrent optimization; Level set method; Cellular materials**