Accepted Manuscript

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PII: S0045-7825(16)30738-1
DOI: http://dx.doi.org/10.1016/j.cma.2016.12.007
Reference: CMA 11253

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date: 13 July 2016
Revised date: 1 November 2016
Accepted date: 5 December 2016

Please cite this article as: Y. Wang, F. Chen, M.Y. Wang, Concurrent design with connectable graded microstructures, *Comput. Methods Appl. Mech. Engrg.* (2016), http://dx.doi.org/10.1016/j.cma.2016.12.007

Concurrent design with connectable graded microstructures

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Abstract

This paper proposes a novel multiscale concurrent design method to provide insight into the optimal structural design based on micro-architectures, where both the spatially-varying microstructural configurations and their macroscopic distribution are optimized in an integrated manner. A shape metamorphosis technology is developed to interpolate a prototype microstructure (PM) to generate a family of graded microstructures (GMs) that are connectable to each other in a natural way since they present similar topological features and material distribution patterns at their edges. The concurrent design optimizes configuration of the PM at the microscopic level and coordinates the compatible generated GMs at the macroscopic level in a double-loop manner, which ensures a sufficiently large design space. Numerical examples demonstrate that, compared to the one-scale design strategy, i.e. the macrostructure topology optimization and the homogenous microstructure design method, the proposed approach is able to produce remarkably improved optimized solutions. Furthermore, the obtained structures show good manufacturability to which the additive manufacturing technology is applicable without extensive post-modification.

Keywords Topology optimization; Concurrent design; Connectable microstructure; Graded microstructure; Shape interpolation

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