# MULTISCALE CONSTITUTIVE MODELING USING MECHANICS OF STRUCTURE GENOME

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## KEYWORDS

Multiscale structural mechanics; Mechanics of structure genome; Multiscale constitutive modelling

## ABSTRACT

This talk presents a new approach to multiscale constitutive modelling of heterogeneous structures and materials using the recently discovered mechanics of structure genome (MSG). Based on the concept of structure genome, which is defined as the smallest mathematical building block of the structure, MSG can construct constitutive models for all types of structures including 3D solids, 2D plates/shells, and 1D beams, directly linking the structural properties with microstructural details. For example, MSG can directly compute the torsional stiffness of a composite beam in terms of fibre/matrix materials. When specialized to 3D structures, this approach provides a general-purpose micromechanics theory which can provide a much better alternative to the RVE analysis and asymptotic homogenization theory in terms of efficiency, accuracy, and versatility. For example, for unidirectional composites, MSG can compute the complete set of 3D properties using a 2D domain, while a 3D domain is needed for all other computational homogenization techniques. MSG provides a unified treatment for all microstructures (periodic, aperiodic, partially periodic) with its accuracy guaranteed to be the best by the principle of minimum information loss. With MSG, multiscale constitutive modelling is simplified to answer three fundamental questions: 1) what is the original model? 2) what is the model I want? 3) what is the SG (i.e. the analysis domain)? In this talk, we will demonstrate the power of MSG through various applications: 1) the complete set of 3D properties for composite laminates when they are approximated as equivalent anisotropic solids; 2) free-edge stresses of laminates with arbitrary cross-sectional shape

and arbitrary layup sequences; 3) the buckling and post-buckling of stiffened composite panels; 4) the strength prediction of composites by carrying out progressive failure analyses by applying failure and material degradation criterion at the fibre and material level instead of lamina level; 5) perform multiscale constitutive modelling of textile composites starting from the fibre/matrix scale. All the results will be validated by directional numerical simulation (DNS). Finally, instead of blindly following a building block approach as what has been practicing in industry, we will show that MSG allows one to choose the starting scale and ending scale and capture details as needed and affordable.

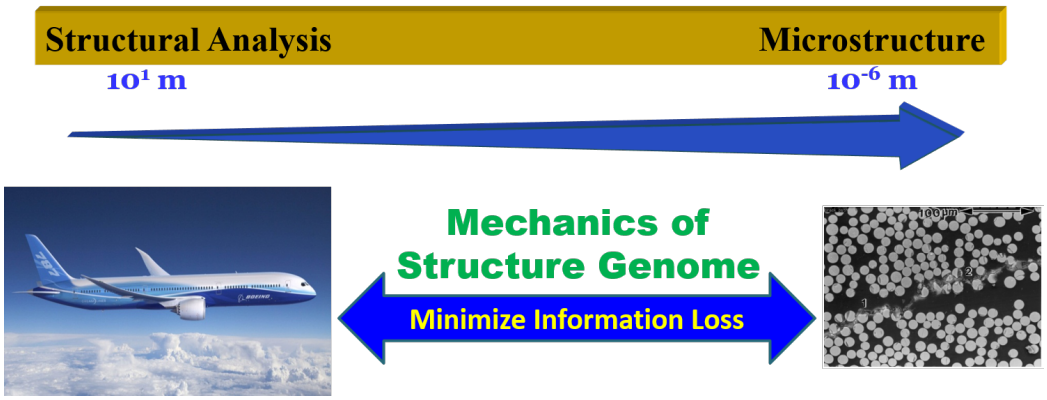


Figure 1: The basic idea of mechanics of structure genome

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