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MULTISCALE MODELING OF SHELLS WITH HETEROGENEOUS MICRO AND NANOSTRUCTURE

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The aim of this work is to propose a simple but versatile computational homogenization framework that accounts for thin structures composed of heterogeneities of both micro and nanometric dimensions. Such structures include a wide range of composite thin sheets and panels which are increasingly applied in aerospace and automotive industries, as well as heterogeneous thin shells on nanometric scale, such as nanofilms, whose potential for applications in miniaturized electromechanical systems attracts tremendous attention in research area. Particular attention has been oriented to various instability phenomena such as buckling, which represent special interest for thin shell structures but consistently create numerical challenge for multiscale analysis.

On the macroscopic scale, the real heterogeneous structure is modeled towards a homogenized shell continuum, which in this work is based on a 7-parameter shell formulation with transversal Enhanced Assumed Strain (EAS) enrichment. Scale transition is achieved upon resolution of a set of microscopic boundary value problems on a Representative Volume Element (RVE), which in our case refers to a volume model that fully captures the heterogeneities through the shell thickness. The method has been initially developed in the context of small deformations on the microscopic scale, but an extension has been proposed to account for large displacements with possible global buckling on the macroscopic scale. The technique has been validated first on models with continuum microstructures, for which some examples involve large displacements and rotations. Then, the method is applied on thin film structures of nanoscale thickness. For such cases, the RVEs are based on discrete atomistic models that we study using Molecular Dynamics. Subsequent effort has been made to take care of the bridge between discrete particle model and continuum medium.

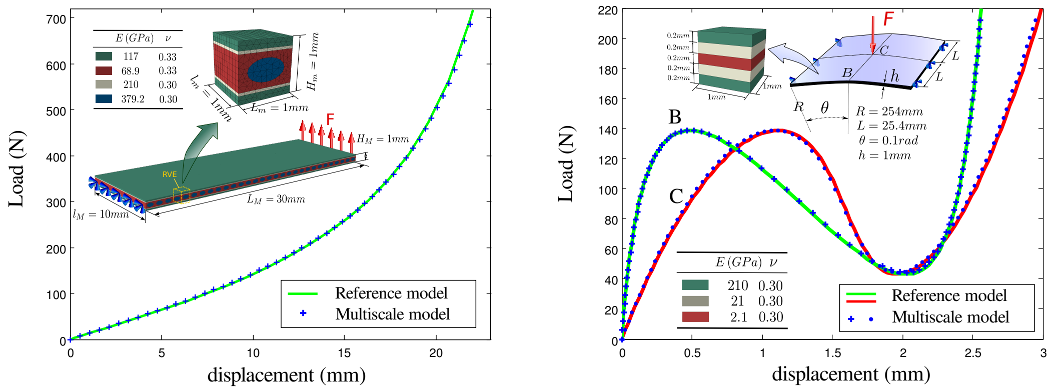

Figure 1: Validation of the shell multiscale framework. **Left**: Bending of a composite thin plate with fiber reinforcement. **Right**: Snap-through buckling of a multiphase thin roof. For both examples, multiscale models are compared to reference results obtained using Abaqus.

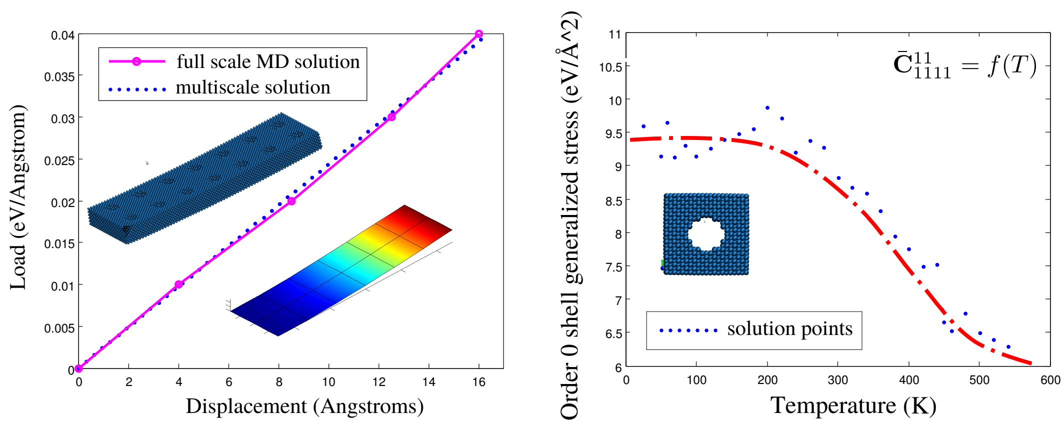

Figure 2: Validation of the multiscale framework on discrete atomistic models. **Left**: Bending test based on a Nickel nanofilm structure with vertical holes. **Right**: Study of temperature influence on the equivalent shell tensile stiffness. Both the RVE and the macroscopic reference model are investigated using molecular dynamics.

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