An efficient multiscale method for wave propagation analysis of functionally graded sandwich plate with nanopores

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Abstract

In this research, we develop a highly efficient multiscale method for wave propagation analysis of functionally graded sandwich plate with nanopores. The plate is composed of different layers with different volume fraction of porosities, leading to functionally graded effective properties.
At microscale, the local equilibrium equations are solved efficiently using semi-analytical locally-exact elasticity approach, with the strong surface effects of nanopores modelled using Gurtin-Murdoch model, yielding effective properties of each layer. Fourier series function is employed for tackling the microscale governing differential equations with the unknown coefficients solved through the implementation of a balanced variational principle based on periodic boundary conditions, thus the approach is mesh-free and with high-fidelity. At macroscale, the wave propagation problem in functionally graded plate is investigated using shear deformation theory. The dispersion relations are obtained by solving an eigenvalue problem. The influence of surface type, nanopore radius, volume fractions, and their distribution on dispersion relations are systematically investigated, providing guidance for designing functionally graded plate with nanopores for optimized dispersion relations. We believe this work has following novelties: providing a highly efficient multiscale method for wave propagation analysis using a semi-analytical locally elasticity approach; investigating the influence of surface effect on dispersion relation in the framework of multiscale analysis.

Keywords: Dynamic homogenization; wave propagation; dispersion relation; surface-effect