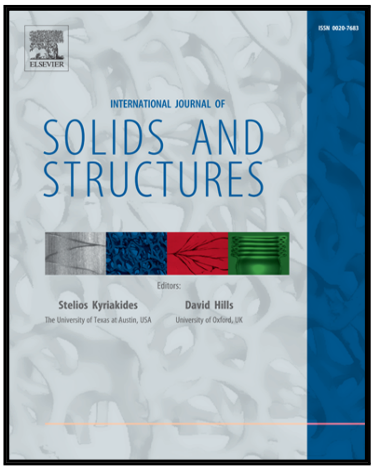

Multiple spheroidal cavities with surface stress as a model of nanoporous solid

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Multiple spheroidal cavities with surface stress as a model of nanoporous solid

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Abstract

The multiple cavity model of nanoporous solid has been developed which takes into account the elastic stiffness of matrix solid, porosity, shape, size and arrangement of cavities as well as the effects of their interaction. To describe the pertinent to nano level size effect of the stress field and effective stiffness, the Gurtin-Murdoch model that includes both surface tension and surface stiffness has been applied. A complete semi-analytical solution to the model problem has been obtained by the multipole expansion method. The displacement perturbation field induced by each cavity is expanded over a set of the vector solutions of Lamé equation in spheroidal basis. Expansion of the displacement and stress fields in terms of the vector surface harmonics reduces the surface conditions to an infinite linear system for the multipole strengths. The superposition principle and re-expansion formulas for the partial vector solutions extend this theory to problems involving multiple cavities. The method provides accurate evaluation of the stress field with the interaction effects taken into account. Also, the derived solution constitutes a mathematical background of the modified Maxwell homogenization scheme. The stiffness tensor of nanoporous solid is found by equating the induced dipole moment of equivalent inclusion to the total dipole moment of individual cavities. Numerical study demonstrate an accuracy and computational efficiency of the developed approach and shows quite a significant combined effect of the cavity shape and surface tension and stiffness on the stress field and macroscopic stiffness of nanoporous solid.

Key words: nanoporous solid, spheroid, surface stress, multipole expansion, effective stiffness, Maxwell scheme

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