Accepted Manuscript

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PII: S0022-5096(17)30090-X
DOI: 10.1016/j.jmps.2017.05.008
Reference: MPS 3113

To appear in: *Journal of the Mechanics and Physics of Solids*

Received date: 7 February 2017
Revised date: 10 May 2017
Accepted date: 15 May 2017

Please cite this article as: Hadrien Laubie, Siavash Monfared, Farhang Radjaï, Roland Pellenq, Franz-Josef Ulm, Disorder-Induced Stiffness Degradation of Highly Disordered Porous Materials, *Journal of the Mechanics and Physics of Solids* (2017), doi: 10.1016/j.jmps.2017.05.008

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Disorder-Induced Stiffness Degradation of Highly Disordered Porous Materials

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Abstract

The effective mechanical behavior of multiphase solid materials is generally modeled by means of homogenization techniques that account for phase volume fractions and elastic moduli without considering the spatial distribution of the different phases. By means of extensive numerical simulations of randomly generated porous materials using the lattice element method, the role of local textural properties on the effective elastic properties of disordered porous materials is investigated and compared with different continuum micromechanics -based models. It is found that the pronounced disorder-induced stiffness degradation originates from stress concentrations around pore clusters in highly disordered porous materials. We identify a single disorder parameter, φs_a, which combines a measure of the spatial disorder of pores (the clustering index, s_a) with the pore volume fraction (porosity φ) to scale the disorder-induced stiffness degradation. Thus, we conclude that the classical continuum micromechanics models with one spherical pore phase, due to their underlying homogeneity assumption fall short of addressing the clustering effect, unless additional texture information is introduced, e.g. in form of the shift of the percolation threshold with disorder, or other functional relations between volume fractions and spatial disorder; as illustrated herein for a differential scheme model representative of a two-phase (solid–pore) composite

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