
Accepted Manuscript

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PII: S0022-5096(16)30895-X
DOI: 10.1016/j.jmps.2017.02.012
Reference: MPS 3069

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

Received date: 8 December 2016
Revised date: 26 February 2017
Accepted date: 27 February 2017

Please cite this article as: R. Biswas, L.H. Poh, A micromorphic computational homogenization framework for heterogeneous materials, *Journal of the Mechanics and Physics of Solids* (2017), doi: 10.1016/j.jmps.2017.02.012

# A micromorphic computational homogenization framework for heterogeneous materials

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**Abstract**

The conventional first-order computational homogenization framework is restricted to problems where the macro characteristic length scale is much larger than the underlying Representative Volume Element (RVE). In the absence of a clear separation of length scales, higher-order enrichment is required to capture the influence of the underlying rapid fluctuations, otherwise neglected in the first-order framework. In this contribution, focusing on matrix-inclusion composites, a novel computational homogenization framework is proposed such that standard continuum models at the micro-scale translate onto the macro-scale to recover a micromorphic continuum. Departing from the conventional $FE^2$ framework where a macroscopic strain tensor characterizes the average deformation within the RVE, our formulation introduces an additional macro kinematic field to characterize the average strain in the inclusions. The two macro kinematic fields, each characterizing a particular aspect of deformation within the RVE, thus provide critical information on the underlying rapid fluctuations. The net effect of these fluctuations, as well as the interactions between RVEs, are next incorporated naturally into the macroscopic virtual power statement through the Hill-Mandel condition. The excellent predictive capability of the proposed homogenization framework is illustrated through three benchmark examples. It is shown that the homogenized micromorphic model adequately captures the material responses, even in the absence of a clear separation of length scales between macro and micro.

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