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Micro-to-macro transition accounting for general imperfect interfaces

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Abstract

The objective of this contribution is to establish a micro-to-macro transition framework to study the behavior of heterogeneous materials whereby the influence of interfaces at the microscale is taken into account. The term “interface” refers to a zero-thickness model that represents the finite thickness “interphase” between the constituents of the micro-structure. For geometrically equivalent samples, due to increasing area-to-volume ratio with decreasing size, interfaces demonstrate a more pronounced effect on the material response at small scales. A remarkable outcome is that including interfaces introduces a length-scale and our interface-enhanced computational homogenization captures a size effect in the material response even if linear prolongation conditions are considered. Furthermore, the interface model in this contribution is general imperfect in the sense that it allows for both jumps of the deformation as well as for the traction across the interface. Both cohesive zone model and interface elasticity theory can be derived as two limit cases of this general model. We establish a consistent computational homogenization scheme accounting for general imperfect interfaces. Suitable boundary conditions to guarantee meaningful averages are derived. Clearly, this general framework reduces to classical computational homogenization if the effect of interfaces is ignored. Finally, the proposed theory is elucidated via a series of numerical examples.

Keywords: General imperfect interface, Cohesive zone, Interface elasticity, Computational homogenization, Size effect, Nano-materials

1. Introduction

Effective macroscopic properties of a heterogeneous material can be estimated from the response of its underlying micro-structure using homogenization procedures. These mature procedures need to be extended to account for the role of interfaces between the constituents at the microscale and consequently to capture the size-effect missing in

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