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A micromechanics approach for the effective thermal conductivity of composite materials with general linear imperfect interfaces

Yao Koutsawa[a,*], Argyrios Karatrantos[a], Wenbin Yu[b], David Ruch[a]

[a]*Materials Research and Technology Department, Luxembourg Institute of Science and Technology, 5, rue Bommel, Z.A.E. Robert Steichen, L-4940 Hautcharage, Luxembourg*
[b]*Purdue University, West Lafayette, IN 47907-2045, USA*

Abstract

The mechanics of structure genome has been extended to heat conduction problem of composite materials with a general linear thermal imperfect interface model. This full field micromechanics approach is applied to predict the effective thermal conductivity of composite materials containing thermal imperfect contact between the matrix and the reinforcements. Examples of spheroidal particles reinforced composites are used to demonstrate the robustness and accuracy of this micromechanics theory. The size-dependency of the overall thermal conductivity shows the importance of imperfect interfaces in modeling the thermal behavior of composite materials. The proposed micromechanics method is versatile and can be applied for estimating the effective thermal conductivity of nanocomposite materials.

Keywords: Micromechanics, Structure genome, Imperfect interfaces, Strong and weak discontinuities, Thermal conductivity

1. Introduction

Composite materials contain usually imperfect interfaces between the matrix phase and the reinforcements (long/short fibers, particles, etc). This may be due to the atomic lattices mismatch, phonons scattering, poor mechanical or chemical adherence, surface contamination, oxide and interphase diffusion/reaction layers, debonding, etc [1–3]. Such imperfect interface may significantly affect the effective properties of composite materials and make them size-dependent [4, 5] and must therefore be taken into account in a rigorous predictive model.

In the heat conduction problems, the imperfect thermal contact condition between the reinforcements and the surrounding matrix is typically described by the lowly-conducting (LC) and the high-conducting (HC) interface models [2, 6–10]. On one hand, the imperfect LC interface model assumes the normal heat flux to be continuous through the interface whereas the temperature jump is non-zero and proportional to the normal flux [11]. On the other hand, the imperfect HC interface model assumes continuity of the temperature and a jump of the normal heat flux is taken proportional to the surface temperature or the surface Laplacian of the

*Corresponding author. Tel.: +352 275 88 87 48 79, Fax: +352 275 885.
Email address: `yao.koutsawa@list.lu` (Yao Koutsawa)