Multi-Scale Modelling of Graphene/Polymer Nanocomposite Thermal Behaviour

Asimina Manta[1]
Matthieu Gresil[1,2], Constantinos Soutis[2]

[1]i-composites lab, School of Materials,
[2]Aerospace Research Institute,
University of Manchester, Sackville Street, Manchester, M1 3NJ, UK.

asimina.manta@postgrad.manchester.ac.uk

Abstract

The advances in electrical applications, hybrid powertrains and other aeronautical structures require polymer systems to exhibit enhanced thermal response for better thermal management, decreasing developed temperature fields and achieving better thermal energy dissipation. Because of its exceptional electrical and thermal transport, graphene is one of the most promising candidates for reinforcing thermally insulating polymers. Experimental investigation of nanocomposites can be time and financially expensive exercise. Hence simulation tools seem to be attractive to effectively optimise the material architecture (amount, size, shape, distribution of graphene) under any loading conditions. The vast majority of available predictive methods on thermal response are limited to the calculation of thermal conductivity, while they are a combination of molecular dynamics (MD) simulations and Finite Element (FE) analysis [1],[2], or are based on Effective Medium Approximation (EMA) theory[3]. In this numerical work, a FE multi-scale model is proposed, consisting of a unit cell predicting the local thermal response and a representative volume element (RVE) calculating the overall thermal performance of the nanocomposite taking into account its architecture (Figure 1). In addition to this, an appropriate algorithm is developed to predict the thermal transient response that is used to obtain the thermal diffusivity. Numerical results are compared against corresponding analytical and experimental data [3] and, it will be shown that the finite element model can successfully simulate the thermal response of the nanocomposite as illustrated in Figure 2.

References

[1] B. Mortazavi et al., *Carbon*, 60, (2013) 356–365
[2] A. Manta et al., *Appl Compos Mater*, Spec. Issue,(2016),1-20
[3] K. Chu et al., *EPL*, 100,(2012), 36001

Figures

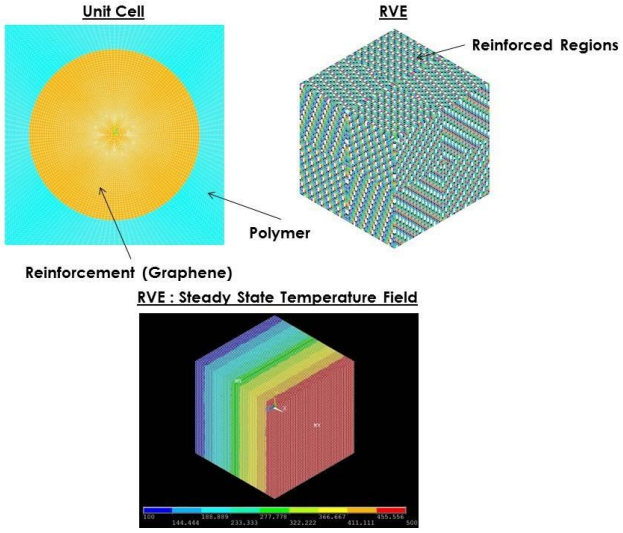

Figure 1: Presentation of the multi-scale model

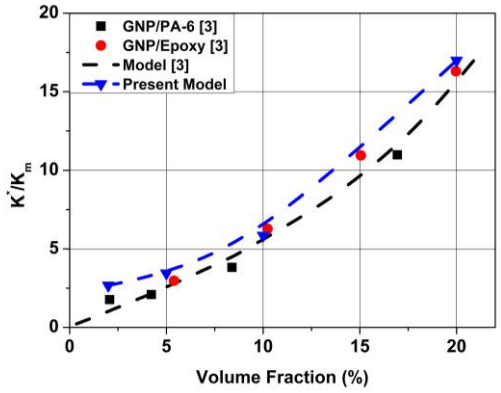

Figure 2: Comparison of the presented model with analytical and experimental results