

Preface

Over the last decades, an increasing number of functional and structural parts, made so far with metals, has been progressively reengineered by replacing metallic materials by polymers, reinforced polymers, and composites. The motivation for this substitution may be the weight reduction, the simpler, cheaper or faster forming process, or the ability to exploit additional functionalities.

The fillers usually employed cover a broad range involving many scales: (i) the nanometer scale (e.g., carbon nanotubes, graphene, fullerene, nanodiamonds); (ii) the micrometer to the millimeter scale (particles and short fibers); (iii) the centimeter scale of fibers used in SMC and BMC composite processes; and finally (iv) the macroscopic scale where fibrous reinforcements are made of continuous fibers arranged in bundles.

When load-bearing capacities are especially looked for, continuous fiber reinforced polymers are selected. In that case, the impregnation of the reinforcement with a low viscosity polymer involves the flow of a Newtonian or non-Newtonian fluid in the complex multi-scale microstructure related to the fiber and tow arrangement. Reinforced polymers are selected instead of high performance polymers of equivalent properties since the latter are generally more expensive.

When looking for functional properties, the use of nano-charges opens a wide spectrum of possibilities but also raises new challenges, such as dispersion of charges into the polymer matrix and occurrence of aggregation and disaggregation mechanisms. Suspensions of practical interest involve many scales and many concentration regimes, the latter ranging from dilute to highly concentrated.

In the present monograph, we survey modern developments related to the multi-scale modeling and simulation of polymers (Chap. 1, by Roland Keunings), reinforced polymers that involve a flowing microstructure (Chap. 2, by Francisco Chinesta), and continuous fiber-reinforced composites, wherein the fluid flows inside a nearly stationary multi-scale microstructure (Chap. 3, by Christophe Binetruy).

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