Numerical Modeling of Nanomaterials' Response to Microwaves

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Recently, nanomaterials have been the subject of enormous interest for applications in many areas, including industrial, biomedical, scientific, and military applications. Microwave processing of nanomaterials or nanomaterials embedded in host media has also seen a surge of interest recently. Among the most popular nanomaterials are carbon based nanomaterials, such as carbon nanotubes and graphene, and metal nanoparticles, such as aluminum and copper. Most published research concerning interaction of microwaves with nanomaterials is based on experimental work. On the other hand, published work on the theoretical simulation and modeling of to predict heating response of such materials due to microwave energy is scarce. Theoretical modeling of the response of nanomaterials to microwaves is a challenging problem due to the size of the particles involved. The theoretical problem also involves modeling the electromagnetic behavior as well as the thermal and heat transfer problem. The two problems, EM and thermal, will be coupled if the material's properties are temperature dependent, adding to the complexity of developing accurate and efficient theoretical models.

In this paper, development of methods to predict the microwave response of nanomaterials are discussed. In particular, simulation and modeling of two types of problems are presented, a material consisting of the nano particles alone, for example, a matrix of aluminum or copper particles) and a material consisting of nano particles embedded in a host medium (for example, carbon nanotubes dispersed in a polymer). Simulations of the electromagnetic problem to obtain the electric and magnetic fields within the material, as well as the thermal problem to predict the transient temperature distribution throughout the material are described.