Editorial

Modeling and Characterization of the Interaction of Electromagnetic Wave with Nanocomposites and Nanostructured Materials

Christian Brosseau

Département de Physique, Université de Bretagne Occidentale, 29238 Brest Cedex 3, France

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Nanostructured materials represent a size limit of the miniaturization trend of current technology. Interest in nanophases has expanded as investigators have recognized that many of the properties of finely divided matter strongly depend on the interfacial properties of the constituents by virtue of the high fraction of the overall material which is in the vicinity of an interface as well as of the confinement of electrons, excitons, and photons in small volumes. One of the interesting and important issues in predicting and understanding nanostructures and their functional behaviors is whether the properties of matter evolve gradually from bulk, as system size is reduced, and what determines this evolution behavior.

The electromagnetic characterization of nanomaterials can be considered a major part of the emerging field of nanotechnology. The potentially profound implications both for the transport properties and optics are only beginning to be explored. In that respect, multicomponent magnetic nanophases are of significant technological interest, that is, they can be considered as prospective granular magnetic films for tunable or nonreciprocal millimeter wave devices for monolithic microwave integrated circuit applications. This has also stimulated studies of the magnetoelectric effect, that is, the polarization of a material in an applied field or an induced magnetization in an external electric field.

The practical importance and industrial interest in these materials demand optimization of several types of properties in these materials. These properties include polarization, magnetization, and stability of the materials to mechanical, electrical, and magnetic fields applied during processing and operation. One of the fundamental goals of this field should be the understanding of the relationships of these properties on the composition, particle size and boundaries variations, defect structure and separation of the residual pores, but in most cases they are not well-understood.

In classical electrodynamics, the response of a material to electric and magnetic fields is characterized by two fundamental quantities: the permittivity ϵ and the magnetic permeability μ . In spite of the advances made, there is still no general agreement on interpretation of the experimental data of ϵ and μ of nanostructured materials since these quantities depend sensitively on the microstructural properties such as grain size, particle shape, and grain boundaries type.

Another related issue is the modeling of the polarization and magnetization mechanisms for these nanophases. In the effective medium approaches derived from continuum electromagnetism, only the volume fraction, or the particle number density, appears, while it is now well accepted that for dispersed two-phase nanostructures, appropriate descriptors of the interfaces should also appear. Therefore, collective magnetic and electromagnetic behaviors in nanosystems are challenging in terms of both experimental observation and development of theoretical analyses.

This special issue is dedicated to diverse topics related to electromagnetism of nanostructured materials. The contributors to this issue have endeavored to be selective, choosing and documenting those results to have the highest relevance and reliability. There was no attempt to be exhaustive and comprehensive. The careful selection of the topics included, however, suggests that the most attractive feature of these nanostructures is that their dielectric and magnetic properties can be varied over a wide range by the choice of the shape, size, and connectivity of the constituents in the structure. This issue contains nine survey contributions describing several active areas in this field of research. A relatively small number of contributions can only skim the surface of the exciting developments in this area. Our goal is only to illustrate the current status in the understanding of the electromagnetic properties of heterostructures. Clearly, the interplay between processing, structure, and macroscopic

properties is an important engineering and scientific concern. Both the editor and contributors of this volume would feel well rewarded if this issue helps relieve some of the problems of finding useful information on the morphological and electromagnetic properties of nanostructures.

Christian Brosseau