Journal of Nanophotonics

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Special Section Guest Editorial: Fundamental and Applied Nanoelectromagnetics

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Ongoing rapid progress in the synthesis of different nanostructures and their fascinating physical and chemical properties not associated with bulk materials symbolizes a fundamental breakthrough in the physics and chemistry of condensed matter, significantly extending our knowledge of the nature of solids and our capabilities to control their properties. No other area of materials research combines the exciting progress in fundamental research with the immediate promise of its realization in new devices and products that have both high societal impact and high commercial potential. Naturally, as a result we see a significant and potentially long-lasting increase of human resources and financial investments into this research field all over the world.

Solid-state nanostructures are constitutive and geometric nanononhomogeneities in semiconductor and dielectric mediums. Graphene, fullerenes and nanotubes, semiconductor structures with reduced dimensionality, such as quantum wells, wires and dots, and metallic nanoparticles, can be mentioned as examples. Despite their different physical natures, these objects share the common property of having extremely small dimensions in one or more directions. These dimensions are about one or two orders of magnitude bigger than the characteristic interatomic distance, and appear to be comparable to the electron's de Broglie wavelength, thereby providing a discrete spectrum of energy states in one or several directions. Apart from that, the intrinsic spatial nonhomogeneity of nanostructures dictates nanoscale nonhomogeneity of electromagnetic fields in them. Complementary characters of these two key factors whose interplay drastically modifies the electronic and optical properties of nanostructures as compared to bulk mediums often escape the attention of researchers, especially if the research concerns electromagnetic waves in nanostructures beyond the optical range—the traditional scope of nanophotonics. The emergence of nanosized structures as key building blocks of nanoelectronic and nanophotonic devices extends the operational range of circuit components—e.g., interconnects, transmission lines, and antennas—to terahertz and far-infrared frequencies. Quantum mechanics come into play to a full extent in determining peculiar dispersion laws of components. Obviously, such an extension requires the development of new functional components and new physical models of their operation, as well as the radical modification of the basic principles of circuit theory, which conventionally relies on macroscopic electrodynamics. The potential of nanosized elements and nanostructured materials for electromagnetic fields manipulation and processing had motivated the recent invention of a new research discipline, nanoelectromagnetics, which conceptually is a fusion of classical electrodynamics with novel methods and approaches of condensed matter physics.

To keep the process in the mainstream of nanoscience and nanotechnology development, as any interdisciplinary research topic, nanoelectromagnetics needs an intensive knowledge exchange between different scientific communities belonging to fundamental and applied electromagnetics, chemistry, and technology of nanostructures and nanocomposites, physics of nanostructure systems, etc. Such a need brought about the international conference Fundamental and Applied Nanoelectromagnetics (FANEM'12, Minsk, Belarus, May 22–25, 2012, http://www.nano.bsu.by/fanem12), which has been organized by the Belarusian State University under the support of EU FP7 project BY-NanoERA and International Science and Technology Center.

This conference aimed to provide a forum for scientists specializing in different areas of the nanoparticle and nanostructured materials synthesis and applications to interact with their

0091-3286/2012/$25.00

counterparts working in the areas of electromagnetic theory and applied electromagnetics, to both stimulate the development of nanoelectromagnetics and introduce the language and the problems of the present-day electromagnetics and photonics to the nanomaterials research community. The conference had a very wide scope that encompassed various aspects of general theory, modeling, design, synthesis, characterization, and applications ranging from commercial thin-film coatings to metamaterials to circuit components and nanodevices. More than 120 oral and poster presentation talks were delivered, including 6 key lectures and 11 invited talks.

In this special section, the reader will find a set of relevant papers, which has been expanded from the presentations at FANEM'12.

Acknowledgments

The guest editor thanks the members of the conference program committee, the national organizing committee, all of the authors who contributed to the special section, and the reviewers for their splendid cooperation. Support from ISTC (agreement SWS196-12-SB-89) and project FP7-266529 BY-NanoERA is acknowledged, which made the conference possible. I also have the pleasure to thank consortium members of the ISTC project B-1708 and EU FP7 projects FP7-230778 TERACAN, FP7-247007 CACOMEL, and FP7-318617 FAEMCAR, who participated in the FANEM'12 conference and its program committee, as well as its valuable proceedings.