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Progress in Nanophotonics 2

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Preface to *Progress in Nanophotonics*

As the first example, recent advances in photonic systems demand drastic increases in the degree of integration of photonic devices for large-capacity, ultrahigh-speed signal transmission and information processing. Device size has to be scaled down to nanometric dimensions to meet this requirement, which will become even more strict in the future. As the second example, photonic fabrication systems demand drastic decreases in the size of the fabricated patterns for assembling ultra-large-scale integrated circuits. These requirements cannot be met even if the sizes of the materials are decreased by advanced methods based on nanotechnology. It is essential to decrease the size of the electromagnetic field used as a carrier for signal transmission, processing, and fabrication. Such a decrease in the size of the electromagnetic field beyond the diffraction limit of the propagating field can be realized in optical near fields. Nanophotonics, a novel optical technology that utilizes the optical near field, was proposed by M. Ohtsu (the editor of this monograph series) in 1993 in order to meet these requirements. However, it should be noted that the true nature of nanophotonics involves not only its ability to meet the above requirements. It is also its ability to realize qualitative innovations in photonic devices, fabrication techniques, energy conversion, and information processing systems by utilizing novel functions and phenomena made possible by optical near-field interactions, which are otherwise impossible as long as conventional propagating light is used. Based on interdisciplinary studies on condensed-matter physics, optical science, and quantum field theory, nano-materials and optical energy transfer in the nanometric regime have been extensively studied in the last two decades. Through these studies, novel theories on optical near fields have been developed, and a variety of novel phenomena have been found. The results of this basic research have been applied to develop nanometer-sized photonic devices, nanometer-resolution fabrication, highly efficient energy conversion, and novel information processing, resulting in qualitative innovations. Further advancement in these areas is expected to establish novel optical sciences in the nanometric space, which can be applied to further progress in nanophotonics in order to support the sustainable development of peoples lives all over the world. This unique monograph series entitled Progress in Nanophotonics in the Springer Series in Nano-optics and Nanophotonics is being introduced to review the results of advanced studies in the field of nanophotonics and covers the most recent topics of theoretical and experimental interest in relevant fields, such as classical and quantum optical sciences, nanometer-sized condensed matter physics, devices, fabrication techniques, energy conversion, information processing, architectures, and algorithms. Each chapter is written by leading scientists in the relevant field. Thus, this monograph series will provide high-quality scientific and technical information to scientists, engineers, and students who are and will be engaged in nanophotonics research. As compared with the previous monograph series entitled "Progress in Nano-Electro-Optics" (edited by M. Ohtsu, published in the Springer Series in Optical Science), this monograph series deals not only with optical science on the nanometer scale, but also its applications to technology. I am grateful to Dr. C. Ascheron of Springer-Verlag for his guidance and suggestions throughout the preparation of this monograph series.

Tokyo Motoichi Ohtsu
August 2010

Preface to Volume II

This volume contains five review articles focusing on various but mutually related topics in nanophotonics written by the world'fs leading scientists. The first article describes near-field excitation dynamics in molecules. A generalized theoretical description of a light-matter interaction is given on the basis of the multipolar Hamiltonian. The second article is devoted to describing experimental results for wavelength up-converting a phonon-assisted excitation process with degenerate beams and nondegenerate beams in dye grains. Application to optical pulse-shape measurement is also reviewed. The third article describes a fabrication method of semiconductor quantum dots, including self-assembly of InAs quantum dots based on the Stranski-Krastanov growth mode. Fabrication and application of ultrahigh-density quantum dots by a strain compensation technique are also reviewed. The fourth article is devoted to single-nanotube spectroscopy and time-resolved spectroscopy for studying novel excitonic properties of single-walled carbon nanotubes. The striking features of ecxitons in the carbon nanotube, multiple-exciton states, charged exciton formation, and exciton-multiplication are reviewed. The last article describes microfluidic and extended-nano fluidic techniques. It claims that nanophotonics is used as a key technology since the space size becomes smaller than the wavelength in extended-nano space.

This volume is published with the support of Prof. Yatsui of the University of Tokyo, an associate editor. I hope that this volume will be a valuable resource for readers and future specialists in nanophotonics.

Tokyo
February 2013

Motoichi Ohtsu

Contents

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