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 Ohtsu (the editor of this monograph series) in 1993 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, but 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 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 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 Ascheron of Springer-Verlag for his guidance and suggestions throughout the preparation of this monograph series.

Tokyo *Motoichi Ohtsu*
January 2011

Preface

This volume contains six review articles focusing on various but mutually related topics in nanophotonics written by the world's leading scientists. Chapter 1 describes the concept of the dressed photon and its applications to qualitatively innovative optical devices, fabrication techniques, energy conversion, and systems. Chapter 2 is devoted to describing basic concepts necessary for two-dimensional parallel processing of light–matter interactions on the nanometer scale to realize probe-free nanophotonic systems. Additionally, the concepts and some demonstrations of the hierarchy inherent in nanophotonics, based on the hierarchy between optical near- and far-fields, are described as practical applications of optical near-field interactions. Chapter 3 describes self-organized fabrication of composite semiconductor quantum dots, which can be exploited for size- and position-controlled quantum dots for novel nanophotonic devices. Chapter 4 is devoted to near-field spectroscopy of metallic nanostructures, particularly visualization of plasmon wave functions and optical fields using near-field methods. Chapter 5 concerns simple experimental approaches for constructing metallic nanoarrays on a solid surface for applications to miniaturized optical devices, sensors, and single-molecule detection. For these applications, the author describes a unique approach for fabricating one-dimensional metal nanoparticle arrays on surfaces by applying highly aligned DNA molecules or nanofibers on a surface as a template. The last chapter, Chap. 6, describes chemical preparation of metal nanoparticles and their assembly formation processes. Various metal and semiconductor nanoparticles are studied according to their unique properties controlled by their sizes. 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
January 2011

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http://www.springer.com/978-3-642-17480-3

Progress in Nanophotonics 1
Ohtsu, M. (Ed.)
2011, XIV, 238 p., Hardcover
ISBN: 978-3-642-17480-3