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Motoichi Ohtsu (Ed.)

Progress in Nano-Electro-Optics I

Basics and Theory of Near-Field Optics

With 118 Figures

Springer

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Preface to *Progress in Nano-Electro-Optics*

Recent advances in electro-optical systems demand drastic increases in the degree of integration of photonic and electronic devices for large-capacity and 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. In the case of photonic devices, this requirement cannot be met only by decreasing the sizes of materials. It is indispensable to decrease the size of the electromagnetic field used as a carrier for signal transmission. 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.

Near-field optics has progressed rapidly in elucidating the science and technology of such fields. Exploiting an essential feature of optical near fields, i.e., the resonant interaction between electromagnetic fields and matter in nanometric regions, important applications and new directions such as studies in spatially resolved spectroscopy, nano-fabrication, nano-photonic devices, ultrahigh-density optical memory, and atom manipulation have been realized and significant progress has been reported. Since nano-technology for fabricating nanometric materials has progressed simultaneously, combining the products of these studies can open new fields to meet the above-described requirements of future technologies.

This unique monograph series entitled “Progress in Nano-Electro-Optics” is being introduced to review the results of advanced studies in the field of electro-optics at nanometric scales and covers the most recent topics of theoretical and experimental interest on relevant fields of study (e.g., classical and quantum optics, organic and inorganic material science and technology, surface science, spectroscopy, atom manipulation, photonics, and electronics). Each chapter is written by leading scientists in the relevant field. Thus, high-quality scientific and technical information is provided to scientists, engineers, and students who are and will be engaged in nano-electro-optics and nano-photonics research.

I gratefully thank the members of the editorial advisory board for valuable suggestions and comments on organizing this monograph series. I wish to express my special thanks to Dr. T. Asakura, Editor of the Springer Series in Optical Sciences, Professor Emeritus, Hokkaido University for recommending me to publish this monograph series. Finally, I extend an acknowledgement to Dr. Claus Ascheron of Springer-Verlag, for his guidance and suggestions, and to Dr. H. Ito, an associate editor, for his assistance throughout the preparation of this monograph series.

Yokohama, October 2002 *Motoichi Ohtsu*

Preface to Volume I

This volume contains five review articles focusing on various aspects of nano-electro-optics. The first article deals with fiber probes and related devices for generating and detecting optical near fields with high efficiency and resolution. These are essential tools for studying and applying optical near fields, and thus the article is most appropriate as the first chapter in this monograph series.

The second article is devoted to modulation of an electron beam by optical near fields. It is an important study on fundamental physical processes involving electron–light interaction, including quantum effects. This interaction is related to the well known Smith–Purcell and Schwarz–Hora effects.

The third article concerns fluorescence spectroscopy. To excite sample molecules, an evanescent surface plasmon field close to metallic surfaces is utilized, which is becoming an important and popular technique in studying nanometric species such as dye molecules.

The article that follows describes the spatially resolved near-field photoluminescence spectroscopy of semiconductor quantum dots, which will become a essential component in future electro-optical devices and systems. This spectroscopy also provides high spectral resolution, and thus it is a powerful tool for collecting precise information about a single quantum dot with a photoluminescence linewidth an order of magnitude narrower than that of ensemble quantum dots.

The last article deals with the quantum theory of optical near fields based on the concepts of a projection operator and an exciton–polariton. Since this theory concerns the optical near-field system coupling nanometric and macroscopic systems, it accounts for all the essential features of interaction between optical near fields and nano-matter, atoms, and molecules. Further, it can also be utilized to design future nano-electro-optical devices and systems.

I hope that this volume will be a valuable resource for readers and future specialists.

Yokohama, October 2002 *Motoichi Ohtsu*

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