# Toward Functional Nanomaterials

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# Preface

Advanced probes and new fabrication techniques enable nanomaterials to pervade multiple disciplines, including physics, chemistry, engineering and biology. Nanomaterials have been extensively investigated with various kinds of morphologies (nanoparticles, nanowhiskers, nanorods, nanowires, nanoclusters, quantum dots, etc.) and compositions (semiconductor, metal, polymer, etc.). Impressive progress has been made on directed assembly and synthesis, structure, and property characterization, as well as nanoscale device concepts and performance by a diverse group of experts. However, in spite of continued advancements in various aspects of functional nanomaterials, numerous challenges must still be overcome at different stages for practical applications to be realized.

It seems that there is a need for a book in which individual research groups comprehensively review their up-to-date efforts and simulate further developments in other laboratories. Therefore, I believe that this book, which consists of twelve chapters from nine countries, is a timely undertaking.

"Fabrication of Oxide Nanoparticles by Ion Implantation and Thermal Oxidation" is an in-depth review of the formation of oxide nanoparticles by metal ion implantation and subsequent thermal oxidation. Amekura and Kishimoto believe that there is a potential for an "embedded" breakthrough in the field of oxide nanoparticles similar to "Hache's finding of a breakthrough" in the field of metal nanoparticles. In "Design of Solution-Grown ZnO Nanostructures", Pauporté reviews significant progress toward the growth of well-controlled ZnO nanostructures in solution. He argues that solution-based methods are cost-effective and that the resulting nanostructures are easy to scale up for applications. In "Self-Assembled Metal Nanostructures in Semiconductor Structures", Ruffino et al. describe the self-assembly of metal nanostructures in semiconductor structures and demonstrate the consistency between structural and electrical measurements. In "Nanocrystal - Based Polymer Composites as Novel Functional Materials", Striccoli et al. focus on the incorporation of luminescent nanocrystals in plastic and structural polymers to obtain composite materials for integration in optoelectronic, photonic, and sensing devices.

While the first four chapters emphasize the fabrication of functional nanomaterials, chapters written by J. Li and S.-H. Wei, K. Miura et al., Sh. Michaelson et al., J.

Wei, and M. Gmitra and J. Barnaś 5–9 focus attention on their properties, behavior, and applications.

"Large-Scale *Ab Initio* Study of Size, Shape, and Doping Effects on Electronic Structure of Nanocrystals" covers the recent development of large-scale *ab initio* pseudopotential methods for calculating electronic structures of nanocrystals. Li and Wei demonstrate significant effects of size, shape, and doping on the properties of nanostructures. In "Chaotic Behavior Appearing in Dynamic Motions of Nanoscale Particles", Miura et al. reveal the dynamical motion of nanoscale particles with observations of chaotic behaviors. In "Hydrogen Concentration, Bonding Configuration and Electron Emission Properties of Polycrystalline Diamond Films: From Micro- to Nanometric Grain Size", Hoffman et al. summarize the studies of diamond films of varying grain size and thickness carried out in their laboratory. They reveal the impact of diamond grain size on hydrogen concentration, the shape of the Raman spectra, and the results of high resolution electron energy loss spectroscopy. In "Super-Resolution Optical Effects of Nanoscale Nonlinear Thin Film Structure and Ultrahigh -Density Information Storage", Wei introduces super-resolution optical effects of nanoscale nonlinear thin films and their application to ultrahigh density optical information storage. "Spin-Transfer and Current-Induced Spin Dynamics in Spin Valves: Diffusive Transport Regime" provides a demonstration by Gmitra and Barnaś of spin-transfer and current-induced spin dynamics in spin valves.

Gago et al. present a comprehensive overview of nanostructure evolution during nanopatterning by ion beam sputtering in "Self-Organized Surface Nanopatterning by Ion Beam Sputtering". While previous reviews are mainly devoted to ripple patterns, the focus of this chapter is on nanodot patterns due to their novelty and variety of applications. This is a must-have reference chapter for any researcher in the field of ion beam sputtering with an interest in nanotechnology. "Area-Selective Depositions of Self-assembled Monolayers on Patterned $SiO_2$/Si Surfaces" demonstrates area-selective depositions of self-assembled monolayers on patterned $SiO_2$/Si surfaces. Wang and Urisu believe that such a technique offers the potential for many practical applications, such as biosensor fabrication, cell studies, and tissue engineering.

While the above chapters focus on experimental manipulation of functional nanomaterials, virtual synthesis of electronic nanomaterials is the subject of the last chapter. Pozhar and Mitchel create atomic clusters and artificial molecules by computing the minimum total system energy. Perhaps these virtual nanomaterials exemplify possible outcomes of future experimental synthesis.

Last but not least, I am delighted to dedicate this book to my daughters, CC and KK. CC is ten years old and knows that nanomaterials are something small. The impact of nanotechnology to CC is nothing more than the iPod nano. KK is two years old and loves to read books loudly without knowing any words. I will record how she reads this book once it is published. I believe that nanotechnology will shape a better future for CC, KK, and all the children of the world!

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# Contents

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