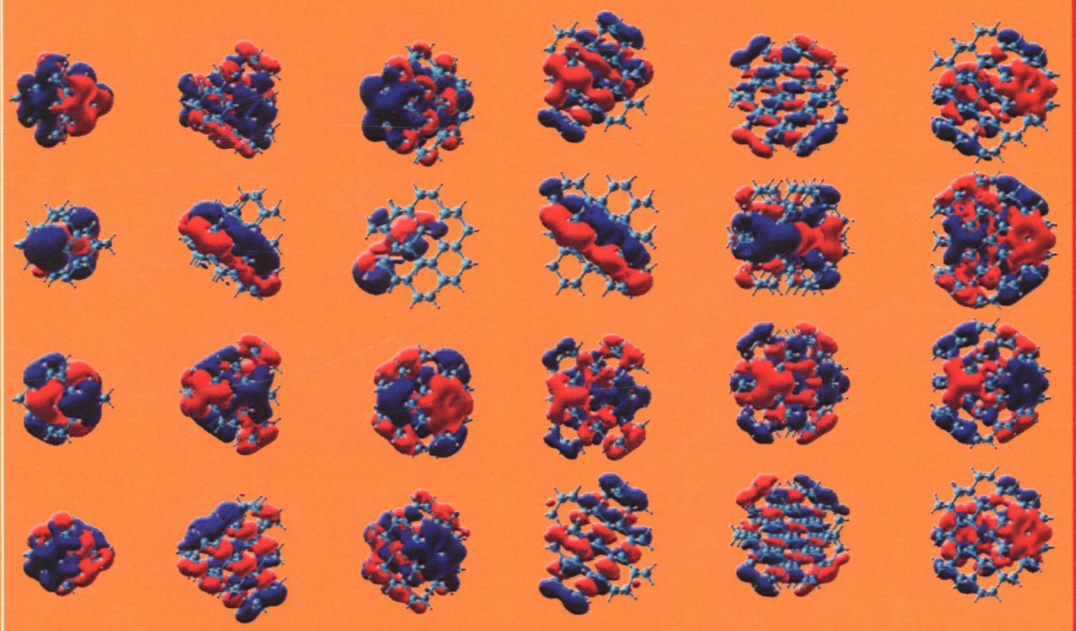
SERIES IN MATERIALS SCIENCE AND ENGINEERING



SILICON NANOMATERIALS SOURCEBOOK VOLUME I

Low-Dimensional Structures, Quantum Dots, and Nanowires

Edited by
Klaus D. Sattler

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SERIES IN MATERIALS SCIENCE AND ENGINEERING

Materials Science / Physics

This comprehensive tutorial guide to silicon nanomaterials spans from fundamental properties, growth mechanisms, and processing of nanosilicon to electronic device, energy conversion and storage, biomedical, and environmental applications. It also presents core knowledge with basic mathematical equations, tables, and graphs in order to provide the reader with the tools necessary to understand the latest technology developments.

From low-dimensional structures, quantum dots, and nanowires to hybrid materials, arrays, networks, and biomedical applications, this Sourcebook is a complete resource for anyone working with this materials:

- Covers fundamental concepts, properties, methods, and practical applications.
- Focuses on one important type of silicon nanomaterial in every chapter.
- Discusses formation, properties, and applications for each material.
- Written in a tutorial style with basic equations and fundamentals included in an extended introduction.
- Highlights materials that show exceptional properties as well as strong prospects for future applications.

Klaus D. Sattler is professor physics at the University of Hawaii, Honolulu, having earned his PhD at the Swiss Federal Institute of Technology (ETH) in Zurich. He was honored with the Walter Schottky Prize from the German Physical Society, and is the editor of the sister work also published by Taylor & Francis, Carbon Nanomaterials Sourcebook, as well as the acclaimed multi-volume *Handbook of Nanophysics.*

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VOLUME I

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Silicon Nanomaterials Sourcebook

VOLUME ONE

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Proposals for new volumes in the series may be directed to Lu Han, senior publishing editor at CRC Press, Taylor & Francis Group (lu.han@taylorandfrancis.com).

Preface

Silicon is one of the most technologically important materials today owing to its omnipresent significance in microelectronics. Its nanoscale forms, such as nanocrystals, porous silicon, quantum wells, or nanowires, have stimulated great interest among scientists because of their special physical properties, such as light emission, field emission, and quantum confinement effects. The progress made in the synthesis of silicon nanostructures in recent years has attracted considerable attention. Today, large quantities of silicon nanomaterials can be produced, and they are investigated with the most advanced analytical instruments available.

While silicon is the essential semiconductor material for modern microelectronic devices, this sourcebook shows a much wider range of applications, which are possible for silicon on the nanometer scale. Mostly inspired by the discovery of new carbon allotropes, methods have been developed in the last two decades for silicon to obtain similar low-dimensional and nanoscale morphologies and structures. When the size of silicon is reduced to the 1–100 nm range, quantum confinement can significantly affect the properties and performance of the material. Another inspiration came from the discovery of visible light emission from porous silicon, which inspired many scientists to start research on nanoscale silicon. Electronic and photonic studies of these materials have revealed peculiar effects and have subsequently been extended toward biomedicine with applications in tissue engineering, drug delivery, biosensing, radiotherapy, and sonodynamic therapy. This is possible because of the good biocompatibility and biodegradability of nanoscale silicon and tunable surface derivatization. Fabrication of subwavelength nanostructures has allowed for development of antireflection materials as well as other photon management structures such as materials with light-trapping properties, with applications in optoelectronic devices, photodetectors, and phototransistors.

Silicon Nanomaterials Sourcebook provides an introduction to synthetic methods used for the production of various silicon nanoscale morphologies and structures. Among these methods are solution synthesis and microwave-assisted synthesis, pulsed laser ablation, electrodeposition and plasma synthesis, metal-assisted chemical edging, interface functionalization, and nanoscale interface manipulations.

Volume One of the sourcebook covers low-dimensional silicon nanostructures such as nanosheets, clusters, nanoparticles, nanocrystals, nanowires, and nanotubes. Structural, electronic, and photonic properties of these materials may differ significantly from the silicon bulk properties.

Volume Two focuses on functional and industrial nanosilicon, describing materials such as nanowire, nanopencil and nanopore arrays, core–shell nanostructures, or porous silicon templates. These nanostructures have interesting antireflection, photonic, and thermoelectric properties. They have a wide range of applications as sonosensors, solar cells, for Li-ion batteries, for energy storage, biomedicine, solar energy conversion, chemical and biological sensing techniques, DNA sequencing, or quantum information.

The Sourcebook comprehensively covers the many aspects of silicon nanomaterials. It reflects the interdisciplinary nature of this field bringing together physics, chemistry, materials science, molecular biology, engineering, and medicine. Its contents include growth mechanisms and fundamental properties as well as electronic device, energy storage, biomedical, and environmental applications. It is a unique reference for industrial professionals and university students, offering deep insight into a wide range of areas from science to engineering. While addressing the current knowledge and the latest advances, it also includes basic mathematical equations, tables, and graphs. This provides the reader with the tools necessary to understand the current status of the field as well as future technology development of nanoscale silicon materials and structures.

Editor

Klaus D. Sattler pursued his undergraduate and master's courses at the University of Karlsruhe in Germany. He received his PhD under the guidance of Professors G. Busch and H.C. Siegmann at the Swiss Federal Institute of Technology (ETH) in Zurich, where he was among the first to study spin-polarized photoelectron emission. In 1976, he began a group for atomic cluster research at the University of Konstanz in Germany, where he built the first source for atomic clusters and led his team to pioneering discoveries such as "magic numbers" and "Coulomb explosion." He was at the University of California, Berkeley, for 3 years as a Heisenberg fellow, where he initiated the first studies of atomic clusters on surfaces with a scanning tunneling microscope.

Dr. Sattler accepted a position as professor of physics at the University of Hawaii, Honolulu, in 1988. There, he initiated a research group for nanophysics, which, using scanning probe microscopy, obtained the first atomic-scale images of carbon nanotubes directly confirming the graphene network. In 1994, his group produced the first carbon nanocones. He has also studied the formation of polycyclic aromatic hydrocarbons (PAH) and nanoparticles in hydrocarbon flames in collaboration with ETH Zurich. Other research has involved the nanopatterning of nanoparticle films, charge density waves on rotated graphene sheets, band gap studies of quantum dots, and graphene folds. His current work focuses on novel nanomaterials and solar photocatalysis with nanoparticles for the purification of water.

He is the editor of the sister reference, *Carbon Nanomaterials Sourcebook* (CRC Press, 2016), *Fundamentals of Picoscience* (CRC Press, 2014), and the seven-volume *Handbook of Nanophysics* (CRC Press, 2011). Among his many other accomplishments, Dr. Sattler was awarded the prestigious Walter Schottky Prize from the German Physical Society in 1983. At the University of Hawaii, he teaches courses in general physics, solid state physics, and quantum mechanics.

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