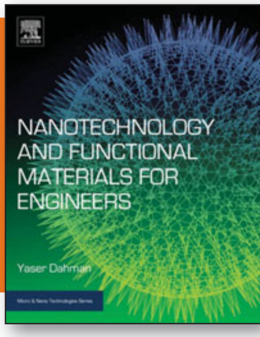


Nanotechnology and Functional Materials for Engineers

Yaser Dahman

Elsevier, 2017

282 pages, $130.00 (e-book $130.00)

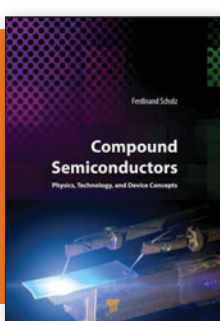
ISBN 9780323512565

In recent years, the subject of nanotechnology applied to engineering has seen a significant growth in both academia and industry. This book presents the fundamental concepts, techniques, and applications of nanotechnology in different engineering fields. It will be of interest to senior undergraduate and graduate students in chemical and materials engineering, electrical engineering, biomedical engineering, chemistry, physics, and related disciplines, as well as researchers, engineers, and technicians interested in applications of nanotechnology.

Each chapter deals with a major aspect of nanotechnology related to synthesis and processing of different types of nanomaterials and their applications, while also presenting the current state of the art and future perspectives. Chapter 1 provides the basic concepts of nanotechnology in a simple but comprehensive manner. It also presents a historical perspective and the current status of this field. Using a theoretical background, chapter 2 explains the main techniques for characterization of nanoparticle properties, such as morphology, crystal structure, and composition. The different types of nanomaterials are presented and explored in chapter 3. The mechanisms of response to different stimuli of these nanomaterials are discussed, and four potential applications are described: (1) entrapping ability as nanocarriers, (2) biological potential, (3) field-effect transistors, and (4) field-emission displays. Chapter 4 is devoted to the manufacturing methods and materials for various types of nanosensors for applications in medicine, security, environmental sensing, and industrial sensing. Chapters 5–8 deal with nanoparticles, nanopolymers, carbon nanotubes, and nanoshells, respectively. The methods of synthesis, the fundamental properties, and applications of these materials are summarized. Chapter 9 highlights the electronic and electro-optic nanotechnology. Some examples of devices, such as displays, dendrimers, modulators, and photodetectors, are described. Chapter 10 discusses the methods of preparation of self-assembling nanostructures. It also presents the definition, background, and principles of self-assembly. The last chapter presents applications in nanomedicine, highlighting nanopharmaceuticals, nano-ophthalmology, tissue engineering, and bone engineering. A good number of adequate and up-to-date references are provided at the end of the book.

This book is well written and well illustrated with figures and tables, which allows easy reading and comprehension. It can be used as a textbook. There are no homework exercises, but some examples are shown. It covers the main aspects of nanotechnology for engineering applications and can serve as a good source for courses on this topic.

***Reviewer: Mariana Amorim Fraga**, full professor and researcher in the Applied Nanoscience and Plasma Technology Group at Universidade Brasil, Brazil.*



Compound Semiconductors: Physics, Technology, and Device Concepts

Ferdinand Scholz

Pan Stanford, 2017

306 pages, $149.95 (e-book $49.46)

ISBN 9789814774079

This is a well-organized, concise introduction to the field of compound semiconductors and their applications in optoelectronic and electronic devices. The fundamental science and technology necessary to understand research in this field is covered in easy-to-read text: short paragraphs, bullet lists of key points, copious figures, and short chapters (typically less than 20 pages). There is a logical flow from basic properties through process technologies to device applications. The emphasis is on III–V compound semiconductors, particularly gallium arsenide, indium phosphide, and gallium nitride, with the occasional comparison to silicon. Aside from the coverage on gallium nitride, many of the characterization techniques and materials processing methods have been well established and written about for close to 40 years; more than 75% of the references are from before 2000. Still, Scholz's presentation is fresh with its inclusion of quantum effects, low dimensional systems, and group III nitrides and their distinctive properties.

The book is roughly divided into four sections.The first four chapters cover the basic properties of compound semiconductors and their synthesis. The defining general properties of semiconductors such as crystal lattices, energy bandgaps, and charge-carrier statistics are covered in chapter 1. The distinguishing properties of compound semiconductors, their direct bandgaps, the ability to control the bandgap by forming alloys such as $Al_xGa_{1-x}As$, and energy bandgap discontinuities realized with heterojunctions, are described in chapter 2. Methods of growing bulk

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single crystals from melts (the Czochralski method) and solutions (the Bridgman method) are detailed in chapter 3. Chapter 4 describes the main epitaxial growth methods, including liquid-phase epitaxy, metal–organic vapor-phase epitaxy, and molecular beam epitaxy.

The second section, chapters 5–7, is an overview of characterization methods. How the electrical properties of charge mobility and carrier concentrations are measured by the Hall effect and CV methods is the subject of chapter 5. Optical characterization by photoluminescence and absorption, and structural characterization by x-ray diffraction of the properties are recounted in chapters 6 and 7.

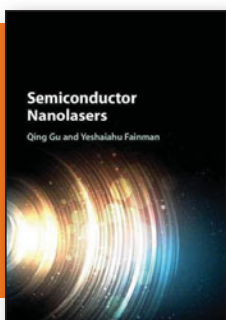
The third section describes some of the distinguishing characteristics important to compound semiconductors. Chapter 8 chronicles the property changes introduced by quantum wells and their applications. The importance of strain as a design parameter for changing the band structure and its influence on the critical thickness are covered next in chapter 9. Chapter 10 describes the methods of synthesizing quantum wells, wires, and dots. Group III nitrides are distinctive enough to have their own chapter; the challenges of doping, forming ternary alloys in the nitride system, and the implications of polarization and piezoelectricity are described in chapter 11.

The final section, chapters 12 and 13, is on devices at which compound semiconductors excel due to their direct bandgaps and high carrier mobilities. These include optoelectronic devices, such as light-emitting diodes, laser diodes, and solar cells, and electronic devices, especially field-effect transistors and heterobipolar transistors.

This could be used as a textbook, as questions are included at the end of each chapter. There are a few questions that require quantitative numerical solutions, but the vast majority are more qualitative, requiring only descriptive answers.

This book presents a good overview of compound semiconductors, their properties, synthesis, characterization, and device applications. It is appropriate for upper-level undergraduates or graduate students.

***Reviewer: J.H. Edgar**, Department of Chemical Engineering, Kansas State University, USA.*



Semiconductor Nanolasers

Qing Gu and Yeshaiahu Fainman

Cambridge University Press, 2017
332 pages, $155.00 (e-book $124.00)
ISBN 9781107110489

This introduction to the growing literature on nanolasers is self-contained, and sufficiently user-friendly to appeal to an intended audience that includes "graduate students, researchers and professionals in optoelectronics, photonics, applied physics, nanotechnology and materials science." That broad reach is evident in the Introduction, which begins with a history of laser miniaturization and the fundamentals of laser action, and then uses the evolution of the microscale vertical-cavity surface-emitting laser (VCSEL) to highlight the challenges in photonic materials and optoelectronics found in photonic crystal defect-cavity lasers, nanowire, cavity-free and metal-dielectric-metal (MDM) lasers, and coherent sources based on surface plasmon amplification.

Succeeding chapters explicate critical technical issues in these nanolaser types, and cover optical cavity design, optimization of the principal mode structures, and operation of coaxial and MDM nanolasers in optical and plasmonic modes. Chapters 2, 4, and 5 cover nanolasers that incorporate metallic elements in photonic and plasmonic modes or as antennas to shape output radiation patterns. Chapter 7 covers electrically pumped nanolasers and analyzes indium phosphide devices. The focus on optical design and performance is complemented in chapter 8 by a detailed multiphysics design study of the thermal, electrical, and materials design issues for nanolasers. Chapters 9 and 10 deliver stimulating excursions into the realms of cavity-free lasers and inversionless exciton-polariton lasers.

The concluding chapter acknowledges that the engineering maturity or technological readiness of nanolasers requires a discussion of the emerging *potential* of nanolasers, rather than specific applications, in the context of integrated photonics platforms and waveguides. This recognizes that the technological utility of nanolasers ultimately rests on their chip-scale integration into photonic devices employing electrical pumping. From that perspective, the final section on silicon-compatible miniature lasers is appropriate and instructive.

Although not conceived as a textbook (e.g., the book lacks homework problems), parts of the monograph would be suitable for courses in photonics or quantum electronics. For example, chapter 3 on the Purcell effect treats a complicated topic with admirable clarity, augmented by Appendix A with a compact review of nonrelativistic quantum electrodynamics. Chapter 6 compares multiple-quantum well versus bulk semiconductor materials as optical-gain media, rendering itself as a course module on laser physics. Also, one could couple chapter 8 with Appendix C, which treats the thermal issues surrounding VCSELs using COMSOL Multiphysics software, as the basis for a project on thermal design of nanolaser components.

The authors are experts in this topical area and also have produced a substantial body of collaborative work. That history may well be at the heart of the impressive thematic, conceptual, and editorial coherence of the text.

***Reviewer: Richard F. Haglund Jr.**, Department of Physics and Astronomy, Vanderbilt University, USA.*

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