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.

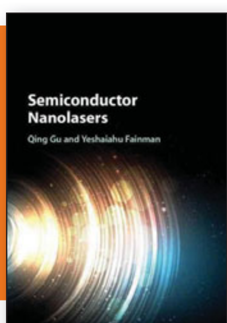
The third section describes some of the distinguishing characteristics important to compound semiconductors. Chapter 8 chronicles the property changes introduced by quantum wells and their applications. The importance of strain as a design parameter for changing the band structure and its influence on 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

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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.*