

# Preface

“Laser” is a coined word, formed by taking the initials of words in the phrase “Light Amplification by Stimulated Emission of Radiation.” The laser was invented in 1960 and was a ruby laser in which optical light was emitted and amplified in a ruby crystal. The semiconductor laser was invented in 1962.

Semiconductor lasers are being used as principal devices in the technical fields of optoelectronics, such as the optical fiber communication system, the optical disc system, and the optical precise measuring system. Under certain operating situations, however, semiconductor lasers often show undesired performance characteristics such as instability of lasing mode and generation of extra noise. Understanding of these complex characteristics is not easy to achieve, because semiconductor lasers have specific physics that do not play a part in other electrical and optical devices.

This book is written for students, engineers, and researchers who wish to study a unified theoretical account of the operating principles of semiconductor lasers based on theoretical physics rather than on phenomenological treatments. The above-mentioned complex operating characteristics are logically analyzed in this book, which consists of four major sections.

In Part I, “Fundamental Theory,” descriptions from quantum electronics focusing specifically on the semiconductor laser are provided from the broader perspective of quantum mechanics. The basic subject matter required to construct a standard semiconductor laser theory is treated here. The author explains the theoretical developments of semiconductor laser theory in a concise but self-contained manner, relying on the Appendices to provide help in understanding related principles and theorems.

The required background material for readers includes classical electromagnetic theory, quantum mechanics, and semiconductor physics. Familiarity with the content of these fields is assumed. Readers wishing to skip the derivation of lasing gain and go directly to a study of the mechanism of laser instability and noise can jump to [Chap. 9](#) in Part II and omit the fundamental theory in Part I.

Although laser quality is evaluated with a view toward achieving a lower threshold current level, higher efficiency, and higher optical power, properties of the lasing modes, and noise problems are also subjects required in the evaluation of laser quality. Criteria for these properties require an understanding of nonlinear phenomena and other complex physics in semiconductor lasers.

One example, namely, whether we can achieve single-mode operation, is analyzed from the perspective of nonlinear gain and discussion of mode competition phenomena. Another example, which is a serious issue for semiconductor lasers, is so-called feedback noise, induced by reflections of output light from connecting optical devices such as optical lenses, optical fibers, or optical discs. The mechanism for feedback noise generation and the technology to suppress it are explained in terms of nonlinear properties and quantum mechanical fluctuations. Theoretical treatments of nonlinear properties, mode competition phenomena, and noise are given in Part II, “Advanced Theory for Mode Competition and Noise.”

The standard structures used in semiconductor lasers are the double heterojunction, the stripe structure, and the Fabry–Perot cavity made of cleaved facets. Besides these standard structures, many other structures have been developed to achieve more superior operating characteristics and wider applications.

In Part III, “Structures for Superior Characteristics in the Semiconductor Lasers,” the quantum well structure, distributed feedback and mode-selective lasers, and surface-emitting lasers are introduced.

The Appendices, comprising the fourth major section, present related principles and theorems to facilitate understanding of the basis of the theories covered in the book, making it unnecessary to draw upon other sources to achieve that understanding.

Kanazawa, Japan

Minoru Yamada

Theory of Semiconductor Lasers  
From Basis of Quantum Electronics to Analyses of the  
Mode Competition Phenomena and Noise  
Yamada, M.  
2014, XI, 303 p. 137 illus., 1 illus. in color., Hardcover  
ISBN: 978-4-431-54888-1