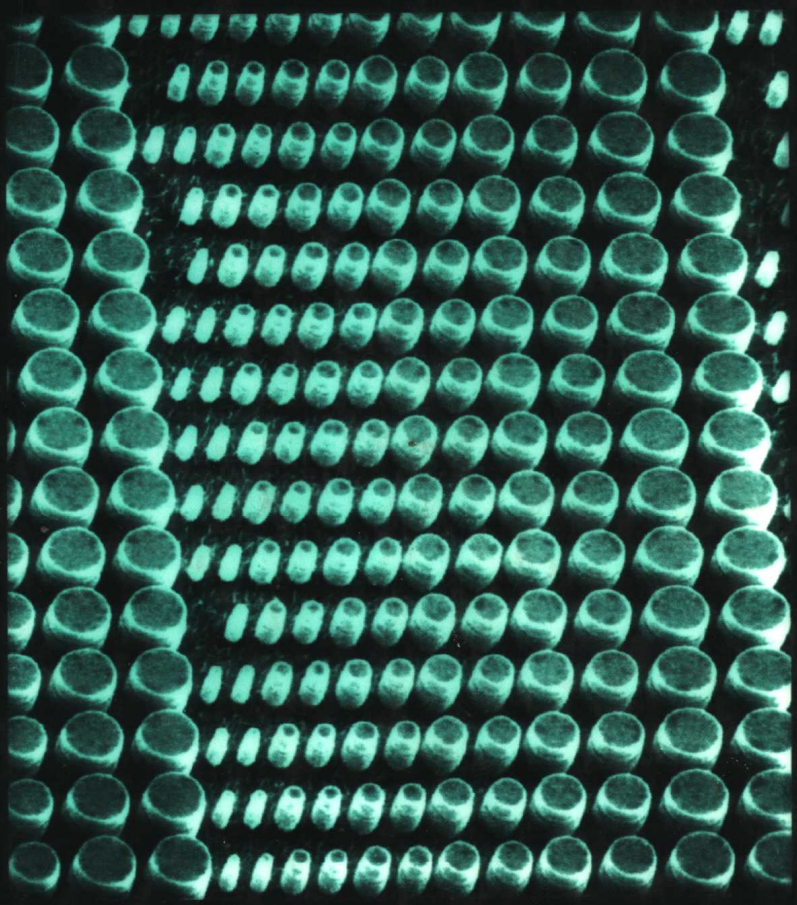
Optical Electronics in Modern Communications

FIFTH EDITION



Amnon Yariv

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Fifth Edition

Amnon Yariv
California Institute of Technology

New York Oxford
Oxford University Press
1997

Oxford University Press

Oxford New York
Athens Auckland Bangkok Bogotá Bombay Buenos Aires
Calcutta Cape Town Dar es Salaam Delhi Florence Hong Kong
Istanbul Karachi Kuala Lumpur Madras Madrid Melbourne
Mexico City Nairobi Paris Singapore Taipei Tokyo Toronto

and associated companies in
Berlin Ibadan

Published by Oxford University Press, Inc.,
198 Madison Avenue, New York, New York, 10016-4314

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Library of Congress Cataloging-in-Publication Data
Yariv, Amnon.
Optical electronics in modern communications / Amnon Yariv.—5th ed.
p. cm.—(The Oxford series in electrical engineering)
Rev. ed of: Optical electronics. 4th ed., c1991.
Includes bibliographical references and index.
ISBN 0-19-510626-1 (cl)
1. Lasers. 2. Fiber optics. 3. Electrooptical devices.
4. Acoustooptical devices. 5. Photoelectronic devices. I. Title.
II. Series.
TA 1675.Y37 1996
621.382'7—dc20 95-52302

9 8 7 6

Printed in the United States of America
on acid-free paper

Optical Electronics in Modern Communications

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Preface to the Fifth Edition

"If it is beautiful, wear it around your neck. If it serves a useful purpose, carry it on your back. It if is neither, get rid of it."

In the process of deciding which material to include in this new edition and which to discard, I attempted to follow the above-quoted advice of my sergeant major (whose name I forgot) in the Israeli army as we were preparing to go into the field. I thus limited the material to what I consider, subjectively, beautiful, or important, or, on more than one occasion, both. The user of this book will have his own candidates for each of these categories, which, I hope, are not different from mine. In the process, most of the topics and chapters of the fourth edition survived the transition to the fifth. A considerable amount of new material, however, has been added. The changes reflect the continuous ascendance of optical communication as the foremost communication technology. With the new additions, the center of gravity of the book has swung clearly to the side of low-power, communication-related topics that made it appropriate to change the title to *Optical Electronics in Modern Communications*.

The main new features of this edition are:

1. Use of the transfer function Fourier transform formalism to treat pulse propagation in fibers.
2. The temporal-spatial equivalence of pulse and beam propagation including temporal lenses.
3. Compensation of dispersive pulse spread in fibers.

4. New treatment of the optical susceptibility ($\chi'(\nu)$ and $\chi''(\nu)$), using the Kramers–Kroning relations. Derivation of Kramers–Kroning relations.
5. A major overhaul of the discussion on distributed feedback lasers, including a treatment of gain-coupled lasers.
6. Dynamic chirp in semiconductor lasers.
7. Vertical-cavity semiconductor lasers.
8. A new chapter on solitons, with a first-principles derivation of the propagation equation in nonlinear fibers.
9. A new chapter consisting of a classical treatment of quantum optics and quantum noise, consequences for optical measurements, shot noise, and "squeezing" of amplitude fluctuations, below the classical limit, by degenerate parametric amplification.

The academic requirements for the use of this book are unchanged from those stated in the preface to the fourth edition, repeated here.

I am indebted to Mrs. Jana Mercado and Mrs. Mary Eleanor Johnson for typing and editing under fire. I also benefited from specific technical inputs by John Kitching, William Marshall, John O'Brien, and Matt McAdams.

To Mr. Ali Adibi my deep appreciation for the countless hours spent rederiving all the major results. The errors and inconsistencies that he corrected will go a long way toward making this a rigorous and relatively error-free text.

Pasadena, California
June 1996

Amnon Yariv

Preface to the Fourth Edition

The five years that have intervened since the appearance of the third edition of *OPTICAL ELECTRONICS* witnessed significant technical developments in the field and the emergence of some major trends. A few of the important developments are

1. Optical fiber communication has established itself as the key communication technology.
2. The semiconductor laser and especially the longer wavelength GaInAsP/InP version has emerged as the main light source for high-data-rate optical fiber communication systems.
3. Quantum well semiconductor lasers started replacing their conventional counterparts for high-data-rate long distance communication and most other sophisticated applications including ultra-low threshold and mode-locked lasers.
4. Optical fiber amplifiers are causing a minor revolution in fiber communication due to their impact on very long distance transmission and on large scale optical distribution systems.

The accumulated weight of the new developments was such that when I last taught the course at Caltech in 1989 I found myself using a substantial fraction of course material that was not included in the text. The fourth edition brings this material into the fold. The main additions to the third edition, include major revisions and new chapters dealing with

1. Jones calculus and its extension to Faraday effect elements.
2. Radiometry and infrared detection.
3. Optical fiber amplifiers and their impact on fiber communication links.
4. Laser arrays.
5. Distributed feedback lasers, including multi-element lasers with phase shift sections.
6. Quantum well and ultra-low threshold semiconductor lasers.
7. Photorefractive crystals and two-beam coupling in dynamic holography and image processing.
8. Two-beam coupling and phase conjugation in stimulated Brillouin scattering.
9. Intensity fluctuations and coherence in semiconductor lasers and their impact on fiber communication systems.

The book continues to be aimed at the student interested in learning how to generate and manipulate optical radiation and how to use it to transmit information. At Caltech the course is taken, almost in equal proportions, by electrical engineering, physics, and applied physics students. About half the students tend to be seniors and the rest graduate students.

The prerequisites for taking the course at Caltech are a sound undergraduate background in electromagnetic theory—usually a one year course in this area—and an introcution to atomic physics.

The hands-on and research flavor of the book owes greatly to the exciting mix of visitors, talented students, and postdocs who bombard me continually with their newest findings and thoughts.

This edition includes acknowledged and unacknowledged contributions from Chris Harder, Kerry Vahala, Eli Kapon, Kam Lau, Pamela Derry, Israel Ury, Nadav Bar-Chaim, Hank Blauvelt, Michael Mittelstein, Lars Eng, Norman Kwong, Shu Wu Wu, Bin Zhao, and Rudy Hoffmeister. The Caltech Applied Physics 130 and 131 classes during 1987 and 1989, helped ferret out inconsistencies and insisted on clearer presentations.

My wife Fran and my administrative assistant Jana Mercado are responsible for the typing and editing. To them and to all of the above, my gratitude.

Pasadena, California
January 1991

Amnon Yariv

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