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This book is volume II of a series of books on silicon photonics. It gives a fascinating picture of the state-of-the-art in silicon photonics from a component perspective. It presents a perspective on what can be expected in the near future. It is formed from a selected number of reviews authored by world leaders in the field, and is written from both academic and industrial viewpoints. An in-depth discussion of the route towards fully integrated silicon photonics is presented. This book will be useful not only to physicists, chemists, materials scientists, and engineers but also to graduate students who are interested in the fields of micro- and nanophotonics and optoelectronics. A complete survey of modern design and analysis techniques for optical waveguides This volume thoroughly details modern and widely accepted methods for designing the optical waveguides used in telecommunications systems. It offers a straightforward presentation of the sophisticated techniques used in waveguide analysis and enables a quick grasp of modern numerical methods with easy mathematics. The book is intended to guide the reader to a comprehensive understanding of optical waveguide analysis through self-study. This comprehensive presentation includes: * An extensive and exhaustive list of mathematical manipulations * Detailed explanations of common design methods: finite element method (FEM), finite difference method (FDM), beam propagation method (BPM), and finite difference time-domain method (FD-TDM) * Explanations for numerical solutions of optical waveguide problems with sophisticated techniques used in modern computer-aided design (CAD) software * Solutions to Maxwell's equations and the Schrodinger equation The authors provide excellent self-study material for practitioners, researchers, and students, while also presenting detailed mathematical manipulations that can be easily understood by readers who are unfamiliar with them. Introduction to Optical Waveguide Analysis presents modern design methods in a comprehensive and easy-to-understand format. One of the most methodical treatments of electromagnetic wave propagation, radiation, and scattering—including new applications and ideas Presented in two parts, this book takes an analytical approach on the subject and emphasizes new ideas and applications used today. Part one covers fundamentals of electromagnetic wave propagation, radiation, and scattering. It provides ample end-of-chapter problems and offers a 90-page solution manual to help readers check and comprehend their work. The second part of the book explores up-to-date applications of electromagnetic waves—including radiometry, geophysical remote sensing and imaging, and biomedical and signal processing applications. Written by a world renowned authority in the field of electromagnetic research, this new edition of Electromagnetic Wave Propagation, Radiation, and Scattering: From Fundamentals to Applications presents detailed applications with useful appendices, including mathematical formulas, Airy function, Abel's equation, Hilbert transform, and Riemann surfaces. The book also features newly revised material that focuses on the following topics: Statistical wave theories—which have been extensively applied to topics such as geophysical remote sensing, bio-electromagnetics, bio-optics, and bio-ultrasound imaging Integration of several distinct yet related disciplines, such as statistical wave theories, communications, signal processing, and time reversal imaging New phenomena of multiple scattering, such as coherent scattering and memory effects Multiphysics applications that combine theories for different physical phenomena, such as seismic coda waves, stochastic wave theory, heat diffusion, and temperature rise in biological and other media Metamaterials and solitons in optical fibers, nonlinear phenomena, and porous media Primarily a textbook for graduate courses in electrical engineering, Electromagnetic Wave Propagation, Radiation, and Scattering is also ideal for graduate students in bioengineering, geophysics, ocean engineering, and geophysical remote sensing. The book is also a useful reference for engineers and scientists working in fields such as geophysical remote sensing, bio–medical engineering in optics and ultrasound, and new materials and integration with signal processing. The increasingly widespread use of optical chemical sensor technology has paved the way for a broad range of exciting new applications in areas such as medicine, biotechnology, remote control, and the environment. In fact, this technique is growing so rapidly that it has proven difficult to obtain updated reference material on the subject -- until now. This book covers the principles of operation of electromagnetic waveguides and transmission lines. The approach is divided between mathematical descriptions of basic behaviors and treatment of specific types of waveguide structures. Classical (distributed-network) transmission lines, their basic properties, their connection to lumped-element networks, and the distortion of pulses are discussed followed by a full field analysis of waveguide modes. Modes of specific kinds of waveguides - traditional hollow metallic waveguides, dielectric (including optical) waveguides, etc. are discussed. Problems of excitation and scattering of waveguide modes are addressed, followed by discussion of real systems and performance. This comprehensive resource provides a thorough introduction to the principles of electronic circuits operating in the radio, microwave, and millimeter-wave frequency ranges. The book highlights the fundamental physical laws of classical electromagnetics using a foundation of Maxwell's equations to give insight into the operating principles of circuit elements of all kinds, from lumped elements to transmission lines, waveguides, optical fibers, and quasi-optical structures. Standard passive system components like filters, splitters, couplers, hybrids, baluns, and antennas are explained to acclimate the reader to considering multiple technological solutions for common design problems. A basic overview of active circuit designs, such as amplifiers, mixers, and multipliers is also provided, along with discussion of the performance characteristics of electronic systems, including noise and linearity. Emphasis is placed on visualization and understanding of how and why electronic circuits of all frequencies are built and operate the way they do. Readers learn how to match an amplifier for optimum noise performance over the broadest bandwidth with the fewest number of elements and how to visualize the coupling of various modes in a mixed waveguide-type structure and avoid resonances due to trapped, higher-order modes. The book provides the tools needed to design and optimize a launcher from microstrip into waveguide, and whether the best characteristics can be achieved by incorporating matching elements in the microstrip section, the waveguide section, or both. Packed with references and examples, readers learn not only how to do the math but what the math means. CD-ROM contains: "modified Marcatili's and Goell'd methods." "Co-published with Oxford University Press Long considered the most comprehensive account of electromagnetic theory and analytical methods for solving waveguide and cavity problems, this new Second Edition has been completely revised and thoroughly updated -- approximately 40% new material!Packed with examples and applications FIELD THEORY OF GUIDED WAVES provides solutions to a large number of practical structures of current interest. The book includes an exceptionally complete discussion of scalar and Dyadic Green functions. Both a valuable review and source of basic information on applied mathematical topics and a hands-on source for solution methods and techniques, this book belongs on the desk of all engineers working in microwave and antenna systems!" Sponsored by: IEEE Antennas and Propagation Society Fundamentals of Optical Waveguides is an essential resource for any researcher, professional or student involved in optics and communications engineering. Any reader interested in designing or actively working with optical devices must have a firm grasp of the principles of lightwave propagation. Katsunari Okamoto has presented this difficult technology clearly and concisely with several illustrations and equations. Optical theory encompassed in this reference includes coupled mode theory, nonlinear optical effects, finite element method, beam propagation method, staircase concatenation method, along with several central theorems and formulas. Since the publication of the well-received first edition of this book, planar lightwave circuits and photonic crystal fibers have fully matured. With this second edition the advances of these fibers along with other improvements on existing optical technologies are completely detailed. This comprehensive volume enables readers to fully analyze, design and simulate optical atmospheres. Exceptional new chapter on Arrayed-Waveguide Grating (AWG) In-depth discussion of Photonic Crystal Fibers (PCFs) Thorough explanation of Multimode Interference Devices (MMI) Full coverage of polarization Mode Dispersion (PMD) This book delivers an in-depth examinations of the three basic field-theoretical methods used for the design aid of different waveguide components. You'll find CAD algorithms, examples of their applications, and operational principles of various components used in antenna feed systems. This book covers the principles of operation of electromagnetic waveguides and transmission lines. The approach is divided between mathematical descriptions of basic behaviors and treatment of specific types of waveguide structures. Classical (distributed-network) transmission lines, their basic properties, their connection to lumped-element networks, and the distortion of pulses are discussed followed by a full field analysis of waveguide modes. Modes of specific kinds of waveguides - traditional hollow metallic waveguides, dielectric (including optical) waveguides, etc. are discussed. Problems of excitation and scattering of waveguide modes are addressed, followed by discussion of real systems and performance. Provides a comprehensive discussion of planar transmission lines and their applications, focusing on physical understanding, analytical approach, and circuit models Planar transmission lines form the core of the modern high-frequency communication, computer, and other related technology. This advanced text gives a complete overview of the technology and acts as a comprehensive tool for radio frequency (RF) engineers that reflects a linear discussion of the subject from fundamentals to more complex arguments. Introduction to Modern Planar Transmission Lines: Physical, Analytical, and Circuit Models Approach begins with a discussion of waves on transmission lines and waves in material medium, including a large number of illustrative examples from published results. After explaining the electrical properties of dielectric media, the book moves on to the details of various transmission lines including waveguide, microstrip line, co-planar waveguide, strip line, slot line, and coupled transmission lines. A number of special and advanced topics are discussed in later chapters, such as fabrication of planar transmission lines, static variational methods for planar transmission lines, multilayer planar transmission lines, spectral domain analysis, resonators, periodic lines and surfaces, and metamaterial realization and circuit models. Emphasizes modeling using physical concepts, circuit-models, closed-form expressions, and full derivation of a large number of expressions Explains advanced mathematical treatment, such as the variation method, conformal mapping method, and SDA Connects each section of the text with forward and backward cross-referencing to aid in personalized self-study Introduction to Modern Planar Transmission

Lines is an ideal book for senior undergraduate and graduate students of the subject. It will also appeal to new researchers with the inter-disciplinary background, as well as to engineers and professionals in industries utilizing RF/microwave technologies. Dielectric optical waveguides have been investigated for more than two decades. In the last ten years they have had the unique position of being simultaneously the backbone of a very practical and fully developed technology, as well as an extremely exciting area of basic, forefront research. Existing waveguides can be divided into two sets: one consisting of waveguides which are already in practical use, and the second of those which are still at the laboratory stage of their evolution. This book is divided into two separate parts: the first dealing with anisotropic waveguides, and the second with nonlinear behaviour. Nonlinear behaviour in optical waveguides is a topic of current research interest, an effect eagerly being sought in waveguides. The relative importance of nonlinearity versus anisotropy in theoretical papers changes enormously from problem to problem. Many theories can be quite useful and enlightening even though they neglect entirely one of the two aspects. Scientists may find their research work leading them in the near future to deal simultaneously with anisotropy and nonlinearity in order to pursue their own investigations. This book will be of interest to researchers who first need to understand the individual topics, suitably chosen from the two parts of this work, thus providing them with the necessary ingredients to pursue their explorations. The book is written for an undergraduate course on the transmission lines and waveguides. It provides comprehensive coverage of four terminal networks, filters, transmission lines and various types of waveguides. The book starts with explaining the symmetrical and asymmetrical four terminal networks which form the basis of filters. Then book provides the detailed discussion of various types of filters. The discussion of composite filters and crystal filter is also included in the book. The book covers the transmission line parameters in detail along with reflection on a line, reflection loss and reflection factor. The chapter on transmission line at radio frequency includes parameters of line at high frequency, standing waves, standing wave ratio, single stub matching, double stub matching and Smith chart. The book covers the various aspects of guided waves between parallel planes. It also provides the discussion of rectangular and circular waveguides. At the end book incorporates the discussion of resonators. Each chapter provides the detailed explanation of the topic, practical examples and variety of solved problems. The explanations are given using very simple and lucid language. All the chapters are arranged in a specific sequence which helps to build the understanding of the subject in a logical fashion. The book explains the philosophy of the subject which makes the understanding of the concepts very clear and makes the subject more interesting. The investigation of wave propagation in non-uniform transmission lines is common to many engineering situations. This book presents and develops the mathematical tools required to effectively examine and analyze propagation processes of waves of various natures using the cross section method, in artificial and non-artificial waveguides. These techniques are used in the solution of practical situations in various fields, such as plasma heating in nuclear fusion, materials processing and radar and satellite communication systems. This is a comprehensive treatment of optical waveguide theory. Optical Waveguides describes waveguide phenomena in classical optical terms. This book discusses mode propagation by using equivalent plane waves, polarization, rays, and intensity distributions. Comprised of seven chapters, this book starts with an overview of the history of optical waveguides with emphasis on the earliest studies of dielectric guides. This text then explores the theoretical treatment of guided waves in planar dielectric waveguides in terms of the characteristic modes of these structures. Other chapters consider the interferometric description of the coupling of a uniform beam of light into a thin film through the mechanism of frustrated total reflection. This book discusses as well the properties of the modes of fiber optical waveguides. The final chapter deals with the general properties of the characteristic TE wave (modes) of a symmetric slab guide by direct solution of the homogeneous Maxwell equations. Students of optics and physics, as well as electronic, optical, and communications engineers, will find this book useful. The Essence of Dielectric Waveguides provides an overview of the fundamental behavior of guided waves, essential to finding and interpreting the results of electromagnetic waveguide problems. Clearly and concisely written as well as brilliantly organized, this volume includes a detailed description of the fundamentals of electromagnetics, as well as a new discussion on boundary conditions and attenuation. It also covers the propagation characteristics of guided waves along classical canonical dielectric structures – planar, circular cylindrical, rectangular and elliptical waveguides. What's more, the authors have included extensive coverage of inhomogeneous structures and approximate methods, as well as several powerful numerical approaches specifically applicable to dielectric waveguides. The most comprehensive book on waveguide nonlinear optic devices, this volume presents a systematic description of the NLO field, with an emphasis on devices that use ferroelectric waveguides. It ranges from an introduction to the concepts of waveguides to the most recent experimental results. Introduction: Electromagnetic waves. Waveguides as transmission lines. Elements of network theory. General microwave circuit theorems. Waveguide circuit elements. Resonant cavities as microwave circuit elements. Radial transmission lines. Waveguide junctions with several arms. Mode transformations. Dielectrics in waveguides. The symmetry of waveguide junctions. A textbook for an introductory graduate course in electromagnetic waveguides, covering such types as low attenuation, dielectric, and the natural wave guides in the ionosphere and in mine tunnels. Annotation copyrighted by Book News, Inc., Portland, OR This monograph explains the theory of quantum waveguides, that is, dynamics of quantum particles confined to regions in the form of tubes, layers, networks, etc. The focus is on relations between the confinement geometry on the one hand and the spectral and scattering properties of the corresponding quantum Hamiltonians on the other. Perturbations of such operators, in particular, by external fields are also considered. The volume provides a unique summary of twenty-five years of research activity in this area and indicates ways in which the theory can develop further. The book is fairly self-contained. While it requires some broader mathematical physics background, all the basic concepts are properly explained and proofs of most theorems are given in detail, so there is no need for additional sources. Without a parallel in the literature, the monograph by Exner and Kovarik guides the reader through this new and exciting field. Fundamentals of Optical Waveguides is an essential resource for any researcher, professional or student involved in optics and communications engineering. Any reader interested in designing or actively working with optical devices must have a firm grasp of the principles of lightwave propagation. Katsunari Okamoto has presented this difficult technology clearly and concisely with several illustrations and equations. Optical theory encompassed in this reference includes coupled mode theory, nonlinear optical effects, finite element method, beam propagation method, staircase concatenation method, along with several central theorems and formulas. Since the publication of the well-received first edition of this book, planar lightwave circuits and photonic crystal fibers have fully matured. With this second edition the advances of these fibers along with other improvements on existing optical technologies are completely detailed. This comprehensive volume enables readers to fully analyze, design and simulate optical atmospheres. Features: + Exceptional new chapter on Arrayed-Waveguide Grating (AWG) + In depth discussion of Photonic Crystal Fibers (PCFs) + Thorough explanation of Multimode Interference Devices (MMI) + Full coverage of polarization Mode Dispersion (PMD) About the Author: Katsunari Okamoto was born in Hiroshima, Japan, on October 19, 1949. He received the B.S., M.S., and Ph.D. in electronic engineering from Tokyo University, Japan, in 1972, 1974, and 1977, respectively. He has engaged in research on the transmission characteristics of various fibers, including PANDA fibers, as well as fiber-optic components, and proposed the idea of dispersion-flattened fibers (DFF) on which he has also experimented. Dr. Okamoto has worked for the Optical Fiber Group in Southampton, England and the NTT Photonics Laboratories at the Ibaraki R&D Center, where he developed various AWGs and integrated-optic add/drop multiplexers. He is a fellow of IEEE and a research fellow of NTT Science and Core Technology Laboratory Group. In 2003, he started Okamoto Laboratory Ltd. Okamoto Laboratory is an R&D consulting company that deals with the custom design of optical fibers and functional planar lightwave circuits. Up-to-date coverage of the analysis and applications of coplanarwaveguides to microwave circuits and antennas The unique feature of coplanar waveguides, as opposed to moreconventional waveguides, is their uniplanar construction, in whichall of the conductors are aligned on the same side of thesubstrate. This feature simplifies manufacturing and allows fasterand less expensive characterization using on-wafer techniques. Coplanar Waveguide Circuits, Components, and Systems isan engineer's complete resource, collecting all of the availabledata on the subject. Rainee Simons thoroughly discusses propagationparameters for conventional coplanar waveguides and includesvaluable details such as the derivation of the fundamentalequations, physical explanations, and numerical examples. Coverage also includes: Discontinuities and circuit elements Transitions to other transmission media Directional couplers, hybrids, and magic T Microelectromechanical systems based switches and phaseshifters Tunable devices using ferroelectric materials Photonic bandgap structures Printed circuit antennas Unites classical and modern photonics approaches, providing a thorough understanding of the interplay between plane waves, diffraction and modal analysis. Recently, the rapid development of radiofrequency (RF)/microwave and photonic/optical waveguide technologies has had a significant impact on the current electronic industrial, medical and information and communication technology (ICT) fields. This book is a self-contained collection of valuable scholarly papers related to waveguide design, modeling, and applications. This book contains 20 chapters that cover three main subtopics of waveguide technologies, namely RF and microwave waveguide, photonic and optical waveguide and waveguide analytical solutions. Hence, this book is particularly useful to the academics, scientists, practicing researchers and postgraduate students whose work relates to the latest waveguide technologies. Although the theory and principles of optical waveguides have been established for more than a century, the technologies have only been realized in recent decades. Optical Waveguides: From Theory to Applied Technologies combines the most relevant aspects of waveguide theory with the study of current detailed waveguiding technologies, in particular, photonic devices, telecommunication applications, and biomedical optics. With self-contained chapters written by well-known specialists, the book features both fundamentals and applications. The first three chapters examine the theoretical foundations and bases of planar optical waveguides as well as critical optical properties such as birefringence and nonlinear optical phenomena. The next several chapters focus on contemporary waveguiding technologies that include photonic devices and telecommunications. The book concludes with discussions on additional technological applications, including biomedical optical waveguides and the potential of neutron waveguides. As optical waveguides play an increasing part in modern technology, photonics will become to the 21st century what electronics were to the 20th century. Offering both novel insights for experienced professionals and introductory material for novices, this book facilitates a better understanding of the new information era—the photonics century. A complete guide to optical waveguide modes This in-depth work explains how transverse optical waveguide geometry influences field distribution and polarization properties. You will gain a thorough understanding of the fundamental physics of mode structure. Optical Waveguide Modes covers single- and few-mode optical waveguides with an emphasis on single-core and multicore optical fibers and couplers, including a large range of geometries and anisotropies. Analysis is performed using extensions of the weak-guidance perturbation formalism together with elementary group representation theory. This definitive volume offers a detailed introduction to and classification of diverse forms of fundamental and higher-order modes and various polarization manifestations. Coverage includes: Electromagnetic theory for anisotropic media Weak guidance for longitudinally invariant fibers Circular isotropic longitudinally invariant fibers Azimuthal symmetry breaking Birefringence: linear, radial, and circular Multicore and multifiber couplers The most comprehensive book on waveguide nonlinear optic devices, this volume presents a systematic description of the NLO field, with an emphasis on devices that use ferroelectric waveguides. It ranges from an introduction to the concepts of waveguides to the most recent experimental results. The ridge waveguide, which is a rectangular waveguide with one or more metal inserts (ridges), is an important transmission line in microwave engineering, now widely used in commercial electronics and communications devices. This book collects together much of the work of Professor Helszajn, an international authority in the field, and will enable the reader to have direct access to this important work without need for exhaustive search of research papers. Generously illustrated, it is likely to become the definitive reference source on this topic. Presents the equivalent-circuit parameters for a large number of microwave structures. This publication provides a comprehensive and systematically organized coverage of higher order finite-difference time-domain or FDTD schemes, demonstrating their potential role as a powerful modeling tool in computational electromagnetics. Special emphasis is drawn on the analysis of contemporary waveguide and antenna structures. Acknowledged as a significant breakthrough in the evolution of the original Yee's algorithm, the higher order FDTD operators remain the subject of an ongoing scientific research. Among their indisputable merits, one can distinguish the enhanced levels of accuracy even for coarse grid resolutions, the fast convergence rates, and the adjustable stability. In fact, as the fabrication standards of modern systems get stricter, it is apparent that such properties become very appealing for the accomplishment of elaborate and credible designs. Our intent in producing this book was to provide a text that would be comprehensive enough for an introductory course in integrated optics, yet concise enough in its mathematical derivations to be easily readable by a practicing engineer who desires an overview of the field. The response to the first edition has indeed been gratifying; unusually strong demand has caused it to be sold out during the initial year of publication, thus providing us with an early opportunity to produce this updated and improved second edition. This development is fortunate, because integrated optics is a very rapidly progressing field, with significant new research being regularly reported. Hence, a new chapter (Chap. 17) has been added to review recent progress and to provide numerous additional references to the relevant technical literature. Also, thirty-five new problems for practice have been included to supplement those at the ends of chapters in the first edition. Chapters I through 16 are essentially unchanged, except for brief updating revisions and corrections of typographical errors. Because of the time limitations imposed by the need to provide an uninterrupted supply of this book to those using it as a course text, it has been possible to include new references and to briefly describe recent developments only in Chapter 17. However, we hope to provide details of this continuing progress in a future edition. For decades, the surface-plasmon-polariton wave guided by the interface of simple isotropic materials dominated the scene. However, in recent times research on electromagnetic surface waves guided by planar interfaces has expanded into new and exciting areas. In the 1990's research focused on advancing knowledge of the newly discovered Dyakonov wave. More recently, much of the surface wave research is motivated by the proliferation of nanotechnology and the growing number of materials available with novel properties. This book leads the reader from the relatively simple surface-plasmon-polariton wave with isotropic materials to the latest research on various types of electromagnetic surface waves guided by the interfaces of complex materials enabled by recent developments in nanotechnology. This includes: Dyakonov waves guided by interfaces formed with columnar thin films, Dyakonov-Tamm waves guided by interfaces formed with sculptured thin films, and multiple modes of surface-plasmon-polariton waves guided by the interface of a metal and a periodically varying dielectric material. Gathers research from the past 5 years in a single comprehensive view of electromagnetic surface waves. Written by the foremost experts and researchers in the field. Layered presentation explains topics with an introductory overview level up to a highly technical level. The basic of the BPM technique in the frequency domain relies on treating the slowly varying envelope of the monochromatic electromagnetic field under paraxial propagation, thus allowing efficient numerical computation in terms of speed and allocated memory. In addition, the BPM based on finite differences is an easy way to implement robust and efficient computer codes. This book presents several approaches for treating the light: wide-angle, scalar approach, semivectorial treatment, and full vectorial treatment of the electromagnetic fields. Also, special topics in BPM cover the simulation of light propagation in anisotropic media, non-linear materials, electro-optic materials, and media with gain/losses, and describe how BPM can deal with strong index discontinuities or waveguide gratings, by introducing the bidirectional-BPM. BPM in the time domain is also described, and the book includes the powerful technique of finite difference time domain method, which fills the gap when the standard BPM is no longer applicable. Once the description of these numerical techniques have been detailed, the last chapter includes examples of passive, active and functional integrated photonic devices, such as waveguide reflectors, demultiplexers, polarization converters, electro-optic modulators, lasers or frequency converters. The book will help readers to understand several BPM approaches, to build their own codes, or to properly use the existing commercial software based on these numerical techniques.