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DWDM Network Designs and Engineering
Solutions Applications of Modern RF Photonics
Essentials of Photonics, Second Edition Modern
Applications in Optics and Photonics Silicon
Photonics Sub-wavelength Photonics from
Solution-processing Photonic Polymer Systems

The collection of articles in this book offers a penetrating shaft into the still burgeoning subject of light propagation and localization in photonic crystals and disordered media. While the subject has its origins in physics, it has broad significance and applicability in disciplines such as engineering, chemistry, mathematics, and medicine. Unlike other branches of physics, where the phenomena under consideration require extreme conditions of temperature, pressure, energy, or isolation from competing effects, the phenomena related to light localization survive under the most ordinary of conditions. This provides the science described in this book with broad applicability and vitality. However, the greatest challenge to the further development of this field is in the reliable and inexpensive synthesis of materials of the required composition, architecture and length scale, where the proper balance between order and disorder is realized. Similar challenges have been faced and overcome in fields such as semiconductor science and technology. The challenge of photonic crystal synthesis has inspired a variety of novel fabrication protocols such as self-assembly and optical interference lithography that offer much less expensive approaches than conventional semiconductor microlithography. Once these challenges are fully met, it is likely that light propagation and localization in photonic microstructures will be at the heart of a 21st-century revolution in science and technology. —From the Introduction, Sajeew John, University of Toronto, Ontario, Canada One of the first books specifically focused on disorder in photonic structures, *Optical Properties of Photonic Structures: Interplay of Order and Disorder* explores how both order and disorder provide the key to the different regimes of light transport and to the systematic localization and trapping of light. Collecting contributions from

leaders of research activity in the field, the book covers many important directions, methods, and approaches. It describes various one-, two-, and three-dimensional structures, including opals, aperiodic Fibonacci-type photonic structures, photonic amorphous structures, photonic glasses, Lévy glasses, and hypersonic, magnetophotonic, and plasmonic-photonic crystals with nanocavities, quantum dots, and lasing action. The book also addresses practical applications in areas such as optical communications, optical computing, laser surgery, and energy. This book gives a fascinating picture of the state-of-the-art in silicon photonics and a perspective on what can be expected in the near future. It is composed of 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 microphotonics and optoelectronics. Reflecting changes in the field in the ten years since the publication of the first edition, *The Handbook of Photonics, Second Edition* explores recent advances that have affected this technology. In this new, updated second edition editor Mool Gupta is joined by John Ballato, strengthening the handbook with their combined knowledge and the continued contributions of world-class researchers. New in the Second Edition: Information on optical fiber technology and the economic impact of photonics Coverage of emerging technologies in nanotechnology Sections on optical amplifiers, and polymeric optical materials The book covers photonics materials, devices, and systems, respectively. An introductory chapter, new to this edition, provides an overview of photonics technology, innovation, and economic development. Resting firmly on the foundation set by the first edition, this new edition continues to serve as a source for introductory material and a collection of published data for research and training in this field, making it the reference of first resort. Given silicon's versatile material properties, use of low-cost silicon photonics continues to move beyond light-speed data transmission through

fiber-optic cables and computer chips. Its application has also evolved from the device to the integrated-system level. A timely overview of this impressive growth, *Silicon Photonics for Telecommunications and Biomedicine* summarizes state-of-the-art developments in a wide range of areas, including optical communications, wireless technologies, and biomedical applications of silicon photonics. With contributions from world experts, this reference guides readers through fundamental principles and focuses on crucial advances in making commercial use of silicon photonics a viable reality in the telecom and biomedical industries. Taking into account existing and anticipated industrial directions, the book balances coverage of theory and practical experimental research to explore solutions for obstacles to the viable commercialization of silicon photonics. The book's special features include: A section on silicon plasmonic waveguides Detailed coverage of novel III-V applications A chapter on 3D integration Discussion of applications for energy harvesting/photovoltaics This book reviews the most important technological trends and challenges. It presents topics involving major silicon photonics applications in telecommunications, high-power photonics, and biomedicine. It includes discussion of silicon plasmonic waveguides, piezoelectric tuning of silicon's optical properties, and applications of two-photon absorption. Expert authors with industry research experience examine the challenge of hybridizing III-V compound semiconductors on silicon to achieve monolithic light sources. They also address economic compatibility and heat dissipation issues in CMOS chips, challenges in designing electronic photonics integrated circuits, and the need for standardization in computer-aided design of industrial chips. This book gives an authoritative summary of the latest research in this emerging field, covering key topics for readers from various disciplines with an interest in integrated photonics. Representing a further step towards enabling the convergence of computing and communication, this handbook and reference treats germanium electronics and optics on an equal footing. Renowned experts paint the big picture, combining both introductory material

and the latest results. The first part of the book introduces readers to the fundamental properties of germanium, such as band offsets, impurities, defects and surface structures, which determine the performance of germanium-based devices in conjunction with conventional silicon technology. The second part covers methods of preparing and processing germanium structures, including chemical and physical vapor deposition, condensation approaches and chemical etching. The third and largest part gives a broad overview of the applications of integrated germanium technology: waveguides, photodetectors, modulators, ring resonators, transistors and, prominently, light-emitting devices. An invaluable one-stop resource for both researchers and developers. This unique new resource presents applications of modern RF photonic systems that use RF photonic components for commonly used signal processing systems. This book provides insight into how a variety of systems work together, including RF down conversion, analog to digital conversion, RF oscillators, and frequency identification. A comparison of analog versus digital systems is presented. Readers find in-depth coverage of analog delay lines using RF photonics, various system architectures, and details about RF photonic component performance. Signal processing utilizing RF photonics and the need for down conversion is discussed. The many advancements in analog delay line performance are explained, including those in photodetector, optical fibers, and optical and amplifier modulators. The book highlights the advantages of using oscillators utilizing RF photonics and explores the elements of phase noise, timing jitter, and optoelectronic oscillators. The benefits of signal identification, isolation, and separation of RF photonics are identified. Professionals are brought up to speed on RF frequency identification using optical injection locking. The book provides discussions on the fundamentals and advancements in integrated RF photonics and explains how to design an RF photonic downconverter. It covers additional applications of integrated photonic circuits and gives an explanation of why to use different modulation formats for different applications. Fundamentals of Photonics A complete, thoroughly updated, full-color third

edition Fundamentals of Photonics, Third Edition is a self-contained and up-to-date introductory-level textbook that thoroughly surveys this rapidly expanding area of engineering and applied physics. Featuring a blend of theory and applications, coverage includes detailed accounts of the primary theories of light, including ray optics, wave optics, electromagnetic optics, and photon optics, as well as the interaction of light and matter. Presented at increasing levels of complexity, preliminary sections build toward more advanced topics, such as Fourier optics and holography, photonic-crystal optics, guided-wave and fiber optics, LEDs and lasers, acousto-optic and electro-optic devices, nonlinear optical devices, ultrafast optics, optical interconnects and switches, and optical fiber communications. The third edition features an entirely new chapter on the optics of metals and plasmonic devices. Each chapter contains highlighted equations, exercises, problems, summaries, and selected reading lists. Examples of real systems are included to emphasize the concepts governing applications of current interest. Each of the twenty-four chapters of the second edition has been thoroughly updated. A comprehensive resource to designing and constructing analog photonic links capable of high RF performance Fundamentals of Microwave Photonics provides a comprehensive description of analog optical links from basic principles to applications. The book is organized into four parts. The first begins with a historical perspective of microwave photonics, listing the advantages of fiber optic links and delineating analog vs. digital links. The second section covers basic principles associated with microwave photonics in both the RF and optical domains. The third focuses on analog modulation formats—starting with a concept, deriving the RF performance metrics from basic physical models, and then analyzing issues specific to each format. The final part examines applications of microwave photonics, including analog receive-mode systems, high-power photodiodes applications, radio astronomy, and arbitrary waveform generation. Covers fundamental concepts including basic treatments of noise, sources of distortion and propagation effects Provides design equations in easy-to-use forms as quick

reference Examines analog photonic link architectures along with their application to RF systems A thorough treatment of microwave photonics, Fundamentals of Microwave Photonics will be an essential resource in the laboratory, field, or during design meetings. The authors have more than 55 years of combined professional experience in microwave photonics and have published more than 250 associated works. The most up-to-date book available on the physics of photonic devices This new edition of Physics of Photonic Devices incorporates significant advancements in the field of photonics that have occurred since publication of the first edition (Physics of Optoelectronic Devices). New topics covered include a brief history of the invention of semiconductor lasers, the Lorentz dipole method and metal plasmas, matrix optics, surface plasma waveguides, optical ring resonators, integrated electroabsorption modulator-lasers, and solar cells. It also introduces exciting new fields of research such as: surface plasmonics and micro-ring resonators; the theory of optical gain and absorption in quantum dots and quantum wires and their applications in semiconductor lasers; and novel microcavity and photonic crystal lasers, quantum-cascade lasers, and GaN blue-green lasers within the context of advanced semiconductor lasers. Physics of Photonic Devices, Second Edition presents novel information that is not yet available in book form elsewhere. Many problem sets have been updated, the answers to which are available in an all-new Solutions Manual for instructors. Comprehensive, timely, and practical, Physics of Photonic Devices is an invaluable textbook for advanced undergraduate and graduate courses in photonics and an indispensable tool for researchers working in this rapidly growing field. Optical computers and photonic integrated circuits in high capacity optical networks are hot topics, attracting the attention of expert researchers and commercial technology companies. Optical packet switching and routing technologies promise to provide a more efficient source of power, and footprint scaling with increased router capacity; integrating more optical processing elements into the same chip to increase on-chip processing capability and system intelligence has become a priority. This

book is an in-depth look at modelling techniques and the simulation of a wide range of liquid crystal based modern photonic devices with enhanced high levels of flexible integration and enhanced power processing. It covers the physics of liquid crystal materials; techniques required for modelling liquid crystal based devices; the state-of-the-art liquid crystal photonic based applications for telecommunications such as couplers, polarization rotators, polarization splitters and multiplexer-demultiplexers; liquid core photonic crystal fiber (LC-PCF) sensors including biomedical and temperature sensors; and liquid crystal photonic crystal based encryption systems for security applications. Key features Offers a unique source of in-depth learning on the fundamental principles of computational liquid crystal photonics. Explains complex concepts such as photonic crystals, liquid crystals, waveguides and modes, and frequency- and time-domain techniques used in the design of liquid crystal photonic crystal photonic devices in terms that are easy to understand. Demonstrates the useful properties of liquid crystals in a diverse and ever-growing list of technological applications. Requires only a foundational knowledge of mathematics and physics. 'Proceedings of SPIE' offer access to the latest innovations in research and technology and are among the most cited references in patent literature. Photonics deals with the applications of light in science and technology including a vast number of different topics from engineering to telecommunications, to medicine, computing, metrology, and on and on. The book covers different topics related to the properties of the coherent interaction of light with matter in the frame of classical electrodynamics introducing the basic concepts in this field to undergraduate students and young researchers approaching this field. The contents include a revision of the fundamental properties of light and of the classical theory of light emission and introduces the basic equations describing the propagation of light beams and light pulses, including light propagation in uniaxial crystals and diffraction. A list of solved problems is included at the end of each chapter and the bibliography at the end covers both a basic and a more specialized literature for those students

likely to go more deeply into the fascinating ideas of this field. The importance of photonics in science and engineering is widely recognized and will continue to increase through the foreseeable future. In particular, applications in telecommunications, medicine, astronomy, industrial sensing, optical computing and signal processing continue to become more diverse. *Essentials of Photonics, Second Edition* describes the entire range of photonic principles and techniques in detail. Previously named *Essentials of Optoelectronics*, this newly named second edition of a bestseller reflects changes that have occurred in this field. The book presents a new approach that concentrates on the physical principles, demonstrating their interdependence, and developing them to explain more complex phenomena. It gives insight into the underlying physical processes in a way that is readable and easy to follow, as well as entirely self-contained. Written by an author with many years of experience in teaching and research, this book includes a detailed treatment of lasers, waveguides (including optical fibres), modulators, detectors, non-linear optics and optical signal processing. This new edition is brought up-to-date with additional sections on photonic crystal fibres, distributed optical-fibre sensing, and the latest developments in optical-fibre communications. A comprehensive book on DWDM network design and implementation solutions

Design Software Included Study various optical communication principles as well as communication methodologies in an optical fiber Design and evaluate optical components in a DWDM network Learn about the effects of noise in signal propagation, especially from OSNR and BER perspectives Design optical amplifier-based links Learn how to design optical links based on power budget Design optical links based on OSNR Design a real DWDM network with impairment due to OSNR, dispersion, and gain tilt Classify and design DWDM networks based on size and performance Understand and design nodal architectures for different classification of DWDM networks Comprehend different protocols for transport of data over the DWDM layer Learn how to test and measure different parameters in DWDM networks and optical systems The demand for Internet bandwidth grows as new applications,

new technologies, and increased reliance on the Internet continue to rise. Dense wavelength division multiplexing (DWDM) is one technology that allows networks to gain significant amounts of bandwidth to handle this growing need. *DWDM Network Designs and Engineering Solutions* shows you how to take advantage of the new technology to satisfy your network's bandwidth needs. It begins by providing an understanding of DWDM technology and then goes on to teach the design, implementation, and maintenance of DWDM in a network. You will gain an understanding of how to analyze designs prior to installation to measure the impact that the technology will have on your bandwidth and network efficiency. This book bridges the gap between physical layer and network layer technologies and helps create solutions that build higher capacity and more resilient networks. Companion CD-ROM The companion CD-ROM contains a complimentary 30-day demo from VPIphotonics; for VPItransmissionMaker; the leading design and simulation tool for photonic components, subsystems, and DWDM transmission systems. VPItransmissionMaker contains 200 standard demos, including demos from Chapter 10, that show how to simulate and characterize devices, amplifiers, and systems. The term photonics can be used loosely to refer to a vast array of components, devices, and technologies that in some way involve manipulation of light. One of the most powerful numerical approaches available to engineers developing photonic components and devices is the Finite Element Method (FEM), which can be used to model and simulate such components/devices and analyze how they will behave in response to various outside influences. This resource provides a comprehensive description of the formulation and applications of FEM in photonics applications ranging from telecommunications, astronomy, and sensing, to chemistry, imaging, and biomedical R&D. This book emphasizes practical, problem-solving applications and includes real-world examples to assist readers in understanding how mathematical concepts translate to computer code for finite element-based methods applicable to a range of photonic structures. In addition, this is the perfect support to anyone using the COMSOL

Multiphysics© RF Module. This edited volume covers technological developments and current research trends in the field of photonics, plasmonics and optics, focusing on photonic crystals, semiconductor optical devices, optical communications and optical sensors, with an emphasis on practical sectors. It broadly contains the latest research domains contributed by experts and researchers in their respective fields with a major focus on the basic physics. Works in the area of electromagnetic bandgap structures (EBG) and metasurfaces are included for applications in different aspects of communications systems. Further, it covers research phenomena of microwave photonic devices to develop miniaturized high-frequency devices. FEATURES Reviews nonlinear optical phenomena related with materials and crystals and plasmonic effects on device fabrications Contains a detailed analysis on photonic crystals with their applications in making all-optical passive components Focusses on nonlinear optics, more precisely on crystals and materials, and computational aspects on evaluating their properties from Maxwell's equations Presents an extensive study on the physics of EBG structures for application in antenna and high-frequency communications Includes metamaterials and metasurfaces for applications in photonics as well as in microwave engineering for high-frequency communication systems Photonics, Plasmonics and Information Optics: Research and Technological Advances is aimed at researchers, professionals and graduate students in optical communication, silicon photonics, photonic crystals, semiconductor optical devices, metamaterials and metasurfaces, and microwave photonics. Optics and photonics are among the key technologies of the 21st century, and offer potential for novel applications in areas such as sensing and spectroscopy, analytics, monitoring, biomedical imaging/diagnostics, and optical communication technology. The high degree of control over light fields, together with the capabilities of modern processing and integration technology, enables new optical measurement systems with enhanced functionality and sensitivity. They are attractive for a range of applications that were previously inaccessible. This Special Issue aims to provide an overview of some of the most

advanced application areas in optics and photonics and indicate the broad potential for the future. Fundamentals of Photonics A complete, thoroughly updated, full-color third edition Fundamentals of Photonics, Third Edition is a self-contained and up-to-date introductory-level textbook that thoroughly surveys this rapidly expanding area of engineering and applied physics. Featuring a blend of theory and applications, coverage includes detailed accounts of the primary theories of light, including ray optics, wave optics, electromagnetic optics, and photon optics, as well as the interaction of light and matter. Presented at increasing levels of complexity, preliminary sections build toward more advanced topics, such as Fourier optics and holography, photonic-crystal optics, guided-wave and fiber optics, LEDs and lasers, acousto-optic and electro-optic devices, nonlinear optical devices, ultrafast optics, optical interconnects and switches, and optical fiber communications. The third edition features an entirely new chapter on the optics of metals and plasmonic devices. Each chapter contains highlighted equations, exercises, problems, summaries, and selected reading lists. Examples of real systems are included to emphasize the concepts governing applications of current interest. Each of the twenty-four chapters of the second edition has been thoroughly updated. The main objective of this International Workshop in Vigo is to target this major problem by bringing together scientists and engineers specialized on various different topics related to group IV semiconductors. In five consecutive sessions dedicated to - Group IV materials: CMOS and further extension of the roadmap - Group IV materials: Nano-photonics - Material aspects and characterization on nano-scale - Nanostructures and material processing on atomic scale This book is volume III of a series of books on silicon photonics. It reports on the development of fully integrated systems where many different photonics component are integrated together to build complex circuits. This is the demonstration of the fully potentiality of silicon photonics. It contains a number of chapters written by engineers and scientists of the main companies, research centers and universities active in the field. It can be of use for all those persons

interested to know the potentialities and the recent applications of silicon photonics both in microelectronics, telecommunication and consumer electronics market. Silicon photonics technology, which has the DNA of silicon electronics technology, promises to provide a compact photonic integration platform with high integration density, mass-producibility, and excellent cost performance. This technology has been used to develop and to integrate various photonic functions on silicon substrate. Moreover, photonics-electronics convergence based on silicon substrate is now being pursued. Thanks to these features, silicon photonics will have the potential to be a superior technology used in the construction of energy-efficient cost-effective apparatuses for various applications, such as communications, information processing, and sensing. Considering the material characteristics of silicon and difficulties in microfabrication technology, however, silicon by itself is not necessarily an ideal material. For example, silicon is not suitable for light emitting devices because it is an indirect transition material. The resolution and dynamic range of silicon-based interference devices, such as wavelength filters, are significantly limited by fabrication errors in microfabrication processes. For further performance improvement, therefore, various assisting materials, such as indium-phosphide, silicon-nitride, germanium-tin, are now being imported into silicon photonics by using various heterogeneous integration technologies, such as low-temperature film deposition and wafer/die bonding. These assisting materials and heterogeneous integration technologies would also expand the application field of silicon photonics technology. Fortunately, silicon photonics technology has superior flexibility and robustness for heterogeneous integration. Moreover, along with photonic functions, silicon photonics technology has an ability of integration of electronic functions. In other words, we are on the verge of obtaining an ultimate technology that can integrate all photonic and electronic functions on a single Si chip. This e-Book aims at covering recent developments of the silicon photonic platform and novel functionalities with heterogeneous material integrations on this platform. This book

explores the state-of-the-art in computational modelling techniques for photonic devices. In this book, the author provides a comprehensive coverage of modern numerical modelling techniques for designing photonic devices for use in modern optical telecommunications systems. In addition the book presents the state-of-the-art in computational photonics techniques, covering methods such as full-vectorial finite-element beam propagation, bidirectional beam propagation, complex-envelope alternative direction implicit finite difference time domain, multiresolution time domain, and finite volume time domain. The book guides the reader through the concepts of modelling, analysing, designing and optimising the performance of a wide range of photonic devices by building their own numerical code using these methods. Key Features: Provides a thorough presentation of the state-of-the-art in computational modelling techniques for photonics. Contains broad coverage of both frequency- and time-domain techniques to suit a wide range of photonic devices. Reviews existing commercial software packages for photonics. Presents the advantages and disadvantages of the different modelling techniques as well as their suitability for various photonic devices. Shows the reader how to model, analyse, design and optimise the performance of a wide range of photonic devices by building their own numerical code using these methods. Accompanying website contains the numerical examples representing the numerical techniques in this book, as well as several design examples (http://www.wiley.com/go/obayya_computational) This book will serve as an invaluable reference for researchers, optical telecommunications engineers, engineers in the photonics industry. PhD and MSc students undertaking courses in the areas of photonics and optical telecommunications will also find this book of interest. This book sets out to build bridges between the domains of photonic device physics and neural networks, providing a comprehensive overview of the emerging field of "neuromorphic photonics." It includes a thorough discussion of evolution of neuromorphic photonics from the advent of fiber-optic neurons to today's state-of-the-art integrated laser neurons, which are a current focus of international research.

Neuromorphic Photonics explores candidate interconnection architectures and devices for integrated neuromorphic networks, along with key functionality such as learning. It is written at a level accessible to graduate students, while also intending to serve as a comprehensive reference for experts in the field. The Handbook of Photonics for Biomedical Science analyzes achievements, new trends, and perspectives of photonics in its application to biomedicine. With contributions from world-renowned experts in the field, the handbook describes advanced biophotonics methods and techniques intensively developed in recent years. Addressing the latest problems in biomedical optics and biophotonics, the book discusses optical and terahertz spectroscopy and imaging methods for biomedical diagnostics based on the interaction of coherent, polarized, and acoustically modulated radiation with tissues and cells. It covers modalities of nonlinear spectroscopic microscopies, photonic technologies for therapy and surgery, and nanoparticle photonic technologies for cancer treatment and UV radiation protection. The text also elucidates the advanced spectroscopy and imaging of normal and pathological tissues. This comprehensive handbook represents the next step in contemporary biophotonics advances. By collecting recently published information scattered in the literature, the book enables researchers, engineers, and medical doctors to become familiar with major, state-of-the-art results in biophotonics science and technology. "Furnishes the necessary background information, methods of characterization, and applications of optic and photonic systems based on polymers. Provides detailed tutorial chapters that offer in-depth explanations of optic and photonic fundamentals and synthesis techniques." A comprehensive and self-contained introductory text covering all the fundamental concepts and major principles of photonics. Proceedings of SPIE present the original research papers presented at SPIE conferences and other high-quality conferences in the broad-ranging fields of optics and photonics. These books provide prompt access to the latest innovations in research and technology in their respective fields. Proceedings of SPIE are among the most cited references in patent literature. In

recent years, photonics has found increasing applications in such areas as communications, signal processing, computing, sensing, display, printing, and energy transport. Now, Fundamentals of Photonics is the first self-contained introductory-level textbook to offer a thorough survey of this rapidly expanding area of engineering and applied physics. Featuring a logical blend of theory and applications, coverage includes detailed accounts of the primary theories of light, including ray optics, wave optics, electromagnetic optics, and photon optics, as well as the interaction of light with matter, and the theory of semiconductor materials and their optical properties. Presented at increasing levels of complexity, these sections serve as building blocks for the treatment of more advanced topics, such as Fourier optics and holography, guidedwave and fiber optics, photon sources and detectors, electro-optic and acousto-optic devices, nonlinear optical devices, fiber-optic communications, and photonic switching and computing. Included are such vital topics as: Generation of coherent light by lasers, and incoherent light by luminescence sources such as light-emitting diodes Transmission of light through optical components (lenses, apertures, and imaging systems), waveguides, and fibers Modulation, switching, and scanning of light through the use of electrically, acoustically, and optically controlled devices Amplification and frequency conversion of light by the use of wave interactions in nonlinear materials Detection of light by means of semiconductor photodetectors Each chapter contains summaries, highlighted equations, problem sets and exercises, and selected reading lists. Examples of real systems are included to emphasize the concepts governing applications of current interest, and appendices summarize the properties of one- and two-dimensional Fourier transforms, linear-systems theory, and modes of linear systems. An Instructor's Manual presenting detailed solutions to all the problems in the book is available from the Wiley editorial department. While group theory and its application to solid state physics is well established, this textbook raises two completely new aspects. First, it provides a better understanding by focusing on problem solving and making extensive use of

Mathematica tools to visualize the concepts. Second, it offers a new tool for the photonics community by transferring the concepts of group theory and its application to photonic crystals. Clearly divided into three parts, the first provides the basics of group theory. Even at this stage, the authors go beyond the widely used standard examples to show the broad field of applications. Part II is devoted to applications in condensed matter physics, i.e. the electronic structure of materials. Combining the application of the computer algebra system Mathematica with pen and paper derivations leads to a better and faster understanding. The exhaustive discussion shows that the basics of group theory can also be applied to a totally different field, as seen in Part III. Here, photonic applications are discussed in parallel to the electronic case, with the focus on photonic crystals in two and three dimensions, as well as being partially expanded to other problems in the field of photonics. The authors have developed Mathematica package GTPack which is available for download from the book's homepage. Analytic considerations, numerical calculations and visualization are carried out using the same software. While the use of the Mathematica tools are demonstrated on elementary examples, they can equally be applied to more complicated tasks resulting from the reader's own research.

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