

Peter **Markoš** • Costas M. **Soukoulis**



WAVE PROPAGATION

FROM **ELECTRONS TO PHOTONIC CRYSTALS**
AND **LEFT-HANDED MATERIALS**

Wave Propagation From Electrons To Photonic Crystals And Left Handed Materials

S Ben Porath



Wave Propagation From Electrons To Photonic Crystals And Left Handed Materials:

Wave Propagation Peter Markos, Costas M. Soukoulis, 2008-04-01 This textbook offers the first unified treatment of wave propagation in electronic and electromagnetic systems and introduces readers to the essentials of the transfer matrix method a powerful analytical tool that can be used to model and study an array of problems pertaining to wave propagation in electrons and photons It is aimed at graduate and advanced undergraduate students in physics materials science electrical and computer engineering and mathematics and is ideal for researchers in photonic crystals negative index materials left handed materials plasmonics nonlinear effects and optics Peter Markos and Costas Soukoulis begin by establishing the analogy between wave propagation in electronic systems and electromagnetic media and then show how the transfer matrix can be easily applied to any type of wave propagation such as electromagnetic acoustic and elastic waves The transfer matrix approach of the tight binding model allows readers to understand its implementation quickly and all the concepts of solid state physics are clearly introduced Markos and Soukoulis then build the discussion of such topics as random systems and localized and delocalized modes around the transfer matrix bringing remarkable clarity to the subject Total internal reflection Brewster angles evanescent waves surface waves and resonant tunneling in left handed materials are introduced and treated in detail as are important new developments like photonic crystals negative index materials and surface plasmons Problem sets aid students working through the subject for the first time

Wave Propagation Peter Markoš, C. M. Soukoulis, 2008 This textbook offers the first unified treatment of wave propagation in electronic and electromagnetic systems and introduces readers to the essentials of the transfer matrix method a powerful analytical tool that can be used to model and study an array of problems pertaining to wave propagation in electrons and photons It is aimed at graduate and advanced undergraduate students in physics materials science electrical and computer engineering and mathematics and is ideal for researchers in photonic crystals negative index materials left handed materials plasmonics nonlinear effects

Theory of Electrostatic Waves in Hyperbolic Metamaterials Afshin Moradi, 2023-12-13 This book covers electrostatic properties of hyperbolic metamaterials HMMs a fascinating class of metamaterials which combine dielectric and metal components Due to the hyperbolic topology of the isofrequency surface in HMMs the so called resonance cone direction exists and as a result propagation of quasi electrostatic waves or more commonly electrostatic waves close to the resonance cone with large wave vectors is possible However the investigation of electrostatic wave properties in HMMs is largely overlooked in most works on the subject and the purpose of this monograph is to fill this gap This book gives a thorough theoretical treatment of propagation reflection and refraction of electrostatic waves in HMMs of various dimensions and geometries It will be of interest to students and researchers who work on electrical and optical properties of metamaterials

Springer Handbook of Lasers and Optics Frank Träger, 2012-05-05 This new edition features numerous updates and additions Especially 4 new chapters on Fiber Optics Integrated Optics Frequency Combs and Interferometry reflect the

changes since the first edition In addition major complete updates for the chapters Optical Materials and Their Properties Optical Detectors Nanooptics and Optics far Beyond the Diffraction Limit Features Contains over 1000 two color illustrations Includes over 120 comprehensive tables with properties of optical materials and light sources Emphasizes physical concepts over extensive mathematical derivations Chapters with summaries detailed index Delivers a wealth of up to date references

Introduction to Micro- and Nanooptics Jürgen Jahns, Stefan Helfert, 2012-11-12 This first textbook on both micro and nanooptics introduces readers to the technological development physical background and key areas The opening chapters on the physics of light are complemented by chapters on refractive and diffractive optical elements The internationally renowned authors present different methods of lithographic and nonlithographic fabrication of microoptics and introduce the characterization and testing of microoptics The second part of the book is dedicated to optical microsystems and MEMS optical waveguide structures and optical nanostructures including photonic crystals and metamaterials Each chapter includes exercises illustrating a sample approach to new and complex topics making the textbook suitable for lectures on optics as part of a physics or electrical engineering course

Extreme Photonics & Applications Trevor Hall, Sergey V. Gaponenko, 2009-11-24 Extreme Photonics Applications arises from the 2008 NATO Advanced Study Institute in Laser Control Monitoring in New Materials Biomedicine Environment Security and Defense Leading experts in the manipulation of light offered by recent advances in laser physics and nanoscience were invited to give lectures in their fields of expertise and participate in discussions on current research applications and new directions The sum of their contributions to this book is a primer for the state of scientific knowledge and the issues within the subject of photonics taken to the extreme frontiers molding light at the ultra finest scales which represents the beginning of the end to limitations in optical science for the benefit of 21st Century technological societies Laser light is an exquisite tool for physical and chemical research Physicists have recently developed pulsed lasers with such short durations that one laser shot takes the time of one molecular vibration or one electron rotation in an atom which makes it possible to observe their internal electronic structure thereby enabling the study of physical processes and new chemical reactions In parallel advances in micro and nano structured photonic materials allow the precise manipulation of light on its natural scale of a wavelength Photonic crystals plasmons and related metamaterials composed of subwavelength nanostructures permit the manipulation of their dispersive properties and have allowed the experimental confirmation of bizarre new effects such as slow light and negative refraction These advances open a vista on a new era in which it is possible to build lasers and engineer materials to control and use photons as precisely as it is already possible to do with electrons <http://www.photonics.uottawa.ca/nato/asi/2008/>

VLSI Micro- and Nanophotonics El-Hang Lee, Louay Eldada, Manijeh Razeghi, Chennupati Jagadish, 2018-09-03 Addressing the growing demand for larger capacity in information technology VLSI Micro and Nanophotonics Science Technology and Applications explores issues of science and technology of micro nano scale photonics and integration for broad scale and chip scale Very Large Scale

Integration photonics This book is a game changer in the sense that it is quite possibly the first to focus on VLSI Photonics Very little effort has been made to develop integration technologies for micro nanoscale photonic devices and applications so this reference is an important and necessary early stage perspective on this field New demand for VLSI photonics brings into play various technological and scientific issues as well as evolutionary and revolutionary challenges all of which are discussed in this book These include topics such as miniaturization interconnection and integration of photonic devices at micron submicron and nanometer scales With its disruptive creativity and unparalleled coverage of the photonics revolution in information technology this book should greatly impact the future of micro nano photonics and IT as a whole It offers a comprehensive overview of the science and engineering of micro nanophotonics and photonic integration Many books on micro nanophotonics focus on understanding the properties of individual devices and their related characteristics However this book offers a full perspective from the point of view of integration covering all aspects of benefits and advantages of VLSI scale photonic integration the key technical concept in developing a platform to make individual devices and components useful and practical for various applications

Solid-State Physics, Fluidics, and Analytical Techniques in Micro- and Nanotechnology Marc J. Madou, 2011-06-13 Providing a clear theoretical understanding of MEMS and NEMS Solid State Physics Fluidics and Analytical Techniques in Micro and Nanotechnology focuses on nanotechnology and the science behind it including solid state physics It provides a clear understanding of the electronic mechanical and optical properties of solids relied on in integrated circuits ICs MEMS and NEMS After exploring the rise of Si MEMS and NEMS in a historical context the text discusses crystallography quantum mechanics the band theory of solids and the silicon single crystal It concludes with coverage of photonics the quantum hall effect and superconductivity Fully illustrated in color the text offers end of chapter problems worked examples extensive references and a comprehensive glossary of terms Topics include Crystallography and the crystalline materials used in many semiconductor devices Quantum mechanics the band theory of solids and the relevance of quantum mechanics in the context of ICs and NEMS Single crystal Si properties that conspire to make Si so important Optical properties of bulk 3D metals insulators and semiconductors Effects of electron and photon confinement in lower dimensional structures How evanescent fields on metal surfaces enable the guiding of light below the diffraction limit in plasmonics Metamaterials and how they could make for perfect lenses changing the photonic field forever Fluidic propulsion mechanisms and the influence of miniaturization on fluid behavior Electromechanical and optical analytical processes in miniaturized components and systems The first volume in Fundamentals of Microfabrication and Nanotechnology Third Edition Three Volume Set the book presents the electronic mechanical and optical properties of solids that are used in integrated circuits MEMS and NEMS and covers quantum mechanics electrochemistry fluidics and photonics It lays the foundation for a qualitative and quantitative theoretical understanding of MEMS and NEMS

Photonic Crystals and Light Localization in the 21st Century C. M. Soukoulis, 2001 This excellent survey of the field of

photonic crystals random lasers and light localization covers theoretical and experimental aspects as well as applications The introductory lectures are accessible to non specialists Topics include new fabrication techniques and structures with either dielectric or metallic components *Choice*, 2009 *Journal of Zhejiang University*, 2006 **American Doctoral Dissertations**, 2002 *Dissertation Abstracts International*, 2004 **Advanced Accelerator Concepts** Manoel Conde, Catherine Eyberger, 2006-12-13 This workshop covered the general field of advanced particle accelerators exploring the science and technology of a multitude of novel acceleration schemes Various schemes under study utilize combinations of plasmas laser beams dielectric materials and RF power The development of technologies that will enable the design of future high energy physics machines is the underlying goal of this workshop *Advanced Numerical and Theoretical Methods for Photonic Crystals and Metamaterials* D Felbacq, 2016-11-29 *Proceedings of the Conference, Wave Propagation: from Electrons to Photonic Crystals and Metamaterials* Maria Kafesaki, Ekmel Ozbay, 2012 **Wave Propagation in Photonic Crystals and Metamaterials**, 2009 Photonic crystals and metamaterials both composed of artificial structures are two interesting areas in electromagnetism and optics New phenomena in photonic crystals and metamaterials are being discovered including some not found in natural materials This thesis presents my research work in the two areas Photonic crystals are periodically arranged artificial structures mostly made from dielectric materials with period on the same order of the wavelength of the working electromagnetic wave The wave propagation in photonic crystals is determined by the Bragg scattering of the periodic structure Photonic band gaps can be present for a properly designed photonic crystal Electromagnetic waves with frequency within the range of the band gap are suppressed from propagating in the photonic crystal With surface defects a photonic crystal could support surface modes that are localized on the surface of the crystal with mode frequencies within the band gap With line defects a photonic crystal could allow the propagation of electromagnetic waves along the channels The study of surface modes and waveguiding properties of a 2D photonic crystal will be presented in Chapter 1 Metamaterials are generally composed of artificial structures with sizes one order smaller than the wavelength and can be approximated as effective media Effective macroscopic parameters such as electric permittivity ϵ magnetic permeability μ are used to characterize the wave propagation in metamaterials The fundamental structures of the metamaterials affect strongly their macroscopic properties By designing the fundamental structures of the metamaterials the effective parameters can be tuned and different electromagnetic properties can be achieved One important aspect of metamaterial research is to get artificial magnetism Metallic split ring resonators SRRs and variants are widely used to build magnetic metamaterials with effective μ *Proceedings of the Conference Wave Propagation: from Electrons to Photonic Crystals and Metamaterials ; Held in Rethymnon, Crete, Greece 8 - 11 June 2011, in Honor of Prof. C. M. Soukoulis' 60th Birthday* WavePro Rethymnon, 2012 **Wave Propagation in Photonic Crystals and Metamaterials** Bingnan Wang, 2009 *Advanced Numerical Techniques for Photonic Crystals* Didier Felbacq, 2016-12-07

This book provides a set of theoretical and numerical tools useful for the study of wave propagation in metamaterials and photonic crystals. While concentrating on electromagnetic waves, most of the material can be used for acoustic or quantum waves. For each presented numerical method, numerical code written in MATLAB is presented. The codes are limited to 2D problems and can be easily translated in Python or Scilab and used directly with Octave as well.

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