Low Profile Natural And Metamaterial Antennas Analysis Methods And Applications Ieee Press Series On Electromagnetic Wave Theory

This book commemorates four decades of research by Professor Magdy F. Iskander (Life Fellow IEEE) on materials and devices for the radiation, propagation, scattering, and applications of electromagnetic waves, chiefly in the MHz-THz frequency range as well on electromagnetics education. This synopsis of applied electromagnetics, stemming from the life and times of just one person, is meant to inspire junior researchers and reinvigorate mid-level researchers in the electromagnetics community. The authors of this book are internationally known researchers, including 14 IEEE fellows, who highlight interesting research and new directions in theoretical, experimental, and applied electromagnetics.

Presents recent progress in low-profile natural and metamaterial antennas This book presents the full range of low-profile antennas that use novel elements and take advantage of new concepts in antenna implementation, including metamaterials. Typically formed by constructing lattices of simple elements, metamaterials possess electromagnetic properties not found in naturally occurring materials, and show great promise in a number of low-profile antenna implementations. Introductory chapters

define various natural and metamaterial-based antennas and provide the fundamentals of writing computer programs based on the method of moments (MoM) and the finite-difference time-domain method (FDTDM). Chapters then discuss low-profile natural antennas classified into base station antennas, mobile card antennas, beam-forming antennas, and satellite-satellite and earth-satellite communications antennas. Final chapters look at various properties of low-profile metamaterial-based antennas, revealing the strengths and limitations of the metamaterial-based straight line antenna (metaline antenna), metamaterial-based loop antenna (metaloop), open metaloop antenna, the effects of counter dual-band CP radiation, and more. Offers comprehensive coverage of both metamaterials and natural materials for low-profile antennas Written by an internationally-recognized expert in the field of low-profile antennas Depicts actual high-performance low-profile antennas for the antenna engineer Draws on classroom-tested material in graduate courses and short courses over the past 20 years Low-Profile Natural and Metamaterial Antennas is a must-have reference book for advanced undergraduate and graduate level students as well as antenna engineers interested in low-profile antenna design theory.

About the book: This book is the first comprehensive review on acoustic metamaterials; novel materials which can manipulate sound waves in surprising ways, which include collimation, focusing, cloaking, sonic screening and extraordinary transmission. It covers both experimental and theoretical aspects of acoustic and elastic waves

propagating in structured composites, with a focus on effective properties associated with negative refraction, lensing and cloaking. Most related books in the field address electromagnetic metamaterials and focus on numerical methods, and little (or no) experimental section. Each chapter will be authored by an acknowledged expert, amongst the topics covered will be experimental results on non-destructive imaging, cloaking by surface water waves, flexural waves in thin plates. Applications in medical ultrasound imaging and modeling of metamaterials will be emphasized too. The book can serve as a reference for researchers who wish to build a solid foundation of wave propagation in this class of novel materials.

Metamaterials have attracted enormous interests from both physics and engineering communities in the past 20 years, owing to their powerful ability in manipulating electromagnetic waves. However, the functionalities of traditional metamaterials are fixed at the time of fabrication. To control the EM waves dynamically, active components are introduced to the meta-atoms, yielding active metamaterials. Recently, a special kind of active metamaterials, digital coding and programmable metamaterials, are proposed, which can achieve dynamically controllable functionalities using field programmable gate array (FPGA). Most importantly, the digital coding representations of metamaterials set up a bridge between the digital world and physical world, and allow metamaterials to process digital information directly, leading to information metamaterials. In this Element, we review the evolution of information metamaterials,

mainly focusing on their basic concepts, design principles, fabrication techniques, experimental measurement and potential applications. Future developments of information metamaterials are also envisioned.

Nature-inspired computation is an interdisciplinary topic area that connects the natural sciences to computer science. Since natural computing is utilized in a variety of disciplines, it is imperative to research its capabilities in solving optimization issues. The Handbook of Research on Natural Computing for Optimization Problems discusses nascent optimization procedures in nature-inspired computation and the innovative tools and techniques being utilized in the field. Highlighting empirical research and best practices concerning various optimization issues, this publication is a comprehensive reference for researchers, academicians, students, scientists, and technology developers interested in a multidisciplinary perspective on natural computational systems.

Metamaterials:Theory, Design, and Applications goes beyond left-handed materials (LHM) or negative index materials (NIM) and focuses on recent research activity. Included here is an introduction to optical transformation theory, revealing invisible cloaks, EM concentrators, beam splitters, and new-type antennas, a presentation of general theory on artificial metamaterials composed of periodic structures, coverage of a new rapid design method for inhomogeneous metamaterials, which makes it easier to design a cloak, and new developments including but not limited to experimental

verification of invisible cloaks, FDTD simulations of invisible cloaks, the microwave and RF applications of metamaterials, sub-wavelength imaging using anisotropic metamaterials, dynamical metamaterial systems, photonic metamaterials, and magnetic plasmon effects of metamaterials.

Learn about the revolutionary new technology of negative-refractionmetamaterials Negative-Refraction Metamaterials: Fundamental Principles andApplications introduces artificial materials that support theunusual electromagnetic property of negative refraction. Readerswill discover several classes of negative-refraction materialsalong with their exciting, groundbreaking applications, such aslenses and antennas, imaging with super-resolution, microwavedevices, dispersion-compensating interconnects, radar, anddefense. The book begins with a chapter describing the fundamentals ofisotropic metamaterials in which a negative index of refraction isdefined. In the following chapters, the text builds on thefundamentals by describing a range of useful microwave devices andantennas. Next, a broad spectrum of exciting new research andemerging applications is examined, including: * Theory and experiments behind a super-resolving,negative-refractive-index transmission-line lens * 3-D transmission-line metamaterials with a negative refractiveindex * Numerical simulation studies of negative refraction of Gaussianbeams and associated focusing phenomena * Unique advantages and theory of shaped lenses made ofnegative-refractive-index metamaterials * A new type of transmission-line metamaterial that is anisotropicand

supports the formation of sharp steerable beams (resonancecones) * Implementations of negative-refraction metamaterials at opticalfrequencies * Unusual propagation phenomena in metallic waveguides partiallyfilled with negative-refractive-index metamaterials * Metamaterials in which the refractive index and the underlyinggroup velocity are both negative This work brings together the best minds in this cutting-edgefield. It is fascinating reading for scientists, engineers, andgraduate-level students in physics, chemistry, materials science,photonics, and electrical engineering.

This edited volume Wearable Technologies is a collection of reviewed and relevant research chapters, offering a comprehensive overview of recent developments in the field of computer engineering. The book comprises single chapters authored by various researchers and edited by an expert active in the computer engineering research area. All chapters are complete in themselves but united under a common research study topic. This publication aims at providing a thorough overview of the latest research efforts.

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.

Leading experts explore the exotic properties and excitingapplications of electromagnetic metamaterials Metamaterials: Physics and Engineering Explorations givesreaders a clearly written, richly illustrated introduction to themost recent research developments in the area of electromagneticmetamaterials. It explores the fundamental physics, the designs,and the

engineering aspects, and points to a myriad of excitingpotential applications. The editors, acknowledged leaders in thefield of metamaterials, have invited a group of leading researchersto present both their own findings and the full array ofstate-of-the-art applications for antennas, waveguides, devices,and components. Following a brief overview of the history of artificialmaterials, the publication divides its coverage into two majorclasses of metamaterials. The first half of the publicationexamines effective media with single (SNG) and double negative(DNG) properties; the second half examines electromagnetic band gap(EBG) structures. The book further divides each of these classesinto their three-dimensional (3D volumetric) and two-dimensional(2D planar or surface) realizations. Examples of each type ofmetamaterial are presented, and their known and anticipatedproperties are reviewed. Collectively, Metamaterials: Physics and EngineeringExplorations presents a review of recent research advancesassociated with a highly diverse set of electromagneticmetamaterials. Its multifaceted approach offers readers acombination of theoretical, numerical, and experimentalperspectives for a better understanding of their behaviors andtheir potentialapplications in components, devices, and systems.Extensive reference lists provide opportunities to exploreindividual topics and classes of metamaterials in greaterdepth. With full-color illustrations throughout to clarify concepts andhelp visualize actual results, this book provides a dynamic,user-friendly resource for students, engineers, physicists, andother researchers in the areas of electromagnetic materials,microwaves, millimeter waves, and optics. It equips newcomers witha basic understanding of metamaterials and their potentialapplications. Advanced researchers will benefit fromthought-provoking perspectives that will deepen their knowledge andlead them to new areas of investigation.

In-depth analysis of the theory, properties and description of the most potential technological applications of metamaterials for the realization of novel devices such as subwavelength lenses, invisibility cloaks, dipole and reflector antennas, high frequency telecommunications, new designs of bandpass filters, absorbers and concentrators of EM waves etc. In order to create a new devices it is necessary to know the main electrodynamical characteristics of metamaterial structures on the basis of which the device is supposed to be created. The electromagnetic wave scattering surfaces built with metamaterials are primarily based on the ability of metamaterials to control the surrounded electromagnetic fields by varying their permeability and permittivity characteristics. The book covers some solutions for microwave wavelength scales as well as exploitation of nanoscale EM wavelength such as visible specter using recent advances of nanotechnology, for instance in the field of nanowires, nanopolymers, carbon nanotubes and graphene. Metamaterial is suitable for scholars from extremely large scientific domain and therefore given to engineers, scientists, graduates and other interested professionals from photonics to nanoscience and from material science to antenna engineering as a comprehensive reference on this artificial materials of tomorrow. Hyperbolic metamaterials were originally introduced to overcome the diffraction limit of optical imaging. Soon thereafter it was realized that hyperbolic metamaterials demonstrate a number of novel phenomena resulting from the broadband singular behavior of their density of photonic states. These novel phenomena and applications include super resolution imaging, new stealth technologies, enhanced quantum-electrodynamic effects, thermal hyperconductivity, superconductivity, and interesting gravitation theory analogs. Here I review typical material systems, which exhibit hyperbolic behavior and outline important new applications of

hyperbolic metamaterials, such as imaging experiments with plasmonic hyperbolic metamaterials and novel VCSEL geometries, in which the Bragg mirrors may be engineered in such a way that they exhibit hyperbolic properties in the long wavelength infrared range, so that they may be used to efficiently remove excess heat from the laser cavity. I will also discuss potential applications of self-assembled photonic hypercrystals. This system bypasses 3D nanofabrication issues, which typically limit hyperbolic metamaterial applications. Photonic hypercrystals combine the most interesting features of hyperbolic metamaterials and photonic crystals.

A comprehensive survey of boundary conditions as applied in antenna and microwave engineering, material physics, optics, and general electromagnetics research. Boundary conditions are essential for determining electromagnetic problems. Working with engineering problems, they provide analytic assistance in mathematical handling of electromagnetic structures, and offer synthetic help for designing new electromagnetic structures. Boundary Conditions in Electromagnetics describes the most-general boundary conditions restricted by linearity and locality, and analyzes basic plane-wave reflection and matching problems associated to a planar boundary in a simple-isotropic medium. This comprehensive text first introduces known special cases of particular familiar forms of boundary conditions — perfect electromagnetic conductor, impedance, and DB boundaries — and then examines various general forms of boundary conditions. Subsequent chapters discuss sesquilinear boundary conditions and practical computations on wave scattering by objects defined by various boundary conditions. The practical applications of less-common boundary conditions, such as for metamaterial and metasurface engineering, are referred to throughout the text. This book:

Describes the mathematical analysis of fields associated to given boundary conditions Provides examples of how boundary conditions affect the scattering properties of a particle Contains ample in-chapter exercises and solutions, complete references, and a detailed index Includes appendices containing electromagnetic formulas, Gibbsian 3D dyadics, and four-dimensional formalism Boundary Conditions in Electromagnetics is an authoritative text for electrical engineers and physicists working in electromagnetics research, graduate or post-graduate students studying electromagnetics, and advanced readers interested in electromagnetic theory.

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.

This book presents selected research papers on current developments in the fields of soft computing and signal processing from the Third International Conference on Soft Computing and Signal Processing (ICSCSP 2020). The book covers topics such as soft sets, rough sets, fuzzy logic, neural networks, genetic algorithms and machine learning and discusses various aspects of these topics, e.g., technological considerations, product implementation and application issues.

Among the branches of classical physics, electromagnetism is the domain which experiences the most spectacular development, both in its fundamental and practical aspects. The quantum corrections which generate non-linear terms of the standard

Maxwell equations, their specific form in curved spaces, whose predictions can be confronted with the cosmic polarization rotation, or the topological model of electromagnetism, constructed with electromagnetic knots, are significant examples of recent theoretical developments. The similarities of the Sturm-Liouville problems in electromagnetism and quantum mechanics make possible deep analogies between the wave propagation in waveguides, ballistic electron movement in mesoscopic conductors and light propagation on optical fibers, facilitating a better understanding of these topics and fostering the transfer of techniques and results from one domain to another. Industrial applications, like magnetic refrigeration at room temperature or use of metamaterials for antenna couplers and covers, are of utmost practical interest. So, this book offers an interesting and useful reading for a broad category of specialists. Metamaterial technology has provided us with new tools to explore fascinating applications and physical phenomena. Metamaterials have also inspired many scientists and engineers to think about concepts and ideas under a new light. In this work, we look at ways to use metamaterial technologies to solve modern-day challenges. In particular, we have realized covers enabled by metamaterials and metasurfaces that strongly suppress scattering at all angles, still allowing for field penetration inside the “cloaked” region. This important property opens great opportunities across a multitude of sensor applications. There are many current and forward-looking applications where a sensor with control over its presence to a given

environment is of great interest. Advantages of our approach are simplicity of fabrication, resiliency to loss and manufacturing imperfections, extraordinarily low and conformal profile, and natural integration with electronics. In this work, we explore practical applications of our cloaking techniques including: low observability, interference reduction from closely spaced co-located antennas, and reduction or modulation of the scattering of receiving dipole antennas, while maintaining any desired level of received power. With such designs, high-performance sensing and measurement techniques, as well as commercial antenna applications, such as co-site antenna platforms and side-lobe level reduction can be envisioned.

Metamaterials have become one of the most important emerging technologies in the scientific community due to its unusual electromagnetic properties. Consequently, during the last years, a huge deal of efforts has been concentrated in order to design functional components and devices based on metamaterials for many potential applications. The main objective of this book is to present in-depth analysis of the theory, properties, and realizations of novel devices that could be integrated within modern and future communication systems. The book contains 11 chapters written by acknowledged experts, researchers, academics, and microwave engineers, providing comprehensive information and covering a wide range of topics on several aspects of microwaves and optics, including polarization conversion, asymmetric transmission, transmission lines, filters, plasmonic lenses, tunable metamaterials, light manipulation,

absorbers, and antennas, among others. This book is suitable for scholars from large scientific domain and therefore given to engineers, scientists, graduates, and other interested professionals as a reference on these artificial materials of tomorrow.

This proceedings book discusses state-of-the-art research on uncertainty quantification in mechanical engineering, including statistical data concerning the entries and parameters of a system to produce statistical data on the outputs of the system. It is based on papers presented at Uncertainties 2020, a workshop organized on behalf of the Scientific Committee on Uncertainty in Mechanics (Mécanique et Incertain) of the AFM (French Society of Mechanical Sciences), the Scientific Committee on Stochastic Modeling and Uncertainty Quantification of the ABCM (Brazilian Society of Mechanical Sciences) and the SBMAC (Brazilian Society of Applied Mathematics).

This book discusses bulk solids that derive their mechanical properties not from those of their base materials, but from their designed microstructures. Focusing on the negative mechanical properties, it addresses topics that reveal the counter-intuitive nature of solids, specifically the negativity of properties that are commonly positive, such as negative bulk modulus, negative compressibility, negative hygroexpansion, negative thermal expansion, negative stiffness phase, and negative Poisson’s ratio. These topics are significant not only due to the curiosity they have sparked, but also because of the possibility of designing materials and structures that can behave in ways that are not normally expected in conventional solids, and as such, of materials that can

outperform solids and structures made from conventional materials. The book includes illustrations to facilitate learning, and, where appropriate, reference tables. The presentation is didactic, starting with simple cases, followed by increasingly complex ones. It provides a solid foundation for graduate students, and a valuable resource for practicing materials engineers seeking to develop novel materials through the judicious design of microstructures and their corresponding mechanisms.

Provides systematic coverage of the theory, physics, functional designs, and engineering applications of advanced electromagnetic surfaces.

Backscattering and RF Sensing for Future Wireless Communication Discover what lies ahead in wireless communication networks with this insightful and forward-thinking book written by experts in the field Backscattering and RF Sensing for Future Wireless Communication delivers a concise and insightful picture of emerging and future trends in increasing the efficiency and performance of wireless communication networks. The book shows how the immense challenge of frequency saturation could be met via the deployment of intelligent planar electromagnetic structures. It provides an in-depth coverage of the fundamental physics behind these structures and assesses the enhancement of the performance of a communication network in challenging environments, like densely populated urban centers. The distinguished editors have included resources from a variety of leading voices in the field who discuss topics such as the engineering of metasurfaces at a large scale, the electromagnetic analysis of

planar metasurfaces, and low-cost and reliable backscatter communication. All of the included works focus on the facilitation of the development of intelligent systems designed to enhance communication network performance. Readers will also benefit from the inclusion of: A thorough introduction to the evolution of wireless communication networks over the last thirty years, including the imminent saturation of the frequency spectrum An exploration of state-of-the-art techniques that next-generation wireless networks will likely incorporate, including software-controlled frameworks involving artificial intelligence An examination of the scattering of electromagnetic waves by metasurfaces, including how wave propagation differs from traditional bulk materials A treatment of the evolution of artificial intelligence in wireless communications Perfect for researchers in wireless communications, electromagnetics, and urban planning, Backscattering and RF Sensing for Future Wireless Communication will also earn a place in the libraries of government policy makers, technologists, and telecom industry stakeholders who wish to get a head start on understanding the technologies that will enable tomorrow's wireless communications. The aim of this book is to show some applications of fractal analysis in the fields of sciences. The first chapter introduces the readers to the book, while the second chapter shows the methods and challenges of fractal analysis of time-series data sets. The third chapter demonstrates fractal geometry as an attractive choice for miniaturized planar microwave filter design. The fourth chapter presents fractal antennas for wearable

applications. The objective of the fifth chapter is to show some Parrondian games in discrete dynamic systems, while the last chapter reveals fractal structures of carbon nanotube system arrays.

Substrate-Integrated Millimeter-Wave Antennas for Next-Generation Communication and Radar Systems The first and only comprehensive text on substrate-integrated mmW antenna technology, state-of-the-art antenna design, and emerging wireless applications Substrate-Integrated Millimeter-Wave Antennas for Next-Generation Communication and Radar Systems elaborates the most important topics related to revolutionary millimeter-wave (mmW) technology. Following a clear description of fundamental concepts including substrate-integrated waveguides and loss analysis, the text treats key design methods, prototyping techniques, and experimental setup and testing. The authors also highlight applications of mmW antennas in 5G wireless communication and next-generation radar systems. Readers are prepared to put techniques into practice through practical discussions of how to set up testing for impedance matching, radiation patterns, gain from 24GHz up to 325 GHz, and more. This book will bring readers state-of-the-art designs and recent progress in substrate-integrated mmW antennas for emerging wireless applications. Substrate-Integrated Millimeter-Wave Antennas for Next-Generation Communication and Radar Systems is the first comprehensive text on the topic, allowing readers to quickly master mmW technology. This book: Introduces basic concepts such as metamaterials Huygens's

surface, zero-index structures, and pattern synthesis Describes prototyping in the form of fabrication based on printed-circuit-board, low-temperature-co-fired-ceramic and micromachining Explores applications for next-generation radar and imaging systems such as 24-GHz and 77-GHz vehicular radar systems Elaborates design methods including waveguide-based feeding network, three-dimensional feeding structure, dielectric loaded aperture antenna element, and low-sidelobe synthesis The mmW is one of today's most important emerging technologies. This book provides graduate students, researchers, and engineers with the knowledge they need to deploy mmW systems and develop new antenna designs with low cost, low loss, and low complexity.
This book explores both the state-of-the-art and the latest achievements in UWB antennas and propagation. It has taken a theoretical and experimental approach to some extent, which is more useful to the reader. The book highlights the unique design issues which put the reader in good pace to be able to understand more advanced research.
Fractal analysis has entered a new era. The applications to different areas of knowledge have been surprising. Let us begin with the fractional calculus-fractal geometry relationship, which allows for modeling with extreme precision of phenomena such as diffusion in porous media with fractional partial differential equations in fractal objects. Where the order of the equation is the same as the fractal dimension, this allows us to make calculations with enormous precision in diffusion phenomena-

particularly in the oil industry, for new spillage prevention. Main applications to industry, design of fractal antennas to receive all frequencies and that is used in all cell phones, spacecraft, radars, image processing, measure, porosity, turbulence, scattering theory. Benoit Mandelbrot, creator of fractal geometry, would have been surprised by the use of fractal analysis presented in this book: "Part I: Petroleum Industry and Numerical Analysis"; "Part II: Fractal Antennas, Spacecraft, Radars, Image Processing, and Measure"; and "Part III: Scattering Theory, Porosity, and Turbulence." It's impossible to picture today's research without fractal analysis.

The sensing, adapting, responding, multifunctionality, low energy, small size and weight, ease of forming, and low-cost attributes of smart textiles and their multidisciplinary scope offer numerous end uses in medical, sports and fitness, military, fashion, automotive, aerospace, the built environment, and energy industries. The research and development on these new and high-value materials cross scientific boundaries, redefine material science design and engineering, and enhance quality of life and our environment. “Novel Smart Textiles” is a focused Special Issue that reports the latest research of this field and facilitates dissemination, networking, discussion, and debate.

This book covers the study of electromagnetic wave theory and describes how electromagnetic technologies affect our daily lives. From ER to ET: How Electromagnetic Technologies Are Changing Our Lives explores electromagnetic wave

theory including its founders, scientific underpinnings, ethical issues, and applications through history. Utilizing a format of short essays, this book explains in a balanced, and direct style how electromagnetic technologies are changing the world we live in and the future they may create for us. Quizzes at the end of each chapter provide the reader with a deeper understanding of the material. This book is a valuable resource for microwave engineers of varying levels of experience, and for instructors to motivate their students and add depth to their assignments. In addition, this book: Presents topics that investigate all aspects of electromagnetic technology throughout history Explores societal and global issues that relate to the field of electrical engineering (emphasized in current ABET accreditation criteria) Includes quizzes relevant to every essay and answers which explain technical perspectives Rajeev Bansal, PhD, is a professor of Electrical and Computer Engineering at the University of Connecticut. He is a member of IEEE and the Connecticut Academy of Science and Engineering. He is a Fellow of the Electromagnetics Academy. His editing credits include Fundamentals of Engineering Electromagnetics and Engineering Electromagnetics: Applications. Dr. Bansal contributes regular columns to IEEE Antennas and Propagation Magazine and IEEE Microwave Magazine.

From science fiction to science laboratories Discover the State of the Art in Photonic Metamaterials Metamaterials—composite media with unusual optical properties—have revolutionized the landscape of optical science and engineering

over the past decades. Metamaterials have transformed science-fiction-like concepts of superresolution imaging and optical cloaking to the realm of science laboratories, and further promise to transform these into the realm of our everyday life. This new era of optical metamaterials calls for the development of experimental and theoretical methods capable of analyzing optical behavior on the multitude of scales—from the nanometer scale of individual inhomogeneity, to the micrometer level and the larger scale of metamaterials-based devices. Tutorials in Metamaterials offers a collection of chapters that were designed as self-contained tutorials describing photonic metamaterials and the state of the art in metamaterials research. Chapters cover: Linear and nonlinear properties of photonic metamaterials and their potential applications Fabrication techniques for optical metamaterials, ranging from electron-beam lithography, focused ion beam milling, and nanoimprint lithography to direct laser writing Recent achievements in metatamerial research at visible, IR, and microwave frequencies Novel applications of metamaterials for light guiding, steering, and refraction Efforts to compensate and eliminate optical loss by introducing optical gain into the metamaterial matrix A comprehensive overview of metamaterial photonics, this reference is suitable for graduate students as well as physicists and engineers interested in entering this dynamic new field.

The first general textbook to offer a complete overview ofmetamaterial theory and its microwave applications Metamaterials with Negative Parameters represents theonly unified treatment of metamaterials available in one convenientbook. Devoted mainly to metamaterials that can be characterized bya negative effective permittivity and/or permeability, the bookincludes a wide overview of the most important topics, scientificfundamentals, and technical applications of metamaterials. Chapter coverage includes: the electrodynamics of left-handedmedia, synthesis of bulk metamaterials, synthesis of metamaterialsin planar technology, microwave applications of metamaterialconcepts, and advanced and related topics, including SRR- andCSRR-based admittance surfaces, magneto- and electro-inductivewaves, and sub-diffraction imaging devices. A list of problems andreferences is included at the end of each chapter, and abibliography offers a complete, up-to-daterepresentation of thecurrent state of the art in metamaterials. Geared toward students and professionals alike, Metamaterialswith Negative Parameters is an ideal textbook for postgraduatecourses and also serves as a valuable introductory reference forscientists and RF/microwave engineers.

This book opens a new avenue to an engendering field of applied physics, located at the OC crossingOCO of modern photonics, electromagnetics,

acoustics and material science. It also highlights the concept of OC non-localityOCO, which proves to be not a special feature of quantum phenomena, but is shown to have an important counterpart in classical physics and its engineering applications too. Furthermore, it visualizes the physical results by means of simple analytical presentations, reduced sometimes to the elementary functions.

Metamaterials have provided applications in spectral ranges covering radio frequencies and ultraviolet. However, most applications have been extrapolated to the visible or near-infrared after being developed at the GHz level. This is due to technological reasons since fabrication of microwave antennas is not as demanding as THz resonators or plasmonic nanostructures. Accordingly, this book has been divided into three parts. In the first part, fundamentals of metamaterials and metadevices are discussed, while describing recent advances in the field. In the second part, the discussion is extended to the different spectral ranges focusing on the strategies for enabling the reconfigurability of metadevices. Given the increasing interest in THz applications, these can be found in the third part.

Describes applications of time-domain EM reciprocity and the Cagniard-deHoop technique to achieve solutions to fundamental antenna radiation and scattering

problems This book offers an account of applications of the time-domain electromagnetic (TD EM) reciprocity theorem for solving selected problems of antenna theory. It focuses on the development of both TD numerical schemes and analytical methodologies suitable for analyzing TD EM wave fields associated with fundamental antenna topologies. Time-Domain Electromagnetic Reciprocity in Antenna Modeling begins by applying the reciprocity theorem to formulate a fundamentally new TD integral equation technique – the Cagniard-deHoop method of moments (CdH-MoM) – regarding the pulsed EM scattering and radiation from a thin-wire antenna. Subsequent chapters explore the use of TD EM reciprocity to evaluate the impact of a scatterer and a lumped load on the performance of wire antennas and propose a straightforward methodology for incorporating ohmic loss in the introduced solution methodology. Other topics covered in the book include the pulsed EM field coupling to transmission lines, formulation of the CdH-MoM concerning planar antennas, and more. In addition, the book is supplemented with simple MATLAB code implementations, so that readers can test EM reciprocity by conducting (numerical) experiments. In addition, this text: Applies the thin-sheet boundary conditions to incorporate dielectric, conductive and plasmonic properties of planar antennas Provides illustrative numerical examples that validates the described methodologies

Presents analyzed problems at a fundamental level so that readers can fully grasp the underlying principles of solution methodologies Includes appendices to supplement material in the book Time-Domain Electromagnetic Reciprocity in Antenna Modeling is an excellent book for researchers and professors in EM modeling and for applied researchers in the industry.

Electromagnetic metamaterials-from fundamental physics to advanced engineering applications This book presents an original generalized transmission line approach associated with non-resonant structures that exhibit larger bandwidths, lower loss, and higher design flexibility. It is based on the novel concept of composite right/left-handed (CRLH) transmission line metamaterials (MMs), which has led to the development of novel guided-wave, radiated-wave, and refracted-wave devices and structures. The authors introduced this powerful new concept and are therefore able to offer readers deep insight into the fundamental physics needed to fully grasp the technology. Moreover, they provide a host of practical engineering applications. The book begins with an introductory chapter that places resonant type and transmission line metamaterials in historical perspective. The next six chapters give readers a solid foundation in the fundamentals and practical applications: Fundamentals of LH MMs describes the fundamental physics and exotic properties of left-handed

metamaterials TL Theory of MMs establishes the foundations of CRLH structures in three progressive steps: ideal transmission line, LC network, and real distributed structure Two-Dimensional MMs develops both a transmission matrix method and a transmission line method to address the problem of finite-size 2D metamaterials excited by arbitrary sources Guided-Wave Applications and Radiated-Wave Applications present a number of groundbreaking applications developed by the authors The Future of MMs sets forth an expert view on future challenges and prospects This engineering approach to metamaterials paves the way for a new generation of microwave and photonic devices and structures. It is recommended for electrical engineers, as well as physicists and optical engineers, with an interest in practical negative refractive index structures and materials.