

Tie Jun Cui  
David R. Smith  
Ruopeng Liu  
*Editors*

# Metamaterials

Theory, Design,  
and Applications

A large, stylized graphic of a metamaterial unit cell, resembling a split-ring resonator, is centered on the cover. It is rendered in a dark red color with a blue gradient, set against a background of horizontal lines with small arrows pointing to the right. The graphic is partially obscured by the title text.

 Springer

# Metamaterials Theory Design And Applications

**Matthias Maasch**



## **Metamaterials Theory Design And Applications:**

**Metamaterials** Tie Jun Cui, David Smith, Ruopeng Liu, 2009-10-30 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

**Metamaterials with Negative Parameters** Ricardo Marqués, Ferran Martín, Mario Sorolla, 2011-09-20 The first general textbook to offer a complete overview of metamaterial theory and its microwave applications Metamaterials with Negative Parameters represents the only unified treatment of metamaterials available in one convenient book Devoted mainly to metamaterials that can be characterized by a negative effective permittivity and or permeability the book includes a wide overview of the most important topics scientific fundamentals and technical applications of metamaterials Chapter coverage includes the electrodynamics of left handed media synthesis of bulk metamaterials synthesis of metamaterials in planar technology microwave applications of metamaterial concepts and advanced and related topics including SRR and CSRR based admittance surfaces magneto and electro inductive waves and sub diffraction imaging devices A list of problems and references is included at the end of each chapter and a bibliography offers a complete up to date representation of the current state of the art in metamaterials Geared toward students and professionals alike Metamaterials with Negative Parameters is an ideal textbook for postgraduate courses and also serves as a valuable introductory reference for scientists and RF microwave engineers

**Theory and Applications of Electromagnetic Metamaterials** Fajun Xiao, Weiren Zhu, Xingzhan Wei, Ivan Rukhlenko, 2021-10-01 *Mechanics of Metamaterials with Negative Parameters* Teik-Cheng Lim, 2020-07-23 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

**Tunable Microwave Metamaterial Structures** Matthias Maasch,2016-01-23 This book presents original findings on tunable microwave metamaterial structures and describes the theoretical and practical issues involved in the design of metamaterial devices Special emphasis is given to tunable elements and their advantages in terms of feeding network simplification Different biasing schemes and feeding network topologies are presented together with extensive prototype measurements and simulations The book describes a novel unique solution for beam steering and beam forming applications and thus paves the way for the diffusion of new agile communication system components At the same time it provides readers with an outstanding and timely review of wave propagation in periodic structures tunability of metamaterials and the technological constraints that need to be considered in the design of reconfigurable microwave components

**Handbook of Nanoscience, Engineering, and Technology** William A. Goddard III,Donald Brenner,Sergey Edward Lyshevski,Gerald J Iafrate,2018-09-03 In his 1959 address There is Plenty of Room at the Bottom Richard P Feynman speculated about manipulating materials atom by atom and challenged the technical community to find ways of manipulating and controlling things on a small scale This visionary challenge has now become a reality with recent advances enabling atomistic level tailoring and control of materials Exemplifying Feynman s vision Handbook of Nanoscience Engineering and Technology Third Edition continues to explore innovative nanoscience engineering and technology areas Along with updating all chapters this third edition extends the coverage of emerging nano areas even further Two entirely new sections on energy and biology cover nanomaterials for energy storage devices photovoltaics DNA devices and assembly digital microfluidic lab on a chip and much more This edition also includes new chapters on nanomagnet logic quantum transport at the nanoscale terahertz emission from Bloch oscillator systems molecular logic electronic optics in graphene and electromagnetic metamaterials With contributions from top scientists and researchers from around the globe this color handbook presents a unified up to date account of the most promising technologies and developments in the nano field It sets the stage for the next revolution of nanoscale manufacturing where scalable technologies are used to manufacture large numbers of devices with complex functionalities

**Chimera States in Complex Networks** Eckehard Schöll,Anna Zakharova,Ralph G. Andrzejak,2020-01-03

**Electromagnetic Metamaterials** Christophe Caloz,Tatsuo Itoh,2006 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

**Fundamentals of Photonics** Bahaa E. A. Saleh, Malvin Carl Teich, 2020-03-04 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

*Electromagnetic Interactions with Materials* Susan A. Farhat, 2010 *Metamaterials II* Vladimír Kuzmiak, Tomasz Szoplik, Peter Markos, 2007 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 **Metamaterials-by-Design** Andrea Alù, Nader Engheta, Andrea Massa, Giacomo Oliveri, 2024-04-04 Metamaterials by Design Theory Technologies and Vision is devoted to a comprehensive review of the latest advancements and current trends in the field of system level oriented metamaterial design methods technologies and future perspectives Starting from the theoretical and methodological motivations of this research to macro scale

performance driven design of volumetric and planar metamaterials the book introduces advanced task oriented modeling approaches including specific reference to their multi scale multi physics customization in recent metamaterial science and engineering In the introduction of these concepts particular attention is paid to the illustration of the physical mechanisms and phenomena at the basis of the field manipulation capabilities enabled by metamaterials Contributions from industry and academic perspectives on active and passive metamaterial enhanced devices for communications and sensing are included The final part of the volume is aimed at providing a perspective regarding the current trends future research and application tracks in system performance driven metamaterial design methodologies and technologies included potential applications in future reconfigurable and cognitive materials Includes comprehensive review of the research developments methodologies and opportunities in the field of metamaterials by design Discusses new and emerging applications of metamaterials in microwave and terahertz spectrum photonics and optics scenarios Reviews performance driven metamaterial design methodologies and technologies in communications and sensing

Journal of Zhejiang University ,2006 FDTD Modeling of Metamaterials: Theory and Applications Yang Hao,Raj Mittra,2008-10-01 Master powerful new modeling tools that let you quantify and represent metamaterial properties with never before accuracy This first of its kind book brings you up to speed on breakthrough finite difference time domain techniques for modeling metamaterial characteristics and behaviors in electromagnetic systems This practical resource comes complete with sample FDTD scripts to help you pave the way to new metamaterial applications and advances in antenna microwave and optics engineering You get in depth coverage of state of the art FDTD modeling techniques and applications for electromagnetic bandgap EBG structures left handed metamaterials LHMs wire medium metamaterials for optics and other practical metamaterials You find steps for computing dispersion diagrams dealing with material dispersion properties and verifying the left handedness Moreover this comprehensive volume offers guidance for handling the unique properties possessed by metamaterials including how to define material parameters characterize the interface of metamaterial slabs and quantify their spatial as well as frequency dispersion characteristics The book also presents conformal and dispersive FDTD modeling of electromagnetic cloaks perfect lens and plasmonic waveguides as well as other novel antenna microwave and optical applications Over 190 illustrations support key topics throughout the book

**Metamaterials** Nader Engheta,Richard W. Ziolkowski,2006-07-11 Modern metamaterials is relatively new less than two years old and evolving rapidly It has captured the interest of researchers because theoretically predicted exciting fundamental electromagnetic phenomena can now be realized experimentally and novel devices are feasible This is the critical resource sought by readers who need fundamental knowledge and applications provided by pre eminent experts in this field

*Physics of Multiantenna Systems and Broadband Processing* T. K. Sarkar,M. Salazar-Palma,Eric L. Mokole,2008-06-30 An analysis of the physics of multiantenna systems Multiple Input Multiple Output MIMO technology is one of the current hot topics in emerging wireless technologies This book fills the important need for an

authoritative reference on the merits of MIMO systems based on physics and provides a sound theoretical basis for its practical implementation The book also addresses the important issues related to broadband adaptive processing Written by three internationally known researchers Physics of Multiantenna Systems and Broadband Processing Provides a thorough discussion of the physical and mathematical principles involved in MIMO and adaptive systems Examines the electromagnetic framework of wireless communications systems Uses Maxwell's theory to provide a system based framework for the abstract concept of channel capacity Performs various numerical simulations to observe how a typical system will behave in practice Provides a mathematical formulation for broadband adaptive processing and direction of arrival estimation using real antenna arrays Integrates signal processing and electromagnetics to address the performance of realistic multiantenna systems With Physics of Multiantenna Systems and Broadband Processing communication systems engineers graduate students researchers and developers will gain a thorough scientific understanding of this important new technology

**Integrated Semiconductor Nanostructures and Low Loss Metal for Metamaterial Applications**

Logeeswaran Veerayah Jayaraman, 2010

**Negative-Refractive Metamaterials** G. V. Eleftheriades, K. G.

Balmain, 2005-07-07 Learn about the revolutionary new technology of negative refraction metamaterials Negative Refraction Metamaterials Fundamental Principles and Applications introduces artificial materials that support the unusual electromagnetic property of negative refraction Readers will discover several classes of negative refraction materials along with their exciting groundbreaking applications such as lenses and antennas imaging with super resolution microwave devices dispersion compensating interconnects radar and defense The book begins with a chapter describing the fundamentals of isotropic metamaterials in which a negative index of refraction is defined In the following chapters the text builds on the fundamentals by describing a range of useful microwave devices and antennas Next a broad spectrum of exciting new research and emerging 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 refractive index Numerical simulation studies of negative refraction of Gaussian beams and associated focusing phenomena Unique advantages and theory of shaped lenses made of negative refractive index metamaterials A new type of transmission line metamaterial that is anisotropic and supports the formation of sharp steerable beams resonance cones Implementations of negative refraction metamaterials at optical frequencies Unusual propagation phenomena in metallic waveguides partially filled with negative refractive index metamaterials Metamaterials in which the refractive index and the underlying group velocity are both negative This work brings together the best minds in this cutting edge field It is fascinating reading for scientists engineers and graduate level students in physics chemistry materials science photonics and electrical engineering

**The Stripline Circulator** Joseph Helszajn, 2008-06-30 Stripline circulator theory and applications from the world's

foremost authority The stripline junction circulator is a unique three port non reciprocal microwave junction used to connect

a single antenna to both a transmitter and a receiver Its operation relies on the interaction between an electron spin in a suitably magnetized insulator with an alternating radio frequency magnetic field In its simplest form it consists of a microwave planar gyromagnetic resonator symmetrically coupled by three transmission lines This book explores the magnetic interaction involved in the stripline circulator s operation the nature of the microwave resonator shape and the network problem that arises in coupling the microwave resonator to the microwave circuit The stripline circulator is an important device met across a wide range of industries including wireless military radar and satellite communications The book s design tables are a unique feature offering valuable design support Written by an international authority on non reciprocal microwave circuits and devices the book is organized into logical blocks of chapters that focus on specific effects and circuit aspects of the stripline circulator Among the highlights of coverage are Spatial shape demagnetizing factors of magnetic insulators Standing wave solutions of wye gyromagnetic planar resonators Lumped element circulators Negative permeability tracking and semi tracking circulators Four port single junction circulators Fabrication of very weakly and weakly magnetized microstrip circulators The final chapter explores important and continuing discrepancies between theoretical models and actual practice For designers building circulators isolators and phase shifters researchers working on the limitation of ferrite devices and graduate students intending to work in the field Dr Helszajn s insights and perspectives are invaluable

*Electromagnetic Shielding* Salvatore Celozzi, Rodolfo Araneo, Giampiero Lovat, 2008-04-18 This reference provides a survey of options for the reduction of the electromagnetic field levels in prescribed areas This is a resource for practicing telecommunications and electrical engineers as well as researchers in industry and academia who are involved in the design and analysis of electromagnetic shielding structures Jacket



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