Acoustic Metamaterials And Wave Control Frontier Research In Computation And Mechanics Of Materials

The 3rd International Conference on Material Engineering and Manufacturing (ICMEM 2019) and the 4th International Conference on Materials Engineering and Nanotechnology (ICMEN 2019) were dedicated to new research developments and advances in the fields of material engineering, nanotechnology, and manufacturing technologies. We hope that the presented collection of scientific papers will be interesting and useful for many engineers and researchers.

This comprehensive book presents all aspects of acoustic metamaterials and phononic crystals. The emphasis is on acoustic wave propagation phenomena at interfaces such as refraction, especially unusual refractive properties and negative refraction. A thorough discussion of the mechanisms leading to such refractive phenomena includes local resonances in metamaterials and scattering in phononic crystals.

This book presents the most recent theoretical developments and numerical/experimental validations of new metamaterials and phononic crystals for the broadband absorption of elastic waves and vibrations in structures. These nine chapters explore many aspects of phononic crystals and acoustic/elastic metamaterials, including sound attenuation/absorption, extraordinary transmission, wave broadband mitigation, wave steering, cloaking via the transformation method, optimization of

phononic crystals, and active acoustic metamaterials.

The purpose of this dissertation is to model, simulate and design metamaterials for underwater sound and elastic wave control. Water-based acoustic metamaterials usually suffer from low transmission due to the impedance mismatch with water; elastic metamaterials also suffer from this issue not only because of the impedance mismatch to the host medium, but also due to the multiple wave types existing simultaneously at the interface between the inclusions and the background matrix. This dissertation focuses on the theoretical modeling and computational design of broadband high transmission metamaterial devices. Several related topics are discussed. (1) A semi-analytical method for band diagram computation of three dimensional (3D) lattices is developed in this dissertation. It has significant applications in 3D pentamode metamaterial design. (2) Acoustic transmission through gratings of parallel plates displaying anisotropic inertia is also investigated. It is found that broadband impedance matching and total acoustic transmission can be achieved if the plane wave is incident at the so-called intromission angle ±[theta]i. (3) Elastic wave transmission through aligned parallel plates are studied theoretically by considering the coupling between different types of waves in elastic half-spaces and in the plates. The results are applied in the design and optimization of elastic metamaterials. (4) Elastic waves in fluid-saturated anisotropic double porosity medium of cubic symmetry is also investigated as an extension to Biot's theory of poroelasticity. A third dilatational wave is predicted in a

double porosity fluid-saturated gyroid structure and demonstrated using finite element (FEM) simulations. The second part of the dissertation focuses on several novel devices for manipulating acoustic and elastic waves. Metallic metamaterial unit cells of the hexagonal lattice type are employed to mimic the quasi-static acoustic properties of water, and to provide a certain range of index for gradient index (GRIN) metamaterial design. The advantage of such a metamaterial element is that it has in-plane isotropy and only allows one propagating mode within the frequency range of interest. (5) A flat GRIN lens is designed by tuning the unit cells to obey a modified hyperbolic secant index profile, such that a normally incident plane wave transmits through the lens efficiently and focuses at a single point. The side lobe suppression and aberration reduction abilities of the GRIN lens are demonstrated in both simulations and in underwater experiments (carried out by colleagues at the University of Texas at Austin). (6) An elastic shell based metamaterial element, which provides a wider range of index at the quasi-static regime, is adopted in the design of a conformal lens for converting a monopole source to highly directional plane wave beams. The required bulk modulus and density distributions are derived using conformal transformation acoustics mapping from a unit circle to a triangle. The mapping function is adjustable which allows energy radiating preferentially into different directions. Two collimation devices are designed using fluid-saturated shells and demonstrated using full wave FEM simulations. (7) A novel class of elastic metamaterial composed of "effective plates" are introduced to

design high transmission devices for elastic waves. Several devices for focusing SV-wave, splitting P- and SV-waves, and asymmetric transmission are designed and demonstrated using full wave FEM simulations.

Metamaterials represent a new emerging innovative field of research which has shown rapid acceleration over the last couple of years. In this handbook, we present the richness of the field of metamaterials in its widest sense, describing artificial media with sub-wavelength structure for control over wave propagation in four volumes. Volume 1 focuses on the fundamentals of electromagnetic metamaterials in all their richness, including metasurfaces and hyperbolic metamaterials. Volume 2 widens the picture to include elastic, acoustic, and seismic systems, whereas Volume 3 presents nonlinear and active photonic metamaterials. Finally, Volume 4 includes recent progress in the field of nanoplasmonics, used extensively for the tailoring of the unit cell response of photonic metamaterials. In its totality, we hope that this handbook will be useful for a wide spectrum of readers, from students to active researchers in industry, as well as teachers of advanced courses on wave propagation. Contents: Volume 1: Electromagnetic Metamaterials (Ekaterina Shamonina): PrefaceElectromagnetic Metamaterials: Homogenization and Effective Properties of Mixtures (Ari Sihvola)Effective Medium Theory of Electromagnetic and Quantum Metamaterials (Mário G Silveirinha)Hyperbolic Metamaterials (Igor I Smolyaninov)Circuit and Analytical Modelling of Extraordinary Transmission Metamaterials (Francisco Medina,

Francisco Mesa, Raul Rodríguez-Berral and Carlos Molero)Electromagnetic Metasurfaces: Synthesis, Realizations and Discussions (Karim Achouri and Christophe Caloz)Metasurfaces for General Control of Reflection and Transmission (Sergei Tretyakov, Viktar Asadchy and Ana Díaz-Rubio)Scattering at the Extreme with Metamaterials and Plasmonics (Francesco Monticone and Andrea Alù)All-Dielectric Nanophotonics: Fundamentals, Fabrication, and Applications (Alexander Krasnok, Roman Savelev, Denis Baranov and Pavel Belov)Tunable Metamaterials (Ilya V Shadrivov and Dragomir N Neshev)Spatial Solitonic and Nonlinear Plasmonic Aspects of Metamaterials (Allan D Boardman, Alesandro Alberucci, Gaetano Assanto, Yu G Rapoport, Vladimir V Grimalsky, Vasyl M Ivchenko and Eugen N Tkachenko)Metamaterial Catheter Receivers for Internal Magnetic Resonance Imaging (Richard R A Syms, Ian R Young and Laszlo Solymar)Microwave Sensors Based on Symmetry Properties and Metamaterial Concepts (Jordi Naqui, Ali K Horestani, Christophe Fumeaux and Ferran Martín)Volume 2: Elastic, Acoustic, and Seismic Metamaterials (Richard Craster and Sébastien Guenneau): PrefaceDynamic Homogenization of Acoustic and Elastic Metamaterials and Phononic Crystals (Richard Craster, Tryfon Antonakakis and Sébastien Guenneau)Acoustic Metamaterial (Nicholas Fang, Jun Xu, Navid Nemati, Nicolas Viard and Denis Lafarge)Flat Lens Focusing of Flexural Waves in Thin Plates (Patrick Sebbah and Marc Dubois)Space–Time Cloaking (Martin W McCall and Paul Kinsler)Soda Cans Metamaterial: Homogenization and

Beyond (Fabrice Lemoult, Geoffroy Lerosey, Nadège Kaïna and Mathias Fink)New Trends Toward Locally-Resonant Metamaterials at the Mesoscopic Scale (Philippe Roux, Matthieu Rupin, Fabrice Lemoult, Geoffroy Lerosey, Andrea Colombi, Richard Craster, Sébastien Guenneau, William A Kuperman and Earl G Williams)Seismic Metamaterials: Controlling Surface Rayleigh Waves Using Analogies with Electromagnetic Metamaterials (Stéphane Brûlé, Stefan Enoch, Sébastien Guenneau and

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.

This book is a collection of papers presented at Acoustics and Vibration of Mechanical Structures 2017 – AVMS 2017 – highlighting the current trends and state-of-the-art developments in the field. It covers a broad range of topics, such as noise and vibration control, noise and vibration generation and propagation, the effects of noise and vibration, condition monitoring and vibration testing, modeling, prediction and simulation of noise and vibration, environmental and occupational noise and vibration, noise and vibration attenuators, as well as biomechanics and bioacoustics. The book also presents analytical, numerical and experimental techniques for evaluating linear and non-linear noise and vibration problems (including strong nonlinearity). It is primarily intended for academics, researchers and professionals, as well as PhD students in various fields of the acoustics and vibration of mechanical structures.

This book addresses theoretical and experimental methods for exploring microstructured metamaterials, with a special focus on wave dynamics, mechanics, and related physical properties. The authors use various mathematical and physical approaches to examine the mechanical properties inherent to particular types of metamaterials. These include: • Boundary value problems in reduced strain gradient elasticity for composite fiber-reinforced metamaterials • Self-organization of molecules in ferroelectric thin films • Combined models for surface layers of nanostructures • Computer simulation at the micro- and nanoscale • Surface effects with anisotropic

properties and imperfect temperature contacts • Inhomogeneous anisotropic metamaterials with uncoupled and coupled surfaces or interfaces • Special interface finite elements and other numerical and analytical methods for composite structures

In the last few decades, metamaterials have revolutionized the ways in which waves are controlled, and applied in physics and practical situations. The extraordinary properties of metamaterials, such as their locally resonant structure with deep subwavelength band gaps and their ranges of frequency where propagation is impossible, have opened the way to a host of applications that were previously unavailable. Acoustic metamaterials have been able to replace traditional treatments in several sectors, due to their better performance in targeted and tunable frequency ranges with strongly reduced dimensions. This is a training book composed of nine chapters written by experts in the field, giving a broad overview of acoustic metamaterials and their uses. The book is divided into three parts, covering the state-of-the-art, the fundamentals and the real-life applications of acoustic metamaterials.

Metamaterials have been in research limelight for the last few years owing to the exotic electromagnetic features these exhibit. With certain combinational forms of the design, these can be of prudent applications in developing antennas, filters, absorbers, sensors, energy harvesters, and many others. As such, the role of

engineered mediums remains greatly important as the frequency region of operation determines the structure (of the medium(s)) to be developed – the fact that is exploited in the on-demand kind of tailoring the electromagnetic response of metamaterials. The relevant R&D investigators show keen interest in the fabrication of varieties of novel miniaturized devices that can be of great potentials in many micro- as well as nanotechnology-oriented applications. With this view point in mind, the Book provides the glimpse of phenomenal growth of research in this direction through covering the topics pivoted to fundamental descriptions, and theoretical and experimental results reported by pioneering scientists. It is expected that the book will be of benefit to novice researchers (such as graduate students) and expert scientists in universities and research laboratories. Some of the contents in the book are centered on industrial applications of metamaterials, thereby making the volume useful to the R&D scientists in certain industries. In summary, the book

This book presents selected peer-reviewed contributions from the 2017 International Conference on “Physics and Mechanics of New Materials and Their Applications”, PHENMA 2017 (Jabalpur, India, 14–16 October, 2017), which is devoted to processing techniques, physics, mechanics, and applications of advanced materials. The book focuses on a wide spectrum of nanostructures,

ferroelectric crystals, materials and composites as well as promising materials with special properties. It presents nanotechnology approaches, modern environmentally friendly piezoelectric and ferromagnetic techniques and physical and mechanical studies of the structural and physical–mechanical properties of materials. Various original mathematical and numerical methods are applied to the solution of different technological, mechanical and physical problems that are interesting from theoretical, modeling and experimental points of view. Further, the book highlights novel devices with high accuracy, longevity and extended capabilities to operate under wide temperature and pressure ranges and aggressive media, which show improved characteristics, thanks to the developed materials and composites, opening new possibilities for different physico-mechanical processes and phenomena.

As an emerging interdisciplinary field, acoustic metamaterials have generated increasing interests for diverse engineering applications, from noise and vibration alleviation to super-resolution imaging. The book starts with a simple mass-in-mass chain model to illustrate the concept of negative mass due to internal resonance and its impact on wave transmission. The practical transformation theory for controlling acoustic waves is explained. Pentamode acoustic metamaterials and related cloaking design are also included. Finally, the book

ends up with the sub-diffraction-limited acoustic imaging based on metamaterials. This comprehensive title gives a broad overview on different aspects of acoustic metamaterials with a balance of theory and experiment. It is not only a collection of the authors' original works to these interesting topics, but also the main achievements in this field. Researchers, academics, professionals and graduate students in the fields of mechanical engineering, condensed matter physics, new materials, applied physics, and general readers of noise and vibration controls, will find this exciting book to be an indispensible reference material.

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.

Advances in Machine Learning Research and Application: 2011 Edition is a ScholarlyEditions™ eBook that delivers timely, authoritative, and comprehensive information about Machine Learning. The editors have built Advances in Machine Learning Research and Application: 2011 Edition on the vast information databases of ScholarlyNews.™ You can expect the information about Machine Learning in this eBook to be deeper than what you can access anywhere else, as well as consistently reliable, authoritative, informed, and relevant. The content of Advances in Machine Learning Research and Application: 2011 Edition has been produced by the world's leading scientists, engineers, analysts, research institutions, and companies. All of the content is from peer-reviewed sources, and all of it is written, assembled, and edited by the editors at ScholarlyEditions™ and available exclusively from us. You now have a source you can cite with authority, confidence, and credibility. More information is available at http://www.ScholarlyEditions.com/.

Since the concept was first proposed at the end of the 20thCentury, metamaterials have been the subject of much research anddiscussion throughout

the wave community. More than 10 years later,the number of related published articles is increasingsignificantly. On the one hand, this success can be attributed to dreams of newphysical objects which are the consequences of the singularproperties of metamaterials. Among them, we can consider theexamples of perfect lensing and invisibility cloaking. On otherhand, metamaterials also provide new tools for the design of well-knownwave functions such as antennas for electromagnetic waves. The goal of this book is to propose an overview of the concept ofmetamaterials as a perspective on a new practical tool for wavestudy and engineering. This includes both the electromagnetic spectrum,from microwave to optics, and the field of acoustic waves. Contents 1. Overview of Microwave and Optical Metamaterial Technologies,Didier Lippens. 2. MetaLines: Transmission Line Approach for the Design ofMetamaterial Devices, Bruno Sauviac. 3. Metamaterials for Non-Radiative Microwave Functions andAntennas, Divitha Seetharamdoo and Bruno Sauviac. 4. Toward New Prospects for Electromagnetic Compatibility, DivithaSeetharamdoo. 5. Dissipative Loss in Resonant Metamaterials, Philippe Tassin,Thomas Koschny, and Costas M. Soukoulis. 6. Transformation Optics and Antennas, André de Lustrac, ShahNawaz Burokur and Paul-Henri Tichit. 7. Metamaterials for Control of Surface Electromagnetic and LiquidWaves, Sébastien Guenneau, Mohamed

Farhat, Muamer Kadic,Stefan Enoch and Romain Quidant. 8. Classical Analog of Electromagnetically Induced Transparency,Philippe Tassin, Thomas Koschny and Costas M. Soukoulis.

Phononic crystals are artificial periodic structures that can alter efficiently the flow of sound, acoustic waves, or elastic waves. They were introduced about twenty years ago and have gained increasing interest since then, both because of their amazing physical properties and because of their potential applications. The topic of phononic crystals stands as the cross-road of physics (condensed matter physics, wave propagation in inhomogeneous and periodic media) and engineering (acoustics, ultrasonics, mechanical engineering, electrical engineering). Phononic crystals cover a wide range of scales, from meter-size periodic structures for sound in air to nanometer-size structures for information processing or thermal phonon control in integrated circuits. Phononic crystals have a definite relation with the topic of photonic crystals in optics. The marriage of phononic and photonic crystals also provides a promising structural basis for enhanced sound and light interaction. As the topic is getting popular, it is nowadays presented and discussed at various international conferences. After the first ten years during which the topic has remained mainly theoretical with a few proof-of-concept demonstrations in the literature, the evolution has been

towards applications, instrumentation, and novel designs. The physical explanations for various effects are now well understood and efficient numerical methods and analysis tools have been developed. The book contains a comprehensive set of finite element model (FEM) scripts for solving basic phononic crystal problems. The scripts are short, easy to read, and efficient, allowing the reader to generate for him(her)self band structures for 2D and 3D phononic crystals, to compute Bloch waves, waveguide and cavity modes, and more.

Sound-Power Flow: A practitioner's handbook for sound intensity is a guide for practitioners and research scientists in different areas of acoustical science. There are three fundamental quantities in acoustics: sound pressure, sound particle velocity, and sound intensity. This book is about sound intensity and demonstrates the advantages and uses of acoustical sensing compared with other forms of sensing. It describes applications such as: measuring total sound power; directional hearing of humans and mammals; echolocation; measuring sound-power flow in ducts; and uses of non-contact, focused, high-frequency, pulse-echo ultrasonic probes. This book presents computational approaches using standard mathematics, and relates these to the measurement of sound-power flow in air and water. It also uses linear units rather than logarithmic units –

this making computation in acoustics simpler and more accessible to advanced mathematics and computing. The book is based on work by the author and his associates at General Motors, the University of Mississippi, and Sonometrics.

This book presents the latest developments and applications of micromechanics and nanomechanics. It particularly focuses on some recent applications and impact areas of micromechanics and nanomechanics that have not been discussed in traditional micromechanics and nanomechanics books on metamaterials, micromechanics of ferroelectric/piezoelectric, electromagnetic materials, micromechanics of interface, size effects and strain gradient theories, computational and experimental nanomechanics, multiscale simulations and theories, soft matter composites, and computational homogenization theory. This book covers analytical, experimental, as well as computational and numerical approaches in depth.

Metamaterials and Wave ControlJohn Wiley & Sons

Phononic crystals and acoustic metamaterials are heterogeneous materials that enable manipulation of elastic waves. An important characteristic of these heterogeneous systems is their ability to tailor the propagation of elastic waves due to the existence of band gaps -- frequency ranges of strong wave attenuation. In this Thesis, I report discoveries of three new types of band gaps: i)

Band gaps induced by geometric frustration in periodic acoustic channel networks; ii) Band gap induced by high connectivity in periodic beam lattices; and iii) Topological band gaps in gyroscopic phononic crystals that protects one-way edge waves. The investigations presented here shed new light on the rich dynamic properties of phononic crystals and acoustic metamaterials, opening avenues for new strategies to control mechanical waves in elastic systems.

This volume provides an overview of the recent advances in the field of paper microfluidics, whose innumerable research domains have stimulated considerable efforts to the development of rapid, cost-effective and simplified point-of-care diagnostic systems. The book is divided into three parts viz. theoretical background of paper microfluidics, fabrication techniques for paper-based devices, and broad applications. Each chapter of the book is self-explanatory and focuses on a specific topic and its relation to paper microfluidics and starts with a brief description of the topic's physical background, essential definitions, and a short story of the recent progress in the relevant field. The book also covers the future outlook, remaining challenges, and emerging opportunities. This book shall be a tremendous up-to-date resource for researchers working in the area globally.

Metamaterials are composite materials whose dynamic microstructure results in

macroscopically observable properties beyond those available in nature. The emergence of metamaterials has enabled unprecedented control of electromagnetic, elastodynamic, and acoustic wave propagation and has led to technologies including invisibility cloaks, super- and hyper-lenses, and subwavelength bandgaps. These effects are made possible through the hidden degrees of freedom afforded by the dynamic microstructure. Analytically, the macroscopically observed parameters are the result of a dynamic homogenization procedure using weighted field averages over a representative volume element of the composite. After performing the homogenization procedure, constitutive relations reveal the dependencies between macroscopic fields and metamaterial properties. Recent research has demonstrated that dynamic homogenization results in constitutive relations that are coupled, which is not the case for most traditional materials. This general effect is well-known in electromagnetism and is known as bianisotropy, but the analogous effect in elastodynamics and acoustics was discovered more recently and is also often referred to as Willis coupling. However, most current homogenization schemes are modeled to determine macroscopic properties in the same form as traditional materials and therefore do not account for coupled constitutive relations. Additionally in the absence of embedded sources, metamaterial parameters are

non-unique, which allows for macroscopic descriptions that only include traditional parameters or traditional parameters and coupling parameters. For acoustic metamaterials, the traditional properties are density and compressibility. The additional coupling parameters result in macroscopic momentum density and volume strain fields that are coupled due to both being dependent on macroscopic acoustic particle velocity and pressure fields. This dissertation explores the analogs between bianisotropy in electromagnetism, elastodynamics, and acoustics and the consequences of neglecting these effects on the physical interpretation of acoustic metamaterial parameters. The analogs are used to provide a qualitative understanding of the origin of coupling parameters, and a multiple scattering homogenization procedure is derived to demonstrate coupling due to asymmetry and nonlocal effects. Additionally, the restrictions of causality, passivity, and reciprocity on acoustic metamaterial parameters are derived, and it is demonstrated that macroscopic descriptions that neglect bianisotropy in one-dimensional acoustic metamaterials do not in general satisfy these restrictions. Sonic/phononic crystals termed acoustic/sonic band gap media are elastic analogues of photonic crystals and have also recently received renewed attention in many acoustic applications. Photonic crystals have a periodic dielectric modulation with a spatial scale on the order of the optical wavelength. The design

and optimization of photonic crystals can be utilized in many applications by combining factors related to the combinations of intermixing materials, lattice symmetry, lattice constant, filling factor, shape of the scattering object, and thickness of a structural layer. Through the publications and discussions of the research on sonic/phononic crystals, researchers can obtain effective and valuable results and improve their future development in related fields. Devices based on these crystals can be utilized in mechanical and physical applications and can also be designed for novel applications as based on the investigations in this Special Issue.

Since the concept was first proposed at the end of the 20th Century, metamaterials have been the subject of much research and discussion throughout the wave community. More than 10 years later, the number of related published articles is increasing significantly. On the one hand, this success can be attributed to dreams of new physical objects which are the consequences of the singular properties of metamaterials. Among them, we can consider the examples of perfect lensing and invisibility cloaking. On other hand, metamaterials also provide new tools for the design of well-known wave functions such as antennas for electromagnetic waves. The goal of this book is to propose an overview of the concept of metamaterials as a perspective on a new practical

tool for wave study and engineering. This includes both the electromagnetic spectrum, from microwave to optics, and the field of acoustic waves. Contents 1. Overview of Microwave and Optical Metamaterial Technologies, Didier Lippens. 2. MetaLines: Transmission Line Approach for the Design of Metamaterial Devices, Bruno Sauviac. 3. Metamaterials for Non-Radiative Microwave Functions and Antennas, Divitha Seetharamdoo and Bruno Sauviac. 4. Toward New Prospects for Electromagnetic Compatibility, Divitha Seetharamdoo. 5. Dissipative Loss in Resonant Metamaterials, Philippe Tassin, Thomas Koschny, and Costas M. Soukoulis. 6. Transformation Optics and Antennas, André de Lustrac, Shah Nawaz Burokur and Paul-Henri Tichit. 7. Metamaterials for Control of Surface Electromagnetic and Liquid Waves, Sébastien Guenneau, Mohamed Farhat, Muamer Kadic, Stefan Enoch and Romain Quidant. 8. Classical Analog of Electromagnetically Induced Transparency, Philippe Tassin, Thomas Koschny and Costas M. Soukoulis.

This book highlights the acoustical metamaterials' capability to manipulate the direction of sound propagation in solids which in turn control the scattering, diffraction and refraction, the three basic mechanisms of sound propagation in solids. This gives rise to several novel theories and applications and hence the name new acoustics. As an introduction, the book mentions that symmetry of acoustic fields is the theoretical

framework of acoustical metamaterials. This is then followed by describing that acoustical metamaterials began with locally resonant sonic materials which ushered in the concept of negative acoustic parameters such as mass density and bulk modulus. This complies with form invariance of the acoustic equation of motion which again exemplifies the symmetry property of acoustic fields.

This book provides an in-depth analysis as well as an overview of phononic crystals. This book discusses numerous techniques for the analysis of phononic crystals and covers, among other material, sonic and ultrasonic structures, hypersonic planar structures and their characterization, and novel applications of phononic crystals. This is an ideal book for those working with micro and nanotechnology, MEMS (microelectromechanical systems), and acoustic devices. This book also: Presents an introduction to the fundamentals and properties of phononic crystals Covers simulation techniques for the analysis of phononic crystals Discusses sonic and ultrasonic, hypersonic and planar, and three-dimensional phononic crystal structures Illustrates how phononic crystal structures are being deployed in communication systems and sensing systems

This book is the first of 2 special volumes dedicated to the memory of Gérard Maugin. Including 40 papers that reflect his vast field of scientific activity, the contributions discuss non-standard methods (generalized model) to demonstrate the wide range of subjects that were covered by this exceptional scientific leader. The topics range from

micromechanical basics to engineering applications, focusing on new models and applications of well-known models to new problems. They include micro–macro aspects, computational endeavors, options for identifying constitutive equations, and old problems with incorrect or non-satisfying solutions based on the classical continua assumptions.

This book offers an essential introduction to the notions of sound wave topology, duality, coherence and wave-mixing, which constitute the emerging new science of sound. It includes general principles and specific examples that illuminate new non-conventional forms of sound (sound topology), unconventional quantum-like behavior of phonons (duality), radical linear and nonlinear phenomena associated with loss and its control (coherence), and exquisite effects that emerge from the interaction of sound with other physical and biological waves (wave mixing). The book provides the reader with the foundations needed to master these complex notions through simple yet meaningful examples. General principles for unraveling and describing the topology of acoustic wave functions in the space of their Eigen values are presented. These principles are then applied to uncover intrinsic and extrinsic approaches to achieving non-conventional topologies by breaking the time reversal symmetry of acoustic waves. Symmetry breaking can impart topological immunity to wave degradation from imperfection scattering and catalyze controlled coherence. In the intrinsic case and the phonon representation of acoustic waves, the self-interaction/interference of a wave

through its supporting medium exposes the notion of duality in the quantum statistics (i.e. boson vs. fermion characterized by the symmetry of multiple particle states) and how the quantum analogue behaviors of sound can be exploited in the form of novel sound-based information transfer and processing devices. By considering media that mix different types of waves, the book addresses the interaction of sound with other physical and biological waves but also brings to light examples of extrinsic processes that can lead to symmetry breaking. The coherent conversion of sound into other types of waves as well as the sound-induced non-conventional topology of elastic, electronic, spin and biological waves are presented in the case of media exhibiting elasto-electronic, photo-elastic, magneto-elastic effects and biological mechano-transduction. Requiring no advanced knowledge of wave propagation, An Introduction to Metamaterials and Waves in Composites focuses on theoretical aspects of metamaterials, periodic composites, and layered composites. The book gives novices a platform from which they can start exploring the subject in more detail. After introducing concepts related to elasticity, acoustics, and electrodynamics in media, the text presents plane wave solutions to the equations that describe elastic, acoustic, and electromagnetic waves. It examines the plane wave expansion of sources as well as scattering from curved interfaces, specifically spheres and cylinders. The author then covers electrodynamic, acoustic, and elastodynamic metamaterials. He also describes examples of transformations, aspects of acoustic cloaking, and applications of

pentamode materials to acoustic cloaking. With a focus on periodic composites, the text uses the Bloch-Floquet theorem to find the effective behavior of composites in the quasistatic limit, presents the quasistatic equations of elastodynamic and electromagnetic waves, and investigates Brillouin zones and band gaps in periodic structures. The final chapter discusses wave propagation in smoothly varying layered media, anisotropic density of a periodic layered medium, and quasistatic homogenization of laminates. This book provides a launch pad for research into elastic and acoustic metamaterials. Many of the ideas presented have yet to be realized experimentally—the book encourages readers to explore these ideas and bring them to technological maturity.

Engineering practice has revealed that innovative technologies' structural applications require new design concepts related to developing materials with mechanical properties tailored for construction purposes. This would allow the efficient use of engineering materials. The efficiency can be understood in a simplified and heuristic manner as the optimization of performance and the proper combination of structural components, leading to the consumption of the least amount of natural resources. The solution to the eco-optimization problem, based on the adequate characterization of the materials, will enable implementing environmentally friendly engineering principles when the efficient use of advanced materials guarantees the required structural safety. Identifying fundamental relationships between the structure of advanced composites and their

physical properties is the focus of this book. The collected articles explore the development of sustainable composites with valorized manufacturability corresponding to Industrial Revolution 4.0 ideology. The publications, amongst others, reveal that the application of nano-particles improves the mechanical performance of composite materials; heat-resistant aluminium composites ensure the safety of overhead power transmission lines; chemical additives can detect the impact of temperature on concrete structures. This book demonstrates that construction materials' choice has considerable room for improvement from a scientific viewpoint, following heuristic approaches.

Manufacturing Techniques for Materials: Engineering and Engineered provides a cohesive and comprehensive overview of the following: (i) prevailing and emerging trends, (ii) emerging developments and related technology, and (iii) potential for the commercialization of techniques specific to manufacturing of materials. The first half of the book provides the interested reader with detailed chapters specific to the manufacturing of emerging materials, such as additive manufacturing, with a valued emphasis on the science, technology, and potentially viable practices specific to the manufacturing technique used. This section also attempts to discuss in a lucid and easily understandable manner the specific advantages and limitations of each technique and goes on to highlight all of the potentially viable and emerging technological applications. The second half of this archival volume focuses on a wide

spectrum of conventional techniques currently available and being used in the manufacturing of both materials and resultant products. Manufacturing Techniques for Materials is an invaluable tool for a cross-section of readers including engineers, researchers, technologists, students at both the graduate level and undergraduate level, and even entrepreneurs.

Acoustic/Elastic metamaterials have attracted increased attention in recent times. Metamaterials are defined as special materials that exhibit unusual properties not normally found in normal materials. These unusual properties are derived from the specially designed microstructures rather than the chemical composition of the material. Based on the concept of locally resonant metamaterials, these materials are applied in many applications such as impact wave attenuation, blast wave mitigation and wave control and manipulation due to their flexibility and tailoring properties for various needed applications. In this thesis, we present the development of a dissipative elastic metamaterial with multiple Maxwell-type resonators for dynamic load mitigation. Besides the wave attenuation of dynamic loads, we also investigate the asymmetric transmission of elastic waves which has recently been realized by linear structures. We design and propose different diatomic and triatomic elastic metamaterials to obtain large asymmetric elastic wave transmission in multiple low-frequency bands. All these frequency bands can be theoretically predicted to realize one-way wave propagation along different directions of transmission. All proposed models in this research are

analytically investigated and numerically verified by both analytical lattice and continuum models. Also, the dynamic responses of the proposed models are explored and analyzed in time and frequency domains. The effect of damping on the proposed models is also investigated for more practical applications. Lastly, experimental verification is further conducted to observe wave asymmetric transmission bands and transient wave responses in time and frequency domains are also explored.

This research monograph provides a brief overview of the authors' research in the area of ordered granular media over the last decade. The exposition covers one-dimensional homogeneous and dimer chains in great detail incorporating novel analytical tools and experimental results supporting the analytical and numerical studies. The proposed analytical tools have since been successfully implemented in studying two-dimensional dimers, granular dimers on on-site perturbations, solitary waves in Toda lattices to name a few. The second part of the monograph dwells on weakly coupled homogeneous granular chains from analytical, numerical and experimental perspective exploring the interesting phenomenon of Landau–Zener tunneling in granular media. The final part of the monograph provides a brief introduction to locally resonant acoustic metamaterials incorporating internal rotators and the resulting energy channeling mechanism in unit-cells and in one- and two-dimensional lattices. The monograph provides a comprehensive overview of the research in this interesting domain. However, this exposition is not all exhaustive with regard to equally exciting research by other researchers across the globe, but we provide an exhaustive list of references for the interested readers to further explore in this direction.

Experimental and Applied Mechanics, Volume 6: Proceedings of the 2014 Annual Conference on Experimental and Applied Mechanics, the sixth volume of eight from the Conference, brings together contributions to important areas of research and engineering. The collection presents early findings and case studies on a wide range of topics, including: Advances in Residual Stress Measurement Methods Residual Stress Effects on Material Performance Inverse Problems and Hybrid Techniques Thermoelastic Stress Analysis Infrared Techniques Research in Progress Applications in Experimental Mechanics

Bringing together contributions on a diverse range of topics, this text explores the relationship between discrete and continuum mechanics as a tool to model new and complex metamaterials. Providing a comprehensive bibliography and historical review of the field, it covers mechanical, acoustic and pantographic metamaterials, discusses Naive Model Theory and Lagrangian discrete models, and their applications, and presents methods for pantographic structures and variational methods for multidisciplinary modeling and computation. The relationship between discrete and continuous models is discussed from both mathematical and engineering viewpoints, making the text ideal for those interested in the foundation of mechanics and computational applications, and innovative viewpoints on the use of discrete systems to model metamaterials are presented for those who want to go deeper into the field. An ideal text for graduate students and researchers interested in continuum approaches to the study of modern materials, in mechanical engineering, civil engineering, applied mathematics, physics, and materials science.

This book delivers a comprehensive and up-to-date treatment of practical applications of metamaterials, structured media, and conventional porous materials. With increasing levels of

urbanization, a growing demand for motorized transport, and inefficient urban planning, environmental noise exposure is rapidly becoming a pressing societal and health concern. Phononic and sonic crystals, acoustic metamaterials, and metasurfaces can revolutionize noise and vibration control and, in many cases, replace traditional porous materials for these applications. In this collection of contributed chapters, a group of international researchers reviews the essentials of acoustic wave propagation in metamaterials and porous absorbers with viscothermal losses, as well as the most recent advances in the design of acoustic metamaterial absorbers. The book features a detailed theoretical introduction describing commonly used modelling techniques such as plane wave expansion, multiple scattering theory, and the transfer matrix method. The following chapters give a detailed consideration of acoustic wave propagation in viscothermal fluids and porous media, and the extension of this theory to non-local models for fluid saturated metamaterials, along with a description of the relevant numerical methods. Finally, the book reviews a range of practical industrial applications, making it especially attractive as a white book targeted at the building, automotive, and aeronautic industries.

To meet the demands of students, scientists and engineers for a systematic reference source, this book introduces, comprehensively and in a single voice, research and development progress in emerging metamaterials and derived functional metadevices. Coverage includes electromagnetic, optical, acoustic, thermal, and mechanical metamaterials and related metadevices. Metamaterials are artificially engineered composites with designed properties beyond those attainable in nature and with applications in all aspects of materials science. From spatially tailored dielectrics to tunable, dynamic materials properties and unique

nonlinear behavior, metamaterial systems have demonstrated tremendous flexibility and functionality in electromagnetic, optical, acoustic, thermal, and mechanical engineering. Furthermore, the field of metamaterials has been extended from the mere pursuit of various exotic properties towards the realization of practical devices, leading to the concepts of dynamically-reconfigurable metadevices and functional metasurfaces. The book explores the fundamental physics, design, and engineering aspects, as well as the full array of state-of-the-art applications to electronics, telecommunications, antennas, and energy harvesting. Future challenges and potential in regard to design, modeling and fabrication are also addressed.
This book presents a collection of chapters on the current problems of the theory of dynamical processes in generalized continua and structures, and has been compiled to commemorate the 70th birthday of Prof. Dmitry Indeitsev – a leading specialist in the field of dynamical processes in solids, fluids and structures. It discusses various applications related to Prof. Indeitsev's contributions, including various discrete and continuous dynamic models of structures and media, as well as a number of dynamical processes in generalized media.