Design and Development of MEMS Based Guided Beam Type Piezoelectric Energy Harvester

Wireless sensors and sensor networks (WSNs) are nowadays becoming increasingly important due to their decisive advantages. Different trends towards the Internet of Things (IoT), Industry 4.0 and 5G Networks address massive sensing and admit to have wireless sensors delivering measurement data directly to the Web in a reliable and easy manner. These sensors can only be supported, if sufficient energy efficiency and flexible solutions are developed for energy-aware wireless sensor nodes. In the last years, different possibilities for energy harvesting have been investigated showing a high level of maturity. This book gives therefore an overview on fundamentals and techniques for energy harvesting and energy transfer from different points of view. Different techniques and methods for energy transfer, management and energy saving on network level are reported together with selected interesting applications. The book is interesting for researchers, developers and students in the field of sensors, wireless sensors, WSNs, IoT and manifold application fields using related technologies. The book is organized in four major parts. The first part of the book introduces essential fundamentals and methods, while the second part focusses on vibration converters and hybridization. The third part is dedicated to wireless energy transfer, including both RF and inductive energy transfer. Finally, the fourth part of the book treats energy saving and management strategies. The main contents are:

- Essential fundamentals and methods of wireless sensors
- Energy harvesting from vibration Hybrid vibration energy converters Electromagnetic transducers Piezoelectric transducers Magneto-electric transducers Non-linear broadband converters
- Energy transfer via magnetic fields RF energy transfer Energy saving techniques
- Energy management strategies

Applications in agriculture Applications in structural health monitoring Application in power grids

Prof. Dr. Olfa Kanoun is professor for measurement and sensor technology at Chemnitz university of technology. She is specialist in the field of sensors and sensor systems design.

Wireless Power/Data Transfer, Energy Harvesting System Design
This book presents basic and advanced concepts for energy harvesting and energy efficiency, as well as related technologies, methods, and their applications. The book provides up-to-date knowledge and discusses the state-of-the-art equipment and methods used for energy harvesting and energy efficiency, combining theory and practical applications. Containing over 200 illustrations and problems and solutions, the book begins with overview chapters on the status quo in this field. Subsequent chapters introduce readers to advanced concepts and methods. In turn, the final part of the book is dedicated to technical strategies, efficient methods and applications in the field of energy efficiency, which also makes it of interest to technicians in industry. The book tackles problems commonly encountered using basic methods of energy harvesting and energy efficiency, and proposes advanced methods to resolve these issues. All the methods proposed have been validated through simulation and experimental results. These “hot topics” will continue to be of interest to scientists and engineers in future decades and will provide challenges to researchers around the globe as issues of climate change and changing energy policies become more pressing. Here, readers will find all the basic and advanced concepts they need. As such, it offers a valuable, comprehensive guide for all students and practicing engineers who wishing to learn about and work in these fields.

Advances in Rotor Dynamics, Control, and Structural Health Monitoring

The book starts with the fundamentals of triboelectric nanogenerators (TENGs), and continues through to fabrication technologies to achieve flexible and stretchable. Then self-powered flexible microsystems are introduced and application examples are presented, including TENG-based active sensors, TENG-powered actuators, artificial intelligence and integrated systems.

Applications of Energy Harvesting Technologies in Buildings

Digital transformation (DT) has become a buzzword. Every industry segment across the globe is consciously jumping toward digital innovation and disruption to get ahead of their competitors. In other words, every aspect of running a business is being digitally empowered to reap all the benefits of the digital paradigm. All kinds of digitally enabled businesses across the globe are intrinsically capable of achieving bigger and better things for their constituents. Their consumers, clients, and customers will realize immense benefits with real digital transformation initiatives and implementations. The much-awaited business transformation can be easily and elegantly accomplished with a workable and winnable digital transformation strategy, plan, and execution. There are several enablers and accelerators for realizing the much-discussed digital transformation. There are a lot of digitization and digitalization technologies available to streamline and speed up the process of the required transformation. Industrial Internet of Things (IIoT) technologies in close association with decisive advancements in the artificial intelligence (AI) space can bring forth the desired transitions. The other prominent and dominant technologies toward forming digital organizations include cloud IT, edge/fog computing, real-time data analytics platforms, blockchain technology, digital twin paradigm, virtual and augmented reality (VR/AR) techniques, enterprise mobility, and 5G communication. These technological innovations are intrinsically competent and versatile enough to fulfill the varying requirements for establishing and sustaining digital enterprises. Enterprise Digital Transformation: Technology, Tools, and Use Cases features chapters on the evolving aspects of digital transformation and intelligence. It covers the unique competencies of digitally transformed enterprises, IIoT use cases, and applications. It explains promising technological solutions widely associated with digital innovation and disruption. The book focuses on setting up and sustaining smart factories that are fulfilling the Industry 4.0 vision that is realized through the IIoT and allied technologies.

Energy Harvesting Autonomous Sensor Systems

This book provides a thorough guide to the use of numerical methods in energy systems and applications. It presents methods for analysing engineering applications for energy systems, discussing finite difference, finite element, and other advanced numerical methods. Solutions to technical problems relating the application of these methods to energy systems are also thoroughly explored. Readers will discover diverse perspectives of the contributing authors and extensive discussions of issues including: • a wide variety of numerical methods concepts and related energy
Based On Piezoelectric And

systems applications; • systems equations and optimization, partial differential equations, and finite difference method; • methods for solving nonlinear equations, special methods, and their mathematical implementation in multi-energy sources; • numerical investigations of electrochemical fields and devices; and • issues related to numerical approaches and optimal integration of energy consumption. This is a highly informative and carefully presented book, providing scientific and academic insight for readers with an interest in numerical methods and energy systems.

Nonlinear Aspects and Performance of Hybrid Aeroelastic Energy Harvesters

This research provides a platform for a novel innovative approach toward an off-grid energy harvesting system for Maglev VAWT. This stand-alone system can make a difference for using small-scale electronic devices. The configuration presents a 200 W 12 V 16 Pole AFPMSG attached to Maglev VAWT of 14.5 cm radius and 60 cm of height. The energy harvesting circuit shows better efficiency in charging battery in all aspects compared to direct charging of battery regardless with or without converter. Based on analysis and results carried out in this research, all feasibility studies and information are provided for the next barrier.

Energy Harvesting and Energy Efficiency

This book is a printed edition of the Special Issue "Piezoelectric MEMS" that was published in Micromachines

Energy Harvesting Wireless Communications

Piezoelectric energy is a renewable alternative energy source that operates on a smaller scale than renewable energy generation plants which generate Mega-Giga Watts of power. Its potential to 'eliminate' contemporary batteries, which are classified as hazardous wastes, makes it an important technological advancement in a world increasingly concerned about eliminating waste, increasing sustainability and shifting to more 'green' consumption habits. Authored by a pioneer of piezoelectric actuators and piezoelectric energy harvesting, this unique compendium provides a solid theoretical background of piezoelectrics, practical material selection, device design optimization, and energy harvesting electric circuits. Included in each chapter are a list of chapter essentials, check points, example problems and solutions, and practice problems. Written for advanced undergraduate and graduate students, university researchers, and industry engineers studying or working in the field of piezoelectric energy harvesting systems, the useful reference text provides readers with the essential knowledge to conduct research and raises readers' awareness of known pitfalls and mis-directions in the field.

Triboelectric Nanogenerators

Discover state-of-the-art developments in textile-based wearable and stretchable electronics from leaders in the field In Textile-Based Energy Harvesting and Storage Devices for Wearable Electronics, renowned researchers Professor Xing Fan and his co-authors deliver an insightful and rigorous exploration of textile-based energy harvesting and storage systems. The book covers the principles of smart fibers and fabrics, as well as their fabrication methods. It introduces, in detail, several fiber- and fabric-based energy harvesting and storage devices, including photovoltaics, piezoelectrics, triboelectrics, supercapacitors, batteries, and sensing and self-powered electric fabrics. The authors also discuss expanded functions of smart fabrics, like stretchability, hydrophobicity, air permeability and color-changeability. The book includes sections on emerging electronic fibers and textiles, including stress-sensing, strain-sensing, and chemical-sensing textiles, as well as emerging self-powered electronic textiles. Textile-Based Energy Harvesting and Storage Devices for Wearable Electronics concludes with an in-depth treatment of upcoming challenges, opportunities, and commercialization requirements for electronic textiles, providing valuable insight into a highly lucrative new commercial sector. The book also offers: A thorough introduction to the evolution from classical functional fibers to intelligent fibers and textiles An exploration of typical film deposition technologies, like dry-process film deposition and wet-process technologies for roll-to-roll device fabrication Practical discussions of the fabrication process of intelligent fibers and textiles, including
the synthesis of classical functional fibers and nano/micro assembly on fiber materials In-depth examinations of energy harvesting and energy storage fibers, including photovoltaic, piezoelectric, and supercapacitor fibers Perfect for materials scientists, engineering scientists, and sensor developers, Textile-Based Energy Harvesting and Storage Devices for Wearable Electronics is also an indispensable resource for electrical engineers and professionals in the sensor industry seeking a one-stop reference for fiber- and fabric-based energy harvesting and storage systems for wearable and stretchable power sources.

**Piezoelectric MEMS**

A thorough treatment of the principles, applications and system integration of energy harvesting technology.

**Organic Ferroelectric Materials and Applications**

Energy Harvesting Autonomous Sensor Systems: Design, Analysis, and Practical Implementation provides a wide range of coverage of various energy harvesting techniques to enable the development of a truly self-autonomous and sustainable energy harvesting wireless sensor network (EH-WSN). It supplies a practical overview of the entire EH-WSN system from energy source all the way to energy usage by wireless sensor nodes/network. After an in-depth review of existing energy harvesting research thus far, the book focuses on: Outlines two wind energy harvesting (WEH) approaches, one using a wind turbine generator and one a piezoelectric wind energy harvester Covers thermal energy harvesting (TEH) from ambient heat sources with low temperature differences Presents two types of piezoelectric-based vibration energy harvesting systems to harvest impact or impulse forces from a human pressing a button or switch action Examines hybrid energy harvesting approaches that augment the reliability of the wireless sensor node’s operation Discusses a hybrid wind and solar energy harvesting scheme to simultaneously use both energy sources and therefore extend the lifetime of the wireless sensor node Explores a hybrid of indoor ambient light and TEH scheme that uses only one power management circuit to condition the combined output power harvested from both energy sources Although the author focuses on small-scale energy harvesting, the systems discussed can be upsized to large-scale renewable energy harvesting systems. The book goes beyond theory to explore practical applications that not only solve real-life energy issues but pave the way for future work in this area.

**Micro Energy Harvesting**

**Supercapacitor-Based Hybrid Energy Harvesting for Low-Voltage System**

This book introduces an innovative and high-efficiency technology for mechanical energy harvesting. The book covers the history and development of triboelectric nanogenerators, basic structures, working principles, performance characterization, and potential applications. It is divided into three parts: Part A illustrates the fundamental working modes of triboelectric nanogenerators with their prototype structures and theoretical analysis; Part B and Part C introduce two categories of applications, namely self-powered systems and self-powered active sensors. The book will be an ideal guide to scientists and engineers beginning to study triboelectric nanogenerators or wishing to deepen their knowledge of the field. Readers will be able to place the technical details about this technology in context, and acquire the necessary skills to reproduce the experimental setups for fabrication and measurement.

**Energy Harvesting Autonomous Sensor Systems**

Energy Harvesting Autonomous Sensor Systems: Design, Analysis, and Practical Implementation provides a wide range of coverage of various energy harvesting techniques to enable the development of a truly self-autonomous and sustainable energy harvesting wireless sensor network (EH-WSN). It supplies a practical overview of the entire EH-WSN system from energy source all the way to energy usage by wireless sensor nodes/network. After an in-depth review of existing energy harvesting research thus far, the book focuses on: Outlines two wind energy harvesting (WEH) approaches, one using a wind turbine generator and one a piezoelectric wind energy harvester Covers thermal energy harvesting (TEH) from ambient heat sources with low temperature differences Presents two types of piezoelectric-based vibration energy harvesting systems to harvest impact or impulse forces from a human pressing a button or switch action Examines hybrid energy harvesting approaches that augment the reliability of the wireless sensor node’s operation Discusses a hybrid wind and solar energy harvesting scheme to simultaneously use both energy sources and therefore extend the lifetime of the wireless sensor node Explores a hybrid of indoor ambient light and TEH scheme that uses only one power management circuit to condition the combined output power harvested from both energy sources Although the author focuses on small-scale energy harvesting, the systems discussed can be upsized to large-scale renewable energy harvesting systems. The book goes beyond theory to explore practical applications that not only solve real-life energy issues but pave the way for future work in this area.
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**Beyond-CMOS Nanodevices 1**

Wind Turbines and Aerodynamics Energy Harvesters not only presents the most research-focused resource on aerodynamic energy harvesters, but also provides a detailed review on aeroacoustics characteristics. The book considers all developing aspects of 3D printed miniature and large-size Savonious wind harvesters, while also introducing and discussing bladeless and aeroelastic harvesters. Following with a review of Off-shore wind turbine aerodynamics modeling and measurements, the book continues the discussion by comparing the numerical codes for floating offshore wind turbines. Each chapter contains a detailed analysis and numerical and experimental case studies that consider recent research design, developments, and their application in practice. Written by an experienced, international team in this cross-disciplinary field, the book is an invaluable reference for wind power engineers, technicians and manufacturers, as well as researchers examining one of the most promising and efficient sources of renewable energy. Offers numerical models and case studies by experienced authors in this field Contains an overview and analysis of the latest research Explores 3D printing technology and the production of wind harvesters for real applications Includes, and uses, ANSYS FLUENT case files

**Design, Modelling and Fabrication of a Hybrid Energy Harvester**

Wireless Power Transfer (WPT) is considered to be an innovative game changing technology. The same radio wave and electromagnetic field theory and technology for wireless communication and remote sensing is applied for WPT. In conventional wireless communication systems, information is "carried" on a radio wave and is then transmitted over a distance. In WPT however, the energy of the radio wave itself is transmitted over a distance. Wireless communication technology has proven to be extremely useful, however in future it should be even more useful to apply both wireless communication and wireless power technologies together. There are various WPT technologies, e.g. inductive near field WPT, resonance coupling WPT, WPT via radio waves, and laser power transfer. Recent Wireless Power Transfer Technologies via Radio Waves focusses on recent technologies and applications of the WPT via radio waves in far field. The book also covers the history, and future, of WPT via radio waves, as well as safety, EMC and coexistence of radio waves for WPT. Technical topics discussed in the book include: Radio Wave Generation Radio Wave Amplification with Solid States Circuit and Microwave Tubes Antenna and Beam Forming Technologies Radio Wave Conversion/Rectification to Electricity Battery-less Sensor Applications toward Internet of Things (IoT) Solar Power Satellite Application Safety, EMC, Coexistence of Radio Waves for the WPT WPT is an old technology based on the basic theory of radio waves, however WPT is also a state-of-the-art technology for the latest applications in IoT, sensor networks, wireless chargers for mobile phones, and solar power satellite. The theory behind these technologies, as well as applications, are explained in this book.

**Design of Miniaturized Variable-Capacitance Electrostatic Energy Harvesters**
The recent advent of micro-electro-mechanical systems has increased the demand for localized energy harvesting. The autonomous gadgets, structural health monitoring sensors, wireless sensors, and pacemakers are all paving their ways in our lives. These electronic devices demand innovative ways of powering them effectively and efficiently. Various ambient excitations can be used from the environment like base or aeroelastic. For converting this wasted mechanical energy, several transduction mechanisms are employed, like piezoelectric, electromagnetic, and electrostatic. This dissertation is a step forward in meeting the localized energy demand for operating low-power electronic devices by using a hybrid formation of piezoelectric material and electromagnet-coil arrangement for harnessing aeroelastic oscillations. Therefore in the first part of this dissertation, this hybrid configuration is utilized to discuss energy harvesting by a cantilever beam and prismatic-shaped cylinder subjected to wind flow from transverse direction, by using a special class of aeroelastic oscillations known as galloping. After establishing the importance of accurate modeling of aeroelastic galloping force, we proceed on to discuss about hybrid energy harvesting. The inclined square section cylinders are investigated to harvest aeroelastic energy offered by galloping oscillations using accurate modeling proposed in the first part, again by using a hybrid configuration. The last part of harvesting energy by galloping oscillation using a hybrid transduction mechanism deals with using the same cantilever based hybrid galloping harvester, but this time by inclusion of a non-rigid support exhibiting non-zero slope. The impact of such support on piezoelectric and electromagnetic energy harvesting is investigated in detail. The second part of this dissertation deals with using the same hybrid configuration for harnessing aeroelastic energy by using another, rather well-known class, named vortex-induced vibrations. The different tools of nonlinear dynamics and vibrations, such as Galerkin discretization, Normal form of Hopf bifurcation, and shooting method are used to dissect the hybrid energy harvesters in length throughout the Dissertation. It is concluded at the end that hybrid energy harvesters come with their own added shunt damping effects because of an additional transducer to a single functioning transducer, whether an added piezoelectric layer or an electromagnet-inductive coil. At the same time, careful selection of the electrical load resistances of respective piezoelectric and electromagnetic circuits would interplay with each other, can help bring the overall coupled damping of hybrid formation to acceptable reduced levels. This careful selection can help replace a sole classical electromagnetic or piezoelectric harvester with a hybrid one which can power multiple electronic lower power gadgets.

Intelligent Materials and Structures

Digital transformation (DT) has become a buzzword. Every industry segment across the globe is consciously jumping toward digital innovation and disruption to get ahead of their competitors. In other words, every aspect of running a business is being digitally empowered to reap all the benefits of the digital paradigm. All kinds of digitally enabled businesses across the globe are intrinsically capable of achieving bigger and better things for their constituents. Their consumers, clients, and customers will realize immense benefits with real digital transformation initiatives and implementations. The much-awaited business transformation can be easily and elegantly accomplished with a workable and winnable digital transformation strategy, plan, and execution. There are several enablers and accelerators for realizing the much-discussed digital transformation. There are a lot of digitization and digitalization technologies available to streamline and speed up the process of the required transformation. Industrial Internet of Things (IIoT) technologies in close association with decisive advancements in the artificial intelligence (AI) space can bring forth the desired transitions. The other prominent and dominant technologies toward forming digital organizations include cloud IT, edge/fog computing, real-time data analytics platforms, blockchain technology, digital twin paradigm, virtual and augmented reality (VR/AR) techniques, enterprise mobility, and 5G communication. These technological innovations are intrinsically competent and versatile enough to fulfill the varying requirements for establishing and sustaining digital enterprises. Enterprise Digital Transformation: Technology, Tools, and Use Cases features chapters on the evolving aspects of digital transformation and intelligence. It covers the unique competencies of digitally transformed enterprises, IIoT use cases, and applications. It explains promising technological solutions widely associated with digital innovation and disruption. The book focuses on setting up and
sustaining smart factories that are fulfilling the Industry 4.0 vision that is realized through the IIoT and allied technologies.

**Shock & Vibration, Aircraft/Aerospace, and Energy Harvesting, Volume 9**

With its inclusion of the fundamentals, systems and applications, this reference provides readers with the basics of micro energy conversion along with expert knowledge on system electronics and real-life microdevices. The authors address different aspects of energy harvesting at the micro scale with a focus on miniaturized and microfabricated devices. Along the way they provide an overview of the field by compiling knowledge on the design, materials development, device realization and aspects of system integration, covering emerging technologies, as well as applications in power management, energy storage, medicine and low-power system electronics. In addition, they survey the energy harvesting principles based on chemical, thermal, mechanical, as well as hybrid and nanotechnology approaches. In unparalleled detail this volume presents the complete picture -- and a peek into the future -- of micro-powered microsystems.

**Textile-Based Energy Harvesting and Storage Devices for Wearable Electronics**

This book consists of selected and peer-reviewed papers presented at the 13th International Conference on Vibration Problems (ICOVP 2017). The topics covered in this book are broadly related to the fields of structural health monitoring, vibration control and rotor dynamics. In the structural health monitoring section studies on nonlinear dynamic analysis, damage identification, viscoelastic model of concrete, and seismic damage assessment are thoroughly discussed with analytical and numerical techniques. The vibration control part includes topics such as multi-storied stacked tuned mass dampers, vibration isolation with elastomeric mounts, and nonlinear active vibration absorber. This book will be useful for beginners, researchers and professionals interested in the field of vibration control, structural health monitoring and rotor dynamics.

**Wind Turbines and Aerodynamics Energy Harvesters**

**Essentials Of Piezoelectric Energy Harvesting**

As sources of energy are becoming more scarce and expensive, energy harvesting is receiving more global interest and is currently a growing field. Energy harvesting is the process of converting ambient energy, such as vibration, to electrical energy that can power a multitude of applications. Vibration energy is the by-product of everyday life; it is generated from any perceivable activity. While typically viewed as noise, there is a strong potential for harvesting this energy and deploying it to useful applications. The focus of this thesis will be using vibration as the ambient source of energy. Hybrid energy harvesters employ more than one of the harvesting technologies. In this thesis, two hybrid harvesters that utilize piezoelectric, magnetostrictive, and electromagnetic technologies are designed, modelled, and tested. Both of these harvesters have beams that are spiral in shape. The use of the spiral geometry allows the system to have a lower natural frequency as opposed to the traditional cantilever beam, while still maintaining a high volume of active material. The first harvester that is discussed is the P-MSM harvester. It utilizes piezoelectric and magnetostrictive material. Both materials are configured in a spiral beam geometry and allowed to resonate independently. The resonance frequency of these two materials is designed to create wideband energy harvesting. This allows the harvester to be operating efficiently even if the ambient vibration shifts a small amount. The second harvester that is discussed is the P-MAG harvester. It utilizes piezoelectric and electromagnetic technologies. It also incorporates a spiral geometry for the piezoelectric layers and includes a magnet attached at the centre. The magnet is placed in the centre of the spiral to reduce the natural frequency of the system and to also actively contribute to the harvesting. This harvester has two sources operating at the same resonant frequency, which allows it to have a larger power output than if the sources were separated. Finally, finite element analysis was used to model both harvesters. ANSYS was used for the piezoelectric material and COMSOL was used for the electromagnetic material. The results are compared to the experimental and are in good agreement.
Hybrid Energy Harvesting

Organic Ferroelectric Materials and Applications aims to bring an up-to-date account of the field with discussion of recent findings. This book presents an interdisciplinary resource for scientists from both academia and industry on the science and applications of molecular organic piezo- and ferroelectric materials. The book addresses the fundamental science of ferroelectric polymers, molecular crystals, supramolecular networks, and other key and emerging organic materials systems. It touches on important processing and characterization methods and provides an overview of current and emerging applications of organic piezoelectrics and ferroelectrics for electronics, sensors, energy harvesting, and biomedical technologies. Organic Ferroelectric Materials and Applications will be of special interest to those in academia or industry working in materials science, engineering, chemistry, and physics. Provides an overview of key physical properties of the emerging piezoelectric and ferroelectric molecular and supramolecular systems Discusses best practices of processing, patterning, and characterization methods and techniques Addresses current and emerging applications for electronics, materials development, sensors, energy harvesting, and biomedical technologies

Micro and Nano Energy Harvesting Technologies

This volume surveys recent research on autonomous sensor networks from the perspective of enabling technologies that support medical, environmental and military applications. State of the art, as well as emerging concepts in wireless sensor networks, body area networks and ambient assisted living introduce the reader to the field, while subsequent chapters deal in depth with established and related technologies, which render their implementation possible. These range from smart textiles and printed electronic devices to implanted devices and specialized packaging, including the most relevant technological features. The last four chapters are devoted to customization, implementation difficulties and outlook for these technologies in specific applications.

Hybrid Energy Harvesting Towards a Sustainable Energy System

This book presents device design, layout design, FEM analysis, device fabrication, and packaging and testing of MEMS-based piezoelectric vibration energy harvesters. It serves as a complete guide from design, FEM, and fabrication to characterization. Each chapter of this volume illustrates key insight technologies through images. The book showcases different technologies for energy harvesting and the importance of energy harvesting in wireless sensor networks. The design, simulation, and comparison of three types of structures single beam cantilever structure, cantilever array structure, and guided beam structure have also been reported in one of the chapters. In this volume, an elaborate characterization of two-beam and four-beam fabricated devices has been carried out. This characterization includes structural, material, morphological, topological, dynamic, and electrical characterization of the device. The volume is very concise, easy to understand, and contains colored images to understand the details of each process.

Enterprise Digital Transformation

Power Management Circuits for Hybrid Energy Harvesting

Autonomous Multi-Input Hybrid Energy Harvester Circuit

Seeking renewable and clean energies is essential for releasing the heavy reliance on mineral-based energy and remedying the threat of global warming to our environment. In the last decade, explosive growth in research and development efforts devoted to microelectromechanical systems (MEMS) technology and nanowires-related nanotechnology have paved a great foundation for new mechanisms of harvesting mechanical energy at the micro/nano-meter scale. MEMS-based inertial sensors have been the enabler for numerous applications associated with smart phones, tablets, and
mobile electronics. This is a valuable reference for all those faced with the challenging problems created by the ever-increasing interest in MEMS and nanotechnology-based energy harvesters and their applications. This book presents fundamental physics, theoretical design, and method of modeling for four mainstream energy harvesting mechanisms -- piezoelectric, electromagnetic, electrostatic, and triboelectric. Readers are provided with a comprehensive technical review and historical view of each mechanism. The authors also present current challenges in energy harvesting technology, technical reviews, design requirements, case studies, along with unique and representative examples of energy harvester applications.

Energy Harvesting

This new edition of our 2016 book provides insight into designing intelligent materials and structures for special application in engineering. Literature is updated throughout and a new chapter on optics fibers has been added. The book discusses simulation and experimental determination of physical material properties, such as piezoelectric effects, shape memory, electro-rheology, and distributed control for vibrations minimization.

Autonomous Sensor Networks

Energy Harvesting Wireless Communications offers a review of the most current research as well as the basic concepts, key ideas and powerful tools of energy harvesting wireless communications. Energy harvesting is both renewable and cheap and has the potential for many applications in future wireless communication systems to power transceivers by utilizing environmental energy such as solar, thermal, wind, and kinetic energy. The authors—noted experts in the field—explore the power allocation for point-to-point energy harvesting channels, power allocation for multi-node energy harvesting channels, and cross-layer design for energy harvesting links. In addition, they offer an in-depth examination of energy harvesting network optimization and cover topics such as energy harvesting ad hoc networks, cost aware design for energy harvesting assisted cellular networks, and energy harvesting in next generation cellular networks.

Energy Harvesting for Wireless Sensor Networks

Shock & Vibration, Aircraft/Aerospace, Energy Harvesting, Volume 9: Proceedings of the 33rd IMAC, A Conference and Exposition on Structural Dynamics, 2015, the ninth volume of ten from the Conference brings together contributions to this important area of research and engineering. The collection presents early findings and case studies on fundamental and applied aspects of Shock & Vibration, Aircraft/Aerospace, Energy Harvesting, including papers on: Energy Harvesting Adaptive Support Shock Calibration Operating Data Applications

Hybrid Energy Systems

The book presents select proceedings of the International Conference on Micro and Nanoelectronics Devices, Circuits and Systems (MNDCS-2021). The volume includes cutting-edge research papers in the emerging fields of micro and nanoelectronics devices, circuits, and systems from experts working in these fields over the last decade. The book is a unique collection of chapters from different areas with a common theme and will be immensely useful to academic researchers and practitioners in the industry who work in this field.

Micro and Nanoelectronics Devices, Circuits and Systems

Engineered Polymeric Fibrous Materials

This book focuses on emerging wireless power/data and energy harvesting technologies, and highlights their fundamental requirements, followed by recent advancements. It provides a various
technical overview and analysis of key techniques for wireless power/data and energy harvesting system design. The state-of-the-art system introduced in this book will benefit designers looking to develop wireless power transfer and energy harvesting technologies in a variety of fields, such as wearable, implantable devices, home appliances, and electric vehicles.

**Enterprise Digital Transformation**

This book offers a comprehensive review of the state-of-the-art in innovative Beyond-CMOS nanodevices for developing novel functionalities, logic and memories dedicated to researchers, engineers and students. It particularly focuses on the interest of nanostructures and nanodevices (nanowires, small slope switches, 2D layers, nanostructured materials, etc.) for advanced More than Moore (RF-nanosensors-energy harvesters, on-chip electronic cooling, etc.) and Beyond-CMOS logic and memories applications.

**Flexible and Stretchable Triboelectric Nanogenerator Devices**

Hybrid Energy Systems: Strategy for Industrial Decarbonization demonstrates how hybrid energy and processes can decarbonize energy industry needs for power and heating and cooling. It describes the role of hybrid energy and processes in nine major industry sectors and discusses how hybrid energy can offer sustainable solutions in each. Introduces the basics and examples of hybrid energy systems. Examines hybrid energy and processes in coal, oil and gas, nuclear, building, vehicle, manufacturing and industrial processes, computing and portable electronic, district heating and cooling, and water sectors. Shows that hybrid processes can improve efficiency and that hybrid energy can effectively insert renewable fuels in the energy industry. Serves as a companion text to the author’s book Hybrid Power: Generation, Storage, and Grids. Written for advanced students, researchers, and industry professionals involved in energy-related processes and plants, this book offers latest research and practical strategies for application of the innovative field of hybrid energy.

**Numerical Methods for Energy Applications**

Engineered Polymeric Fibrous Materials explains cutting edge techniques for the engineering of fibrous materials from physical, mechanical, and chemical points of view. Both conventional and nanofibers are described in this uniquely comprehensive book, for a wide range of applications including biomedical, automotive, aerospace, agriculture, energy, and environmental. This book refers to recent advances made in both academia and industry, in topics such as fiber-reinforced composites, fibrous thermal insulators, drug delivery and tissue engineering, and smart textiles and energy, and explains how fibrous structures are engineered to offer new solutions to important problems. The first two chapters provide basic introductory information to allow a wider range of readers to engage with the book. Addresses hot emerging topics including smart materials, wearable energy harvesters, and solar fuel production. Includes valuable technical advice that is useful to industries including aerospace, biomedical, and energy. Covers the full lifecycle of the material, from processing and treatment through to end usage.

**Fabrication and Characterization of Hybrid Energy Harvesting Microdevices**

**Recent Wireless Power Transfer Technologies via Radio Waves**

This timely new resource explores the available energy sources within commercial and residential buildings and the available technologies for energy harvesting. Energy harvesting within built environments is presented using strong research and commercial examples. This book includes clear and concise case studies on solar cell powered sensor nodes for emotion monitoring systems in ambient assistive living environments and inductive/RF power transfers. Thermoelectric energy harvesting and power management circuit design, airflow and vibration energy harvesting is also explored. The book concludes with a look at the future of energy harvesting in buildings.