Cavity Optomechanics Nano And Micromechanical Resonators Interacting With Light Quantum Science And Technology

This authoritative book introduces and summarizes the latest models and skills required to design and fabricate nanomechanical resonators with a focus on nanomechanical sensing. It also establishes the theoretical foundation for courses on micro and nanomechanics. This book takes an applied approach to nanomechanics, providing a complete set of mechanical models, including strings and membrane resonators. Also discussed are quality factors, noise issues, transduction techniques, nanomechanical sensing, fabrication techniques, and applications for all common nanomechanical resonator types. It is an ideal book for students and researchers working with micro and nanomechanical resonators.

This volume contains the Proceedings of the NATO Advanced Study Institute "Quantum Optics and Experimental General Relativity" which was held in Bad Windsheim, Federal Republic of Germany, from August 16 to 29, 1981. At first glance, one might wonder why a meeting should cover these two topics, and a good bit of quantum measurement theory as well, all of which seem to be completely unrelated. The key to what one may call this grand unification lies in the effort, underway in a number of laboratories around the world, to detect gravitational radiation. Present research is pursuing the development of two types of detectors: laser interferometers and resonant bar detectors. Be cause the signals that one is trying to measure are so weak the quan tum mechanical nature of the detectors comes into play. The analy sis of the effects which result from this is facilitated by the use of techniques which have been developed in quantum optics over the years. This analysis also forces one to confront certain issues in the quantum theory of measurement. The laser interferometer detectors, using as they do light, are clearly within the realm of subjects usually considered by quantum optics. For example, the analysis of the noise present in such a de tector can make use of the many techniques which have been developed in quantum optics.

This comprehensive handbook has become the definitive reference work in the field of nanoscience and nanotechnology, and this 4th edition incorporates a number of recent new developments. It integrates nanofabrication, nanomaterials, nanodevices, nanomechanics, nanotribology, materials science, and reliability engineering knowledge in just one volume. Furthermore, it discusses various nanostructures; micro/nanofabrication; micro/nanodevices and biomicro/nanodevices, as well as scanning probe microscopy; nanotribology and nanomechanics; molecularly thick films; industrial applications and nanodevice reliability; societal, environmental, health and safety issues; and nanotechnology education. In this new edition, written by an international team of over 140 distinguished experts and put together by an experienced editor with a comprehensive understanding of the field, almost all the chapters are either new or substantially revised and expanded, with new topics of interest added. It is an essential resource for anyone working in the rapidly evolving field of key technology, including mechanical and electrical engineers, materials scientists, physicists, and chemists.

This is the most comprehensive book on the basics, realization and applications of micromechanical photonics. Its purpose is to give the engineering student and the practical engineer a systematic introduction to optical MEMS (Micro electro mechanical systems) and micromechanical photonics. It does this not only through theoretical and experimental results, but also by describing various products and their fields of application.

This book considers various approaches for surpassing the standard quantum limit for force measurements. It then proposes different experimental protocols for using optomechanical interactions to explore quantum behaviors of macroscopic mechanical objects.

Fully revised and in its second edition, this standard reference on nano-optics is ideal for graduate students and researchers alike.

Written by leading experimentalist Warwick P. Bowen and prominent theoretician Gerard J. Milburn, Quantum Optomechanics discusses modern developments in this novel field from experimental and theoretical standpoints. The authors share their insight on a range of important topics, including optomechanical cooling and entanglement; quantum limits on measurement precision and how to overcome them via back-action evading measurements; feedback control; single photon and nonlinear optomechanics; optomechanical synchronization; coupling of optomechanical systems to microwave circuits and two-level systems, such as atoms and superconducting qubits; and optomechanical tests of gravitational decoherence. The book first introduces the basic physics of quantum harmonic oscillators and their interactions with their environment. It next discusses the radiation pressure interaction between light and matter, deriving common Hamiltonians used in quantum optomechanics. It then focuses on the linearized regime of quantum optomechanics before exploring scenarios where the simple linearized picture of quantum optomechanics no longer holds. The authors move on to hybrid optomechanical systems in which the canonical quantum optomechanical system is coupled to another quantum object. They explain how an alternative form of a hybrid optomechanical system leads to the phenomenon of synchronization. They also consider the impact of quantum optomechanics on tests of gravitational physics.

A mechanical oscillator coupled to the optical field in a cavity is a typical cavity optomechanical system. In our textbook, we prepare to introduce the quantum optical properties of optomechanical system, i.e. linear and nonlinear effects. Some quantum optical devices based on optomechanical system are also presented in the monograph, such as the Kerr modulator, quantum optical transistor, optomechanical mass sensor, and so on. But most importantly, we extend the idea of typical optomechanical system to coupled mechanical resonator system and demonstrate that the combined two-level structure and resonator system can serve as a generalized optomechanical system. The quantum optical properties, which exist in typical system, are also presented in the combined two-level structure and resonator system.

Micro and nano-electro-mechanical system (M/NEMS) devices constitute key technological building blocks to enable increased additional functionalities within Integrated Circuits (ICs) in the More-Than-Moore era, as described in the International Technology Roadmap for Semiconductors. The CMOS ICs and M/NEMS dies can be combined in the same package (SiP), or integrated within a single chip (SoC). In the SoC approach the M/NEMS devices are monolithically integrated together with CMOS circuitry allowing the development of compact and low-cost CMOS-M/NEMS devices for multiple applications (physical sensors, chemical sensors, biosensors, actuators, energy actuators, filters, mechanical relays, and others). On-chip CMOS electronics integration can overcome limitations related to the extremely low-level signals in sub-micrometer and nanometer scale electromechanical transducers enabling novel breakthrough applications. This Special Issue aims to gather high quality research contributions dealing with MEMS and NEMS devices monolithically integrated with CMOS, independently of the final application and fabrication approach adopted (MEMS-first, interleaved MEMS, MEMS-last or others).]

This volume continues the tradition of the Advances series. It contains contributions from experts in the field of atomic, molecular, and optical (AMO) physics. The articles contain some review material, but are intended to provide a comprehensive picture of recent important developments in AMO physics. Both theoretical and experimental articles are included in the volume. International experts Comprehensive articles New developments

Exciting new developments are enabling sensors to go beyond the realm of simple sensing of movement or capture of images to deliver information such as location in a built environment, the sense of touch, and the presence of chemicals. These sensors unlock the potential for smarter systems, allowing machines to interact with the world around them in more intelligent and sophisticated ways. Featuring contributions from authors working at the leading edge of sensor technology, Technologies for Smart Sensors and Sensor Fusion showcases the latest advancements in sensors with biotechnology, medical science, chemical detection, environmental monitoring, automotive, and industrial applications. This valuable reference describes the increasingly varied number of sensors that can be integrated into arrays, and examines the growing availability and computational power of communication devices that support the algorithms needed to reduce the raw sensor data from multiple sensors and convert it into the information needed by the sensor array to enable rapid transmission of the results to the required point. Using both SI and US units, the text: Provides a fundamental and analytical understanding of the underlying technology for smart sensors Discusses groundbreaking software and sensor systems as well as key issues surrounding sensor fusion Exemplifies the richness and diversity of development work in the world of smart sensors and sensor fusion Offering fresh insight into the sensors of the future, Technologies for Smart Sensors and Sensor Fusion not only exposes readers to trends but also inspires innovation in smart sensor and sensor system development.

This book focuses on the fabrication and applications of cantilever beams with nanoscale dimensions. Nanometer-size mechanical structures show exceptional properties generated by their reduced dimensions. These properties enable new sensing concepts and transduction mechanisms that will allow the enhancement of the performance of devices to their fundamental limits. A number of scientists are conducting research in the area of nanocantilever beams. The book will particularly benefit researchers and help them consolidate their background in the field. The book aims to be an excellent scientific reference for an audience with diverse backgrounds and interests, including students, academic researchers, industry specialists, policymakers, and enthusiasts.

An optical cavity confines light within its structure and constitutes an integral part of a laser device. Unlike traditional gas lasers, semiconductor lasers are invariably much smaller in dimensions, making optical confinement more critical than ever. In this book, modern methods that control and manipulate light at the micrometer and nanometer scales by using a variety of cavity geometries and demonstrate optical resonance from ultra-violet (UV) to infra-red (IR) bands across multiple material platforms are explored. The book has a comprehensive collection of chapters that cover a wide range of topics pertaining to resonance in optical cavities and are contributed by leading researchers in the field. The topics include theory, design, simulation, fabrication, and characterization of micrometer- and nanometer-scale structures and devices that support cavity resonance via various mechanisms such as Fabry–Pérot, whispering gallery, photonic bandgap, and plasmonic modes. The chapters discuss optical cavities that resonate from UV to IR wavelengths and are based on prominent III-V material systems, including Al, In, and Ga nitrides, ZnO, and GaAs.

Coined as the third revolution in electronics is under way; Manufacturing is going digital, driven by computing revolution, powered by MOS technology, in particular, by the CMOS technology and its development. In this book, the scaling challenges for CMOS: SiGe BiCMOS, THz and niche technology are covered; the first article looks at scaling challenges for CMOS from an industrial point of view (review of the latest innovations); the second article focuses on SiGe BiCMOS technologies (deals with high-speed up to the THz-region), and the third article reports on circuits associated with source/drain integration in 14 nm and beyond FinFET technology nodes. Followed by the last two articles on niche applications for emerging technologies: one deals with carbon nanotube network and plasmonics for the THz region carbon, while the other reviews the recent developments in integrated on-chip nano-optomechanical systems. Contents: PrefaceScaling Challenges for Advanced CMOS Devices (Ajey P Jacob, Ruilong Xie, Min Gyu Sung, Lars Liebmann, Rinus T P Lee and Bill Taylor)High-Speed SiGe BiCMOS Technologies and Circuits (A Mai, I Garcia Lopez, P Rito, R Nagulapalli, A Awny, M Elkhouly, M Eissa, M Ko, A Malignaggi, M Kucharski, H J Ng, K Schmalz and D Kissinger)Optimization of Selective Growth of SiGe for Source/Drain in 14nm and Beyond Nodes FinFETs (Henry H Radamson, Jun Luo, Changliang Qin, Huaxiang Yin, Huilong Zhu, Chao Zhao and Guilei Wang)Dynamic Conductivity and Two-Dimensional Plasmons in Lateral CNT Networks (Maxim Ryzhii, Taiichi Otsuji, Victor Ryzhii, Vladimir Mitin, Michael S Shur, Georgy Fedorov and Vladimir Leiman)Integrated On-Chip Nano-Optomechanical Systems (Zhu Diao, Vincent T K Sauer and Wayne K Hiebert)Author Index Readership: Scientists, engineers, research leaders, and even investors interested in microelectronics, nanoelectronics, and optoelectronics. It is also recommended to graduate students working in these fields.

This book will present the theoretical and technological elements of nanosystems. Among the different topics discussed, the authors include the electromechanical properties of NEMS, the scaling effects that give these their interesting properties for different applications and the current manufacturing processes. The authors aim to provide useful tools for future readers and will provide an accurate picture of current and future research in the field.

This book discusses the most commonly used techniques for characterizing magnetic material properties and their applications. It provides a comprehensive and easily digestible collection and review of magnetic measurement techniques. It also examines the underlying operating principles and techniques of magnetic measurements, and presents current examples where such measurements and properties are relevant. Given the pervasive nature of magnetic materials in everyday life, this book is a vital resource for both professionals and students wishing to deepen their understanding of the subject.

Quantum effects in macroscopic systems have long been a fascination for researchers. Over the past decade mechanical oscillators have emerged as a leading system of choice for many such experiments. The work reported in this thesis investigates the effects of the radiation-pressure force of light on macroscopic mechanical structures. The basic system studied is a mechanical oscillator that is highly reflective and part of an optical resonator. It interacts with the optical cavity mode via the radiation-pressure force. Both the dynamics of the mechanical oscillation and the properties of the light field are modified through this interaction. The experiments use quantum optical tools (such as homodyning and down-conversion) with the goal of ultimately showing quantum behavior of the mechanical center of mass motion. Of particular value are the detailed descriptions of several novel experiments that pave the way towards this goal and are already shaping the field of quantum optomechanics, in particular optomechanical laser cooling and strong optomechanical coupling.

This edition contains carefully selected contributions by leading scientists in high-resolution laser spectroscopy, quantum optics and laser physics. Emphasis is given to ultrafast laser phenomena, implementations of frequency combs, precision spectroscopy and high resolution metrology. Furthermore, applications of the fundamentals of quantum mechanics are widely covered. This book is dedicated to Nobel prize winner Theodor W. Hänsch on the occasion of his 75th birthday. The contributions are reprinted from a topical collection published in Applied Physics B, 2016. Selected contributions are available open access under a CC BY 4.0 license via link.springer.com. Please see the copyright page for further details.

The Progress in Optics series contains more than 300 review articles by distinguished research workers, which have become permanent records for many important developments, helping optical scientists and optical engineers stay abreast of their fields. Comprehensive, in-depth reviews Edited by the leading authority in the field

In the 70s, the interplay between microscale electronics and mechanics gave birth to micro- and nanoelectromechanical systems (MEMS/NEMS) that are prevalent in our daily life. The emergence of silicon photonics in the 90s was a result of the marriage between microelectronics and optics promising extreme communication bandwidth and processing power. A few years ago, the field of microscale optomechanics that harnesses the interaction between light and mechanics on a nanoscale emerged. The field witnessed the birth of many exciting technologies as quantum limited detection of ultra-weak forces, preparation of micromechanical oscillators close to their motional quantum ground states and enabling self-sustaining oscillations of mechanics with light. The aim of this thesis is to explore and address a few challenges in coupled optomechanical systems. So far, most work in this area focuses on single device behaviors. One could imagine that like connecting many transistors together leads to complex computing machines, a network of coupled optomechanical devices have the potential to offer dynamics that are not accessible with single optomechanical devices. In this thesis, I show that indeed, light can be used to synchronize arrays of mechanical oscillators even when they are not physically connected. I will also show in this thesis that coupling distinct optical and mechanical elements together could also enable a new paradigm of devices. We couple a single Carbon Nanotube (CNT) strongly to on-chip high-Q optical microcavi- ties. Despite the tiny size of CNT, we show that the optical microcavity is still extremely sensitive to the CNT motion. We demonstrate that we can observe in real-time the thermal Brownian motion of a single CNT for the first time. The unique carbon-optical system also enables an almost completely dissipative optomechanical system that has not been achieved in any other type of systems to date.

Fundamental Tests of Physics with Optically Trapped Microspheres details experiments on studying the Brownian motion of an optically trapped microsphere with ultrahigh resolution and the cooling of its motion towards the quantum ground state. Glass microspheres were trapped in water, air, and vacuum with optical tweezers; and a detection system that can monitor the position of a trapped microsphere with Angstrom spatial resolution and microsecond temporal resolution was developed to study the Brownian motion of a trapped microsphere in air over a wide range of pressures. The instantaneous velocity of a Brownian particle, in particular, was studied for the very first time, and the results provide direct verification of the Maxwell-Boltzmann velocity distribution and the energy equipartition theorem for a Brownian particle. For short time scales, the ballistic regime of Brownian motion is observed, in contrast to the usual diffusive regime. In vacuum, active feedback is used to cool the center-of-mass motion of an optically trapped microsphere from room temperature to a minimum temperature of about 1.5 mK. This is an important step toward studying the quantum behaviors of a macroscopic particle trapped in vacuum.

QUANTUMCOMM 2009—the International Conference on Quantum Communi- tion and Quantum Networking (from satellite to nanoscale)—took place in Vico Equense near Naples, Italy, during October 26–30, 2009. The conference made a significant step toward stimulating direct dialogue between the communities of quantum physics and quantum information researchers who work with photons, atoms, and electrons in pursuit of the common goal of investigating and utilizing the transfer of physical information between quantum systems. This meeting brought together experts in quantum communication, quantum inf- mation processing, quantum nanoscale physics, quantum photonics, and networking. In the light of traditional approaches to quantum information processing, quantum communication mainly deals with encoding and securely distributing quantum states of light in optical fiber or in free space in order to provide the technical means for quantum cryptography applications. Exciting advances in the area of quantum c- munication over the last decade have made the metropolitan quantum network a re- ity. Several papers presented at this meeting have demonstrated that quantum crypt- raphy is approaching the point of becoming a high-tech application rather than a - search subject. The natural distance limitation of quantum cryptography has been significantly augmented using ideas of global quantum communication with stab- orbit satellites. The results presented at this conference demonstrated that practical secure satellite communication is clearly within reach.

Smart Sensors and MEMS: Intelligent Devices and Microsystems for Industrial Applications, Second Edition highlights new, important developments in the field, including the latest on magnetic sensors, temperature sensors and microreaction chambers. The book outlines the industrial applications for smart sensors, covering direct interface circuits for sensors, capacitive sensors for displacement measurement in the sub-nanometer range, integrated inductive displacement sensors for harsh industrial environments, advanced silicon radiation detectors in the vacuum ultraviolet (VUV) and extreme ultraviolet (EUV) spectral range, among other topics. New sections include discussions on magnetic and temperature sensors and the industrial applications of smart micro-electro-mechanical systems (MEMS). The book is an invaluable reference for academics, materials scientists and electrical engineers working in the microelectronics, sensors and micromechanics industry. In addition, engineers looking for industrial sensing, monitoring and automation solutions will find this a comprehensive source of information. Contains new chapters that address key applications, such as magnetic sensors, microreaction chambers and temperature sensors Provides an in-depth information on a wide array of industrial applications for smart sensors and smart MEMS Presents the only book to discuss both smart sensors and MEMS for industrial applications

New Frontiers in Nanochemistry: Concepts, Theories, and Trends, Volume 1: Structural Nanochemistry is the first volume of the new three-volume set that explains and explores the important concepts from various areas within the nanosciences. This first volume focuses on structural nanochemistry and encompasses the general fundamental aspects of nanochemistry while simultaneously incorporating crucial material from other fields, in particular mathematic and natural sciences, with specific attention to multidisciplinary chemistry. Under the broad expertise of the editor, the volume contains 50 concise yet comprehensive entries from world-renowned scholars, alphabetically organizing a multitude of essential basic and advanced concepts, ranging from algebraic chemistry to new energy technology, from the bondonic theory of chemistry to spintronics, and from fractal dimension and kinetics to quantum dots and tight binding—and much more. The entries contain definitions, short characterizations, uses and usefulness, limitations, references, and more.

Nanotechnology ("nanotech") is the manipulation of matter on an atomic, molecular, and supramolecular scale. The earliest, widespread description of nanotechnology referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macroscale products, also now referred to as molecular nanotechnology. A more generalized description of nanotechnology was subsequently established by the National Nanotechnology Initiative, which defines nanotechnology as the manipulation of matter with at least one dimension sized from 1 to 100 nanometers. This definition reflects the fact that quantum mechanical effects are important at this quantum-realm scale, and so the definition shifted from a particular technological goal to a research category inclusive of all types of research and technologies that deal with the special properties of matter that occur below the given size threshold. It is therefore common to see the plural form "nanotechnologies" as well as "nanoscale technologies" to refer to the broad range of research and applications whose common trait is size. Because of the variety of potential applications (including industrial and military), governments have invested billions of dollars in nanotechnology research. Through its National Nanotechnology Initiative, the USA has invested 3.7 billion dollars. The European Union has invested[when?] 1.2 billion and Japan 750 million dollars.

Nanoscale physics has become one of the rapidly developing areas of contemporary physics because of its direct relevance to newly emerging area, nanotechnologies. Nanoscale devices and quantum functional materials are usually constructed based on the results of fundamental studies on nanoscale physics. Therefore studying physical phenomena in nanosized systems is of importance for progressive development of nanotechnologies. In this context study of complex phenomena in such systems and using them for controlling purposes is of great practical importance. Namely, such studies are brought together in this book, which contains 27 papers on various aspects of nanoscale physics and nonlinear dynamics.

This thesis demonstrates the potential of two platforms to explore experimentally the emerging field of quantum thermodynamics that has remained mostly theoretical so far. It proposes methods to define and measure work in the quantum regime. The most important part of the thesis focuses on hybrid optomechanical devices, evidencing that they are proper candidates to measure directly the fluctuations of work and the corresponding fluctuation theorem. Such devices could also give rise to the observation of mechanical lasing and cooling, based on mechanisms similar to a heat engine. The final part of the thesis studies how quantum coherence can improve work extraction in superconducting circuits. All the proposals greatly clarify the concept of work since they are based on measurable quantities in state of the art devices.

In this thesis, ultimate sensitive measurement for weak force imposed on a suspended mirror is performed with the help of a laser and an optical cavity for the development of gravitational-wave detectors. According to the Heisenberg uncertainty principle, such measurements are subject to a fundamental noise called quantum noise, which arises from the quantum nature of a probe (light) and a measured object (mirror). One of the sources of quantum noise is the quantum back-action, which arises from the vacuum fluctuation of the light. It sways the mirror via the momentum transferred to the mirror upon its reflection for the measurement. The author discusses a fundamental trade-off between sensitivity and stability in the macroscopic system, and suggests using a triangular cavity that can avoid this trade-off. The development of an optical triangular cavity is described and its characterization of the optomechanical effect in the triangular cavity is demonstrated. As a result, for the first time in the world the quantum back-action imposed on the 5-mg suspended mirror is significantly evaluated. This work contributes to overcoming the standard quantum limit in the future.

Assembling an international team of experts, this book reports on the progress in the rapidly growing field of monolithic micro- and nanoresonators. The book opens with a chapter on photonic crystal-based resonators (nanocavities). It goes on to describe resonators in which the closed trajectories of light are supported by any variety of total internal reflection in curved and polygonal transparent dielectric structures. The book also covers distributed feedback microresonators for slow light, controllable dispersion, and enhanced nonlinearity. A portion of coverage is dedicated to the unique properties of resonators, which are extremely efficient tools when conducting multiple applications.

During the last few years cavity-optomechanics has emerged as a new field of research. This highly interdisciplinary field studies the interaction between micro and nano mechanical systems and light. Possible applications range from novel high-bandwidth mechanical sensing devices through the generation of squeezed optical or mechanical states to even tests of quantum theory itself. This is one of the first books in this relatively young field. It is aimed at scientists, engineers and students who want to obtain a concise introduction to the state of the art in the field of cavity optomechanics. It is valuable to researchers in nano science, quantum optics, quantum information, gravitational wave detection and other cutting edge fields. Possible applications include biological sensing, frequency comb applications, silicon photonics etc. The technical content will be accessible to those who have familiarity with basic undergraduate physics.

Cavity OptomechanicsNano- and Micromechanical Resonators Interacting with LightSpringer

Superfluid helium is a quantum liquid that exhibits a range of counter-intuitive phenomena such as frictionless flow. Quantized vortices are a particularly important feature of superfluid helium, and all superfluids, characterized by a circulation that can only take prescribed integer values. However, the strong interactions between atoms in superfluid helium prohibit quantitative theory of vortex behaviour. Experiments have similarly not been able to observe coherent vortex dynamics. This thesis resolves this challenge, bringing microphotonic techniques to bear on two-dimensional superfluid helium, observing coherent vortex dynamics for the first time, and achieving this on a silicon chip. This represents a major scientific contribution, as it opens the door not only to providing a better understanding of this esoteric quantum state of matter, but also to building new quantum technologies based upon it, and to understanding the dynamics of astrophysical superfluids such as those thought to exist in the core of neutron stars.

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.

The beginning of the 20th century saw a revolution in Physics with the discovery that the fundamental constituents of matter and radiation do not obey Newtonian laws, but those of an entirely new theory of motion and its measurement: quantum mechanics. After a century of experimentation in the world of photons, atoms, molecules, and other microscopic particles, the application of quantum laws is presently being extended to the world of macroscopic, engineeredsystems, whose complexity is such that an exhaustive, bottom-up description is both impossible and fruitless. In these so-called quantum machines, the very level of control signals that govern theevolution of the system operates quantum-mechanically. Quantum machines are based on artificial structures like superconducting tunnel junction circuits or semiconductor quantum dots, and this book provides the conceptual tools to build and utilize them.

This book is a thoroughly modern and highly pedagogical graduate-level introduction to quantum optics, a subject which has witnessed stunning developments in recent years and has come to occupy a central role in the 'second quantum revolution'. The reader is invited to explore the fundamental role that quantum optics plays in the control and manipulation of quantum systems, leading to ultracold atoms, circuit QED, quantum information science, quantum optomechanics, and quantum metrology. The building blocks of the subject are presented in a sequential fashion, starting from the simplest physical situations before moving to increasingly complicated ones. This pedagogically appealing approach leads to quantum entanglement and measurement theory being introduced early on and before more specialized topics such as cavity QED or laser cooling. The final chapter illustrates the power of scientific cross-fertilization by surveying cutting-edge applications of quantum optics and optomechanics in gravitational wave detection, tests of fundamental physics, searches for dark matter, geophysical monitoring, and ultraprecise clocks. Complete with worked examples and exercises, this book provides the reader with enough background knowledge and understanding to follow the current journal literature and begin producing their own original research.

The Les Houches Summer School in August 2015 covered the emerging fields of cavity optomechanics and quantum nanomechanics. Optomechanics is flourishing and its concepts and techniques are now applied to a wide range of topics. Modern quantum optomechanics was born in the late 1970s in the framework of gravitational wave interferometry, with an initial focus on the quantum limits of displacement measurements. Carlton Caves, Vladimir Braginsky, and others realized that the sensitivity of the anticipated large-scale gravitational-wave interferometers (GWI) was fundamentally limited by the quantum fluctuations of the measurement laser beam. After tremendous experimental progress, the sensitivity of the upcoming next generation of GWI will effectively be limited by quantum noise. In this way, quantum-optomechanical effects will directly affect the operation of what is arguably the world's most impressive precision experiment. However, optomechanics has also gained a life of its own with a focus on the quantum aspects of moving mirrors. Laser light can be used to cool mechanical resonators well below the temperature of its environment. After proof-of-principle demonstrations of this cooling in 2006, a number of systems were used as the field gradually merged with its condensed matter cousin (nanomechanical systems) to try to reach the mechanical quantum ground state, eventually demonstrated in 2010 by pure cryogenic techniques and just one year later by a combination of cryogenic and radiation-pressure cooling. The book covers all aspects -- historical, theoretical, experimental -- of the field, with its applications to quantum measurement, foundations of quantum mechanics and quantum information. It is an essential read for any new researcher in the field.

The rapid advancement of integrated optoelectronics has been driven considerably by miniaturization. Following the path taken in electronics of reducing devices to their ultimately fundamental forms, for instance single-electron transistors, now optical devices have also been scaled down, creating the increasingly active research fields of integrated and coupled photonic systems. The interactions between the coupled integrated micro- and nanostructures can provide us with the fundamental understanding and engineering of complex systems for a variety of applications. This book aims to bring to the readers the latest developments in the rapidly emerging field of integrated nanophotonic resonators and devices. It compiles cutting-edge research from leading experts who form an interdisciplinary team around the world. The book also introduces the fundamental knowledge of coupled integrated photonic/electronic/mechanical micro- and nanoresonators and their interactions, as well as advanced research in the field.

This book provides a cutting-edge research overview on the latest developments in the field of Optics and Photonics. All chapters are authored by the pioneers in their field and will cover the developments in Quantum Photonics, Optical properties of 2D Materials, Optical Sensors, Organic Opto-electronics, Nanophotonics, Metamaterials, Plasmonics, Quantum Cascade lasers, LEDs, Biophotonics and biomedical photonics and spectroscopy.

Understanding, controlling and, more importantly, enhancing the interaction between light (photons) and spin waves (magnons) can be, among others, a step towards the realization of magnon-mediated microwave-to-optical transducers for quantum computing applications or hybrid solid-state spintronic-photonic interconnections. In this respect, the development of novel composite multifunctional micro/nanostructures — so-called optomagnonic — which simultaneously control optical and spin waves and enhance their interaction, is particularly attractive.This book constitutes a collective work, comprising seven chapters from leading researchers in the field of optomagnonics and related areas. Apart from exciting recent developments, it provides the necessary fundamental knowledge in an explanatory manner and, therefore, it is accessible to non-experts. It is suitable for PhD students, post-docs, and researchers who are willing to get engaged in optomagnonics, while selected parts could also serve as lecture material for advanced courses. With increasing demand for miniaturized optomagnonic devices, this book will be an important resource to researchers working on optomagnonics, magneto-optics, spintronics, as well as on hybrid micro/nano devices for information processing.