



ULTRA-HIGH-Q OPTICAL MICROCAVITIES

Editors

**Yun-Feng Xiao • Chang-Ling Zou
Qihuang Gong • Lan Yang**

World Scientific

Light Matter Interaction Ultra High Q Whispering Microcavities

C.M. Soukoulis



Light Matter Interaction Ultra High Q Whispering Microcavities:

Ultra-high-q Optical Microcavities Yun-feng Xiao, Chang-ling Zou, Qihuang Gong, Lan Yang, 2020-10-29 Confinement and manipulation of photons using microcavities have triggered intense research interest in both basic and applied physics for more than a decade. Prominent examples are whispering gallery microcavities which confine photons by means of continuous total internal reflection along a curved and smooth surface. The long photon lifetime, strong field confinement, and in-plane emission characteristics make them promising candidates for enhancing light-matter interactions on a chip. In this book, we will introduce different ultra-high-Q whispering gallery microcavities and focus on their applications in enhancing light-matter interaction, such as ultralow threshold microlasing, highly sensitive optical biosensing, nonlinear optics, cavity quantum electrodynamics, and cavity optomechanics. *Enhanced Light-Matter Interaction in Ultra-High-Q Whispering Gallery Microcavities*

Yun-Feng Xiao, Chang-Ling Zou, Qihuang Gong, 2020-02-13 Confinement and manipulation of photons using microcavities have triggered intense research interest in both basic and applied physics for more than a decade. Prominent examples are whispering gallery microcavities which confine photons by means of continuous total internal reflection along a curved and smooth surface. The long photon lifetime, strong field confinement, and in-plane emission characteristics make them promising candidates for enhancing light-matter interactions on a chip. In this book, we will introduce different ultra-high-Q whispering gallery microcavities and focus on their applications in enhancing light-matter interaction, such as ultralow threshold microlasing, highly sensitive optical biosensing, nonlinear optics, cavity quantum electrodynamics, and cavity optomechanics. **Single Molecule Sensing Beyond Fluorescence** Warwick Bowen, Frank Vollmer, Reuven Gordon, 2022-03-01 This book provides an interesting snapshot of recent advances in the field of single molecule nanosensing. The ability to sense single molecules and to precisely monitor and control their motion is crucial to build a microscopic understanding of key processes in nature, from protein folding to chemical reactions. Recently, a range of new techniques have been developed that allow single molecule sensing and control without the use of fluorescent labels. This volume provides an overview of recent advances that take advantage of micro and nanoscale sensing technologies and provide the prospect for rapid future progress. The book endeavors to provide basic introductions to key techniques, recent research highlights, and an outlook on big challenges in the field and where it will go in the future. It is a valuable contribution to the field of single molecule nanosensing and it will be of great interest to graduates and researchers working in this topic.

Optical Microcavities Kerry Vahala, 2004 Optical microcavities are structures that enable confinement of light to microscale volumes. The universal importance of these structures has made them indispensable to a wide range of fields. This important book describes the many applications and the related physics, providing both a review and a tutorial of key subjects by leading researchers from each field. **Semiconductor Quantum Science and Technology**, 2020-11-28 Semiconductor quantum science and technology is exploring the exciting and emerging prospects of integrating quantum functionality on

semiconductor platforms to convert current information technology into quantum information technology The past twenty years have led to incredible advances in this field This book brings together the leading scientists who present the main achievements and challenges by reviewing and motivating the state of the art at a tutorial level The key challenges include creating quantum light sources quantum information processing via strong light matter interaction discovering new quantum materials as well as quasiparticles and determining new quantum spectroscopic methodologies for superior control of quantum phenomena As an important step integration of these solutions on a semiconductor chip is discussed and outlook for the future of semiconductor quantum science and technology is given Leading experts present their vision on semiconductor quantum science and technology All aspects needed to realize semiconductor quantum science and technology are explained Quantum semiconductors from overviewed a tutorial introduction to the state of the art Microcavities and Photonic Bandgaps: Physics and Applications J.G. Rarity, Claude Weisbuch, 2012-12-06 The control of optical modes in microcavities or in photonic bandgap PBG materials is coming of age Although these ideas could have been developed some time ago it is only recently that they have emerged due to advances in both atomic physics and in fabrication techniques be it on the high quality dielectric mirrors required for high finesse Fabry Perot resonators or in semiconductor multilayer deposition methods Initially the principles of quantum electro dynamics QED were demonstrated in elegant atomic physics experiments Now solid state implementations are being investigated with several subtle differences from the atomic case such as those due to their continuum of electronic states or the near Boson nature of their elementary excitations the exciton Research into quantum optics brings us ever newer concepts with potential to improve system performance such as photon squeezing quantum cryptography reversible taps photonic de Broglie waves and quantum computers The possibility of implementing these ideas with solid state systems gives us hope that some could indeed find their way to the market demonstrating the continuing importance of basic research for applications be it in a somewhat more focused way than in earlier times for funding **Handbook of Optical Microcavities** Anthony H. W. Choi, 2014-10-06 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 P rot 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

Microcavity Semiconductor Lasers Yong-zhen Huang, Yue-de Yang, 2021-05-24 *Microcavity Semiconductor Lasers* Explore this thorough overview of integrable microcavity semiconductor lasers and their applications from two leading voices in the field Attracting a great deal of attention over the last decades for their promising applications in photonic integration and optical interconnects microcavity semiconductor lasers continue to develop via advances in fundamental physics theoretical analysis and numerical simulations In a new work that will be of interest to researchers and practitioners alike *Microcavity Semiconductor Lasers Principles Design and Applications* delivers an application oriented and highly relevant exploration of the theory fabrication and applications of these practical devices The book focuses on unidirectional emission microcavity lasers for photonic integrated circuits including polygonal microresonators microdisk and microring lasers After an introductory overview of optical microcavities for microlasers and detailed information of the lasers themselves including mode structure control and characteristics and lasing properties the distinguished authors discuss fabrication and applications of different microcavity lasers Prospects for future research and potential new applications round out the book Readers will also benefit from the inclusion of A thorough introduction to multilayer optical waveguides the FDTD Method and Pad Approximation and deformed chaos and unidirectional emission microdisk lasers An exploration of mode analysis for triangle and square microresonators similar as FP Cavity Practical discussions of mode analysis and control for deformed square microlasers An examination of hexagonal microcavity lasers and polygonal microcavities along with vertical radiation loss for 3D microcavities Perfect for laser specialists semiconductor physicists and solid state physicists *Microcavity Semiconductor Lasers Principles Design and Applications* will also earn a place in the libraries of materials scientists and professionals working in the semiconductor and optical industries seeking a one stop reference for integrable microcavity semiconductor lasers

Nanomembranes Yongfeng Mei, Gaoshan Huang, Xiuling Li, 2022-06-15 *Nanomembranes* Provides a thorough overview of the field of nanomembranes covering materials science fabrication processes properties and applications In recent years the unique nature of the nanomembrane has led to new technology and applications in areas including flexible electronics photonics robotics biology microelectromechanical systems and lab on a chip LOC devices Highly suitable for assembling three dimensional structures the nanomembrane can be integrated into devices and systems using conventional thin film technology *Nanomembranes Materials Properties and Applications* is an up to date review of recent advances in the rapidly expanding area within nanoscience and technology Edited by leading researchers the book covers the fabrications properties applications design concepts and challenges of nanomembranes and other nano scale assembled structures In depth chapters address topics including three and four dimensional origami nanomembrane based transient electronics development of inorganic flexible electronics magnetic nanomembranes bio applications of three dimensional scaffolds nanomembrane based micro and nanorobots passive electronic components based on self rolled up nanomembranes and more Covers nanomembranes as well as nanostructures made from semiconductor metal insulator

polymer and composite materials Provides broad overview of two dimensional materials and assembled structures including origami and kirigami structures Explores applications of nanomembrane such as batteries supercapacitors robotics electronics and cell scaffolding Discusses nanomembranes made from polymeric materials mechanical forces during deformation and assembly of nanomembranes Addresses monolayer two dimensional materials such as graphene and transition metal dichalcogenides Nanomembranes Materials Properties and Applications is an invaluable resource for material scientists engineers physicists and chemists in academia and industry and an excellent text for graduate students and researchers across disciplines with interest in the rapidly growing field **Optical Fiber Sensing Technologies**

Tiegen Liu,Junfeng Jiang,Kun Liu,Shuang Wang,2022-03-14 Optical Fiber Sensing Technologies b Explore foundational and advanced topics in optical fiber sensing technologies In Optical Fiber Sensing Technologies Principles Techniques and Applications a team of distinguished researchers delivers a comprehensive overview of all critical aspects of optical fiber sensing devices systems and technologies The book moves from the basic principles of the technology to innovation methods and a broad range of applications including Bragg grating sensing technology intra cavity laser gas sensing technology optical coherence tomography distributed vibration sensing and acoustic sensing The accomplished authors bridge the gap between innovative new research in the field and practical engineering solutions offering readers an unmatched source of practical application ready knowledge Ideal for anyone seeking to further the boundaries of the science of optical fiber sensing or the technological applications for which these techniques are used Optical Fiber Sensing Technologies Principles Techniques and Applications also includes Thorough introductions to optical fiber and optical devices as well as optical fiber Bragg grating sensing technology Practical discussions of Extrinsic Fabry Perot Interferometer based optical fiber sensing technology acoustic sensing technology and high temperature sensing technology Comprehensive explorations of assemble free micro interferometer based optical fiber sensing technology In depth examinations of optical fiber intra cavity laser gas sensing technology Perfect for applied and semiconductor physicists Optical Fiber Sensing Technologies Principles Techniques and Applications is also an invaluable resource for professionals working in the semiconductor optical and sensor industries as well as materials scientists and engineers for measurement and control Advancements in Optoelectronics

Dr. M. Irshad Ahamed ,Dr. N. Prathap ,Dr. A. Karthikeyan,Mrs. H. Umamaheswari,2025-03-10 **Microcavities** Alexey V. Kavokin,Jeremy J. Baumberg,Guillaume Malpuech,Fabrice P. Laussy,2017-04-28 Microcavities are semiconductor metal or dielectric structures providing optical confinement in one two or three dimensions At the end of the 20th century microcavities have attracted attention due to the discovery of a strong exciton light coupling regime allowing for the formation of superposition light matter quasiparticles exciton polaritons In the following century several remarkable effects have been discovered in microcavities including the Bose Einstein condensation of exciton polaritons polariton lasing superfluidity optical spin Hall and spin Meissner effects amongst other discoveries Currently polariton devices exploiting the

bosonic stimulation effects at room temperature are being developed by laboratories across the world This book addresses the physics of microcavities from classical to quantum optics from a Boltzmann gas to a superfluid It provides the theoretical background needed for understanding the complex phenomena in coupled light matter systems and it presents a broad overview of experimental progress in the physics of microcavities **Photonic Band Gap Materials** C.M.

Soukoulis,2012-12-06 Photonic band gap crystals offer unique ways to tailor light and the propagation of electromagnetic waves In analogy to electrons in a crystal EM waves propagating in a structure with a periodically modulated dielectric constant are organized into photonic bands separated by gaps in which propagating states are forbidden Proposed applications of such photonic band gap crystals operating at frequencies from microwave to optical include zero threshold lasers low loss resonators and cavities and efficient microwave antennas Spontaneous emission is suppressed for photons in the photonic band gap offering novel approaches to manipulating the EM field and creating high efficiency light emitting structures Photonic Band Gap Materials identifies three most promising areas of research The first is materials fabrication involving the creation of high quality low loss periodic dielectric structures The smallest photonic crystals yet fabricated have been made by machining Si wafers along 110 and some have lattice constants as small as 500 microns The second area is in applications Possible applications presented are microwave mirrors directional antennas resonators especially in the 2 GHz region filters waveguides Y splitters and resonant microcavities The third area covers fundamentally new physical phenomena in condensed matter physics and quantum optics An excellent review of recent development covering theoretical experimental and applied aspects Interesting and stimulating reading for active researchers as well as a useful reference for non specialists **Metal Halide Perovskites for Generation, Manipulation and Detection of Light** Juan P.

Martínez-Pastor,Pablo P. Boix,Guichuan Xing,2023-07-20 Metal Halide Perovskites for Generation Manipulation and Detection of Light covers the current state and future prospects of lead halide perovskite photonics and photon sources both from an academic and industrial point of view Advances in metal halide perovskite photon sources lasers based on thin films microcrystals and nanocrystals are comprehensively reviewed with leading experts contributing current advances in theory fundamental concepts fabrication techniques experiments and other important research innovations This book is suitable for graduate students researchers scientists and engineers in academia and R photodetectors lighting lasing nonlinear photonics and quantum technologies Discusses future prospective trends and envisioned applications of metal halide perovskites from near UV to near IR photonics **Experimental Research of Cavity Optomechanics** Zhen Shen,2021-01-12 This thesis

presents experimental research on the interaction between the optical field and the mechanical oscillator in whispering gallery mode microcavities It demonstrates how optomechanical interactions in a microresonator can be used to achieve non magnetic non reciprocity and develop all optically controlled non reciprocal multifunctional photonic devices The thesis also discusses the interaction between the travelling optical and mechanical whispering gallery modes paving the way for non

reciprocal light storage as a coherent circulating acoustic wave with a lifetime of up to tens of microseconds. Lastly, the thesis presents a high frequency phase sensitive heterodyne vibrometer operating up to 10 GHz which can be used for the high resolution non invasive mapping of the vibration patterns of acoustic devices. The results presented here show that optomechanical devices hold great potential in the field of information processing.

Light Scattering in Solids IX Manuel Cardona, Roberto Merlin, 2006-12-15 This volume treats new materials nanotubes and quantum dots and new techniques synchrotron radiation scattering and cavity confined scattering. In the past five years Raman and Brillouin scattering have taken a place among the most important research and characterization methods for carbon nanotubes. Among the novel techniques discussed in this volume are those employing synchrotron radiation as a light source.

Semiconductor Quantum Light Sources Peter Michler, Simone Luca Portalupi, 2024-01-29 The work provides fundamental expertise of quantum optics and photonic quantum technology with particular attention to the generation of non classical light with semiconductor nanostructures. The book is written by experimentalists for experimentalists at various career stages physics and engineering students researchers in quantum optics industry experts in quantum technology. A didactical structure is followed having in each chapter overview and summary of the discussed topics allowing for a quick consultation. The book covers Basics of quantum optics Spectroscopy time resolved measurements quantum optics techniques Principles of non classical light emission Excitation of semiconductor nanostructures and their manipulation Growth and nanofabrication of devices Targeting physics and quantum engineering students as well as research scientists and engineers in academia and industry it provides the practical base for understanding quantum light sources and for evaluating their performances. Thus it enables readers to gain the necessary knowledge to understand design and test novel quantum light sources for various implementations as quantum key distribution quantum repeaters quantum sensors and photonic quantum information processing.

Soft Materials-Based Biosensing Medical Applications Deepak Gupta, Milan Singh, Rishabha Malviya, Sonali Sundram, 2025-06-04 The book offers a comprehensive interdisciplinary overview of how innovative soft materials are revolutionizing biosensing technologies making it an essential read for anyone interested in cutting edge advancements in biomedical research and healthcare. Soft materials include granular materials foams gels polymers surfactants functional organics and biological molecules. These structures can be altered by thermal or mechanical stress due to their ability to self organize into mesoscopic physical structures. They are becoming increasingly significant as functional materials for broader applications because of their rich surface chemistry and versatile functions. A biosensor is an analytical tool for chemical compound detection that combines a biological element with a physicochemical detector. Sensitive biological components such as proteins carbohydrates tissue bacteria and enzymes are collected from a biomimetic element that interacts and binds with the analyte under investigation. In biosensors soft matter may function as both a sensing and transducing component. The interplay of soft matter with biomolecular analytes results in cell signaling pathways diagnostic tests for applications in

low resource environments prospective drug development molecular biodetection chemical sensors and biological sensors Understanding these biomolecular interactions in the context of acute illnesses is critical for biomedical research and healthcare This has fueled efforts to create a biosensor that is effective low cost and label free Several approaches using soft materials to functionalize and tailor structures have greatly advanced science including chemistry physics pharmaceutical science materials science and engineering Soft Materials Based Biosensing Medical Applications summarizes recent advances in soft materials with unique physicochemical properties that synergistically promote biosensing systems Audience The book will be read by researchers materials scientists electronic and AI engineers as well as pharmaceutical and biomedical professionals interested in the uses of biosensing *4D Printing Technology* Bijaya Bikram Samal, Cheruvu Siva Kumar, Shailendra Kumar Varshney, 2025-05-22 The book serves as a comprehensive guide to 4D printing technology exploring its principles materials and applications while offering valuable insights for researchers engineers and innovators in additive manufacturing 4D Printing Technology Principles Materials and Applications is a detailed exploration of 4D printing technology offering readers a comprehensive understanding of how smart materials and additive manufacturing processes come together to create dynamic responsive structures Starting with the foundations of additive manufacturing this volume introduces readers to the rise of smart materials and the evolution from static 3D printing to adaptive 4D printing It covers a wide range of topics including 4D printing at the micro and nano scale the use of polymers and reinforced materials and advanced applications in photonics The volume delves into complex programming of 4D printed materials discussing various stimuli thermal magnetic light based that enable shape shifting behavior Each chapter focuses on practical applications including healthcare innovations like adaptive implants aerospace components that morph based on environmental conditions and novel photonic devices Finally the book discusses key characterization techniques necessary for analyzing the performance and durability of 4D printed parts 4D Printing Technology Principles Materials and Applications serves as a comprehensive reference and an inspiration for future innovations in this rapidly evolving field Readers will find the book Comprehensively covers 4D printing technologies from foundational principles to advanced applications in photonics robotics and micro nano devices Includes contributions from international experts in smart materials advanced manufacturing techniques and application specific innovations Covers important research developments in this field from the last decade Provides detailed discussions on materials shape programming and characterization techniques for 4D printed structures Examines various applications future directions and innovations in 4D printing smart materials and additive manufacturing technologies Audience Manufacturing engineers materials scientists additive manufacturing specialists in all industries academics and researchers in advanced materials biomedical engineering photonics and nanotechnology Dissertation Abstracts International ,2007

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Light Matter Interaction Ultra High Q Whispering Microcavities Introduction

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