

Numerical Modelling of the Optical–Acoustical Characterization of an Anti-Resonant Bragg Hollow Core Fiber

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Abstract: Anti-resonant hollow core fibers (AR-HCFs) provide a promising solution for photothermal spectroscopy and photoacoustic imaging applications. Here, the AR-HCF serves as a micro platform to induce the photothermal/photoacoustic effect. Since the Bragg structure can induce multiple AR effects compared with the general AR-HCF, we proposed a novel device, the AR-BHCF (AR-HCF with Bragg cladding), to enhance the excitation efficiency. The simulation and experimental results validate that the AR-BHCF dominates in having a stronger ability to confine the optical field in the air core indeed. Then, the acoustic signal stimulated by the photoacoustic effect will propagate along with the fiber axial, and part of it will penetrate out of the AR-BHCF. The results revealed that the transmission bandwidth of the acoustic wave in the AR-BHCF ranges from 1 Hz to 1 MHz, covering infrasound to ultrasound. In particular, a constant coefficient of 0.5 exists in the acoustic wave fading process, related to the propagation frequency and time. The acoustic signal can be monitored in real time, assisted by the ultra-highly sensitive sensor head. Therefore, BHCF-based devices combined with photoacoustic techniques may accelerate their sensing applications. Meanwhile, this scheme shines a light on the theoretical foundation of novel short-hand distributed acoustic sensing.

Keywords: multiple AR effects; AR-BHCF; photoacoustic effect; acoustic wave



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1. Introduction

Hollow core fiber (HCF), as a special microstructure device, has enabled sensor size miniaturization. In recent years, the anti-resonant (AR) effect integrated into HCF has shined light on its optical characterization, which is referred to as anti-resonant hollow core fiber (AR-HCF). It is precisely because the AR effect enriches the optical transmission in the HCF, which provides a micro-sized inline platform to achieve diversified sensing detection. In particular, AR-HCF has a great prospect in special scenario sensing applications, such as in the fields of microfluidics [1], photothermal spectroscopy [2], and photoacoustic imaging [3,4]. Moreover, several common physical parameters can be directly detected by monitoring the variation in the AR transmission spectrum. For example, exploiting the drift of the resonance peak can acquire the measurement of temperature [5], displacement [6], stress [7], curvature [8], refractive index [9], and gas pressure [10]. These measurands all take advantage of the AR optical characteristics, which feature resonant peaks and an irregularly coherent envelope [11]. Unlike the direct wavelength demodulation of the aforementioned parameters, the photothermal or photoacoustic effect needs the interaction between light and gas to excite acoustic signals [12]. AR-HCF combined with femtosecond

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Proceedings of the Symposium on Optical and Acoustical Micro-Electronics, New York, N.Y., April 16-18, 1974 Jerome Fox, Mark Howard Schlam, 1975 **Semiconductor Devices and Integrated Electronics** A. G. Milnes, 2012-12-06 For some time there has been a need for a semiconductor device book that carries diode and transistor theory beyond an introductory level and yet has space to touch on a wider range of semiconductor device principles and applications. Such topics are covered in specialized monographs numbering many hundreds but the voluminous nature of this literature limits access for students. This book is the outcome of attempts to develop a broad course on devices and integrated electronics for university students at about senior year level. The educational prerequisites are an introductory course in semiconductor junction and transistor concepts and a course on analog and digital circuits that has introduced the concepts of rectification, amplification, oscillators, modulation and logic, and Switching circuits. The book should also be of value to professional engineers and physicists because of both the information included and the detailed guide to the literature given by the references. The aim has been to bring some measure of order into the subject area examined and to provide a basic structure from which teachers may develop themes that are of most interest to students and themselves. Semiconductor devices and integrated circuits are reviewed and fundamental factors that control power levels, frequency, speed, size and cost are discussed. The text also briefly mentions how devices are used and presents circuits and comments on representative applications. Thus the book seeks a balance between the extremes of device physics and circuit design. Microlithography Bruce W. Smith, Kazuaki Suzuki, 2018-10-03 This new edition of the bestselling *Microlithography: Science and Technology* provides a balanced treatment of theoretical and operational considerations from elementary concepts to advanced aspects of modern submicron microlithography. Each chapter reflects the current research and practices from the world's leading academic and industrial laboratories detailed by a stellar panel of international experts. New in the Second Edition: In addition to updated information on existing material, this new edition features coverage of technologies developed over the last decade since the first edition appeared, including Immersion Lithography, 157nm Lithography, Electron Projection Lithography, EPL, Extreme Ultraviolet EUV Lithography, Imprint Lithography, Photoresists for 193nm and Immersion Lithography. *Microlithography: Science and Technology, Second Edition* authoritatively covers the physics, chemistry, optics, metrology, tools and techniques, resist processing and materials, and fabrication methods involved in the latest generations of microlithography, such as immersion lithography and extreme ultraviolet EUV lithography. It also looks ahead to the possible future systems and technologies that will bring the next generations to fruition. Loaded with illustrations, equations, tables, and time-saving references to the most current literature, this book is the most comprehensive and reliable source for anyone from student to seasoned professional looking to achieve robust, accurate and cost-effective microlithography processes and systems. **Microelectronic Materials and Processes** Roland Levy, 1989-01-31 The

primary thrust of very large scale integration VLS is the miniaturization of devices to increase packing density achieve higher speed and consume lower power The fabrication of integrated circuits containing in excess of four million components per chip with design rules in the submicron range has now been made possible by the introduction of innovative circuit designs and the development of new microelectronic materials and processes This book addresses the latter challenge by assessing the current status of the science and technology associated with the production of VLSI silicon circuits It represents the cumulative effort of experts from academia and industry who have come together to blend their expertise into a tutorial overview and cohesive update of this rapidly expanding field A balance of fundamental and applied contributions cover the basics of microelectronics materials and process engineering Subjects in materials science include silicon silicides resists dielectrics and interconnect metallization Subjects in process engineering include crystal growth epitaxy oxidation thin film deposition fine line lithography dry etching ion implantation and diffusion Other related topics such as process simulation defects phenomena and diagnostic techniques are also included This book is the result of a NATO sponsored Advanced Study Institute AS held in Castelvechio Pascoli Italy Invited speakers at this institute provided manuscripts which were edited updated and integrated with other contributions solicited from non participants to this AS

Acousto-optic Signal Processing Pankaj K. Das, Casimer M. De Cusatis, Sergei Viktorovich Kulakov, 1991 Gain fast access to the underlying theory behind acousto optic devices with this book It illustrates the design process with numerical examples and references to pertinent literature and offers coverage of the fundamentals of acousto optic interaction theory as well as a discussion of surface wave devices and many of the basic acousto optic devices

Handbook of VLSI Microlithography, 2nd Edition John N. Helbert, 2001-04 This handbook gives readers a close look at the entire technology of printing very high resolution and high density integrated circuit IC patterns into thin resist process transfer coatings including optical lithography electron beam ion beam and x ray lithography The book's main theme is the special printing process needed to achieve volume high density IC chip production especially in the Dynamic Random Access Memory DRAM industry The book leads off with a comparison of various lithography methods covering the three major patterning parameters of line space resolution line edge and pattern feature dimension control The book's explanation of resist and resist process equipment technology may well be the first practical description of the relationship between the resist process and equipment parameters The basics of resist technology are completely covered including an entire chapter on resist process defectivity and the potential yield limiting effect on device production Each alternative lithographic technique and testing method is considered and evaluated basic metrology including optical scanning electron microscope SEM techniques and electrical test devices along with explanations of actual printing tools and their design construction and performance The editor devotes an entire chapter to today's sophisticated complex electron beam printers and to the emerging x ray printing technology now used in high density CMOS devices Energetic ion particle printing is a controllable steerable technology that does not rely on resist and

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Handbook of Engineering Acoustics Gerhard Müller, Michael Möser, 2012-11-06 This book examines the physical background of engineering acoustics focusing on empirically obtained engineering experience as well as on measurement techniques and engineering methods for prognostics Its goal is not only to describe the state of art of engineering acoustics but also to give practical help to engineers in order to solve acoustic problems It deals with the origin the transmission and the methods of the abating different kinds of air borne and structure borne sounds caused by various mechanisms from traffic to machinery and flow induced sound In addition the modern aspects of room and building acoustics as well as psychoacoustics and active noise control are covered *Current Engineering Practice*, 1976 A - Airports British

Library, 2012-05-21 No detailed description available for A Airports **Optical and Acoustical Microelectronics** Jerome Fox, 1975 **Progress in Optics**, 1980-01-01 Progress in Optics **III-V Microelectronics** J.P. Nougier, 2014-05-27 As is well known Silicon widely dominates the market of semiconductor devices and circuits and in particular is well suited for Ultra Large Scale Integration processes However a number of III V compound semiconductor devices and circuits have recently been built and the contributions in this volume are devoted to those types of materials which offer a number of interesting properties Taking into account the great variety of problems encountered and of their mutual correlations when fabricating a circuit or even a device most of the aspects of III V microelectronics from fundamental physics to modelling and technology from materials to devices and circuits are reviewed Containing contributions from European researchers of international repute this volume is the definitive reference source for anyone interested in the latest advances and results of

current experimental research in III V microelectronics **Drone Electronics** Mr. Rohit Manglik,2024-03-08 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels **Artificial**

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Microelectronics ,1975 **Behaviour of Electromagnetic Waves in Different Media and Structures** Ali

Akdagli,2011-07-05 This comprehensive volume thoroughly covers wave propagation behaviors and computational techniques for electromagnetic waves in different complex media The chapter authors describe powerful and sophisticated analytic and numerical methods to solve their specific electromagnetic problems for complex media and geometries as well This book will be of interest to electromagnetics and microwave engineers physicists and scientists Uses of Ceramics in Microelectronics: A Survey W. R. Bratschun,1971 Scientific and Technical Aerospace Reports ,1995

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