

Chapter 1

Heterostructure and Quantum Well Physics

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I. INTRODUCTION

Heterostructures are the building blocks of many of the most advanced semiconductor devices presently being developed and produced. They are essential elements of the highest-performance optical sources and detectors [1,2] and are being employed increasingly in high-speed and

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**Wengang (Wayne) Bi, Haochung
(Henry) Kuo, Peicheng Ku, Bo Shen**



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Heterostructures and Quantum Devices Norman G. Einspruch, William R. Frensley, 2014-06-28 Heterostructure and quantum mechanical devices promise significant improvement in the performance of electronic and optoelectronic integrated circuits ICs Though these devices are the subject of a vigorous research effort the current literature is often either highly technical or narrowly focused This book presents heterostructure and quantum devices to the nonspecialist especially electrical engineers working with high performance semiconductor devices It focuses on a broad base of technical applications using semiconductor physics theory to develop the next generation of electrical engineering devices The text covers existing technologies and future possibilities within a common framework of high performance devices which will have a more immediate impact on advanced semiconductor physics particularly quantum effects and will thus form the basis for longer term technology development

VLSI Electronics: Heterostructures and quantum devices Norman G. Einspruch, 1981 Terahertz Sensing Technology - Vol 1: Electronic Devices And Advanced Systems Technology Michael S Shur, Dwight L Woolard, William R Loerop, 2003-07-14 The last research frontier in high frequency electronics now lies in the so called THz or submillimeter wave regime between the traditional microwave and infrared domains Significant scientific and technical challenges within the terahertz THz frequency regime have recently motivated an array of new research activities During the last few years major research programs have emerged that are focused on advancing the state of the art in THz frequency electronic technology and on investigating novel applications of THz frequency sensing This book serves as a detailed reference for the new THz frequency technological advances that are emerging across a wide spectrum of sensing and technology areas

Quantum Well and Superlattice Physics, 1987 Terahertz Sensing Technology: Electronic devices and advanced systems technology Dwight L. Woolard, William R. Loerop, Michael Shur, 2003 The last research frontier in high frequency electronics now lies in the so called THz or submillimeter wave regime between the traditional microwave and infrared domains Significant scientific and technical challenges within the terahertz THz frequency regime have recently motivated an array of new research activities During the last few years major research programs have emerged that are focused on advancing the state of the art in THz frequency electronic technology and on investigating novel applications of THz frequency sensing This book serves as a detailed reference for the new THz frequency technological advances that are emerging across a wide spectrum of sensing and technology areas

Handbook of GaN Semiconductor Materials and Devices Wengang (Wayne) Bi, Haochung (Henry) Kuo, Peicheng Ku, Bo Shen, 2017-10-20 This book addresses material growth device fabrication device application and commercialization of energy efficient white light emitting diodes LEDs laser diodes and power electronics devices It begins with an overview on basics of semiconductor materials physics growth and characterization techniques followed by detailed discussion of advantages drawbacks design issues processing applications and key challenges for state of the art GaN based devices It includes state of the art material synthesis techniques with an

overview on growth technologies for emerging bulk or free standing GaN and AlN substrates and their applications in electronics detection sensing optoelectronics and photonics Wengang Wayne Bi is Distinguished Chair Professor and Associate Dean in the College of Information and Electrical Engineering at Hebei University of Technology in Tianjin China Hao chung Henry Kuo is Distinguished Professor and Associate Director of the Photonics Center at National Chiao Tung University Hsin Tsu Taiwan China Pei Cheng Ku is an associate professor in the Department of Electrical Engineering Computer Science at the University of Michigan Ann Arbor USA Bo Shen is the Cheung Kong Professor at Peking University in China

Advances in Lasers and Electro Optics Nelson Costa, Adolfo Cartaxo, 2010-04-01 Lasers and electro optics is a field of research leading to constant breakthroughs Indeed tremendous advances have occurred in optical components and systems since the invention of laser in the late 50s with applications in almost every imaginable field of science including control astronomy medicine communications measurements etc If we focus on lasers for example we find applications in quite different areas We find lasers for instance in industry emitting power level of several tens of kilowatts for welding and cutting in medical applications emitting power levels from few milliwatt to tens of Watt for various types of surgeries and in optical fibre telecommunication systems emitting power levels of the order of one milliwatt This book is divided in four sections The book presents several physical effects and properties of materials used in lasers and electro optics in the first chapter and in the three remaining chapters applications of lasers and electro optics in three different areas are presented

Terahertz Sensing Technology - Vol 2: Emerging Scientific Applications And Novel Device Concepts Michael S Shur, Dwight L Woolard, William R Loerop, 2004-02-06 The last research frontier in high frequency electronics lies in the so called terahertz or submillimeter wave regime between the traditional microwave and the infrared domains Significant scientific and technical challenges within the terahertz THz frequency regime have recently motivated an array of new research activities During the last few years major research programs have emerged that are focused on advancing the state of the art in THz frequency electronic technology and on investigating novel applications of THz frequency sensing This book provides a detailed review of the new THz frequency technological developments that are emerging across a wide spectrum of sensing and technology areas Volume II presents cutting edge results in two primary areas 1 research that is attempting to establish THz frequency sensing as a new characterization tool for chemical biological and semiconductor materials and 2 theoretical and experimental efforts to define new device concepts within the THz gap

Proceedings of the 12th Annual Conference on the Physics and Chemistry of Semiconductor Interfaces, 29-31 January 1985, Fiesta Inn, Tempe, Arizona Robert S. Bauer, 1985

Encyclopedia of Modern Optics Bob D. Guenther, Duncan Steel, 2018-02-14 The Encyclopedia of Modern Optics Second Edition Five Volume Set provides a wide ranging overview of the field comprising authoritative reference articles for undergraduate and postgraduate students and those researching outside their area of expertise Topics covered include classical and quantum optics lasers optical fibers and optical fiber systems optical materials

and light emitting diodes LEDs Articles cover all subfields of optical physics and engineering such as electro optical design of modulators and detectors This update contains contributions from international experts who discuss topics such as nano photonics and plasmonics optical interconnects photonic crystals and 2D materials such as graphene or holy fibers Other topics of note include solar energy high efficiency LED s and their use in illumination orbital angular momentum quantum optics and information metamaterials and transformation optics high power fiber and UV fiber lasers random lasers and bio imaging Addresses recent developments in the field and integrates concepts from fundamental physics with applications for manufacturing and engineering design Provides a broad and interdisciplinary coverage of specialist areas Ensures that the material is appropriate for new researchers and those working in a new sub field as well as those in industry Thematically arranged and alphabetically indexed with cross references added to facilitate ease of use

Theory of Semiconductor Quantum Devices Fausto Rossi,2011-01-13 Primary goal of this book is to provide a cohesive description of the vast field of semiconductor quantum devices with special emphasis on basic quantum mechanical phenomena governing the electro optical response of new generation nanomaterials The book will cover within a common language different types of optoelectronic nanodevices including quantum cascade laser sources and detectors few electron exciton quantum devices and semiconductor based quantum logic gates The distinguishing feature of the present volume is a unified microscopic treatment of quantum transport and coherent optics phenomena on ultrasmall space and time scales as well as of their semiclassical counterparts

Excitonic and Photonic Processes in Materials Jai Singh,Richard T. Williams,2014-07-29 This book is expected to present state of the art understanding of a selection of excitonic and photonic processes in useful materials from semiconductors to insulators to metal insulator nanocomposites both inorganic and organic Among the featured applications are components of solar cells detectors light emitting devices scintillators and materials with novel optical properties Excitonic properties are particularly important in organic photovoltaics and light emitting devices as also in questions of the ultimate resolution and efficiency of new generation scintillators for medical diagnostics border security and nuclear non proliferation Novel photonic and optoelectronic applications benefit from new material combinations and structures to be discussed

Fundamentals of Terahertz Devices and Applications Dimitris Pavlidis,2021-08-02 An authoritative and comprehensive guide to the devices and applications of Terahertz technology Terahertz THz technology relates to applications that span in frequency from a few hundred GHz to more than 1000 GHz Fundamentals of Terahertz Devices and Applications offers a comprehensive review of the devices and applications of Terahertz technology With contributions from a range of experts on the topic this book contains in a single volume an inclusive review of THz devices for signal generation detection and treatment Fundamentals of Terahertz Devices and Applications offers an exploration and addresses key categories and aspects of Terahertz Technology such as sources detectors transmission electronic considerations and applications optical photonic considerations and applications Worked examplesbased on the contributors

extensive experience highlight the chapter material presented The text is designed for use by novices and professionals who want a better understanding of device operation and use and is suitable for instructional purposes This important book Offers the most relevant up to date research information and insight into the future developments in the technology Addresses a wide range of categories and aspects of Terahertz technology Includes material to support courses on Terahertz Technology and more Contains illustrative worked examples Written for researchers students and professional engineers Fundamentals of Terahertz Devices and Applications offers an in depth exploration of the topic that is designed for both novices and professionals and can be adopted for instructional purposes

Effective Electron Mass in Low-Dimensional Semiconductors

Sitangshu Bhattacharya,Kamakhyia Prasad Ghatak,2012-10-06 This book deals with the Effective Electron Mass EEM in low dimensional semiconductors The materials considered are quantum confined non linear optical III V II VI GaP Ge PtSb₂ zero gap stressed Bismuth carbon nanotubes GaSb IV VI Te II V Bi₂Te₃ Sb III V II VI IV VI semiconductors and quantized III V II VI IV VI and HgTe CdTe superlattices with graded interfaces and effective mass superlattices The presence of intense electric field and the light waves change the band structure of optoelectronic semiconductors in fundamental ways which have also been incorporated in the study of the EEM in quantized structures of optoelectronic compounds that control the studies of the quantum effect devices under strong fields The importance of measurement of band gap in optoelectronic materials under strong electric field and external photo excitation has also been discussed in this context The influence of crossed electric and quantizing magnetic fields on the EEM and the EEM in heavily doped semiconductors and their nanostructures is discussed This book contains 200 open research problems which form the integral part of the text and are useful for both Ph D aspirants and researchers in the fields of solid state sciences materials science nanoscience and technology and allied fields in addition to the graduate courses in modern semiconductor nanostructures The book is written for post graduate students researchers and engineers professionals in the fields of solid state sciences materials science nanoscience and technology nanostructured materials and condensed matter physics

Fundamentals of Photonics Bahaa

E. A. Saleh,Malvin Carl Teich,2020-03-04 Fundamentals of Photonics A complete thoroughly updated full color third edition Fundamentals of Photonics Third Edition is a self contained and up to date introductory level textbook that thoroughly surveys this rapidly expanding area of engineering and applied physics Featuring a blend of theory and applications coverage includes detailed accounts of the primary theories of light including ray optics wave optics electromagnetic optics and photon optics as well as the interaction of light and matter Presented at increasing levels of complexity preliminary sections build toward more advanced topics such as Fourier optics and holography photonic crystal optics guided wave and fiber optics LEDs and lasers acousto optic and electro optic devices nonlinear optical devices ultrafast optics optical interconnects and switches and optical fiber communications The third edition features an entirely new chapter on the optics of metals and plasmonic devices Each chapter contains highlighted equations exercises problems summaries and selected reading lists

Examples of real systems are included to emphasize the concepts governing applications of current interest Each of the twenty four chapters of the second edition has been thoroughly updated

Handbook of Optoelectronic Device Modeling and Simulation Joachim Piprek, 2017-10-10 Optoelectronic devices are now ubiquitous in our daily lives from light emitting diodes LEDs in many household appliances to solar cells for energy This handbook shows how we can probe the underlying and highly complex physical processes using modern mathematical models and numerical simulation for optoelectronic device design analysis and performance optimization It reflects the wide availability of powerful computers and advanced commercial software which have opened the door for non specialists to perform sophisticated modeling and simulation tasks The chapters comprise the know how of more than a hundred experts from all over the world The handbook is an ideal starting point for beginners but also gives experienced researchers the opportunity to renew and broaden their knowledge in this expanding field

Effect of Disorder and Defects in Ion-Implanted Semiconductors: Optical and Photothermal Characterization , 1997-06-12 Defects in ion implanted semiconductors are important and will likely gain increased importance as annealing temperatures are reduced with successive IC generations Novel implant approaches such as MdV implantation create new types of defects whose origin and annealing characteristics will need to be addressed Publications in this field mainly focus on the effects of ion implantation on the material and the modification in the implanted layer after high temperature annealing The editors of this volume and Volume 45 focus on the physics of the annealing kinetics of the damaged layer An overview of characterization techniques and a critical comparison of the information on annealing kinetics is also presented Provides basic knowledge of ion implantation induced defects Focuses on physical mechanisms of defect annealing Utilizes electrical physical and optical characterization tools for processed semiconductors Provides the basis for understanding the problems caused by the defects generated by implantation and the means for their characterization and elimination

Advances in Fabrication and Investigation of Nanomaterials for Industrial Applications Sivashankar Krishnamoorthy, Krzysztof (Kris) Iniewski, 2024-02-29 This book provides readers with a collection of selected articles contributed by leading experts around the world covering recent advances in fabrication and investigation of nanoengineered materials thin films and colloids in application to key emerging industrial sectors The readers are exposed to a variety of concepts ranging from fundamental to applied addressing different application sectors including sensing imaging energy generation energy storage and forensics In addition to key enabling concepts and technologies of interest to broad range of nanomaterials the contributions emphasize semiconductor nanostructures and devices reflecting their continuing interest to academia and industry

Mid-infrared Optoelectronics Eric Tournié, Laurent Cerutti, 2019-10-19 Mid infrared Optoelectronics Materials Devices and Applications addresses the new materials devices and applications that have emerged over the last decade along with exciting areas of research Sections cover fundamentals light sources photodetectors new approaches and the application of mid IR devices with sections discussing LEDs laser diodes and

quantum cascade lasers mid infrared optoelectronics emerging research areas dilute bismide and nitride alloys Group IV materials gallium nitride heterostructures and new nonlinear materials Finally the most relevant applications of mid infrared devices are reviewed in industry gas sensing spectroscopy and imaging This book presents a key reference for materials scientists engineers and professionals working in R D in the area of semiconductors and optoelectronics Provides a comprehensive overview of mid infrared photodetectors and light sources and the latest materials and devices Reviews emerging areas of research in the field of mid infrared optoelectronics including new materials such as wide bandgap materials chalcogenides and new approaches like heterogeneous integration Includes information on the most relevant applications in industry like gas sensing spectroscopy and imaging

Fundamentals of Solid State Engineering Manijeh Razeghi, 2006-06-12 *Fundamentals of Solid State Engineering* 2nd Edition provides a multi disciplinary introduction to Solid State Engineering combining concepts from physics chemistry electrical engineering materials science and mechanical engineering Basic physics concepts are introduced followed by a thorough treatment of the technology for solid state engineering Topics include compound semiconductor bulk and epitaxial thin films growth techniques current semiconductor device processing and nano fabrication technologies Examples of semiconductor devices and a description of their theory of operation are then discussed including transistors semiconductor lasers and photodetectors Revised throughout this second edition includes new chapters on the reciprocal lattice optical properties of semiconductors semiconductor heterostructures semiconductor characterization techniques and an introduction to lasers Additions and improvements have been made to the material on photodetectors and quantum mechanics as well as to the problem sections

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