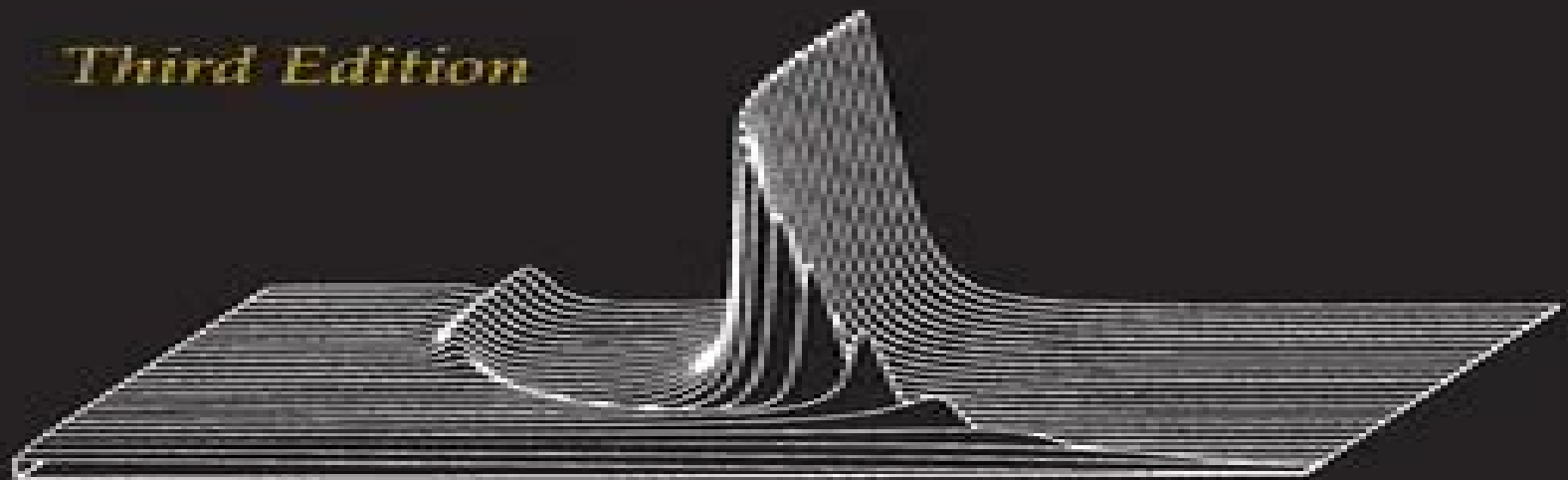


# QUANTUM THEORY OF THE OPTICAL AND ELECTRONIC PROPERTIES OF SEMICONDUCTORS

*Third Edition*



**Hartmut Haug**

**Stephan W. Koch**

**World Scientific**

# Quantum Theory Of Optical And Electronic Properties Of Semiconductors

**Léo Pomar**



## **Quantum Theory Of Optical And Electronic Properties Of Semiconductors:**

**Quantum Theory of the Optical and Electronic Properties of Semiconductors** Hartmut Haug, Stephan W. Koch, 2004 This invaluable textbook presents the basic elements needed to understand and research into semiconductor physics It deals with elementary excitations in bulk and low dimensional semiconductors including quantum wells quantum wires and quantum dots The basic principles underlying optical nonlinearities are developed including excitonic and many body plasma effects Fundamentals of optical bistability semiconductor lasers femtosecond excitation the optical Stark effect the semiconductor photon echo magneto optic effects as well as bulk and quantum confined Franz Keldysh effects are covered The material is presented in sufficient detail for graduate students and researchers with a general background in quantum mechanics

**Quantum Theory of the Optical and Electronic Properties of Semiconductors** Hartmut Haug, Stephan W. Koch, 1993 This substantially revised second edition of the Quantum Theory of the Optical and Electronic Properties of Semiconductors presents the basic elements needed to understand and engage in research in semiconductor physics In this edition misprints have been corrected and new and more detailed material has been added In order to treat the valence band structure of semiconductors an introduction to the  $k \cdot p$  theory and the related description in terms of the Luttinger Hamiltonian was included An introductory chapter on mesoscopic semiconductor structures was added which discusses the envelope function approximation and the modification caused by the spatial quantum confinement In many chapters the results are developed in parallel first for bulk material and then for quasi two dimensional quantum wells and for quasi one dimensional quantum wires Semiconductor quantum dots are treated in a separate chapter The discussion of time dependent and coherent phenomena in semiconductors has been considerably extended by including a section dealing with the theoretical description of photon echoes in semiconductors After the discussion of semiconductor laser physics optical bistability and electroabsorption in semiconductors a new chapter on magneto absorption has been added in which magneto excitons and magneto plasmas in two dimensional systems are discussed The chapter on electron kinetics due to the interaction with longitudinal optical phonons has been extended and a discussion on carrier carrier collisions has been added to the chapter dealing with the semiconductor Bloch equations The material is presented in sufficient detail for graduate students and researchers who have a general background in quantum mechanics

**Quantum Theory of the Optical and electronic Properties of Semiconductors** , *Quantum Theory Of The Optical And Electronic Properties Of Semiconductors* Hartmut Haug, Stephan W Koch, 1990-04-01 The current technological revolution in the development of computing devices has created a demand for a textbook on the quantum theory of the electronic and optical properties of semiconductors and semiconductor devices This book successfully fulfills this need Based on lectures given by the authors it is a comprehensive introduction for researchers or graduate level students to the subject Certain sections can also serve as a graduate level textbook for use in solid state physics courses or for more specialized courses The final chapters establish a

direct link to current research in semiconductor physics

**Quantum Theory of the Optical and Electronic Properties of Semiconductors** Hartmut Haug,1994 *Quantum Theory of the Optical and Electronic Properties of Semiconductors*

Hartmut Haug,2009 *Quantum Theory Of The Optical And Electronic Properties Of Semiconductors (3rd Edition)* Hartmut Haug,Stephan W Koch,1994-10-31 This textbook presents the basic elements needed to understand and engage in research in semiconductor physics It deals with elementary excitations in bulk and low dimensional semiconductors including quantum wells quantum wires and quantum dots The basic principles underlying optical nonlinearities are developed including excitonic and many body plasma effects The fundamentals of optical bistability semiconductor lasers femtosecond excitation optical Stark effect semiconductor photon echo magneto optic effects as well as bulk and quantum confined Franz Keldysh effects are covered The material is presented in sufficient detail for graduate students and researchers who have a general background in quantum mechanics

**Quantum Theory Of The Optical And Electronic Properties Of Semiconductors (5th Edition)** Hartmut Haug,Stephan W Koch,2009-01-22 This invaluable textbook presents the basic elements needed to understand and research into semiconductor physics It deals with elementary excitations in bulk and low dimensional semiconductors including quantum wells quantum wires and quantum dots The basic principles underlying optical nonlinearities are developed including excitonic and many body plasma effects Fundamentals of optical bistability semiconductor lasers femtosecond excitation the optical Stark effect the semiconductor photon echo magneto optic effects as well as bulk and quantum confined Franz Keldysh effects are covered The material is presented in sufficient detail for graduate students and researchers with a general background in quantum mechanics This fifth edition includes an additional chapter on Quantum Optical Effects where the theory of quantum optical effects in semiconductors is detailed Besides deriving the semiconductor luminescence equations and the expression for the stationary luminescence spectrum results are presented to show the importance of Coulombic effects on the semiconductor luminescence and to elucidate the role of excitonic populations

**Ultrafast Phenomena in Semiconductors** Kong-Thon Tsen,2001 There are many books in the market devoted to the review of certain fields This book is different from those in that authors not only provide reviews of the fields but also present their own important contributions to the fields in a tutorial way As a result researchers who are already in the field of ultrafast dynamics in semiconductors and its device applications as well as researchers and graduate students just entering the field will benefit from it This book is made up of recent new developments in the field of ultrafast dynamics in semiconductors It consists of nine chapters Chapter 1 reviews a microscopic many body theory which allows one to compute the linear and non linear optical properties of semiconductor superlattices in the presence of homogeneous electric fields Chapter 2 deals with ultrafast intersubband dynamics in quantum wells and device structures Chapter 3 is devoted to Bloch oscillations in semiconductors and their applications Chapter 4 discusses transient electron transport phenomena such as electron ballistic transport and electron velocity overshoot phenomena as well as non equilibrium phonon

dynamics in nanostructure semiconductors Chapter 5 reviews experimental and theoretical work on the use of the phase properties of one or more ultrashort optical pulses to generate and control electrical currents in semiconductors

**Semiconductor Optics** Claus F. Klingshirn, 2007-03-07 The updated and enlarged new edition of this book provides an introduction to and an overview of semiconductor optics from the IR through the visible to the UV It includes coverage of linear and nonlinear optical properties dynamics magneto and electrooptics high excitation effects some applications experimental techniques and group theory The mathematics is kept as elementary as possible The subjects covered extend from physics to materials science and optoelectronics New or updated chapters add coverage of current topics while the chapters on bulk materials have been revised and updated *CRC Handbook of Chemistry and Physics, 85th Edition* David R. Lide, 2004-06-29 Get a FREE first edition facsimile with each copy of the 85th Researchers around the world depend upon having access to authoritative up to date data And for more than 90 years they have relied on the CRC Handbook of Chemistry and Physics for that data This year is no exception New tables extensive updates and added sections mean the Handbook has again set a new standard for reliability utility and thoroughness This edition features a Foreword by world renowned neurologist and author Oliver Sacks a free facsimile of the 1913 first edition of the Handbook and thumb tabs that make it easier to locate particular data New tables in this edition include Index of Refraction of Inorganic Crystals Upper and Lower Azeotropic Data for Binary Mixtures Critical Solution Temperatures of Polymer Solutions Density of Solvents as a Function of Temperature By popular request several tables omitted from recent editions are back including Coefficients of Friction and Miscibility of Organic Solvents Ten other sections have been substantially revised with some such as the Table of the Isotopes and Thermal Conductivity of Liquids significantly expanded The Fundamental Physical Constants section has been updated with the latest CODATA NIST values and the Mathematical Tables appendix now features several new sections covering topics that include orthogonal polynomials Clebsch Gordan coefficients and statistics *Semiconductor Nanophotonics* Prasanta Kumar Basu, Bratati Mukhopadhyay, Rikmantra Basu, 2022 One of the first comprehensive textbooks dealing with the modern field of Nanophotonics Though emphasis is given on semiconductors optical processes in metals and insulators are discussed as well Provides basic theoretical models in simple terms and discusses the application areas

**Advanced Silicon & Semiconducting Silicon-Alloy Based Materials & Devices** Jo Nijs, 2021-05-30 One of the first books to cover advanced silicon based technologies Advanced Silicon and Semiconducting Silicon Alloy Based Materials and Devices presents important directions for research into silicon its alloy based semiconducting devices and its development in commercial applications The first section deals with single mono crystalline silicon focusing on the effects of heavy doping the structure and electronic properties of defects and their impact on devices the MBE of silicon silicon alloys and metals CVD techniques for silicon and silicon germanium the material properties of silicon germanium strained layers silicon germanium heterojunction bipolar applications FETs IR detectors and resonant tunneling devices in silicon silicon

germanium and d doped silicon and the fascinating properties of crystalline silicon carbide and its applications The second section explores polycrystalline silicon It examines large grain polysilicon substrates for solar cells the properties analysis and modeling of polysilicon TFTs the technology of polysilicon TFTs in LCD displays and the use of polycrystalline silicon and its alloys in VLSI applications With contributors from leading academic and industrial research centers this book provides wide coverage of fabrication techniques material properties and device applications

**Concepts and Applications of Nonlinear Terahertz Spectroscopy** Thomas Elsaesser, Klaus Reimann, Michael Woerner, 2019-02-22 Terahertz THz radiation with frequencies between 100 GHz and 30 THz has developed into an important tool of science and technology with numerous applications in materials characterization imaging sensor technologies and telecommunications Recent progress in THz generation has provided ultrashort THz pulses with electric field amplitudes of up to several megavolts cm This development opens the new research field of nonlinear THz spectroscopy in which strong light matter interactions are exploited to induce quantum excitations and or charge transport and follow their nonequilibrium dynamics in time resolved experiments This book introduces methods of THz generation and nonlinear THz spectroscopy in a tutorial way discusses the relevant theoretical concepts and presents prototypical experimental and theoretical results in condensed matter physics The potential of nonlinear THz spectroscopy is illustrated by recent research including an overview of the relevant literature

**Comprehensive Semiconductor Science and Technology**, 2024-11-28 Semiconductors are at the heart of modern living Almost everything we do be it work travel communication or entertainment all depend on some feature of semiconductor technology Comprehensive Semiconductor Science and Technology Second Edition Three Volume Set captures the breadth of this important field and presents it in a single source to the large audience who study make and use semiconductor devices Written and edited by a truly international team of experts and newly updated to capture key advancements in the field this work delivers an objective yet cohesive review of the semiconductor world The work is divided into three sections fully updated and expanded from the first edition The first section is concerned with the fundamental physics of semiconductors showing how the electronic features and the lattice dynamics change drastically when systems vary from bulk to a low dimensional structure and further to a nanometer size Throughout this section there is an emphasis on the full understanding of the underlying physics especially quantum phenomena The second section deals largely with the transformation of the conceptual framework of solid state physics into devices and systems which require the growth of high purity or doped bulk and epitaxial materials with low defect density and well controlled electrical and optical properties The third section is devoted to design fabrication and assessment of discrete and integrated semiconductor devices It will cover the entire spectrum of devices we see all around us for telecommunications computing automation displays illumination and consumer electronics Provides a comprehensive global picture of the semiconductor world Written and Edited by an international team of experts Compiles the most important semiconductor knowledge into one comprehensive resource

Moves from fundamentals and theory to more advanced knowledge such as applications allowing readers to gain a deeper understanding of the field

**LED Lighting** Malvin Carl Teich, 2025-04-14 LED Lighting is a self contained and introductory level book featuring a blend of theory and applications that thoroughly covers this important interdisciplinary area Building on the underlying fields of optics photonics and vision science it comprises four parts PART I is devoted to fundamentals The behavior of light is described in terms of rays waves and photons Each of these approaches is best suited to a particular set of applications The properties of blackbody radiation thermal light and incandescent light are derived and explained The essentials of semiconductor physics are set forth including the operation of junctions and heterojunctions quantum wells and quantum dots and organic and perovskite semiconductors PART II deals with the generation of light in semiconductors and details the operation and properties of III V semiconductor devices MQWLEDs microLEDs quantum dot devices QLEDs WQLEDs organic semiconductor devices OLEDs SMOLEDs PLEDs WOLEDs and perovskite devices PeLEDs PPeLEDs QPeLEDs PeWLEDs PART III focuses on vision and the perception of color as well as on colorimetry It delineates radiometric and photometric quantities as well as various measures of luminous efficacy and efficiency It also elucidates the significance of commonly used LED lighting metrics such as the color rendering index CRI color temperature CT correlated color temperature CCT and chromaticity diagram PART IV is devoted to LED lighting focusing on its history and salutary features and on how this modern form of illumination is deployed It describes the principal components used in LED lighting including phosphor conversion LEDs PCLEDs for generating cool and warm white light chip on board COB devices color mixing LEDs LED filaments retrofit LED lamps hybrid devices LED luminaires and OLED light panels It concludes with a discussion of smart and connected lighting that reviews plant centric lighting and highlights the roles of gamma and circadian brain rhythms in human centric lighting Finally the performance metrics for traditional and LED light sources are summarized Each chapter contains practical examples highlighted equations color coded figures and an extensive bibliography

**Ultrafast Spectroscopy of Semiconductors and Semiconductor Nanostructures** Jagdeep Shah, 2013-11-21 The field of ultrafast spectroscopy of semiconductors and their nanostructures continues to be an active field of research Exciting new developments have taken place since the first edition of this book was completed in 1995 This revised edition includes a discussion of many of these recent developments in the field This is accomplished by adding a chapter on Recent Developments at the end of the book This approach was selected to provide a discussion of results while they are still relatively recent Results published before the end of May 1998 were considered for inclusion in this book The objective of this revised edition remains the same as before to provide a cohesive discussion of the many diverse contributions of ultrafast spectroscopy to the field of semiconductors Extensive cross references are made to earlier chapters in order to accomplish this goal The chapter on Recent Developments begins with a brief discussion of new lasers new techniques of ultrafast spectroscopy and novel nanostructures This is followed by a section on Coherent Spectroscopy where some of the

most interesting recent developments have taken place These include observation of quantum kinetic effects effects that require going beyond the mean field approach of the semiconductor Bloch equations coherent control of populations and current in semiconductors exciton continuum interactions and many diverse aspects of coherent spectroscopy including studies of microcavities Bragg structures quantum dots and quantum wires      *Plasmonic Effects in Metal-Semiconductor Nanostructures* Alexey A. Toropov, Tatiana V. Shubina, 2015-04-02 Metal semiconductor nanostructures represent an important new class of materials employed in designing advanced optoelectronic and nanophotonic devices such as plasmonic nanolasers plasmon enhanced light emitting diodes and solar cells plasmonic emitters of single photons and quantum devices operating in infrared and terahertz domains The combination of surface plasmon resonances in conducting structures providing strong concentration of an electromagnetic optical field nearby with sharp optical resonances in semiconductors which are highly sensitive to external electromagnetic fields creates a platform to control light on the nanoscale The design of the composite metal semiconductor system imposes the consideration of both the plasmonic resonances in metal and the optical transitions in semiconductors a key issue being their resonant interaction providing a coupling regime In this book the reader will find descriptions of electrodynamics of conducting structures quantum physics of semiconductor nanostructures and guidelines for advanced engineering of metal semiconductor composites These constituents form together the physical basics of the metal semiconductor plasmonics underlying many effective practical applications The list of covered topics also includes the review of recent results such as the achievement of a strong coupling regime and the preservation of non classical statistics of photons in plasmonic cavities combined with semiconductor nanostructures      *Proceedings of the International Conference on Computers and Devices for Communication* ,1998

**Transport of Information-Carriers in Semiconductors and Nanodevices** El-Saba, Muhammad, 2017-03-31 Rapid developments in technology have led to enhanced electronic systems and applications When utilized correctly these can have significant impacts on communication and computer systems Transport of Information Carriers in Semiconductors and Nanodevices is an innovative source of academic material on transport modelling in semiconductor material and nanoscale devices Including a range of perspectives on relevant topics such as charge carriers semiclassical transport theory and organic semiconductors this is an ideal publication for engineers researchers academics professionals and practitioners interested in emerging developments on transport equations that govern information carriers

## Decoding **Quantum Theory Of Optical And Electronic Properties Of Semiconductors**: Revealing the Captivating Potential of Verbal Expression

In a period characterized by interconnectedness and an insatiable thirst for knowledge, the captivating potential of verbal expression has emerged as a formidable force. Its ability to evoke sentiments, stimulate introspection, and incite profound transformations is genuinely awe-inspiring. Within the pages of "**Quantum Theory Of Optical And Electronic Properties Of Semiconductors**," a mesmerizing literary creation penned by a celebrated wordsmith, readers embark on an enlightening odyssey, unraveling the intricate significance of language and its enduring effect on our lives. In this appraisal, we shall explore the book's central themes, evaluate its distinctive writing style, and gauge its pervasive influence on the hearts and minds of its readership.

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