

# Electron-Phonon Interactions in Low-Dimensional Structures

*Edited by*  
Lawrence Challis



# Electron Phonon Interaction In Low Dimensional Structures Series On Semiconductor Science And Technology

**N. Balkan**



## **Electron Phonon Interaction In Low Dimensional Structures Series On Semiconductor Science And Technology:**

Electron-phonon Interactions in Low-dimensional Structures Lawrence John Challis, 2003 The study of electrons and holes confined to two one and even zero dimensions has uncovered a rich variety of new physics and applications This book describes the interaction between these confined carriers and the optic and acoustic phonons within and around the confined regions Phonons provide the principal channel of energy transfer between the carriers and their surroundings and also the main restriction to their room temperature mobility But they have many other roles they provide for example an essential feature of the operation of the quantum cascade laser Since their momenta at relevant energies are well matched to those of electrons they can also be used to probe electronic properties such as the confinement width of 2D electron gases and the dispersion curve of quasiparticles in the fractional quantum Hall effect The book describes both the physics of the electron phonon interaction in the different confined systems and the experimental and theoretical techniques that have been used in its investigation The experimental methods include optical and transport techniques as well as techniques in which phonons are used as the experimental probe The aim of the book is to provide an up to date review of the physics and its significance in device performance It is also written to be explanatory and accessible to graduate students and others new to the field

*Electron-phonon Interactions in Low-dimensional Structures* Lawrence John Challis, 2003 The study of electrons and holes confined to two one and even zero dimensions has uncovered a rich variety of new physics and applications This book describes the interaction between these confined carriers and the optic and acoustic phonons within and around the confined regions

**Electron & Nuclear Spin Dynamics in Semiconductor Nanostructures** M. M. Glazov, 2018-09-05 In recent years the physics community has experienced a revival of interest in spin effects in solid state systems On one hand the solid state systems particularly semiconductors and semiconductor nanosystems allow us to perform benchtop studies of quantum and relativistic phenomena On the other hand this interest is supported by the prospects of realizing spin based electronics where the electron or nuclear spins may play a role of quantum or classical information carriers This book looks in detail at the physics of interacting systems of electron and nuclear spins in semiconductors with particular emphasis on low dimensional structures These two spin systems naturally appear in practically all widespread semiconductor compounds The hyperfine interaction of the charge carriers and nuclear spins is particularly prominent in nanosystems due to the localization of the charge carriers and gives rise to spin exchange between these two systems and a whole range of beautiful and complex physics of manybody and nonlinear systems As a result understanding of the intertwined spin systems of electrons and nuclei is crucial for in depth studying and controlling the spin phenomena in semiconductors The book addresses a number of the most prominent effects taking place in semiconductor nanosystems including hyperfine interaction nuclear magnetic resonance dynamical nuclear polarization spin Faraday and spin Kerr effects processes of electron spin decoherence and relaxation effects of electron spin precession mode locking and frequency focussing as well as fluctuations

of electron and nuclear spins      **Phonons in Low Dimensional Structures** Vasilios N. Stavrou, 2018-12-12 The field of low dimensional structures has been experiencing rapid development in both theoretical and experimental research Phonons in Low Dimensional Structures is a collection of chapters related to the properties of solid state structures dependent on lattice vibrations The book is divided into two parts In the first part research topics such as interface phonons and polaron states carrier phonon non equilibrium dynamics directional projection of elastic waves in parallel array of N elastically coupled waveguides collective dynamics for longitudinal and transverse phonon modes and elastic properties for bulk metallic glasses are related to semiconductor devices and metallic glasses devices The second part of the book contains among others topics related to superconductor phononic crystal carbon nanotube devices such as phonon dispersion calculations using density functional theory for a range of superconducting materials phononic crystal based MEMS resonators absorption of acoustic phonons in the hyper sound regime in fluorine modified carbon nanotubes and single walled nanotubes phonon transport in carbon nanotubes quantization of phonon thermal conductance and phonon Anderson localization      **Bands and Photons**

**in III-V Semiconductor Quantum Structures** Igor Vurgaftman, Matthew P. Lumb, Jerry R. Meyer, 2020-11-22 Semiconductor quantum structures are at the core of many photonic devices such as lasers photodetectors solar cells etc To appreciate why they are such a good fit to these devices we must understand the basic features of their band structure and how they interact with incident light Many books have taken on this task in the past but their treatments tend either to pluck results from the literature and present them as received truths or to rely on unrealistically simple models Bands and Photons in III V Semiconductor Quantum Structures takes the reader from the very basics of III V semiconductors some preparation in quantum mechanics and electromagnetism is helpful and shows how seemingly obscure results such as detailed forms of the Hamiltonian optical transition strengths and recombination mechanisms follow The reader would not need to consult other references to fully understand the material although a few handpicked sources are listed for those who would like to deepen their knowledge further Connections to the properties of novel materials such as graphene and transition metal dichalcogenides are pointed out to help prepare the reader for contributing at the forefront of research in those fields The book also supplies a complete up to date database of the band parameters that enter into the calculations along with tables of optical constants and interpolation schemes for alloys From these foundations the book goes on to derive the characteristics of photonic semiconductor devices with a focus on the mid infrared using the same principles of building all concepts from the ground up explaining all derivations in detail giving quantitative examples and laying out dimensional arguments whenever they can help the reader s understanding      **Concepts in Spin Electronics** Sadamichi Maekawa, 2006-01-26 Nowadays information technology is based on semiconductor and ferromagnetic materials Information processing and computation are based on electron charge in semiconductor transistors and integrated circuits and information is stored on magnetic high density hard disks based on the physics of the electron spins Recently a new branch of physics and

nanotechnology called magneto electronics spintronics or spin electronics has emerged which aims at simultaneously exploiting both the charge and the spin of electrons in the same device A broader goal is to develop new functionality that does not exist separately in a ferromagnet or a semiconductor The aim of this book is to present new directions in the development of spin electronics in both the basic physics and the technology which will become the foundation of future electronics

**Physics of Semiconductors in High Magnetic Fields** Noboru Miura, 2008 This book summarizes most of the fundamental physical phenomena which semiconductors and their modulated structures exhibit in high magnetic fields Readers can learn not only the basic theoretical background but also the present state of the art from the most advanced data in this rapidly growing research area

**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

Semiconductor Detector Systems Helmuth Spieler, 2005-08-25 Semiconductor sensors patterned at the micron scale combined with custom designed integrated circuits have revolutionized semiconductor radiation detector systems Designs covering many square meters with millions of signal channels are now commonplace in high energy physics and the technology is finding its way into many other fields ranging from astrophysics to experiments at synchrotron light sources and medical imaging This book is the first to present a comprehensive discussion of the many facets of highly integrated semiconductor detector systems covering sensors signal processing transistors and circuits low noise electronics and radiation effects The diversity of design approaches is illustrated in a chapter describing systems in high energy physics astronomy and astrophysics Finally a chapter Why things don't work discusses common pitfalls Profusely illustrated this book provides a unique reference in a key area of modern science

Hot Electrons in Semiconductors N. Balkan, 1998 Since the arrival of the transistor in 1947 research in hot

electrons like any field in semiconductor research has grown at a stunning rate From a physicist's point of view the understanding of hot electrons and their interactions with the lattice has always been a challenging problem of condensed matter physics Recently with the advent of novel fabrication techniques such as electron beam or plasma etching and the advanced growth techniques such as the molecular beam epitaxy MBE and metallo organic chemical vapour deposition MOCVD it has become possible to fabricate semiconductor devices with sub micron dimensions where the electrons are confined to two quantum well one quantum wire or zero quantum dot dimensions In devices of such dimensions a few volts applied to the device result in the setting up of very high electric fields hence a substantial heating of electrons Thus electronic transport in the device becomes non linear and can no longer be described using the simple equations of Ohm's law The understanding of the operations of such devices and the realisations of more advanced ones make it necessary to understand the dynamics of hot electrons There is an obvious lack of good reference books on hot electrons in semiconductors The few that exist either cover a very narrow field or are becoming quite outdated This book is therefore written with the aim of filling the vacuum in an area where there is much demand for a comprehensive reference book The book is intended for both established researchers and graduate students and gives a complete account of the historical development of the subject together with current research interests and future trends The contributions are written by leading scientists in the field They cover the physics of hot electrons in bulk and low dimensional device technology The material is organised into subject area that can be classified broadly into five groups 1 introduction and overview 2 hot electron phonon interactions and the ultra fast phenomena in bulk and two dimensional structures 3 hot electrons in both long and short quantum wires and quantum dots 4 hot electron tunnelling and hot electron transport in superlattices and 5 novel devices based on hot electron transport The chapters are grouped according to subject matter as far as possible However although there is much overlap of ideas and concepts each chapter is essentially independent of the others

Intense Terahertz Excitation of Semiconductors Sergey Ganichev, Willi Prettl, 2006 This work presents the first comprehensive treatment of high power terahertz applications to semiconductors and low dimensional semiconductor structures Terahertz properties of semiconductors are in the centre of scientific activities because of the need of high speed electronics

*Domain Walls* Dennis Meier, Jan Seidel, Marty Gregg, Ramamoorthy Ramesh, 2020 As the first of its kind this book identifies major questions and challenges that will influence research on domain walls in the years to come

**Spin Current** Sadamichi Maekawa, Sergio O. Valenzuela, Eiji Saitoh, Takashi Kimura, 2017 In a new branch of physics and technology called spin electronics or spintronics the flow of electrical charge usual current as well as the flow of electron spin the so called spin current are manipulated and controlled together This book is intended to provide an introduction and guide to the new physics and applications of spin current

**Quantum Dot Lasers** Victor Mikhailovich Ustinov, 2003 The book addresses issues associated with physics and technology of injection lasers based on self organized quantum dots

Fundamental and technological aspects of quantum dot edge emitting lasers and VCSELs their current status and future prospects are summarized and reviewed Basic principles of QD formation using self organization phenomena are reviewed Structural and optical properties of self organized QDs are considered with a number of examples in different material systems Recent achievements in controlling the QD properties including the effects of vertical stacking changing the matrix bandgap and the surface density of QDs are reviewed The authors focus on the use of self organized quantum dots in laser structures fabrication and characterization of edge and surface emitting diode lasers their properties and optimization with special attention paid to the relationship between structural and electronic properties of QDs and laser characteristics The threshold and power characteristics of the state of the art QD lasers are demonstrated Issues related to the long wavelength 1.3  $\mu\text{m}$  lasers on a GaAs substrate are also addressed and recent results on InGaAsN based diode lasers presented for the purpose of comparison

**Hybrid Phonons in Nanostructures** Brian K. Ridley, 2017-03-09 The book provides a technical account of the basic physics of nanostructures which are the foundation of the hardware found in all manner of computers It will be of interest to semiconductor physicists and electronic engineers and advanced research students Crystalline nanostructures have special properties associated with electrons and lattice vibrations and their interaction The result of spatial confinement of electrons is indicated in the nomenclature of nanostructures quantum wells quantum wires quantum dots Confinement also has a profound effect on lattice vibrations The documentation of the confinement of acoustic modes goes back to Lord Rayleigh's work in the late nineteenth century but no such documentation exists for optical modes It is only comparatively recently that any theory of the elastic properties of optical modes exists and a comprehensive account is given in this book A model of the lattice dynamics of the diamond lattice is given that reveals the quantitative distinction between acoustic and optical modes and the difference of connection rules that must apply at an interface The presence of interfaces in nanostructures forces the hybridization of longitudinally and transversely polarized modes along with in polar material electromagnetic modes Hybrid acoustic and optical modes are described with an emphasis on polar optical phonons and their interaction with electrons Scattering rates in single heterostructures quantum wells and quantum wires are described and the anharmonic interaction in quantum dots discussed A description is given of the effects of dynamic screening of hybrid polar modes and the production of hot phonons

Nanoscale Science and Technology Nicolás García, M. Nieto-Vesperinas, Hermann Rohrer, 1998 Nanoscale Science and Technology summarizes six years of active research sponsored by NATO with the participation of the leading experts The book provides an interdisciplinary view of several aspects of physics at the atomic scale It contains an overview of the latest findings on the transport of electrons in nanowires and nanoconstrictions the role of forces in probe microscopy the control of structures and properties in the nanometer range aspects of magnetization in nanometric structures and local probes for nondestructive measurement as provided by light and metal clusters near atomic scales

*III-Nitride Semiconductors and their Modern Devices* Bernard Gil, 2013-08-22 This book

is dedicated to GaN and its alloys AlGaInN III V nitrides semiconductors with intrinsic properties well suited for visible and UV light emission and electronic devices working at high temperature high frequency and harsh environments There has been a rapid growth in the industrial activity relating to GaN with GaN now ranking at the second position after Si among all semiconductors This is mainly thanks to LEDs but also to the emergence of lasers and high power and high frequency electronics GaN related research activities are also diversifying ranging from advanced optical sources and single electron devices to physical chemical and biological sensors optical detectors and energy converters All recent developments of nitrides and of their technology are gathered here in a single volume with chapters written by world leaders in the field This third book of the series edited by B Gil is complementary to the preceding two and is expected to offer a modern vision of nitrides and of their devices to a large audience of readers

**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

**Low-Dimensional Systems: Theory, Preparation, and Some Applications**

Luis M. Liz-Marzán,Michael Giersig,2012-12-06 This volume contains papers presented at the NATO Advanced Research Workshop ARW Dynamic Interactions in Quantum Dot Systems held at Hotel Atrium in Puszczkovo near Poznan Poland May 16 19 2002 The term low dimensional systems which is used in the title of this volume refers to those systems which contain at least one dimension that is intermediate between those characteristic of atoms molecules and those of the bulk material Depending on how many dimensions lay within this range we generally speak of quantum wells quantum wires and quantum dots As such an intermediate state some properties of low dimensional systems are very different to those of their molecular and bulk counterparts These properties generally include optical electronic and magnetic properties and all these are partially covered in this book The main goal of the workshop was to discuss the actual state of the art in the broad area of nanotechnology The initial focus was on the innovative synthesis of nanomaterials and their properties such as quantum size effects superparamagnetism or field emission These topics lead us into the various field based interactions including plasmon magnetic spin and exciton coupling The newer more sophisticated methods for characterization of nanomaterials



were discussed as well as the methods for possible industrial applications. In general, chemists and physicists as well as experts on both theory and experiments on nanosized regime structures were brought together to discuss the general phenomena underlying their fields of interest from different points of view. *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.

## **Electron Phonon Interaction In Low Dimensional Structures Series On Semiconductor Science And Technology**

### Book Review: Unveiling the Magic of Language

In an electronic digital era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its capability to stir emotions, provoke thought, and instigate transformation is really remarkable. This extraordinary book, aptly titled "**Electron Phonon Interaction In Low Dimensional Structures Series On Semiconductor Science And Technology**," written by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we will delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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