



Phonons in Semiconductor Nanostructures

Edited by

Jean-Pierre Leburton, Jordi Pascual
and Clivia Sotomayor Torres

NATO ASI Series

Phonons In Semiconductor Nanostructures

Lingjun Ying



Phonons In Semiconductor Nanostructures:

Phonons in Semiconductor Nanostructures J.P. Leburton, J. Pascual, Clivia M. Sotomayor Torres, 2012-12-06 In the last ten years the physics and technology of low dimensional structures has experienced a tremendous development Quantum structures with vertical and lateral confinements are now routinely fabricated with feature sizes below 100 nm While quantization of the electron states in mesoscopic systems has been the subject of intense investigation the effect of confinement on lattice vibrations and its influence on the electron phonon interaction and energy dissipation in nanostructures received attention only recently This NATO Advanced Research Workshop on Phonons in Semiconductor Nanostructures was a forum for discussion on the latest developments in the physics of phonons and their impact on the electronic properties of low dimensional structures Our goal was to bring together specialists in lattice dynamics and nanostructure physics to assess the increasing importance of phonon effects on the physical properties of one ID and zero dimensional OD structures The Workshop addressed various issues related to phonon physics in III V II VI and IV semiconductor nanostructures The following topics were successively covered Models for confined phonons in semiconductor nanostructures latest experimental observations of confined phonons and electron phonon interaction in two dimensional systems elementary excitations in nanostructures phonons and optical processes in reduced dimensionality systems phonon limited transport phenomena hot electron effects in quasi ID structures carrier relaxation and phonon bottleneck in quantum dots

Modeling Phonons in Semiconductor Nanostructures, 2007 *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

Confined Electrons and Photons Elias Burstein, Claude Weisbuch, 1995-05-31 Proceedings of a NATO ASI held in Erice Italy held July 13 26 1993

Hot Carriers in Semiconductor Nanostructures Jagdeep Shah, 2012-12-02 Nonequilibrium hot charge carriers play a crucial role in the

physics and technology of semiconductor nanostructure devices This book one of the first on the topic discusses fundamental aspects of hot carriers in quasi two dimensional systems and the impact of these carriers on semiconductor devices The work will provide scientists and device engineers with an authoritative review of the most exciting recent developments in this rapidly moving field It should be read by all those who wish to learn the fundamentals of contemporary ultra small ultra fast semiconductor devices Topics covered include Reduced dimensionality and quantum wells Carrier phonon interactions and hot phonons Femtosecond optical studies of hot carrier Ballistic transport Submicron and resonant tunneling devices

Phonons in Nanostructures Michael A. Strosio, Mitra Dutta, 2001-08-23 This book focuses on the theory of phonon interactions in nanoscale structures with particular emphasis on modern electronic and optoelectronic devices The continuing progress in the fabrication of semiconductor nanostructures with lower dimensional features has led to devices with enhanced functionality and even novel devices with new operating principles The critical role of phonon effects in such semiconductor devices is well known There is therefore a great need for a greater awareness and understanding of confined phonon effects A key goal of this book is to describe tractable models of confined phonons and how these are applied to calculations of basic properties and phenomena of semiconductor heterostructures The level of presentation is appropriate for undergraduate and graduate students in physics and engineering with some background in quantum mechanics and solid state physics or devices A basic understanding of electromagnetism and classical acoustics is assumed Phonon Interactions in Novel Semiconductor Nanostructures, 1996 During this research effort numerous interactions of confined phonons in nanostructures have been modelled theoretically these include piezoelectric scattering in cylindrical quantum wires generalized piezoelectric scattering rate for elections in a two dimensional election gas Gamma X transitions driven by interface phonons interface optical modes in cylindrical quantum wires microscopic model for election optical phonon interactions in quantum wells optical phonons in quantum dots electron acoustic phonon scattering in both rectangular and cylindrical quantum wires and acoustic modes in quantum wires and dots *Electron and Photon Confinement in Semiconductor Nanostructures* Benoît Deveaud, Antonio Quattropani, Paolo Schwendimann, Società italiana di fisica, 2003 The purpose of this course was to give an overview of the physics of artificial semiconductor structures confining electrons and photons It furnishes the background for several applications in particular in the domain of optical devices lasers light emitting diodes or photonic crystals The effects related to the microactivity polaritons which are mixed electromagnetic radiation exciton states inside a semiconductor microactivity are covered The study of the characteristics of such states shows strong relations with the domain of cavity quantum electrodynamics and thus with the investigation of some fundamental theoretical concepts *Ultrafast Dynamical Processes in Semiconductors* Kong-Thon Tsen, 2004-02-25 An international team of experts describes the optical and electronic properties of semiconductors and semiconductor nanostructures at picosecond and femtosecond time scales The contributions cover the latest research on a wide range of

topics In particular they include novel experimental techniques for studying and characterizing nanostructure materials The contributions are written in a tutorial way so that not only researchers in the field but also researchers and graduate students outside the field can benefit

Non-Equilibrium Dynamics of Semiconductors and Nanostructures

Kong-Thon Tsen, 2018-10-03 The advent of the femto second laser has enabled us to observe phenomena at the atomic timescale One area to reap enormous benefits from this ability is ultrafast dynamics Collecting the works of leading experts from around the globe Non Equilibrium Dynamics of Semiconductors and Nanostructures surveys recent developments in a variety of areas in ultrafast dynamics In eight authoritative chapters illustrated by more than 150 figures this book spans a broad range of new techniques and advances It begins with a review of spin dynamics in a high mobility two dimensional electron gas followed by the generation propagation and nonlinear properties of high amplitude ultrashort strain solitons in solids The discussion then turns to nonlinear optical properties of nanoscale artificial dielectrics optical properties of GaN self assembled quantum dots and optical studies of carrier dynamics and non equilibrium optical phonons in nitride based semiconductors Rounding out the presentation the book examines ultrafast non equilibrium electron dynamics in metal nanoparticles monochromatic acoustic phonons in GaAs and electromagnetically induced transparency in semiconductor quantum wells With its pedagogical approach and practical up to date coverage Non Equilibrium Dynamics of Semiconductors and Nanostructures allows you to easily put the material into practice whether you are a seasoned researcher or new to the field

Hybrid Phonons in Nanostructures

B. K. Ridley, 2017 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

Phonon Raman Scattering in Semiconductors,

Quantum Wells and Superlattices Tobias Ruf, 1998 This book presents recent results of basic research in the field of Raman scattering by optic and acoustic phonons in semiconductors quantum wells and superlattices It also describes various new applications for analytical materials research which have emerged alongside with scientific progress Trends in Raman techniques and instrumentation and their implications for future developments are illustrated *Advanced Semiconductor Heterostructures* Mitra Dutta, Michael A. Strosio, 2003 This volume provides valuable summaries on many aspects of advanced semiconductor heterostructures and highlights the great variety of semiconductor heterostructures that has emerged since their original conception As exemplified by the chapters in this book recent progress on advanced semiconductor heterostructures spans a truly remarkable range of scientific fields with an associated diversity of applications Some of these applications will undoubtedly revolutionize critically important facets of modern technology At the heart of these advances is the ability to design and control the properties of semiconductor devices on the nanoscale As an example the intersubband lasers discussed in this book have a broad range of previously unobtainable characteristics and associated applications as a result of the nanoscale dimensional control of the underlying semiconductor heterostructures As this book illustrates an astounding variety of heterostructures can be fabricated with current technology the potentially widespread use of layered quantum dots fabricated with nanoscale precision in biological applications opens up exciting advances in medicine In addition many more excellent examples of the remarkable impact being made through the use of semiconductor heterostructures are given The summaries in this volume provide timely insights into what we know now about selected areas of advanced semiconductor heterostructures and also provide foundations for further developments Contents Novel Heterostructure Devices Electron Phonon Wave Interactions in Intersubband Laser Heterostructures M Kisin et al Quantum Dot Infrared Detectors and Sources P Bhattacharya et al Generation of Terahertz Emission Based on Intersubband Transitions Q Hu Midinfrared GaSb Based Lasers with Type I Heterointerfaces D V Donetsky et al Advances in Quantum Dot Research and Technology The Path to Applications **Electron Phonon Interactions in Semiconductor Nanostructures** Segi Yu, 1997 **Predicting Phonon Transport in Semiconductor Nanostructures Using Atomistic Calculations and the Boltzmann Transport Equation** Daniel P. Sellan, 2012 Length-Scale Dependent Phonon Interactions Subhash L. Shindé, Gyaneshwar P. Srivastava, 2013-10-29 This book presents a comprehensive description of phonons and their interactions in systems with different dimensions and length scales Internationally recognized leaders describe theories and measurements of phonon interactions in relation to the design of materials with exotic properties such as metamaterials nano mechanical systems next generation electronic photonic and acoustic devices energy harvesting optical information storage and applications of phonon lasers in a variety of fields The emergence of techniques for control of semiconductor properties and geometry has enabled engineers to design structures in which functionality is derived from controlling electron behavior As manufacturing techniques have greatly expanded the list of available materials and the

range of attainable length scales similar opportunities now exist for designing devices whose functionality is derived from controlling phonon behavior. However, progress in this area is hampered by gaps in our knowledge of phonon transport across and along arbitrary interfaces, the scattering of phonons with crystal defects, interface roughness, and mass mixing of delocalized electrons, collective electronic excitations, and solid acoustic vibrations when these occur in structures with small physical dimensions. This book provides a comprehensive description of phonons and their interactions in systems with different dimensions and length scales. Theories and measurements of phonon interactions are described in relation to the design of materials with exotic properties such as metamaterials, nano-mechanical systems, next-generation electronic, photonic, and acoustic devices, energy harvesting, optical information storage, and applications of phonon lasers in a variety of fields. *Phononic and Photonic Semiconductor Nanostructures* Markus Raphael Wagner, 2020

Phonon Kinetics and Heat Removal from Low Dimensional Semiconductor Structures, 2001. Our research on electron-phonon and phonon-phonon processes in low-dimensional semiconductor nanostructures has been focused on the effects of surfaces and interfaces on the electron energy-momentum relaxation rates due to acoustic phonon emission, new specific mechanism of electron interaction with acoustic phonons in semiconductor heterostructures, and phonon-induced processes of charge carrier losing phase coherence in heterostructures. Our research provides the necessary basis for the control of heat dissipation and for the design of nanodevices with electron-phonon relaxation and dephasing rates required for specific applications.

Nanophononics Zlatan Aksamija, 2017-11-22. Heat in most semiconductor materials, including the traditional group IV elements Si, Ge, diamond, III-V compounds, GaAs, wide-bandgap GaN, and carbon allotropes graphene, CNTs, as well as emerging new materials like transition metal dichalcogenides (TMDCs), is stored and transported by lattice vibrations (phonons). Phonon generation through interactions with electrons in nanoelectronics, power and nonequilibrium devices, and light optoelectronics is the central mechanism of heat dissipation in nanoelectronics. This book focuses on the area of thermal effects in nanostructures, including the generation, transport, and conversion of heat at the nanoscale level. Phonon transport, including thermal conductivity in nanostructured materials, as well as numerical simulation methods such as phonon Monte Carlo, Green's functions, and first-principles methods, feature prominently in the book, which comprises four main themes: i) phonon generation, heat dissipation, ii) nanoscale phonon transport, iii) applications, devices including thermoelectrics, and iv) emerging materials, graphene, 2D. The book also covers recent advances in nanophononics, the study of phonons at the nanoscale. Applications of nanophononics focus on thermoelectric (TE) and tandem TE photovoltaic energy conversion. The applications are augmented by a chapter on heat dissipation and self-heating in nanoelectronic devices. The book concludes with a chapter on thermal transport in nanoscale graphene ribbons, covering recent advances in phonon transport in 2D materials. The book will be an excellent reference for researchers and graduate students of nanoelectronics, device engineering, nanoscale heat transfer, and thermoelectric energy conversion. The book could also be a basis for a graduate

special topics course in the field of nanoscale heat and energy

Ultrafast Phenomena in Semiconductors ,2003

Delve into the emotional tapestry woven by in Experience **Phonons In Semiconductor Nanostructures** . This ebook, available for download in a PDF format (*), is more than just words on a page; it's a journey of connection and profound emotion. Immerse yourself in narratives that tug at your heartstrings. Download now to experience the pulse of each page and let your emotions run wild.

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