Phonons in Nanostructures

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CAMBRIDGE

Phonons In Nanostructures

Wolfram Schommers

Phonons In Nanostructures:

Phonons in Nanostructures Michael A. Stroscio,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 **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 *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

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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 *Phonon Focusing and Phonon Transport* Igor Gaynitdinovich Kuleyev,Ivan Igorevich Kuleyev,Sergey Mikhailovich Bakharev,Vladimir Vasilyevich Ustinov,2020-06-08 The monograph is devoted to the investigation of physical processes that govern the phonon transport in bulk and nanoscale single crystal samples of cubic symmetry Special emphasis is given to the study of phonon focusing in cubic crystals and its influence on the boundary scattering and lattice thermal conductivity of bulk materials and nanostructures **Phonons In Nanostructures** M.A. Stroscio, Physics of Semiconductors and Nanostructures Jyoti Prasad Banerjee,Suranjana Banerjee,2019-06-11 This book is a comprehensive text on the physics of semiconductors and nanostructures for a large spectrum of students at the final undergraduate level studying physics material science and electronics engineering It offers introductory and advanced courses on solid state and semiconductor physics on one hand and the physics of low dimensional semiconductor structures on the other in a single text book Key Features Presents basic concepts of quantum theory solid state physics semiconductors and quantum nanostructures such as quantum well quantum wire quantum dot and superlattice In depth description of semiconductor heterojunctions lattice strain and modulation doping technique Covers transport in nanostructures under an electric and magnetic field with the topics quantized conductance Coulomb blockade and integer and fractional quantum Hall effect Presents the optical processes in nanostructures under a magnetic field Includes illustrative problems with hints for solutions in each chapter Physics of Semiconductors and Nanostructures will be helpful to students initiating PhD work in the field of semiconductor nanostructures and devices It follows a unique tutorial approach meeting the requirements of students who find learning the concepts difficult and want to study from a physical perspective **Coherent Acoustic Phonons in Nanostructures Investigated by Asynchronous Optical Sampling** ,2007 *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 **Nanostructures and Alloys** Jonathan Michael Mendoza,Massachusetts Institute of Technology. Department of Mechanical Engineering,2014 Understanding how thermal transport is affected by disorder is crucial to the prediction and engineering of novel materials suitable for thermoelectric and device applications Ab initio methods have demonstrated accurate calculations of the lattice contribution to thermal conductivity in semiconductors and dielectrics Effective field theories and scattering theory have been combined to model alloys and systems with embedded nanostructures The simplest of such effective field theories the Virtual Crystal approximation fails to capture short length scale information due to the inherent coarse graining of the approximation Additionally these methods do not take multiple scattering effects into account In order to address these issues Green s function methods are developed to handle multiple scattering phenomena in systems with large numbers of impurities Explicit calculations from the Green s functions method are able to capture the deviation from the dilute alloy limit in disordered systems Multiple scattering theory developed in this thesis allows for a more precise description of the interaction between phonons and nanostructures The phonon Green s function is computed from the dispersion relation obtained from Density Functional Theory Multiple scattering theory predicts resonance scattering that is not accounted for in first order theory Understanding how these resonances behave in large disordered systems yields insight into thermal transport in alloys When impurities become closely spaced the resonances couple and broaden over a range of frequencies that depends upon the strength of the coupling and the number of impurities These resonant states become significantly coupled in silicon germanium alloys of concentrations over ten percent Scattering rates angle dependent scattering amplitudes and local density of states calculations are subsequently performed for nanostructured germanium slabs embedded in a silicon host The strong coupling between the densely packed system of impurities causes significant broadening over a wide range of phonon frequencies The strong coupling highlights the importance of using Green s functions to capture high frequency effects Furthermore scattering rate calculations as a function of frequency highlight the transition from the Rayleigh regime to the geometric limit Although approximations exist that describe the low and high frequency behavior the transition between the two regimes requires multiple scattering theory The lowest frequency peak in the nanostructure density of states corresponds to the transition frequency between the long and short wavelength asymptotic limits Angle dependent scattering also provides insight into the transition between the Rayleigh and high frequency limits The scattering phase functions exhibit isotropic scattering at long wavelengths which are characteristic of the Rayleigh regime As phonon frequencies increase the scattering profile takes on a much more anisotropic profile reminiscent of interfacial scattering at frequencies away from the band edge High frequency phonon scattering is reminiscent of particle scattering off of hard boundaries 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 **Advances in Semiconductor Nanostructures** Alexander V. Latyshev,Anatoliy V. Dvurechenskii,Alexander L. Aseev,2016-11-10 Advances in Semiconductor Nanostructures Growth Characterization Properties and Applications focuses on the physical aspects of semiconductor nanostructures including growth and processing of semiconductor nanostructures by molecular beam epitaxy ion beam implantation synthesis pulsed laser action on all types of III V IV and II VI semiconductors nanofabrication by bottom up and top down approaches real time observations using in situ UHV REM and high resolution TEM of atomic structure of quantum well nanowires quantum dots and heterostructures and their electrical optical magnetic and spin phenomena The very comprehensive nature of the book makes it an indispensable source of information for researchers scientists and post graduate students in the field of semiconductor physics condensed matter physics and physics of nanostructures helping them in their daily research Presents a comprehensive reference on the novel physical phenomena and properties of semiconductor nanostructures Covers recent developments in the field from all over the world Provides an International approach as chapters are based on results obtained in collaboration with research groups from Russia Germany France England Japan Holland USA Belgium China Israel Brazil and former Soviet Union countries **Topics In Nanoscience - Part I: Basic Views, Complex Nanosystems: Typical Results And Future** Wolfram Schommers,2021-12-17 With the development of the scanning tunneling microscope nanoscience became an important discipline Single atoms could be manipulated in a controlled manner and it became possible to change matter at its ultimate level it is the level on which the properties of matter emerge This possibility enables to construct and to produce devices materials etc with very small sizes and completely new properties That opens up new perspectives for technology and is in particular relevant in connection with nano engineering Nanosystems are unimaginably small and very fast No doubt this is an important characteristic But there is another feature possibly more relevant in connection with nanoscience and nanotechnology The essential point here

is that we work at the ultimate level This is the smallest level at which the properties of our world emerge at which functional matter can exist In particular at this level biological individuality comes into existence This situation can be expressed in absolute terms This is not only the strongest material ever made this is the strongest material it will ever be possible to make D Ratner and M Ratner Nanotechnology and Homeland Security This is a very general statement All aspects of matter are concerned here Through the variation of the composition various forms of matter emerge with different items Nanosystems are usually small but they offer nevertheless the possibility to vary the structure of atomic molecular ensembles creating a diversity of new material specific properties A large variety of experimental possibilities come into play and flexible theoretical tools are needed at the basic level This is reflected in the different disciplines In nanoscience and nanotechnology we have various directions Materials science functional nanomaterials nanoparticles food chemistry medicine with brain research quantum and molecular computing bioinformatics magnetic nanostructures nano optics nano electronics etc The properties of matter which are involved within these nanodisciplines are ultimate in character i e their characteristic properties come into existence at this level The book is organized in this respect **Introduction to Isotopic Materials Science** Vladimir G. Plekhanov,2018-12-05 This book describes new trends in the nanoscience of isotopic materials science Assuming a background in graduate condensed matter physics and covering the fundamental aspects of isotopic materials science from the very beginning it equips readers to engage in high level professional research in this area The book s main objective is to provide insight into the question of why solids are the way they are either because of how their atoms are bonded with one another because of defects in their structure or because of how they are produced or processed Accordingly it explores the science of how atoms interact connects the results to real materials properties and demonstrates the engineering concepts that can be used to produce or improve semiconductors by design In addition it shows how the concepts discussed are applied in the laboratory The book addresses the needs of researchers graduate students and senior undergraduate students alike Although primarily written for materials science audience it will be equally useful to those teaching in electrical engineering materials science or even chemical engineering or physics curricula In order to maintain the focus on materials concepts however the book does not burden the reader with details of many of the derivations and equations nor does it delve into the details of electrical engineering topics **Topics In Nanoscience (In 2 Parts)** Wolfram Schommers,2021-12-17 With the development of the scanning tunneling microscope nanoscience became an important discipline Single atoms could be manipulated in a controlled manner and it became possible to change matter at its ultimate level it is the level on which the properties of matter emerge This possibility enables to construct and to produce devices materials etc with very small sizes and completely new properties That opens up new perspectives for technology and is in particular relevant in connection with nano engineering Nanosystems are unimaginably small and very fast No doubt this is an important characteristic But there is another feature possibly more relevant in connection with nanoscience and

nanotechnology The essential point here is that we work at the ultimate level This is the smallest level at which the properties of our world emerge at which functional matter can exist In particular at this level biological individuality comes into existence This situation can be expressed in absolute terms This is not only the strongest material ever made this is the strongest material it will ever be possible to make D Ratner and M Ratner Nanotechnology and Homeland Security This is a very general statement All aspects of matter are concerned here Through the variation of the composition various forms of matter emerge with different items Nanosystems are usually small but they offer nevertheless the possibility to vary the structure of atomic molecular ensembles creating a diversity of new material specific properties A large variety of experimental possibilities come into play and flexible theoretical tools are needed at the basic level This is reflected in the different disciplines In nanoscience and nanotechnology we have various directions Materials science functional nanomaterials nanoparticles food chemistry medicine with brain research quantum and molecular computing bioinformatics magnetic nanostructures nano optics nano electronics etc The properties of matter which are involved within these nanodisciplines are ultimate in character i e their characteristic properties come into existence at this level The book is organized in this respect **Phonon Engineering Theory of Crystalline Layered Nanostructures** Jovan P. Šetrajčić,Stevo K. Jaćimovski,Siniša M. Vučenović,2016 **Transport in Nanostructures** David Ferry,Stephen Marshall Goodnick,1999-10-28 A comprehensive detailed description of the properties and behaviour of mesoscopic devices

Advanced Solar Cell Materials, Technology, Modeling, and Simulation Fara, Laurentiu,2012-07-31 While measuring the effectiveness of solar cell materials may not always be practical once a device has been created solar cell modeling may allow researchers to obtain prospective analyses of the internal processes of potential materials prior to their manufacture Advanced Solar Cell Materials Technology Modeling and Simulation discusses the development and use of modern solar cells made from composite materials This volume is targeted toward experts from universities and research organizations as well as young professionals interested in pursuing different subjects regarding advanced solar cells *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

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