Introduction To Phonons And Electrons

This monograph is a radical departure from the conventional quantum mechanical approach to electron-phonon interactions. It translates the customary quantum mechanical analysis of the electron-phonon interactions carried out in Fourier space into a predominantly classical analysis carried out in real space. Various electron-phonon interactions such as the polar and nonpolar optical phonons, acoustic phonons that interact via deformation potential and via the piezoelectric effect and phonons in metals, are treated in this monograph by a single, relatively simple “classical” model. This model is shown to apply to electron interactions with the deep lying X-ray levels of atoms, with plasmons and with Cerenkov radiation. The unifying concept that applies to all of these phenomena is a new definition of a coupling constant. The essentially classical interaction of an electron with its surrounding is clearly brought out to be the cause of spontaneous emission of phonons. The same concept also applies to the case of spontaneous emission of photons. While the bulk of this monograph deals with quanta of phonons and quanta of photons, a discussion of the acousto electric effect which is a purely classical phenomenon is presented. The newly defined coupling constant turns out to be valid too for this discussion. This universality of the coupling constant goes far beyond. It is equally applicable to amorphous materials. This significant application gives an analytic formulation of mobility in amorphous materials. Contents: Energy Losses of Hot ElectronsField and Temperature Dependence of Electronic TransportEnergy Losses by Hot Electrons in Solids: A Semiclassical Approach Readership: Physicists, solid state physicists and electronic engineers.
There have been few books devoted to the study of phonons, a major area of condensed matter physics. The Physics of Phonons is a comprehensive theoretical discussion of the most important topics, including some topics not previously presented in book form. Although primarily theoretical in approach, the author refers to experimental results wherever possible, ensuring an ideal book for both experimental and theoretical researchers. The author begins with an introduction to crystal symmetry and continues with a discussion of lattice dynamics in the harmonic approximation, including the traditional phenomenological approach and the more recent ab initio approach, detailed for the first time in this book. A discussion of anharmonicity is followed by the theory of lattice thermal conductivity, presented at a level far beyond that available in any other book. The chapter on phonon interactions is likewise more comprehensive than any similar discussion elsewhere. The sections on phonons in superlattices, impure and mixed crystals, quasicrystals, phonon spectroscopy, Kapitza resistance, and quantum evaporation also contain material appearing in book form for the first time. The book is complemented by numerous diagrams that aid understanding and is comprehensively referenced for further study. With its unprecedented wide coverage of the field, The Physics of Phonons will be indispensable to all postgraduates, advanced undergraduates, and researchers working on condensed matter physics.

While the standard solid state topics are covered, the basic ones often have more detailed derivations than is customary (with an empasis on crystalline solids). Several recent topics are introduced, as are some subjects normally included only in condensed matter physics. Lattice vibrations, electrons, interactions, and spin effects (mostly in magnetism) are discussed the most comprehensively. Many problems are included whose level is from "fill in the steps" to long and challenging, and the text is equipped with references and several comments about experiments with figures and tables.

A second edition with four new chapters for graduate students and researchers in semiconductor physics.

Introduction to the Electron Theory of Metals

Electrons and Phonons in Layered Crystal Structures

Electron Phonon Interactions

Basic atomic, molecular, and solid-state physics

An Introductory Survey

Ten years ago, D.M. Rowe introduced the bestselling CRC Handbook of Thermoelectrics to wide acclaim. Since then, increasing environmental concerns, desire for long-life electrical power sources, and continued progress in miniaturization of electronics has led to a substantial increase in research activity involving thermoelectrics. Reflecting the latest trends and developments, the Thermoelectrics Handbook: Macro to Nano is an extension of the earlier work and covers the entire range of thermoelectrics disciplines. Serving as a convenient reference as well as a thorough introduction to thermoelectrics, this book includes contributions from 99 leading authorities from around the world. Its coverage spans from general principles and theoretical concepts to material preparation and measurements; thermoelectric materials; thermoelements, modules, and devices; and thermoelectric systems and applications. Reflecting the enormous impact of nanotechnology on the field-as the thermoelectric properties of nanostructured materials far surpass the performance of conventional materials-each section progresses systematically from macro-scale to micro/nano-scale topics. In addition, the book contains an appendix listing major manufacturers and suppliers of thermoelectric modules. There is no longer any need to spend hours plodding through the journal literature for information. The Thermoelectrics Handbook: Macro to Nano offers a timely, comprehensive treatment of all areas of thermoelectrics in a single, unified reference.

The physics of nonequilibrium electrons and phonons in semiconductors is an important branch of fundamental physics that has many practical applications, especially in the development of ultrafast and ultrasmall semiconductor devices. This volume is devoted to different trends in the field which are presently at the forefront of research. Special attention is paid to the ultrafast relaxation processes in bulk semiconductors and two-dimensional semiconductor structures, and to their study by different spectroscopic methods, both pulsed and steady-state. The evolution of energy and space distribution of nonequilibrium electrons and the relaxation kinetics of hot carriers and phonons are considered under various conditions such as temperature, doping and pumping intensity by leading experts in the field.

An introduction to the application of Feynman diagram techniques for researchers and advanced undergraduate students in condensed matter theory and many-body physics.

The phonon operators used in describing interacting electron-phonon systems in terms of a secondquantized Hamiltonian Equation (1) are commonly derived from the first-quantized Hamiltonian of the harmonic oscillator, and are therefore not the true creation and annihilation operators of the second-quantized formalism. In this report the multiparticle Schrodinger equation for an electron-ion system is used as the starting point for a derivation of the fully second-quantized Hamiltonian Equation (6), which is expressed in terms of the correct creation and annihilation operators for both electron and phonon fields. The two most significant steps taken in this derivation are the transition from the Schrodinger equation to the corresponding second-quantized Hamiltonian, and the introduction of the true electron and phonon creation and annihilation operators which arise from the expansion of the electron and phonon field operators in appropriate sets of oneparticle wave functions. It is then shown that the conventional phonon operators are equivalent to certain bilinear combinations of the true phonon creation and annihilation operators, at least in the subspace of states having only one particle present in each of the vibrational modes; and the equality of the conventional and of the fully second-quantized Hamiltonians within this subspace of states follows immediately. Finally, it is pointed out that several significant advantages are obtained by using the fully second-quantized Hamiltonian rather than the conventional Hamiltonian in applications of the temperature-dependent double-time Green's function method. (Author).

Introduction to Many-Body Physics

An Introduction to the Principles

Dynamics at Solid State Surfaces and Interfaces

Introduction to Nanophotonics

Real-Time Quantum Dynamics of Electron–Phonon Systems

' This book focuses on phonons and electrons, which the student needs to learn first in solid state physics. The required quantum theory and statistical physics are derived from scratch. Systematic in structure and tutorial in style, the treatment is filled with detailed mathematical steps and physical interpretations. This approach ensures a self-sufficient content for easier teaching and learning. The objective is to introduce the concepts of phonons and electrons in a more rigorous and yet clearer way, so that the student does not need to relearn them in more advanced courses. Examples are the transition from lattice vibrations to phonons and from free electrons to energy bands. The book can be used as the beginning module of a one-year introductory course on solid state physics, and the instructor will have a chance to choose additional topics. Alternatively, it can be taught as a stand-alone text for building the most-needed foundation in just one semester. Contents:Crystal StructureReciprocal Lattice and X-Ray DiffractionLattice Vibrations and PhononsThermal Properties of InsulatorsFree Electron Fermi GasElectron Energy Bands Readership: Undergraduates, graduate students and researchers in physics, materials science and electronic devices. Keywords:Crystal Symmetries;Lattice Vibrations;Phonons;Free Electrons;X-Ray DiffractionReviews:The book is focused, rigorous, and self sufficient. It is filled with meticulous details. I am pleased to see that many questions the students may have when learning these subjects are answered in this book I strongly recommend it to both the teacher and students.J J Chang Professor of Physics Wayne State University The presentation is done well and the author has an easy-to-read style that is almost chatty Overall, I think that the author has succeeded in providing a book for a niche where the beginning student of solid-state physics wants a self-contained book without having to go to another textbook.MRS Bulletin '

Electronic Properties of Crystalline Solids: An Introduction to Fundamentals discusses courses in the electronic properties of solids taught in the Department of Materials Science and Engineering at Stanford University. The book starts with a brief review of classical wave mechanics, discussing concept of waves and their role in the interactions of electrons, phonons, and photons. The book covers the free electron model for metals, and the origin, derivation, and properties of allowed and forbidden energy bands for electrons in crystalline materials. It also examines transport phenomena and optical effects in crystalline materials, including electrical conductivity, scattering phenomena, thermal conductivity, Hall and thermoelectric effects, magnetoresistance, optical absorption, photoconductivity, and other photoelectronic effects in both ideal and real materials. This book is intended for upper-level undergraduates in a science major, or for first- or second-year graduate students with an interest in the scientific basis for our understanding of properties of materials.

This Third Edition of ELECTRONS IN SOLIDS: AN INTRODUCTORY SURVEY, is the result of a thorough re-examination of the entire text, incorporating suggestions and corrections by students and professors who have used the text. Explanations and descriptions have been expanded, and additional information has been added on high Tc superconductors, diamond films, "buckminsterfullerenes," and thin magnetic materials. Adopted by many colleges and universities, this text has proven to be a solid introduction to the electrical, optical and magnetic properties of materials. Key Features * Contains comprehensive coverage of electronic properties in metals, semiconductors, and insulators at a fundamental level * Stresses the use of wave properties as an integrating theme for the discussion of phonons, photons, and electrons * Includes a complete set of illustrative problems along with exercises and answers * Features a careful indication of both Gaussian and SI unit systems

This introductory treatment provides an understanding of the fundamental concepts and principles involved in the study of thermoelectricity in solids and of conduction in general. Aimed at graduate-level students and those interested in basic theory, it will be especially valuable to experimental physicists working in fields connected with electron transport and to theoreticians seeking a survey of thermoelectricity and related questions. Chronicling the early history of thermoelectricity from its discovery to modern times, this text features a considerable amount of experimental data and discusses these findings at length wherever they bear a particular relevance to theory. The author, a well-known authority in this field, draws heavily from his own work on thermoelectrical phenomena as they are observed in the study of metals. Numerous illustrative figures appear throughout the text.

Volume 1 - Current Developments

Nonequilibrium Phonon Dynamics

Introduction to Microfluidics

Fully Second-quantized Hamiltonian for Interacting Electrons and Phonons

Electron-phonon Interactions in Low-dimensional Structures

Electron theory of metals textbook for advanced undergraduate students of condensed-matter physics and related disciplines.

A modern, graduate-level introduction to many-body physics in condensed matter, this textbook explains the tools and concepts needed for a research-level understanding of the correlated behavior of quantum fluids. Starting with an operator-based introduction to the quantum field theory of many-body physics, this textbook presents the Feynman diagram approach, Green's functions and finite-temperature many-body physics before developing the path integral approach to interacting systems. Special chapters are devoted to the concepts of Fermi liquid theory, broken symmetry, conduction in disordered systems, superconductivity and the physics of local-moment metals. A strong emphasis on concepts and numerous exercises make this an invaluable course book for graduate students in condensed matter physics. It will also interest students in nuclear, atomic and particle physics.

This volume is devoted to the electron and phonon energy states of inorganic layered crystals. The distinctive feature of these low-dimensional materials is their easy mechanical cleavage along planes parallel to the layers. This feature implies that the chemical binding within each layer is much stronger than the binding between layers and that some, but not necessarily all, physical properties of layered crystals have two-dimensional character. In Wyckoff's Crystal Structures, SiC and related com pounds are regarded as layered structures, because their atomic layers are alternately stacked according to the requirements of cubic and hexagonal close-packing. How ever, the uniform (tetrahedral) coordination of the atoms in these compounds excludes the kind of structural anisotropy that is fundamental to the materials dis cussed in this volume. An individual layer of a layered crystal may be composed of either a single sheet of atoms, as in graphite, or a set of up to five atomic sheets, as in Bi2 Te3' A layer may also have more complicated arrangements of the atoms, as we find for example in Sb S . But the unique feature common to all these materials is 2 3 the structural anisotropy, which directly affects their electronic and vibrational properties. The nature of the weak interlayer coupling is not very well understood, despite the frequent attribution of the coupling in the literature to van der Waals forces. Two main facts, however, have emerged from all studies.

Description of the behaviour of electrons and phonons in low-dimensional semiconductor systems.

Introduction to Solid State Physics for Materials Engineers

Feynman Diagram Techniques in Condensed Matter Physics

Solid State Theory, Volume 1

Macro to Nano

Electron and Photon Confinement in Semiconductor Nanostructures

Optoelectronics has become an important part of our lives. Wherever light is used to transmit information, tiny semiconductor devices are needed to transfer electrical current into optical signals and vice versa. Examples include light emitting diodes in radios and other appliances, photodetectors in elevator doors and digital cameras, and laser diodes that transmit phone calls through glass fibers. Such optoelectronic devices take advantage of sophisticated interactions between electrons and light. Nanometer scale semiconductor structures are often at the heart of modern optoelectronic devices. Their shrinking size and increasing complexity make computer simulation an important tool to design better devices that meet ever rising perfomance requirements. The current need to apply advanced design software in optoelectronics follows the trend observed in the 1980's with simulation software for silicon devices. Today, software for technology computer-aided design (TCAD) and electronic design automation (EDA) represents a fundamental part of the silicon industry. In optoelectronics, advanced commercial device software has emerged recently and it is expected to play an increasingly important role in the near future. This book will enable students, device engineers, and researchers to more effectively use advanced design software in optoelectronics. Provides fundamental knowledge in semiconductor physics and in electromagnetics, while helping to understand and use advanced device simulation software Demonstrates the combination of measurements and simulations in order to obtain realistic results and provides data on all required material parameters Gives deep insight into the physics of state-of-the-art devices and helps to design and analyze of modern optoelectronic devices

The aim of this textbook is to provide an overview of nanophotonics, a discipline which was developed around the turn of the millennium. This unique and rapidly evolving subject area is the result of a collaboration between various scientific communities working on different aspects of light-matter interaction at the nanoscale. These include near-field optics and super-resolution microscopy, photonic crystals, diffractive optics, plasmonics, optoelectronics, synthesis of metallic and semiconductor nanoparticles, two-dimensional materials, and metamaterials. The book is aimed at graduate students with a background in physics, electrical engineering, material science, or chemistry, as well as lecturers and researchers working within these fields.

The book describes how the electrons in small "low-dimensional" structures interact with their surroundings. It contains a series of linked up to date review chapters as well as explanatory material and is written to be understandable to graduate students and newcomers to the field. All contributions come from leading scientists.

This book develops a methodology for the real-time coupled quantum dynamics of electrons and phonons in nanostructures, both isolated structures and those open to an environment. It then applies this technique to both fundamental and practical problems that are relevant, in particular, to nanodevice physics, laser–matter interaction, and radiation damage in living tissue. The interaction between electrons and atomic vibrations (phonons) is an example of how a process at the heart of quantum dynamics can impact our everyday lives. This is e.g. how electrical current generates heat, making your toaster work. It is also a key process behind many crucial problems down to the atomic and molecular scale, such as the functionality of nanoscale electronic devices, the relaxation of photo-excited systems, the energetics of systems under irradiation, and thermoelectric effects. Electron–phonon interactions represent a difficult many-body problem. Fairly standard techniques are available for tackling cases in which one of the two subsystems can be treated as a steady-state bath for the other, but determining the simultaneous coupled dynamics of the two poses a real challenge. This book tackles precisely this problem.

Introduction to Physics and Simulation

Introduction to the Physics of Matter

Electronic Properties of Crystalline Solids

Semiconductor Optoelectronic Devices

Molecular Electronics

This book offers an up-to-date, compact presentation of basic topics in the physics of matter, from atoms to molecules to solids, including elements of statistical mechanics. The adiabatic separation of the motion of electrons and nuclei in matter and its spectroscopic implications are outlined for molecules and recalled regularly in the study of the dynamics of gases and solids. Numerous experiments are described and more than 160 figures give a clear visual impression of the main concepts. Sufficient detail of mathematical derivations is provided to enable students to follow easily. The focus is on present-day understanding and especially on phenomena fitting various independent-particle models. The historical development of this understanding, and phenomena such as magnetism and superconductivity, where interparticle interactions and nonadiabatic effects play a crucial role, are mostly omitted. A final outlook section stimulates the curiosity of the reader to pursue the study of such advanced topics in graduate courses.

This NATO Advanced Study Institute was the fourth in a series devoted to the subject of phase transitions and instabilities with particular attention to structural phase transforma~ions. Beginning wi th the first Geilo institute in 19'(1 we have seen the emphasis evolve from the simple quasiharmonic soft mode description within the Landau theory, through the unexpected spectral structure re presented by the "central peak" (1973), to such subjects as melting, turbulence and hydrodynamic instabilities (1975). Sophisticated theoretical techniques such as scaling laws and renormalization group theory developed over the same period have brought to this wide range of subjects a pleasing unity. These institutes have been instrumental in placing structural transformations clearly in the mainstream of statistical physics and critical phenomena. The present Geilo institute retains some of the counter cul tural flavour of the first one by insisting whenever possible upon peeking under the skirts of even the most successful phenomenology to catch a glimpse of the underlying microscopic processes. Of course the soft mode remains a useful concept, but the major em phasis of this institute is the microscopic cause of the mode softening. The discussions given here illustrate that for certain important classes of solids the cause lies in the electron phonon interaction. Three major types of structural transitions are considered. In the case of metals and semimetals, the electron phonon interaction relie6 heavily on the topology of the Fermi surface.

Phonons are always present in the solid state even at an absolute temperature of 0 K where zero point vibrations still abound. Moreover, phonons interact with all other excitations of the solid state and, thereby, influence most of its properties. Historically experimental information on phonon transport came from measurements of thermal conductivity. Over the past two decades much more, and much more detailed, information on phonon transport and on many of the inherent phonon interaction processes have come to light from experiments which use nonequilibrium phonons to study their dynamics. The resultant research field has most recently blossomed with the development of ever more sophisticated experimental and theoretical methods which can be applied to it. In fact, the field is moving so rapidly that new members of the research community have difficulties in keeping

up to date. This NATO Advanced Study Institute (ASI) was organized with the objective of overcoming the information barrier between those expert in the field and those who are new to it. Thus it was decided to (i) organize a set of tutorially based lectures covering most of the important facets in the field, and (ii) to produce an Institute proceedings which would serve both as the first general textbook, as well as a valuable reference book, for this field of knowledge.
Introduction / P.J.W. Debye -- Introductory lectures on the free phonon field / H.H. Jensen -- Some aspects of phonon-phonon-interaction / W. Ludwig -- Lectures on phonons and external radiation / A. Sjolander -- Interaction of x-rays with phonons / W. Cochran -- The electron-phonon interaction / J.J. Quinn -- Electron-phonon interaction in semicoductors studies by transport properties / H.G. Reik -- The Mossbauer effect and dynamics of atomic motions in condensed systems / K.S. Singwi -- Interaction of long-wavelength phonons with electrons / A.R. Mackintosh -- Phonons and neutron scattering / B.N. Brockhouse -- Interaction of phonons with photons : infrared, Raman, and Brillouin spectra / E. Burstein -- Electron-phonon interaction and superconductivity / J.R. Schrieffer -- Phonons in liquids / J. de Boer -- Phonons and lattice imperfection / A.A. Maradudin -- Microwave ultrasonics / E.H. Jacobsen -- Energy and charge transport in organic molecular crystals / R.G. Kepler.

Electronic Structure and Properties

Thermoelectrics Handbook

Phonons and Phonon Interactions

Physics and Devices

Thermoelectricity

This two-volume work covers ultrafast structural and electronic dynamics of elementary processes at solid surfaces and interfaces, presenting the current status of photoinduced processes. Providing valuable introductory information for newcomers to this booming field of research, it investigates concepts and experiments, femtosecond and attosecond time-resolved methods, as well as frequency domain techniques. The whole is rounded off by a look at future developments.

This monograph is a radical departure from the conventional quantum mechanical approach to electron-phonon interactions. It translates the customary quantum mechanical analysis of the electron-phonon interactions carried out in Fourier space into a predominantly classical analysis carried out in real space. Various electron-phonon interactions such as the polar and nonpolar optical phonons, acoustic phonons that interact via deformation potential and via the piezoelectric effect and phonons in metals, are treated in this monograph by a single, relatively simple ?classical? model. This model is shown to apply to electron interactions with the deep lying X-ray levels of atoms, with plasmons and with Cerenkov radiation. The unifying concept that applies to all of these phenomena is a new definition of a coupling constant. The essentially classical interaction of an electron with its surrounding is clearly brought out to be the cause of spontaneous emission of phonons. The same concept also applies to the case of spontaneous emission of photons. While the bulk of this monograph deals with quanta of phonons and quanta of photons, a discussion of the acousto electric effect which is a purely classical phenomenon is presented. The newly defined coupling constant turns out to be valid too for this discussion. This universality of the coupling constant goes far beyond. It is equally applicable to amorphous materials. This significant application gives an analytic formulation of mobility in amorphous materials.

Treatise on Materials Science and Technology, Volume 21: Electronic Structure and Properties covers the developments in electron theory and electron spectroscopies. The book discusses the electronic structure of perfect and defective solids; the photoelectron spectroscopy as an electronic structure probe; and the electron-phonon interaction. The text describes the elastic properties of transition metals; the electrical resistivity of metals; as well as the electronic structure of point defects in metals. Metallurgists, materials scientists, materials engineers, and students involved in the related fields will find the book useful.

The textbooks "Solid State Theory" give an introduction to the methods, contents and results of modern solid state physics in two volumes. This first volume has the basic courses in theoretical physics as prerequisites, i.e. knowledge of classical mechanics, electrodynamics and, in particular, quantum mechanics and statistical physics is assumed. The formalism of second quantization (occupation number representation), which is needed for the treatment of many-body effects, is introduced and used in the book. The content of the first volume deals with the classical areas of solid state physics (phonons and electrons in the periodic potential, Bloch theorem, Hartree-Fock approximation, density functional theory, electron-phonon interaction). The first volume is already suitable for Bachelor students who want to go beyond the basic courses in theoretical physics and get already familiar with an application area of theoretical physics, e.g. for an elective subject "Theoretical (Solid State) Physics" or as a basis for a Bachelor thesis. Every solid-state physicist working experimentally should also be familiar with the theoretical methods covered in the first volume. The content of the first volume can therefore also be the basis for a module "Solid State Physics" in the Master program in Physics or, together with the content of the 2nd volume, for a module "Theoretical Solid State Physics" or "Advanced Theoretical Physics". The following

second volume covers application areas such as superconductivity and magnetism to areas that are current research topics (e.g. quantum Hall effect, high-temperature superconductivity, low-dimensional structures).
Introduction to Solid-State Theory
Basics: Phonons and Electrons in Crystals
Solid-State Physics
Advances in Imaging and Electron Physics

A concise, accessible, and up-to-date introduction to solid state physics Solid state physics is the foundation of many of today's technologies including LEDs, MOSFET transistors, solar cells, lasers, digital cameras, data storage and processing. Introduction to Solid State Physics for Materials Engineers offers a guide to basic concepts and provides an accessible framework for understanding this highly application-relevant branch of science for materials engineers. The text links the fundamentals of solid state physics to modern materials, such as graphene, photonic and metamaterials, superconducting magnets, high-temperature superconductors and topological insulators. Written by a noted expert and experienced instructor, the book contains numerous worked examples throughout to help the reader gain a thorough understanding of the concepts and information presented. The text covers a wide range of relevant topics, including propagation of electron and acoustic waves in crystals, electrical conductivity in metals and semiconductors, light interaction with metals, semiconductors and dielectrics, thermoelectricity, cooperative phenomena in electron systems, ferroelectricity as a cooperative phenomenon, and more. This important book: Provides a big picture view of solid state physics Contains examples of basic concepts and applications Offers a highly accessible text that fosters real understanding Presents a wealth of helpful worked examples Written for students of materials science, engineering, chemistry and physics, Introduction to Solid State Physics for Materials Engineers is an important guide to help foster an understanding of solid state physics.
Advances in Imaging and Electron Physics, Volume 202, merges two long-running serials, Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy. The series features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science, digital image processing, electromagnetic wave propagation, electron microscopy and the computing methods used in all these domains. Contains contributions from leading authorities on the subject matter Informs and updates on all the latest developments in the field of imaging and electron physics Provides practitioners interested in microscopy, optics, image processing, mathematical morphology, electromagnetic fields, electron and ion emission with a valuable resource Features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science and digital image processing
Microfluidics deals with fluids flowing in miniaturized systems. It is a young discipline, which is expected to substantially expand over the next few years, stimulated by the considerable development of applications in the pharmaceutical, biomedical and chemical engineering domains. The book is an introduction to this discipline. In the first chapter, it presents a short historical background and discusses the main perspectives of the domain, at economical and scientific levels. Then the physics of miniaturization and the fluid mechanics of microflows are discussed. In the following three chapters, dispersion, electrical and thermal phenomena in miniaturized devices are presented. A brief introduction to microfabrication techniques is given in chapter six and the book concludes by providing a few examples of microfluidic systems. The book is written in a simple, direct, pedagogical way. It emphasizes concepts and understanding, rather than technical detail. It offers a cross-disciplinary view of the field embracing biological, chemical, physical and engineering perspectives. By using the book, the reader will have concepts, methods and data to grasp situations which typically arise in microfluidic systems.
Introduction to Solid-State Theory is a textbook for graduate students of physics and materials science. It also provides the theoretical background needed by physicists doing research in pure solid-state physics and its applications to electrical engineering. The fundamentals of solid-state theory are based on a description by delocalized and localized states and - within the concept of delocalized states - by elementary excitations. The development of solid-state theory within the last ten years has shown that by a systematic introduction of these concepts, large parts of the theory can be described in a unified way. This form of description gives a "pictorial" formulation of many elementary processes in solids, which facilitates their understanding.

Spectroscopy of Nonequilibrium Electrons and Phonons
An Introduction to Fundamentals
A Novel Semiclassical Approach
Introduction to Organic Electronic and Optoelectronic Materials and Devices
The Physics of Phonons

Under certain conditions electrons in a semiconductor become much hotter than the surrounding crystal lattice. When this happens, Ohm's Law breaks down: current no longer increases linearly with voltage and may even decrease. Hot electrons have long been a challenging problem in condensed matter physics and remain important in semiconductor research. Recent advances in technology have led to semiconductors with submicron dimensions, where electrons can be confined to two (quantum well), one (quantum wire), or zero (quantum dot) dimensions. In these devices small voltages heat electrons rapidly, inducing complex nonlinear behavior; the study of hot electrons is central to their further development. This book is the only comprehensive and up-to-date coverage of hot electrons. Intended for both established researchers and graduate students, it gives a complete account of the historical development of the subject, together with current research and future trends, and covers the physics of hot electrons in bulk and low-dimensional device technology. The contributions are from leading scientists in the field and are grouped broadly into five categories: introduction and overview; hot electron-phonon interactions and ultra-fast phenomena in bulk and two-dimensional structures; hot electrons in quantum wires and dots; hot electron tunneling and transport in superlattices; and novel devices based on hot electron transport.

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 semiconconductor 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.

This book focuses on phonons and electrons, which the student needs to learn first in solid state physics. The required quantum theory and statistical physics are derived from scratch. Systematic in structure and tutorial in style, the treatment is filled with detailed mathematical steps and physical interpretations. This approach ensures a self-sufficient content for easier teaching and learning. The objective is to introduce the concepts of phonons and electrons in a more rigorous and yet clearer way, so that the student does not need to relearn them in more advanced courses. Examples are the transition from lattice vibrations to phonons and from free electrons to energy bands.The book can be used as the beginning module of a one-year introductory course on solid state physics, and the instructor will have a chance to choose additional topics. Alternatively, it can be taught as a stand-alone text for building the most-needed foundation in just one semester.

Reflecting rapid growth in research and development on organic/polymeric electronic and photonic materials and devices, Introduction to Organic Electronic and Optoelectronic Materials and Devices provides comprehensive coverage of the state-of-the-art in an accessible format. The book presents fundamentals, principles, and mechanisms complemented by examples, experimental data, and more than 600 figures, more than 500 equations, about 70 tables, more than 150 exercise questions, and more than 1500 reference citations.

Electrons in Solids

Superconductivity in Complex Systems

Electrons and Phonons in Semiconductor Multilayers

Treatise on Materials Science and Technology

Electrons, Phonons and Excitons In Low Dimensional Aperiodic Systems