Charge Transport In Disordered Solids With Applications In Electronics

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Polymers and Small Molecules CRC Press

Physicalkineticsisthe?nalsectionofthecourseoftheoreticalphysics in its standard presentation. It stays at the boundary between g- eral theories and their applications (solid state theory, theory of gases, plasma, and so on), because the treatment of kinetic phenomena always depends on speci?c structural features of materials. On the other hand, the physical kinetics as a part of the quantum theory of macroscopic systems is far from being complete. A number of its fundamental - sues, such as the problem of irreversibility and mechanisms of chaotic responses, are now attracting considerable attention. Other important sections, for example, kinetic phenomena in disordered and/or strongly non-equilibrium systems and, in particular, phase transitions in these systems, are currently under investigation. The quantum theory of m- surements and quantum information processing actively developing in the last decade are based on the quantum kinetic theory. Because a deductive theoretical exposition of the subject is not c- venient, the authors restrict themselves to a lecture-style presentation. Now the physical kinetics seems to be at the stage of development when, according to Newton, studying examples is more instructive than lea- ing rules. In view of these circumstances, the methods of the kinetic theory are presented here not in a general form but as applications for description of speci?c systems and treatment of particular kinetic p- nomena. The quantum features of kinetic phenomena can arise for several r- sons.

Electron Transport Phenomena in Semiconductors John Wiley & Sons

This book contains the first systematic and detailed exposition of the linear theory of the stationary electron transport phenomena in semiconductors. Arbitrary isotropic and anisotropic nonparabolic bands as well as p-Ge-type bands are considered. Phonon drag effect are taken account of in an arbitrary nonquantizing magnetic field. Scattering theory is discussed in detail with account taken of the Bloch wave functions effect. Transport phenomena in the quantizing magnetic field are studied as well as the size effects in thin films. Band structures of the semiconductors and semiconductor compounds of interest are also considered.The main part of the book deals with the three important problems: charge carrier statistics in a semiconductor, classical and quantum theory of the electron transport phenomena. All the theoretical results considered as well as the validity conditions are presented in the form which may be directly used to interpret experimental data.

Quantum Kinetic Theory and Applications Woodhead Publishing

For years, concepts and models relevant to the fields of molecular electronics and organic electronics have been invented in parallel, slowing down progress in the field. This book illustrates how synthetic chemists, materials scientists, physicists, and device engineers can work together to reach their desired, shared goals, and provides the knowledge and intellectual basis for this venture. Supramolecular Materials for Opto-Electronics covers the basic principles of building supramolecular organic systems that fulfil the requirements of the targeted opto-electronic function; specific material properties based on the fundamental synthesis and assembly processes; and provides an overview of the current uses of supramolecular materials in opto-electronic devices. To conclude, a “what’s next” section provides an outlook on the future of the field, outlining the ways overarching work between research disciplines can be utilised. Postgraduate researchers and academics will appreciate the fundamental insight into concepts and practices of supramolecular systems for opto-electronic device integration.

Charge Transport in Disordered Semiconductors in Solid State Sensitized Solar Cells Elsevier

The hopping process, which differs substantially from conventional transport processes in crystals, is the central process in the transport phenomena discussed in this book. Throughout the book the term ``hopping'' is defined as the inelastic tunneling transfer of an electron between two localized electronic states centered at different locations. Such processes do not occur in conventional electronic transport in solids, since localized states are not compatible with the translational symmetry of crystals. The rapid growth of interest in hopping transport has followed in the footsteps of the development of physics of disordered systems during the last three decades. The intense interest in disordered solids can be attributed to the technological potential of the new noncrystalline materials, as well as to new fundamental problems discovered in solid state physics when a crystal is no longer translationally symmetric. In the last decade hopping systems such as organic polymers, biological materials, many oxide glasses, mesoscopic systems, and the new high-temperature superconducting materials in their normal state have attracted much interest. New phenomena investigated recently include interference and coherent scattering in variable range hopping conduction, mesoscopic effects, relaxation processes and thermo-electric power, and thermal conductivity caused by hopping transport. This volume presents the reader with a thorough overview of these recent developments, written by leading experts in the various fields.

Springer

Filling the gap in the literature currently available, this book presents an overview of our knowledge of the physics behind organic semiconductor devices. Contributions from 18 international research groups cover various aspects of this field, ranging from the growth of organic layers and crystals, their electronic properties at interfaces, their photophysics and electrical transport properties to the application of these materials in such different devices as organic field-effect transistors, photovoltaic cells and organic light-emitting diodes. From

the contents: * Excitation Dynamics in Organic Semiconductors * Organic Field-Effect Transistors * Spectroscopy of Organic Semiconductors * Interfaces between Organic Semiconductors and Metals * Analysis and Modeling of Devices * Exciton Formation and Energy Transfer in Organic Light Emitting Diodes * Deposition and Characterization

Structural, Optical, and Electronic Properties CRC Press

Thermoelectric materials can turn temperature differences directly into electricity. To use this to harvest e.g. waste heat with an efficiency that approaches the Carnot efficiency requires a figure of merit ZT larger than 1. Compared with their inorganic counterparts, organic thermoelectrics (OTE) have numerous advantages, such as low cost, large-area compatibility, flexibility, material abundance and an inherently low thermal conductivity. Therefore, organic thermoelectrics are considered by many to be a promising candidate material system to be used in lower cost and higher efficiency thermoelectric energy conversion, despite record ZT values for OTE currently lying around 0.25. A complete organic thermoelectric generator (TEG) normally needs both p-type and n-type materials to form its electric circuit. Molecular doping is an effective way to achieve p- and ntype materials using different dopants, and it is necessary to fundamentally understand the doping mechanism. We developed a simple yet quantitative analytical model and compare it with numerical kinetic Monte Carlo simulations to reveal the nature of the doping effect. The results show the formation of a deep tail in the Gaussian density of states (DOS) resulting from the Coulomb potentials of ionized dopants. It is this deep trap tail that negatively influences the charge carrier mobility with increasing doping concentration. The trends in mobilities and conductivities observed from experiments are in good agreement with the modeling results, for a large range of materials and doping concentrations. Having a high power factor PF is necessary for efficient TEG. We demonstrate that the doping method can heavily impact the thermoelectric properties of OTE. In comparison to conventional bulk doping, sequential doping can achieve higher conductivity by preserving the morphology, such that the power factor can improve over 100 times. To achieve TEG with high output power, not only a high PF is needed, but also having a significant active layer thickness is very important. We demonstrate a simple way to fabricate multi-layer devices by sequential doping without significantly sacrificing PF. In addition to the application discussed above, harvesting large amounts of heat at maximum efficiency, organic thermoelectrics may also find use in low-power applications like autonomous sensors where voltage is more important than power. A large output voltage requires a high Seebeck coefficient. We demonstrate that density of states (DOS) engineering is an effective tool to increase the Seebeck coefficient by tailoring the positions of the Fermi energy and the transport energy in n- and p-type doped blends of conjugated polymers and small molecules. In general, morphology heavily impacts the performance of organic electronic devices based on mixtures of two (or more) materials, and organic thermoelectrics are no exception. We experimentally find that the charge and energy transport is distinctly different in well-mixed and phase separated morphologies, which we interpreted in terms of a variable range hopping model. The experimentally observed trends in conductivity and Seebeck coefficient are reproduced by kinetic Monte Carlo simulations in which the morphology is accounted for.

Anomalous Charge Transport in Semiconductors, Dielectrics, and Nanosystems World Scientific

Amorphous semiconductors are subtances in the amorphous solid state that have the properties of a semiconductor and which are either covalent or tetrahedrally bonded amorphous semiconductors or chelcogenide glasses. Developed from both a theoretical and experimental viewpoint Deals with, amongst others, preparation techniques, structural, optical and electronic properties, and light induced phenomena Explores different types of amorphous semiconductors including amorphous silicon, amorphous semiconducting oxides and chalcogenide glasses Applications include solar cells, thin film transistors, sensors, optical memory devices and flat screen devices including televisions

Theory, Experiment, and Device Simulation Linköping University Electronic Press

Optical Properties of Solids covers the important concepts of intrinsic optical properties and photoelectric emission. The book starts by providing an introduction to the fundamental optical spectra of solids. The text then discusses Maxwell's equations and the dielectric function; absorption and dispersion; and the theory of free-electron metals. The quantum mechanical theory of direct and indirect transitions between bands; the applications of dispersion relations; and the derivation of an expression for the dielectric function in the self-consistent field approximation are also encompassed. The book further tackles current-current correlations; the fluctuation-dissipation theorem; and the effect of surface plasmons on optical properties and photoemission. People involved in the study of the optical properties of solids will find the book invaluable.

Physics and Applications CRC Press

Carbon based pi-conjugated materials offer a broad range of applications, going from molecular electronics and single molecule devices to nanotechnology, plastic electronics and optoelectronics. The proper physical description of such materials is in between that of molecular solids and that of low-dimensional covalent semiconductors. This book is a comprehensive review of their elementary excitations processes and dynamics, which merges the two viewpoints, sometimes very different if not contrasting. In each chapter, a broad tutorial introduction provides a solid physical background to the topic, which is further discussed based on recent experimental results obtained via state-of-the-art techniques. Both the molecular, intra-chain character and the solid state, inter-molecular physics is addressed. Reports on single molecule and single polymer chain spectroscopy introduce the on-site phenomena. Several chapters are dedicated to nano-probes, steady state and transient spectroscopies. The highly ordered state, occurring in single crystals, is also discussed thoroughly. Finally, less conventional tools such as THz spectroscopy are discussed in detail. The book provides a useful introduction to the field for newcomers, and a valid reference for experienced researchers in the field.

Hopping Transport in Solids Springer Science & Business Media

Solid state physics continues to be the most rapidly growing subdiscipline in physics. As a result, entering graduate students wishing to pursue research in this field face the daunting task of not only mastering the old topics but also gaining competence in the problems of current interest, such as the fractional

quantum Hall effect, strongly correlated electron systems, and quantum phase transitions. This book is written to serve the needs of such students. I have attempted in this book to present some of the standard topics in a way that makes it possible to move smoothly to current material. Hence, all the interesting topics are not presented at the end of the book. For example, immediately after the first 50 pages, Anderson's analysis of local magnetic moments is presented as an application of Hartree-Fock theory; this affords a discussion of the relationship with the Kondo model and how scaling ideas can be used to uncloak low-energy physics. As the key problems of current interest in solid state involve some aspects of electron-electron interactions or disorder or both, I have focused on the archetypal problems in which such physics is central. However, only those problems in which there is a consensus view are discussed extensively. In addition, I have placed the emphasis on physics rather than on techniques. Consequently, I focus on a clear presentation of the phenomenology along with a pedagogical derivation of the relevant equations. A key goal of the detailed derivations is to make it possible for the students who have read this book to immediately comprehend research papers on related topics. A key omission in this book is magnetism beyond the Stoner criterion and local magnetic moments. This omission has arisen primarily because the topic is adequately treated in the book by Assa Auerbach.

Nanocrystal Quantum Dots John Wiley & Sons
Fundamentals of Inorganic Glasses, Third Edition, is a comprehensive reference on the field of glass science and engineering that covers numerous, significant advances. This new edition includes the most recent advances in glass physics and chemistry, also discussing groundbreaking applications of glassy materials. It is suitable for upper level glass science courses and professional glass scientists and engineers at industrial and government labs. Fundamental concepts, chapter-ending problem sets, an emphasis on key ideas, and timely notes on suggested readings are all included. The book provides the breadth required of a comprehensive reference, offering coverage of the composition, structure and properties of inorganic glasses. Clearly develops fundamental concepts and the basics of glass science and glass chemistry Provides a comprehensive discussion of the composition, structure and properties of inorganic glasses Features a discussion of the emerging applications of glass, including applications in energy, environment, pharmaceuticals, and more Concludes chapters with problem sets and suggested readings to facilitate self-study

Semiconducting Polymers Morgan & Claypool Publishers
First-generation semiconductors could not be properly termed "doped- they were simply very impure. Uncontrolled impurities hindered the discovery of physical laws, baffling researchers and evoking pessimism and derision in advocates of the burgeoning "pure" physical disciplines. The eventual banish ment of the "dirt" heralded a new era in semiconductor physics, an era that had "purity" as its motto. It was this era that yielded the successes of the 1950s and brought about a new technology of "semiconductor electronics". Experiments with pure crystals provided a powerful stimulus to the develop ment of semiconductor theory. New methods and theories were developed and tested: the effective-mass method for complex bands, the theory of impurity states, and the theory of kinetic phenomena. These developments constitute what is now known as semiconductor phys ics. In the last fifteen years, however, there has been a noticeable shift towards impure semiconductors - a shift which came about because it is precisely the impurities that are essential to a number of major semiconductor devices. Technology needs impure semiconductors, which unlike the first-generation items, are termed "doped" rather than "impure" to indicate that the impurity levels can now be controlled to a certain extent.

From Chemical Structures to Devices John Wiley & Sons
In the field of organic semiconductors researchers and manufacturers are faced with a wide range of potential molecules. This work presents concepts for simulation-based predictions of material characteristics starting from chemical stuctures. The focus lies on charge transport – be it in microscopic models of amorphous morphologies, lattice models or large-scale device models. An extensive introductory review, which also includes experimental techniques, makes this work interesting for a broad readership. Contents: Organic Semiconductor Devices Experimental Techniques Charge Dynamics at Dierent Scales Computational Methods Energetics and Dispersive Transport Correlated Energetic Landscapes Microscopic, Stochastic and Device Simulations Parametrization of Lattice Models Drift – Diusion with Microscopic Link

Properties, Processing, and Applications Academic Press
In this book, a novel approach using equations with derivatives of fractional orders is applied to describe anomalous transport and relaxation in disordered semiconductors, dielectrics and quantum dot systems. A relationship between the self-similarity of transport, the Levy stable limiting distributions and the kinetic equations with fractional derivatives is established. It is shown that unlike the well-known Scher-Montroll and Arkhipov-Rudenko models, which are in a sense alternatives to the normal transport model, fractional differential equations provide a unified mathematical framework for describing normal and dispersive transport. The fractional differential formalism allows the equations of bipolar transport to be written down and transport in distributed dispersion systems to be described.

Photophysics of Molecular Materials Royal Society of Chemistry
Devices based on disordered semiconductors have wide applications. It is difficult to imagine modern life without printers and copiers, LCD monitors and TVs, optical disks, economical solar cells, and many other devices based on disordered semiconductors. However, nowadays books that discuss disordered (amorphous, nanocrystalline, microcrystalline)

Quantum Transport Theory John Wiley & Sons
The standard (Markovian) transport model based on the Boltzmann equation cannot describe some non-equilibrium processes called anomalous that take place in many disordered solids. Causes of anomality lie in non-uniformly scaled (fractal) spatial heterogeneities, in which particle trajectories take cluster form. Furthermore, particles can be located in some domains of small sizes (traps) for a long time. Estimations show that path length and waiting time distributions are often characterized by heavy tails of the power law type. This behavior allows the introduction of time and space derivatives of fractional orders. Distinction of path length distribution from exponential is interpreted as a consequence of media fractality, and analogous property of waiting time distribution as a presence of memory. In this book, a

novel approach using equations with derivatives of fractional orders is applied to describe anomalous transport and relaxation in disordered semiconductors, dielectrics and quantum dot systems. A relationship between the self-similarity of transport, the Levy stable limiting distributions and the kinetic equations with fractional derivatives is established. It is shown that unlike the well-known Scher Montroll and Arkhipov Rudenko models, which are in a sense alternatives to the normal transport model, fractional differential equations provide a unified mathematical framework for describing normal and dispersive transport. The fractional differential formalism allows the equations of bipolar transport to be written down and transport in distributed dispersion systems to be described. The relationship between fractional transport equations and the generalized limit theorem reveals the probabilistic aspects of the phenomenon in which a dispersive to Gaussian transport transition occurs in a time-of-flight experiment as the applied voltage is decreased and/or the sample thickness increased. Recent experiments devoted to studies of transport in quantum dot arrays are discussed in the framework of dispersive transport models. The memory phenomena in systems under consideration are discussed in the analysis of fractional equations. It is shown that the approach based on the anomalous transport models and the fractional kinetic equations may be very useful in some problems that involve nano-sized systems. These are photon counting statistics of blinking single quantum dot fluorescence, relaxation of current in colloidal quantum dot arrays, and some others.

Materials, Devices and Applications Springer

Both an introductory course to broadband dielectric spectroscopy and a monograph describing recent dielectric contributions to current topics, this book is the first to cover the topic and has been hotly awaited by the scientific community.

Narrow-band Solids with Unusual Properties Springer

Written by internationally recognized experts in the field with academic as well as industrial experience, this book concisely yet systematically covers all aspects of the topic. The monograph focuses on the optoelectronic behavior of organic solids and their application in new optoelectronic devices. It covers organic field-effect and organic electroluminescent materials and devices, organic photonics, materials and devices, as well as organic solids in photo absorption and energy conversion. Much emphasis is laid on the preparation of functional materials and the fabrication of devices, from materials synthesis and purification, to physicochemical properties and the basic processes and working principles of the devices. The only book to cover fundamentals, applications, and the latest research results, this is a handy reference for both researchers and those new to the field. From the contents: * Electronic process in organic solids * Organic/polymeric semiconductors for field-effect transistors * Organic/polymeric field-effect transistors * Organic circuits and organic single molecular transistors * Polymer light-emitting Diodes (PLEDs): devices and materials * Organic solids for photonics * Organic photonic devices * Organic solar cells based on small molecules * Polymer solar cells * Dye-sensitized solar cells (DSSCs) * Organic thermoelectric power devices

Physics of Organic Semiconductors John Wiley & Sons

Written in the perspective of an experimental chemist, this book puts together some fundamentals from chemistry, solid state physics and quantum chemistry, to help with understanding and predicting the electronic and optical properties of organic semiconductors, both polymers and small molecules. The text is intended to assist graduate students and researchers in the field of organic electronics to use theory to design more efficient materials for organic electronic devices such as organic solar cells, light emitting diodes and field effect transistors. After addressing some basic topics in solid state physics, a comprehensive introduction to molecular orbitals and band theory leads to a description of computational methods based on Hartree-Fock and density functional theory (DFT), for predicting geometry conformations, frontier levels and energy band structures. Topological defects and transport and optical properties are then addressed, and one of the most commonly used transparent conducting polymers, PEDOT:PSS, is described in some detail as a case study.

Solar Cells World Scientific

Although amorphous semiconductors have been studied for over four decades, many of their properties are not fully understood. This book discusses not only the most common spectroscopic techniques but also describes their advantages and disadvantages. Provides information on the most used spectroscopic techniques Discusses the advantages and disadvantages of each technique