Recombination In Semiconductors

Harmonically modulated luminescence combines the advantages of highly sensitive luminescence metrology with an immediate dynamic access to carrier lifetime in semiconductors at a minimum of required a priori information. The present work covers theoretical, conceptual, and experimental advances of the harmonically modulated luminescence technique. Theoretical constraints of dynamic carrier lifetime techniques are rigorously elaborated, including the proof of their differential nature and their characteristics at nonuniform spatial distributions of recombination rate. The pathway toward a unified, reliable, and versatile harmonically modulated carrier lifetime metrology is delineated - covering the entire solar cell production chain from bare ingots to finished solar cells. Accurate access to miscellaneous relevant recombination and transport properties via harmonically modulated luminescence is demonstrated and experimentally validated, embracing injection-dependent carrier lifetimes at extremely low injection conditions, a spatially resolved carrier lifetime calibration of luminescence images, and accurate approaches to both net dopant concentration and minority carrier mobility.

In recent years, great progress has been made in the understanding of recombination processes controlling the number of excess free carriers in semiconductors under nonequilibrium conditions. As a result, it is now possible to give a comprehensive theoretical description of these processes. The authors have selected a number of experimental results which elucidate the underlying physical problems and enable a test of theoretical models. The following topics are dealt with: phenomenological theory of recombination, theoretical models of shallow and deep localized states, cascade model of carrier capture by impurity centers, capture restricted by diffusion, multiphonon processes, Auger processes, effect of electric field on capture and thermal emission of carriers.

The increases in the reflectivity of germanium, silicon, GaAs, GaSb, InAs, InSb, CdTe, and CdSe have been observed by use of a ruby laser to produce the electron-hole plasma that is responsible for the reflectivity changes and to probe the reflectivity changes. Observations were made with the ruby laser light incident at the pseudo-Brewster angle in order to measure small increases in reflectivity. In the case of the III-V and II-VI semiconductors, the increase in reflectivity was found to exhibit a linear dependence when plotted as a function of the square root of the incident light intensity. Germanium and silicon exhibited a linear dependence of the increase in reflectivity on the incident light intensity. These results agree with the calculated dependence that ascribes the differences between the two groups of semiconductors to the fact that the recombination of electrons and holes is a direct process in the III-V and II-VI compounds and in germanium and silicon occurs mainly by trapping of the free carriers at impurity centers. (Author).

International Conference

With Applications to Optoelectronic Devices

Quantitative Recombination and Transport Properties in Silicon from Dynamic Luminescence

Quantum Confined Laser Devices

An Outlook on the Phenomena and their Applications

This book reviews up-to-date ideas of how the luminescence radiation in semiconductors originates and how to analyze it experimentally. The book fills a gap between general textbooks on optical properties of solids and specialized monographs on luminescence. It is unique in its coherent treatment of the phenomenon of luminescence from the very introductory definitions, from light emission in bulk crystalline and amorphous materials to the advanced chapters that deal with semiconductor nano objects, including spectroscopy of individual nanocrystals. The theory of radiative recombination channels in semiconductors is considered on a level of intuitive physical understanding rather than rigorous quantum mechanical treatment. The book is based on teaching and written in the style of a graduate text with plenty of tutorial material, illustrations, and problem sets at chapter ends. It is designed predominantly for students in physics, optics, optoelectronics and materials science.

The semiconductor laser, invented over 50 years ago, has had an enormous impact on the digital technologies that now dominate so many applications in business, commerce and the home. The laser is used in all types of optical fibre communication networks that enable the operation of the internet, e-mail, voice and skype transmission. Approximately one billion are produced each year for a market valued at around $5 billion. Nearly all semiconductor lasers now use extremely thin layers of light emitting materials (quantum well lasers). Increasingly smaller nanostructures are used in the form of quantum dots. The impact of the semiconductor laser is surprising in the light of the complexity of the physical processes that determine the operation of every device. This text takes the reader from the fundamental optical gain and carrier recombination processes in quantum wells and quantum dots, through descriptions of common device structures to an understanding of their operating characteristics. It has a consistent treatment of both quantum dot and quantum well structures taking full account of their dimensionality, which provides the reader with a complete account of contemporary quantum confined laser diodes. It includes plenty of illustrations from both model calculations and experimental observations. There are numerous exercises, many designed to give a feel for values of key parameters and experience obtaining quantitative results from equations. Some challenging concepts, previously the subject matter of research monographs, are treated here at this level for the first time. To request a copy of the Solutions Manual, visit http://global.oup.com/uk/academic/physics/admin/solutions.

Noise in physical systems - as a consequence of the corpuscular nature of matter - conveys

information about microscopic mechanisms determining the macroscopic behavior of the system. Besides being a source of information, noise also represents a source of annoying disturbances which affect information transMission along a physical system. Therefore, noise analysis can promote our insight into the behavior of a physical system, as well as our knowledge of the natural constraints imposed upon physical-information transmission channels and devices. In recent years the continuous scientific and technical interest in noise problems has led to a remarkable progress in the understanding of noise phenomena. This progress is reflected by the rich material presented at the Fifth International Conference on Noise in Physical Systems. The conference papers originally published in these proceedings cover the various aspects of today's noise research in the fields of solid-state devices, l/f-noise, magnetic and superconducting materials, measuring methods, and theory of fluctuations. Each session of the conference was introduced by one or two invited review lectures which are included in these proceedings in full length. The 12 invited papers and more than 40 contributed papers on specific topics (only three of them have been omitted from the proceedings since they will be published elsewhere) provide a comprehensive survey of the current state-of-the-art and recent advances of noise analysis.

Proceedings of the Symposium on Radiative Recombination in Semiconductors

International Conference, Southampton, Aug./Sept. 1978, Proceedings

Semiconductor Physical Electronics

From Fundamentals to Applications

Proceedings of the Fifth International Conference on Noise, Bad Nauheim, Fed. Rep. of Germany, March 13–16, 1978

Nonradiative Recombination in SemiconductorsElsevier

Since its invention in 1962, the semiconductor laser has come a long way. Advances in material purity and epitaxial growth techniques have led to a variety of semiconductor lasers covering a wide wavelength range of 0. 3- 100 ~m. The development during the 1970s of GaAs semiconductor lasers, emitting in the near-infrared region of 0. 8-0. 9 ~m, resulted in their use for the first generation of optical fiber communication systems. However, to take advantage oflow losses in silica fibers occurring around 1. 3 and 1. 55 ~m, the emphasis soon shifted toward long-wavelength semiconductor lasers. The material system of choice in this wavelength range has been the quaternary alloy InGaAsP. During the last five years or so, the intense development effort devoted to InGaAsP lasers has resulted in a technology mature enough that lightwave transmission systems using InGaAsP lasers are currently being deployed throughout the world. This book is intended to provide a comprehensive account of long-wave length semiconductor lasers. Particular attention is paid to InGaAsP lasers, although we also consider semiconductor lasers operating at longer wave lengths. The objective is to provide an up-to-date understanding of semicon ductor lasers while incorporating recent research results that are not yet available in the book form. Although InGaAsP lasers are often used as an example, the basic concepts discussed in this text apply to all semiconductor lasers, irrespective of their wavelengths.

Solar PV is now the third most important renewable energy source, after hydro and wind power, in terms of global installed capacity. Bringing together the expertise of international PV specialists Photovoltaic Solar Energy: From Fundamentals to Applications provides a comprehensive and up-to-date account of existing PV technologies in conjunction with an assessment of technological developments. Key features: Written by leading specialists active in concurrent developments in material sciences, solar cell research and application-driven R&D. Provides a basic knowledge base in light, photons and solar irradiance and basic functional principles of PV. Covers characterization techniques, economics and applications of PV such as silicon, thin-film and hybrid solar cells. Presents a compendium of PV technologies including: crystalline silicon technologies; chalcogenide thin film solar cells; thin-film silicon based PV technologies; organic PV and III-Vs; PV concentrator technologies; space technologies and economics, life-cycle and user aspects of PV technologies. Each chapter presents basic principles and formulas as well as major technological developments in a contemporary context with a look at future developments in this rapidly changing field of science and engineering. Ideal for industrial engineers and scientists beginning careers in PV as well as graduate students undertaking PV research and high-level undergraduate students.

Charge Injection, Transport and Recombination in Semiconductors

Generation-recombination noise in semiconductors with traps and recombination centers

Generation-recombination noise in semiconductors with traps and...

Radiative Recombination in Semiconductors

Semiconductor Lasers

This report introduces a new mechanism of recom bination in semiconductors and shows that the difficulty lies in the transmission of energy of the element in the act of trapping the nonbasic carrier and how this can be overcome. (Author).

The aim of this book is to give readers a broad review of topical worldwide advancements in theoretical and experimental facts, instrumentation and practical applications erudite by luminescent materials and their prospects in dealing with different types of luminescence like photoluminescence, electroluminescence, thermo-luminescence, triboluminescence, bioluminescence design and applications. The additional part of this book deals with the dynamics, rare-earth ions, photon down-/up-converting materials, luminescence dating, lifetime, bioluminescence microscopical perspectives and prospects towards the basic research or for more advanced applications. This book is divided into four main sections: luminescent materials and their associated phenomena; photo-physical properties and their emerging applications; thermoluminescence dating: from theory to applications, and bioluminescence perspectives and prospects. Individual chapters should serve the broad spectrum of common readers of diverse expertise, layman, students and researchers, who may in this book find easily elucidated fundamentals as well as progressive principles of specific subjects associated with these phenomena. This book was created by 14 contributions from experts in different fields of luminescence and technology from over 20 research institutes worldwide.

In this monograph, investigations of the performance of narrow-gap semiconductor photodiodes are presented, and recent progress in different IR photodiode technologies is discussed: HgCdTe photodiodes, InSb photodiodes, alternatives to HgCdTe III-V and II-VI ternary alloy photodiodes, lead chalcogenide photodiodes, and a new class of photodiodes based on two-dimensional solids. Investigations of the performance of photodiodes operated in different spectral regions are presented.

Hot-electron Loss Via Wiggled Auger Recombination in Semiconductors
Physics of Organic Semiconductors
Narrow-gap Semiconductor Photodiodes
Noise Research in Semiconductor Physics
Luminescence Spectroscopy of Semiconductors

The dynamics of nonradiative recombination processes are investigated by measuring the thermal expansion and subsequent displacement of a sample surface caused by the absorption of a modulated laser beam. 6 refs., 3 figs.

*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*

This book is devoted to the main aspects of the physics of recombination in semiconductors. It is the first book to deal exclusively and comprehensively with the subject, and as such is a self-contained volume, introducing the concepts and mechanisms of recombination from a fundamental point of view. Professor Landsberg is an internationally acknowledged expert in this field, and while not neglecting the occasional historical insights, he takes the reader to the frontiers of current research. Following initial chapters on semiconductor statistics and recombination statistics, the text moves on to examine the main recombination mechanisms: Auger effects, impact ionisation, radiative recombination, defect and multiphonon recombination. The final chapter deals with the topical subject of quantum wells and low-dimensional structures. Altogether the book covers a remarkably wide area of semiconductor physics. The book will be of importance to physicists, electronic engineers and applied mathematicians who are studying or researching the physics and applications of semiconductors. Some parts of the book will be accessible to final-year undergraduates.

Optical Processes in Semiconductors
Physics and Application of Radiative Recombination in Semiconductors (1951-1963)
Optical Gain and Recombination in Semiconductors
Recombination in Semiconductors
Recombination Parameters for Antimonide-Based Semiconductors Using RF Photoreflection Techniques

Graduate text with comprehensive treatment of semiconductor device physics and engineering, and descriptions of real optoelectronic devices.

RF photoreflection measurements and PC-1D simulations have been used to evaluate bulk and surface recombination parameters in antimonide-based materials. PC-1D is used to simulate the photoconductivity response of antimonide-based substrates and doubly-capped epitaxial layers and also to determine how to extract the recombination parameters using experimental results. Excellent agreement has been obtained with a first-order model and test structure simulation when Shockley-Reed-Hall (SRH) recombination is the bulk recombination process. When radiative, Auger and surface recombination are included, the simulation results show good agreement with the model. RF photoreflection measurements and simulations using PC-1D are compatible with a radiative recombination coefficient (B) of approximately 5 x 10-11 cm3/s, Auger coefficient (C) (almost equal to) 1.0 x 10-28 cm6/s and surface recombination velocity (SRV) (almost equal to) 600 cm/s for 0.50-0.55 eV doubly-capped InGaAsSb material with GaSb capping layers using the experimentally determined active layer doping of 2 x 1017 cm-3. Photon recycling, neglected in the analysis and simulations presented, will affect the extracted recombination parameters to some extent.

This book demonstrates the role and abilities of fluctuation in semiconductor physics, and shows what kinds of physical information are involved in the noise characteristics of semiconductor materials and devices, how this information may be decoded and which advantages are inherent to the noise methods. The text provides a comprehensive account of current results, addressing problems which have not previously been covered in Western literature, including the excess noise of tunnel-recombination currents and photocurrents in diodes, fluctuation phenomena in a real photoconductor with different recombination centers, and methods of noise spectroscopy of levels in a wide range of materials and devices.

Radiative Recombination in Semiconductors, Paris, 1964
Generation-recombination Noise in Semiconductors with Traps and Recombination Centers
Photovoltaic Solar Energy
Effects of Radiation on Semiconductors

The purpose of this book is to provide the reader with a self-contained treatment of fundamen tal solid state and semiconductor device physics. The material presented in the text is based upon the lecture notes of a one-year graduate course sequence taught by this author for many years in the ·Department of Electrical Engineering of the University of Florida. It is intended as an introductory textbook for graduate students in electrical engineering. However, many students from other disciplines and backgrounds such as chemical engineering, materials science, and physics have also taken this course sequence, and will be interested in the material presented herein. This book may also serve as a general reference for device engineers in the semiconductor industry. The present volume covers a wide variety of topics on basic solid state physics and physical principles of various semiconductor devices. The main subjects covered include crystal structures, lattice dynamics, semiconductor statistics, energy band theory, excess carrier phenomena and recombination mechanisms, carrier transport and scattering mechanisms, optical properties, photoelectric effects, metal-semiconductor devices, the p--n junction diode, bipolar junction transistor, MOS devices, photonic devices, quantum effect devices, and high speed III-V semiconductor devices. The text presents a unified and balanced treatment of the physics of semiconductor materials and devices. It is intended to provide physicists and mat erials scientists with more device backgrounds, and device engineers with a broader knowledge of fundamental solid state physics.

Comprehensive text and reference covers all phenomena involving light in semiconductors, emphasizing modern applications in semiconductor lasers, electroluminescence, photodetectors, photoconductors, photoemitters, polarization effects, absorption spectroscopy, more. Numerous problems. 339 illustrations.

The effects of electromagnetic radiation and high-energy par ticles on semiconductors can be divided into two main processes: (a) the excitation of electrons (the special case is internal ioniza tion, i. e. , the generation of excess charge carriers); and(b) dis turbance of the periodic structure of the crystal, i. e. , the forma tion of "structural radiation defects. " Naturally, investigations of the effects of radiation on semiconductors cannot be considered in isolation. Thus, for example, the problern of "radiation de fects" is part of the generalproblern of crystal lattice defects and the influence of such defects on the processes occurring in semi conductors. The same is true of photoelectric and similar phe nomena where the action of the radiation is only the start of a complex chain of nonequilibrium electronprocesses. Nevertheless, particularly from the point of view of the experimental physicist, the radiation effects discussed in the present book have inter esting features: several types of radiation may produce the same resul t (for example, ionization by photons and by charged particles) or one type of radiation may produce several effects (ionization and radiation -defect formation). The aim of the author was to consider the most typical prob lems. The subjects discussed differ widely from one another in the extent to which they have been investigated.

Research on Recombination and Fluctuation Theory in Semiconductors

Investigation of Nonradiative Recombination in Semiconductors by Photothermal Displacement Spectroscopy

Surface Recombination in Semiconductors

Noise in Physical Systems

Luminescence