

handbook on physical properties of semiconductors handbook on physical properties of semiconductors

Handbook on Physical Properties of Semiconductors Handbook on Physical Properties of Semiconductors

handbook on physical properties of semiconductors handbook on physical properties of semiconductors serves as an indispensable resource for engineers, researchers, and students delving into the fascinating world of semiconductor materials. Semiconductors lie at the heart of modern electronics, driving innovations from smartphones and solar cells to advanced computing systems. Understanding their physical properties is crucial for designing efficient devices and pushing the boundaries of technology. This handbook offers comprehensive coverage of the essential characteristics, from electrical conductivity and band structure to thermal and optical behaviors, making it a cornerstone for those working in material science and semiconductor physics.

The Importance of a Handbook on Physical Properties of Semiconductors

When tackling semiconductor technology, having a detailed reference that compiles the physical properties of these materials is invaluable. The handbook on physical properties of semiconductors handbook on physical properties of semiconductors provides a centralized, authoritative source of data and explanations that help decode the complex nature of semiconducting materials such as silicon, gallium arsenide, and emerging compounds like perovskites.

Why Physical Properties Matter

Physical properties—such as band gap energy, carrier mobility, dielectric constants, and thermal conductivity—directly influence how a semiconductor performs in real-world applications. For example, the band gap determines the wavelengths of light a material can absorb or emit, which is critical in optoelectronics. Carrier mobility affects the speed and efficiency of electronic devices. Without a thorough understanding of these factors, engineers risk inefficiency or failure in their designs.

Who Benefits from This Handbook?

- **Material Scientists**: Gain insight into the fundamental characteristics and behaviors of various semiconductor materials.
- **Device Engineers**: Use quantitative data to optimize device structures and improve performance.
- **Academics and Students**: Acquire foundational knowledge and reference material for research and study.
- **Industry Professionals**: Stay updated with the latest material properties and trends in semiconductor technologies.

Key Physical Properties Covered in the Handbook

The handbook on physical properties of semiconductors handbook on physical properties of semiconductors is organized to address a broad spectrum of properties that define semiconductor behavior. Here are some of the core physical properties typically explored:

1. Electrical Properties

Electrical characteristics are fundamental since semiconductors are primarily valued for their control over electrical conductivity.

- **Band Gap Energy**: The energy difference between the valence and conduction bands. It influences a material's electrical and optical properties.
- **Carrier Concentration and Mobility**: The density and speed of charge carriers (electrons and holes) determine conductivity.
- **Resistivity and Conductivity**: These parameters quantify how easily current flows through the material.
- **Doping Effects**: Introduction of impurities to modify electrical behavior is critical and well-documented.

2. Optical Properties

Understanding optical properties is vital for applications in LEDs, photodetectors, and solar cells.

- **Absorption Coefficient**: How much light is absorbed at different wavelengths.
- **Refractive Index**: Influences light propagation within the material.
- **Luminescence and Photoluminescence**: Emission of light under excitation, important in optoelectronics.

3. Thermal Properties

Heat dissipation and thermal stability are crucial for device reliability.

- **Thermal Conductivity:** Ability to conduct heat, affecting cooling strategies.
- **Thermal Expansion Coefficients:** Impact mechanical stability under temperature changes.
- **Heat Capacity:** Influences how a semiconductor responds to thermal energy.

4. Mechanical Properties

Though often overlooked, mechanical properties affect fabrication and device longevity.

- **Elastic Modulus:** Describes material stiffness.
- **Hardness and Fracture Toughness:** Important for processing and handling.

Applications and Practical Use of the Handbook

Having a handbook on physical properties of semiconductors at your fingertips can significantly streamline research and development processes.

Material Selection and Comparison

Designers often need to choose between multiple semiconductor materials depending on the application. The handbook's detailed tables and charts enable quick comparisons of parameters like band gap energies, carrier mobilities, and thermal conductivities, helping make informed decisions.

Device Simulation and Modeling

Accurate physical property data is essential for simulating semiconductor devices using computational tools. By referencing reliable values from the handbook, simulation results become more realistic, guiding design improvements before manufacturing.

Educational Resource

For students and educators, the handbook not only offers data but also clear explanations and context, facilitating better understanding of semiconductor physics. It often includes historical insights and experimental methods, enriching the learning experience.

How to Use the Handbook Effectively

To maximize the benefits of the handbook on physical properties of semiconductors, consider these tips:

- **Identify Your Focus Area:** Whether you need electrical, optical, or thermal data, start by pinpointing the relevant section to save time.
- **Cross-Reference with Experimental Data:** Use the handbook as a baseline and compare with recent experimental findings for cutting-edge materials.
- **Consult the Bibliography:** Many handbooks provide references to original research papers, which can be invaluable for deep dives into specific topics.
- **Stay Updated:** Semiconductor materials evolve rapidly; ensure you have access to the latest editions or supplementary materials.

Emerging Trends in Semiconductor Materials and Their Properties

The field of semiconductors is dynamic, with new materials and novel properties continually discovered. The handbook on physical properties of semiconductors often incorporates these advancements to keep its audience informed.

Wide Band Gap Semiconductors

Materials like silicon carbide (SiC) and gallium nitride (GaN) are gaining prominence due to their high breakdown voltages and thermal stability. The handbook includes updated data on these materials, which are crucial for power electronics and RF applications.

Organic and Hybrid Semiconductors

Organic semiconductors and perovskite materials have unique properties that challenge traditional inorganic semiconductors. Their inclusion in modern handbooks reflects their growing importance in flexible electronics and solar energy.

2D Materials and Nanostructures

Graphene, transition metal dichalcogenides (TMDCs), and quantum dots exhibit exceptional electrical and optical properties at the nanoscale. Comprehensive handbooks now incorporate these materials, providing insights into their anisotropic behaviors and quantum effects.

Unlocking the Potential of Semiconductors Through Knowledge

The journey from raw semiconductor materials to high-performance electronic devices is complex and demands precise understanding. The handbook on physical properties of semiconductors acts as a guiding light, charting the path with data-rich, well-organized information.

Whether you're developing next-generation transistors, improving solar cells, or exploring new materials, this handbook equips you with the foundational and advanced knowledge necessary to innovate responsibly and effectively. Its careful compilation of physical parameters fosters confidence in design decisions and accelerates technological progress.

For anyone involved in the semiconductor industry or academia, this resource remains a trusted companion, helping translate the intriguing properties of semiconductors into groundbreaking applications that shape our modern world.

Frequently Asked Questions

What is the 'Handbook on Physical Properties of Semiconductors'?

The 'Handbook on Physical Properties of Semiconductors' is a comprehensive reference book that compiles detailed information on the physical and electronic properties of semiconductor materials, serving as an essential resource for researchers and engineers.

Who are the primary authors or editors of the 'Handbook on Physical Properties of Semiconductors'?

The handbook is commonly edited by renowned experts in semiconductor physics, such as D. J. Adachi, who has contributed significantly to the compilation and organization of semiconductor material data.

What types of semiconductor materials are covered in the handbook?

The handbook covers a wide range of semiconductor materials including elemental semiconductors like silicon and germanium, compound semiconductors such as gallium arsenide (GaAs), indium phosphide (InP), and emerging materials like wide bandgap semiconductors.

How is the 'Handbook on Physical Properties of Semiconductors' useful for semiconductor device design?

The handbook provides detailed quantitative data on properties such as bandgap energy, electron mobility, thermal conductivity, and dielectric constants, which are critical parameters for designing and optimizing semiconductor devices.

Are the physical properties in the handbook temperature dependent?

Yes, the handbook includes temperature-dependent data for many physical properties, enabling users to understand material behavior under various operating conditions.

Is the 'Handbook on Physical Properties of Semiconductors' updated regularly?

New editions and updates are published periodically to include the latest research findings and newly discovered semiconductor materials, ensuring that the handbook remains a current and reliable resource.

Where can I access or purchase the 'Handbook on Physical Properties of Semiconductors'?

The handbook can be accessed through academic libraries, purchased from scientific publishers like Springer or Wiley, or found in digital format on platforms that specialize in scientific literature.

Additional Resources

Handbook on Physical Properties of Semiconductors: A Comprehensive Review

handbook on physical properties of semiconductors **handbook on physical properties of semiconductors** serves as an essential resource for researchers, engineers, and students delving into the intricate world of semiconductor materials. This compendium meticulously catalogs the diverse physical characteristics of semiconductors, providing critical data that supports technological advancements in electronics, optoelectronics, and nanotechnology. As semiconductor technology continues to evolve rapidly, understanding the fundamental physical properties of these materials remains paramount for innovation and practical application.

In-depth Analysis of the Handbook on Physical Properties of Semiconductors

The **handbook on physical properties of semiconductors** stands out for its exhaustive coverage of material parameters, ranging from basic elemental semiconductors like silicon and germanium to compound semiconductors such as gallium arsenide and indium phosphide. The book excels in presenting empirical data alongside theoretical insights, enabling readers to navigate the complex interplay between semiconductor physics and material science.

One of the core strengths of this handbook is its systematic approach to organizing semiconductor properties. Data on electronic band structures, carrier mobilities, effective masses, dielectric constants, and thermal conductivities are presented in a clear, tabular format. This facilitates quick reference while maintaining scientific rigor. Additionally, the integration of temperature-dependent data allows for a deeper understanding of semiconductor behavior in real-world operating conditions.

Significance of Physical Properties in Semiconductor Applications

Physical properties such as bandgap energy, electron affinity, and lattice constants play a pivotal role in determining the performance of semiconductor devices. The **handbook on physical properties of semiconductors** meticulously details these parameters, providing engineers with the necessary data to optimize device design.

For example, the bandgap energy directly influences a semiconductor's optical absorption and emission characteristics, which are critical in designing LEDs and photovoltaic cells. The handbook's comprehensive datasets enable comparison across different materials, aiding in the selection of

semiconductors tailored to specific applications such as high-speed transistors or low-power sensors.

Comparative Data and Material Selection

The handbook facilitates material selection through comparative analysis of physical properties. It juxtaposes parameters like electron mobility and thermal conductivity across a range of semiconductors, highlighting trade-offs that influence device efficiency and longevity. For instance, while silicon offers robust mechanical properties and mature fabrication techniques, compound semiconductors like gallium nitride exhibit superior electron mobility and thermal conductivity, making them suitable for high-frequency and high-power applications.

- **Silicon (Si):** Bandgap ~1.12 eV, moderate electron mobility, well-established fabrication processes.
- **Gallium Arsenide (GaAs):** Bandgap ~1.43 eV, higher electron mobility than silicon, commonly used in microwave and optoelectronics.
- **Indium Phosphide (InP):** Bandgap ~1.35 eV, excellent electron velocity, preferred in high-speed and photonic devices.
- **Gallium Nitride (GaN):** Wide bandgap ~3.4 eV, high thermal conductivity, ideal for power electronics and UV optoelectronics.

This comparative approach within the handbook supports informed decision-making for research and industrial development.

Deeper Insights into Key Physical Properties

Band Structure and Carrier Dynamics

Understanding the electronic band structure is fundamental to semiconductor physics. The handbook on physical properties of semiconductors provides detailed band diagrams and effective mass values that illustrate how electrons and holes propagate within different materials. These parameters directly impact carrier mobility and recombination rates, which are crucial for device speed and efficiency.

Thermal Properties and Device Reliability

Thermal management remains a critical challenge in semiconductor device engineering. The handbook offers extensive data on thermal conductivity and heat capacity, enabling designers to predict how materials will perform under various thermal stresses. Semiconductors with higher thermal conductivity, such as silicon carbide and gallium nitride, are increasingly favored for power devices due to their ability to dissipate heat effectively and maintain operational stability.

Dielectric and Optical Constants

Dielectric constants affect capacitance and insulation properties, influencing the design of transistors and integrated circuits. The handbook rigorously compiles dielectric permittivity values across a range of frequencies and temperatures. Additionally, optical constants such as refractive index and absorption coefficients are extensively documented, providing indispensable information for the development of lasers, photodetectors, and solar cells.

Utility for Academia and Industry

The handbook on physical properties of semiconductors handbook on physical properties of semiconductors is invaluable not only as a reference but also as a teaching tool. Its detailed data tables and graphical representations support academic coursework in semiconductor physics and materials science. Researchers benefit from the comprehensive data sets that reduce the need for redundant experimentation, accelerating innovation cycles.

In industry, the handbook assists materials scientists and device engineers in refining processes and selecting appropriate semiconductor substrates and epitaxial layers. The ability to cross-reference physical properties ensures that product development aligns with performance and reliability targets.

Advantages and Limitations of the Handbook

- **Advantages:**

- Comprehensive and authoritative data compilation
- Clear organization enabling quick access to critical parameters
- Inclusion of temperature-dependent and frequency-dependent

properties

- Wide coverage from elemental to complex compound semiconductors

- **Limitations:**

- Rapidly evolving semiconductor materials, such as novel 2D materials, may not be fully covered
- Some experimental data may have varying degrees of uncertainty depending on source
- Primarily focused on intrinsic properties, with less emphasis on defect states and dopant effects

Despite these limitations, the handbook remains a cornerstone reference for anyone engaged in semiconductor research or application development.

Evolution and Future Perspectives

The landscape of semiconductor materials is continuously expanding, with emerging materials like graphene, transition metal dichalcogenides, and perovskites capturing attention for their exceptional properties. Future editions of the handbook on physical properties of semiconductors are expected to incorporate these novel materials, further broadening its scope.

Moreover, as device architectures become increasingly complex—integrating heterostructures, quantum wells, and nanostructures—comprehensive physical data will be critical for predictive modeling and simulation. The handbook's role in consolidating such information will only grow in significance.

By maintaining a balance between established semiconductor materials and cutting-edge developments, the handbook ensures that professionals remain equipped with the knowledge necessary to navigate an ever-evolving technological domain.

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handbook on physical properties of semiconductors handbook on physical properties of semiconductors: The Physics of Semiconductors Marius Grundmann, 2021-03-06 The 4th edition of this highly successful textbook features copious material for a complete upper-level undergraduate or graduate course, guiding readers to the point where they can choose a specialized topic and begin supervised research. The textbook provides an integrated approach beginning from the essential principles of solid-state and semiconductor physics to their use in various classic and modern semiconductor devices for applications in electronics and photonics. The text highlights many practical aspects of semiconductors: alloys, strain, heterostructures, nanostructures, amorphous semiconductors, and noise, which are essential aspects of modern semiconductor research but often omitted in other textbooks. This textbook also covers advanced topics, such as Bragg mirrors, resonators, polarized and magnetic semiconductors, nanowires, quantum dots, multi-junction solar cells, thin film transistors, and transparent conductive oxides. The 4th edition includes many updates and chapters on 2D materials and aspects of topology. The text derives explicit formulas for many results to facilitate a better understanding of the topics. Having evolved from a highly regarded two-semester course on the topic, The Physics of Semiconductors requires little or no prior knowledge of solid-state physics. More than 2100 references guide the reader to historic and current literature including original papers, review articles and topical books, providing a go-to point of reference for experienced researchers as well.

handbook on physical properties of semiconductors handbook on physical properties of semiconductors: Properties of Semiconductor Alloys Sadao Adachi, 2009-03-12 The main purpose of this book is to provide a comprehensive treatment of the materials aspects of group-IV, III–V and II–VI semiconductor alloys used in various electronic and optoelectronic devices. The topics covered in this book include the structural, thermal, mechanical, lattice vibronic, electronic, optical and carrier transport properties of such semiconductor alloys. The book reviews not only commonly known alloys (SiGe, AlGaAs, GaInPAs, and ZnCdTe) but also new alloys, such as dilute-carbon alloys (CSiGe, CSiSn, etc.), III–N alloys, dilute-nitride alloys (GaNAs and GaInNAs) and Mg- or Be-based II–VI semiconductor alloys. Finally there is an extensive bibliography included for those who wish to find additional information as well as tabulated values and graphical information on the properties of semiconductor alloys.

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handbook on physical properties of semiconductors handbook on physical properties of semiconductors: Photoconductivity and Photoconductive Materials, 2 Volume Set Safa O. Kasap, 2022-06-27 Dieses wichtige Referenzwerk behandelt die grundlegenden Konzepte der Photoleitfähigkeit und der photoleitenden Materialien. Mit Photoconductivity and Photoconductive Materials präsentiert Professor Kasap eine maßgebliche Zusammenstellung der wesentlichen

Grundsätze der Photoleitfähigkeit und stellt eine Auswahl aktueller photoleitfähiger Materialien vor. Der erste Band des zweibändigen Werks beginnt mit einer Darstellung der grundlegenden Konzepte und Definitionen. Es folgt eine Charakterisierung der verschiedenen Techniken auf Grundlage von stationärer, transients und modulierter Photoleitfähigkeit, u.a. der neuen Methode der Ladungsextraktion durch linear steigende Spannung (CELIV). Auch die Physik der Terahertz-Photoleitfähigkeit sowie die Grundlagen der organischen Halbleiter LSoI werden behandelt. Der zweite Band beginnt mit einem umfassenden Überblick über eine Vielzahl unterschiedlicher photoleitfähiger Materialien, wobei der Schwerpunkt auf einige der wichtigsten Photoleiter gelegt wird, darunter hydriertes amorphes Silizium, Cadmium-Quecksilber-Tellurid, verschiedene Röntgenphotoleiter, Diamantfilme, Metallhalogenidperowskite, Nanodrähte und Quantenpunkte. Auch die Anwendungen der photoleitenden Antenne werden erörtert. Das Werk, das zahlreiche Beiträge führender Autoren auf diesem Fachgebiet enthält, bietet den Leserinnen und Lesern außerdem:

- * Eine gründliche Einführung in die Charakterisierung von Halbleitern mit Hilfe von Techniken der Photoleitfähigkeit, insbesondere gleichmäßiger Beleuchtung und Phototräger-Gittertechniken
- * Eine umfassende Darstellung organischer Photoleiter mitsamt Informationen zu Photoerzeugung, Transport und Anwendungen im Druckbereich
- * Praktische Erörterungen der transienten Lichtleitfähigkeit im Flugzeitverfahren inklusive Experimentiertechniken und Interpretationshinweisen
- * Eine eingehende Betrachtung der transienten Photoleitfähigkeit organischer Halbleiterschichten und neuartiger Techniken der transienten Photoleitfähigkeit

Photoconductivity and Photoconductive Materials ist nicht nur ein wichtiges Referenzwerk für Physiker in der Forschung, Materialwissenschaftler und Elektroingenieure, sondern auch ein unverzichtbares Nachschlagewerk für Doktoranden und Studierende höherer Semester, die sich mit dem Bereich der optoelektronischen Materialien beschäftigen, sowie für Forschende in der Industrie.

- * Ein umfassendes zweibändiges Werk mit Beiträgen führender Fachautoren, herausgegeben von einem angesehenen Forscher auf dem Gebiet der Photoleitfähigkeit

handbook on physical properties of semiconductors handbook on physical properties of semiconductors: Properties of Group-IV, III-V and II-VI Semiconductors Sadao Adachi, 2005-06-14 Almost all the semiconductors of practical interest are the group-IV, III-V and II-VI semiconductors and the range of technical applications of such semiconductors is extremely wide. The purpose of this book is twofold:

- * to discuss the key properties of the group-IV, III-V and II-VI semiconductors
- * to systemize these properties from a solid-state physics aspect

The majority of the text is devoted to the description of the lattice structural, thermal, elastic, lattice dynamic, electronic energy-band structural, optical and carrier transport properties of these semiconductors. Some corrective effects and related properties, such as piezoelectric, elastooptic and electrooptic properties, are also discussed. The book contains convenient tables summarizing the various material parameters and the definitions of important semiconductor properties. In addition, graphs are included in order to make the information more quantitative and intuitive. The book is intended not only for semiconductor device engineers, but also physicists and physical chemists, and particularly students specializing in the fields of semiconductor synthesis, crystal growth, semiconductor device physics and technology.

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digital-to-analog and analog-to-digital converters, digital filters, and multichip module technology. Expert contributors discuss applications in machine vision, ad hoc networks, printing technologies, and data and optical storage systems. The book also includes defining terms, references, and suggestions for further reading. This edition features two new sections on fundamental properties and semiconductor devices. With updated material and references in every chapter, Microelectronics, Second Edition is an essential reference for work with microelectronics, electronics, circuits, systems, semiconductors, logic design, and microprocessors.

handbook on physical properties of semiconductors handbook on physical properties of semiconductors: X-Ray Absorption Spectroscopy of Semiconductors Claudia S. Schnohr, Mark C. Ridgway, 2014-11-05 X-ray Absorption Spectroscopy (XAS) is a powerful technique with which to probe the properties of matter, equally applicable to the solid, liquid and gas phases.

Semiconductors are arguably our most technologically-relevant group of materials given they form the basis of the electronic and photonic devices that now so widely permeate almost every aspect of our society. The most effective utilisation of these materials today and tomorrow necessitates a detailed knowledge of their structural and vibrational properties. Through a series of comprehensive reviews, this book demonstrates the versatility of XAS for semiconductor materials analysis and presents important research activities in this ever growing field. A short introduction of the technique, aimed primarily at XAS newcomers, is followed by twenty independent chapters dedicated to distinct groups of materials. Topics span dopants in crystalline semiconductors and disorder in amorphous semiconductors to alloys and nanometric material as well as in-situ measurements of the effects of temperature and pressure. Summarizing research in their respective fields, the authors highlight important experimental findings and demonstrate the capabilities and applications of the XAS technique. This book provides a comprehensive review and valuable reference guide for both XAS newcomers and experts involved in semiconductor materials research.

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Fundamentals of Solid State Engineering, 3rd Edition, provides a multi-disciplinary introduction to solid state engineering, combining concepts from physics, chemistry, electrical engineering, materials science and mechanical engineering. Revised throughout, this third edition includes new topics such as electron-electron and electron-phonon interactions, in addition to the Kane effective mass method. A chapter devoted to quantum mechanics has been expanded to cover topics such as the harmonic oscillator, the hydrogen atom, the quantum mechanical description of angular momentum and the origin of spin. This textbook also features an improved transport theory description, which now goes beyond Drude theory, discussing the Boltzmann approach. Introducing students to the rigorous quantum mechanical way of thinking about and formulating transport processes, this textbook presents the basic physics concepts and thorough treatment of semiconductor characterization technology, designed for solid state engineers.

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diffusion waves in rotating magnetized semiconductors is also presented. This book provides readers with a solid foundation in recent developments and current technologies for producing and characterizing semiconductors, as well as theoretical and computational tools.

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Narottam P. Bansal, J. P. Singh, Song Ko, Ricardo H. R. Castro, Gary Pickrell, Navin Jose Manjooran, Mani Nair, Gurpreet Singh, 2013-07-01 Contains contributed 38 papers from the following seven symposia held during the 2012 Materials Science and Technology (MS&T'12) meeting: Innovative Processing and Synthesis of Ceramics, Glasses and Composites Advances in Ceramic Matrix Composites Solution Based Processing for Ceramic Materials Novel Sintering Processes and News in the Conventional Sintering and Grain Growth Nanotechnology for Energy, Healthcare and Industry Dielectric Ceramic Materials and Electronic Devices Controlled Synthesis, Processing, and Applications of Structure and Functional Nanomaterials

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handbook on physical properties of semiconductors handbook on physical properties of semiconductors: Optical Properties of Materials and Their Applications Jai Singh, 2020-01-07 Provides a semi-quantitative approach to recent developments in the study of optical properties of condensed matter systems Featuring contributions by noted experts in the field of electronic and optoelectronic materials and photonics, this book looks at the optical properties of materials as well as their physical processes and various classes. Taking a semi-quantitative approach to the subject, it presents a summary of the basic concepts, reviews recent developments in the study of optical properties of materials and offers many examples and applications. Optical Properties of Materials and Their Applications, 2nd Edition starts by identifying the processes that should be described in detail and follows with the relevant classes of materials. In addition to featuring four new chapters on optoelectronic properties of organic semiconductors, recent advances in electroluminescence, perovskites, and ellipsometry, the book covers: optical properties of disordered condensed matter and glasses; concept of excitons; photoluminescence, photoinduced changes, and electroluminescence in noncrystalline semiconductors; and photoinduced bond breaking and volume change in chalcogenide glasses. Also included are chapters on: nonlinear optical properties of photonic glasses; kinetics of the persistent photoconductivity in crystalline III-V semiconductors; and transparent white OLEDs. In addition, readers will learn about excitonic processes in quantum wells; optoelectronic properties and applications of quantum dots; and more. Covers all of the fundamentals and applications of optical properties of materials Includes theory, experimental techniques, and current and developing applications Includes four new chapters on optoelectronic properties of organic semiconductors, recent advances in electroluminescence, perovskites, and ellipsometry Appropriate for materials scientists, chemists, physicists and electrical engineers involved in development of electronic materials Written by internationally respected professionals working in physics and electrical engineering departments and government laboratories Optical

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