

Figure 2.14 Physical properties of semiconductor materials.

	Ge	Si	GaAs	SiO <sub>2</sub>
Atomic Weight	72.6	28.09	144.53	60.08
Atoms/cm <sup>3</sup> or Molecules	$4.42 \times 10^{22}$	$5.00 \times 10^{22}$	$2.21 \times 10^{23}$	$2.3 \times 10^{22}$
Crystal Structure	Diamond	Diamond	Zinc-Blends	Amorphous
Atoms/Unit Cell	8	8	8	—
Density	5.32	2.33	5.65	2.27
Energy Gap	0.67	1.11	1.40	8 (approx.)
Dielectric Constant	16.3	11.7	12.0	3.9
Melting Point (°C)	937*	1415*	1238*	1700* (approx.)
Breakdown Field (V/cm)	*5 (approx.)	30 (approx.)	35 (approx.)	600 (approx.)
Linear Coefficient of Thermal Expansion	$5.8 \times 10^{-6}$	$2.5 \times 10^{-6}$	$5.9 \times 10^{-6}$	$0.5 \times 10^{-4}$

# Electronic Properties Of Inhomogeneous Semiconductors

**Zhe Xu**



## **Electronic Properties Of Inhomogeneous Semiconductors:**

*Electronic Properties of Inhomogeneous Semiconductors* A.Y. Shik, 1995-10-06      *Electronic Properties of Doped Semiconductors* B.I. Shklovskii, A.L. Efros, 2013-11-09 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 banishment 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 development 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 physics 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

**Quantum Theory of the Optical and Electronic Properties of Semiconductors** Hartmut Haug, Stephan W. Koch, 2004 This invaluable textbook presents the basic elements needed to understand and research into semiconductor physics It deals with elementary excitations in bulk and low dimensional semiconductors including quantum wells quantum wires and quantum dots The basic principles underlying optical nonlinearities are developed including excitonic and many body plasma effects Fundamentals of optical bistability semiconductor lasers femtosecond excitation the optical Stark effect the semiconductor photon echo magneto optic effects as well as bulk and quantum confined Franz Keldysh effects are covered The material is presented in sufficient detail for graduate students and researchers with a general background in quantum mechanics

*Electronic Properties of Multilayers and Low-Dimensional Semiconductor Structures* J.M. Chamberlain, L. Eaves, J.C. Portal, 2012-12-06 This Advanced Study Institute on the Electronic Properties of Multilayers and Low Dimensional Semiconductor Structures focussed on several of the most active areas in modern semiconductor physics These included resonant tunnelling and superlattice phenomena and the topics of ballistic transport quantised conductance and anomalous magnetoresistance effects in laterally gated two dimensional electron systems Although the main emphasis was on fundamental physics a series of supporting lectures described the underlying technology Molecular Beam Epitaxy Metallo Organic Chemical Vapour Deposition Electron Beam Lithography and other advanced processing technologies Actual and potential applications of low dimensional structures in optoelectronic and high frequency devices were also discussed The ASI took the form of a series of lectures of about fifty minutes duration which were given by senior researchers from a wide range of countries Most of the lectures are recorded in these Proceedings The younger members of the Institute made

the predominant contribution to the discussion sessions following each lecture and in addition provided most of the fifty five papers that were presented in two lively poster sessions The ASI emphasised the impressive way in which this research field has developed through the fruitful interaction of theory experiment and semiconductor device technology Many of the talks demonstrated both the effectiveness and limitations of semiclassical concepts in describing the quantum phenomena exhibited by electrons in low dimensional structures

*New Developments in Semiconductor Research* Thomas S. Miller, 2005 This book includes within its scope studies of the structural electrical optical and acoustical properties of bulk low dimensional and amorphous semiconductors computational semiconductor physics interface properties including the physics and chemistry of heterojunctions metal semiconductor and insulator semiconductor junctions all multi layered structures involving semiconductor components dopant incorporation growth and preparation of materials including both epitaxial e g molecular beam and chemical vapour methods and bulk techniques and in situ monitoring of epitaxial growth processes Also included are appropriate aspects of surface science such as the influence of growth kinetics and chemical processing on layer and device properties The physics of semiconductor electronic and optoelectronic devices are examined including theoretical modelling and experimental demonstration all aspects of the technology of semiconductor device and circuit fabrication structures incorporating Langmuir Blodgett films resists lithography and metalisation where they are concerned with the definition of small geometry structure The structural electrical and optical characterisation of materials and device structures are also included The scope encompasses materials and device reliability reliability evaluation of technologies failure analysis and advanced analysis techniques such as SEM E beam optical emission microscopy acoustic microscopy techniques liquid crystal techniques noise measurement reliability prediction and simulation reliability indicators failure mechanisms including charge migration trapping oxide breakdown hot carrier effects electro migration stress migration package related failure mechanisms and effects of operational and environmental stresses on reliability

**InAs<sub>1</sub>-XPx Semiconductor Solid Solutions in Modern Electronics** Nodar Kekelidze, Elza Khutsishvili, Georgy Kekelidze, Tengiz Qamushadze, 2022-09-23 Semiconductor based devices with increased reliability low cost unusual lightness small size and minimal service have become an important part of our daily lives It is difficult to imagine life without electronic vehicles TVs computers smartphones medical networks and global e commerce As this book argues semiconductors are the main driving force behind economic strength national security and resilience in times of crisis However novel types of semiconductors are needed in order to support ever growing scaling demands today Developing semiconductors with desired properties such as tolerance to radiation for instance is of crucial importance InAs<sub>1</sub> InP solid solutions present an example of such materials used for cutting edge electronic technologies Packed with diagrams and accompanying detailed computations this book provides a comprehensive coverage of InAs<sub>1</sub> xPx solid solutions from the production of single bulk crystals and layers to the thorough study of their properties and to their inexhaustible application

potential in electronics      **Nanophotonic Materials** Ralf B. Wehrspohn, Heinz-Siegfried Kitzerow, Kurt Busch, 2008-09-08  
Nanophotonic Materials Photonic Crystals Plasmonics and Metamaterials summarizes the work and results of a consortium consisting of more than 20 German research groups concentrated on photonics crystals research over the last seven years Illustrated throughout in full color the book provides an overview of these novel materials spanning the entire range from fundamentals to applications      **Applied Electromagnetism and Materials** André Moliton, 2007-03-14 Applied

Electromagnetism and Materials picks up where Basic Electromagnetism and Materials left off by presenting practical and relevant technological information about electromagnetic material properties and their applications This book is aimed at senior undergraduate and graduate students as well as researchers in materials science and is the product of many years of teaching basic and applied electromagnetism Topics range from the spectroscopy and characterization of dielectrics and semiconductors to non linear effects and electromagnetic cavities to ion beam applications in materials science

**Capacitance Spectroscopy of Semiconductors** Jian V. Li, Giorgio Ferrari, 2018-07-06 Capacitance spectroscopy refers to techniques for characterizing the electrical properties of semiconductor materials junctions and interfaces all from the dependence of device capacitance on frequency time temperature and electric potential This book includes 15 chapters written by world recognized leading experts in the field academia national institutions and industry divided into four sections Physics Instrumentation Applications and Emerging Techniques The first section establishes the fundamental framework relating capacitance and its allied concepts of conductance admittance and impedance to the electrical and optical properties of semiconductors The second section reviews the electronic principles of capacitance measurements used by commercial products as well as custom apparatus The third section details the implementation in various scientific fields and industries such as photovoltaics and electronic and optoelectronic devices The last section presents the latest advances in capacitance based electrical characterization aimed at reaching nanometer scale resolution      **Physics of Thin-Film Photovoltaics**

Victor G. Karpov, Diana Shvydka, 2021-11-09 PHYSICS OF THIN FILM PHOTOVOLTAICS Tackling one of the hottest topics in renewables thin film photovoltaics the authors present the latest updates technologies and applications offering the most up to date and thorough coverage available to the engineer scientist or student It appears rather paradoxical that thin film photovoltaics PVs are made of materials that seem unacceptable from the classical PV perspective and yet they often outperform classical PV This exciting new volume solves that paradox by switching to a new physics paradigm Many concepts here fall beyond the classical PV scope The differences lie in device thinness microns instead of millimeters and morphology non crystalline instead of crystalline In such structures the charge carriers can reach electrodes without recombination On the other hand thin disordered structures render a possibility of detrimental lateral nonuniformities recombination highways and their energy spectra give rise to new recombination modes The mechanisms of thermal exchange and device degradation are correspondingly unique The overall objective of this book is to give a self contained in depth discussion of the physics of

thin film systems in a manner accessible to both researchers and students It covers most aspects of the physics of thin film PV including device operations material structure and parameters thin film junction formation analytical and numerical modeling concepts of large area effects and lateral non uniformities physics of shunting both shunt growth and effects and device degradation Also it reviews a variety of physical diagnostic techniques proven with thin film PV Whether for the veteran engineer or the student this is a must have for any library This outstanding new volume Covers not only the state of the art of thin film photovoltaics but also the basics making this volume useful not just to the veteran engineer but the new hire or student as well Offers a comprehensive coverage of thin film photovoltaics including operations modeling non uniformities piezo effects and degradation Includes novel concepts and applications never presented in book format before Is an essential reference not just for the engineer scientist and student but the unassuming level of presentation also makes it accessible to readers with a limited physics background Is filled with workable examples and designs that are helpful for practical applications Is useful as a textbook for researchers students and faculty for understanding new ideas in this rapidly emerging field Audience Industrial professionals in photovoltaics such as engineers managers research and development staff technicians government and private research labs also academic and research universities such as physics chemistry and electrical engineering departments and graduate and undergraduate students studying electronic devices semiconductors and energy disciplines

**Survey of Semiconductor Physics** Karl Wolfgang Böer, 1990 Taking up where the first volume left off this work provides coverage of the inhomogeneous semiconductor It deals mainly with Si and GaAs but also investigates other materials of theoretical and practical interest such as Ge other III V and II VI compounds and amorphous SiH Equipped with this source physicists semiconductor engineers device engineers and fabrication engineers will have access to a vast reservoir of practical information on the design production and operations of semiconductor devices

Quantum Wells: Physics And Electronics Of Two-dimensional Systems Alexander Shik, 1998-01-09 This invaluable book is devoted to the physics technology and device applications of semiconductor structures with ultrathin layers where the electronic properties are governed by the quantum mechanical laws Such structures called quantum wells or structures with the two dimensional electron gas have become one of the most actively investigated objects in modern solid state physics Electronic properties of quantum wells differ dramatically from those of bulk semiconductors which allows one to observe new types of physical phenomena such as the quantum Hall effect and many other so far unknown kinetic and optical effects This in turn offers wide opportunities for creating semiconductor devices based on new principles and it has give birth to the new branch of electronics called nanoelectronics

**Semiconductor Materials Analysis and Fabrication Process Control** G.M. Crean, R. Stuck, J.A. Woollam, 2012-12-02 There is a growing awareness that the successful implementation of novel material systems and technology steps in the fabrication of microelectronic and optoelectronic devices is critically dependent on the understanding and control of the materials the process steps and their interactions The contributions in

this volume demonstrate that characterisation and analysis techniques are an essential support mechanism for research in these fields Current major research themes are reviewed both in the development and application of diagnostic techniques for advanced materials analysis and fabrication process control Two distinct trends are elucidated the emergence and evaluation of sophisticated in situ optical diagnostic techniques such as photoreflectance and spectroellipsometry and the industrial application of ultra high sensitivity chemical analysis techniques for contamination monitoring The volume will serve as a useful and timely overview of this increasingly important field

**Scientific and Technical Aerospace Reports**, 1991 Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database

**The Electron Liquid Paradigm in Condensed Matter Physics** G. Vignale, 2005-02-03 The electron liquid paradigm is at the basis of most of our current understanding of the physical properties of electronic systems Quite remarkably the latter are nowadays at the intersection of the most exciting areas of science materials science quantum chemistry nano electronics biology and quantum computation Accordingly its importance can hardly be overestimated During the past 20 years the field has witnessed momentous developments which are partly covered in this new volume Advances in semiconductor technology have allowed the realizations of ultra pure electron liquids whose density unlike that of the ones spontaneously occurring in nature can be tuned by electrical means allowing a systematic exploration of both strongly and weakly correlated regimes Most of these system are two or even one dimensional and can be coupled together in the form of multi layers or multi wires opening vast observational possibilities On the theoretical side quantum Monte Carlo methods have allowed an essentially exact determination of the ground state energy of the electron liquid and have provided partial answers to the still open question of the structure of its phase diagram Starting from the 1980s some truly revolutionary concepts have emerged which are well represented in this volume

Technical Abstract Bulletin , *Handbook of the Physics of Thin-Film Solar Cells* Karl W. Böer, 2014-04-23 This handbook is a compendium giving a comprehensive description of the basics of semiconductor physics relevant to the design and analysis of thin film solar cell materials It starts from the basics of material science describing the material and its growth defect and electrical properties the basics of its interaction with photons and the involved statistics proceeding to space charge effects in semiconductors and pn junctions Most attention is given to analyze homo and hetero junction solar cells using various models and applying the field of direction analysis for discussing current voltage characteristics and helping to discover the involvement of high field effects in solar cells The comprehensive coverage of the main topics of and relating to solar cells with extensive reference to literature helps scientists and engineers at all levels to reach a better understanding and improvement of solar cell properties and their production The author is one of the founders of thin film solar cell research

Soviet Physics , 1984

**Semiconductor Material and Device Characterization** Dieter K. Schroder, 2015-06-29 This Third Edition updates a landmark text with the latest findings The

Third Edition of the internationally lauded Semiconductor Material and Device Characterization brings the text fully up to date with the latest developments in the field and includes new pedagogical tools to assist readers. Not only does the Third Edition set forth all the latest measurement techniques but it also examines new interpretations and new applications of existing techniques. Semiconductor Material and Device Characterization remains the sole text dedicated to characterization techniques for measuring semiconductor materials and devices. Coverage includes the full range of electrical and optical characterization methods including the more specialized chemical and physical techniques. Readers familiar with the previous two editions will discover a thoroughly revised and updated Third Edition including updated and revised figures and examples reflecting the most current data and information, 260 new references offering access to the latest research and discussions in specialized topics, new problems and review questions at the end of each chapter to test readers' understanding of the material. In addition, readers will find fully updated and revised sections in each chapter. Plus two new chapters have been added. Charge Based and Probe Characterization introduces charge based measurement and Kelvin probes. This chapter also examines probe based measurements including scanning capacitance, scanning Kelvin force, scanning spreading resistance, and ballistic electron emission microscopy. Reliability and Failure Analysis examines failure times and distribution functions and discusses electromigration, hot carriers, gate oxide integrity, negative bias temperature instability, stress induced leakage current, and electrostatic discharge. Written by an internationally recognized authority in the field, Semiconductor Material and Device Characterization remains essential reading for graduate students as well as for professionals working in the field of semiconductor devices and materials. An Instructor's Manual presenting detailed solutions to all the problems in the book is available from the Wiley editorial department.

Transport Processes in Macroscopically Disordered Media Andrei A. Snarskii, Igor V. Bezsudnov, Vladimir A. Sevryukov, Alexander Morozovskiy, Joseph Malinsky, 2016-09-02. This book reflects on recent advances in the understanding of percolation systems to present a wide range of transport phenomena in inhomogeneous disordered systems. Further developments in the theory of macroscopically inhomogeneous media are also addressed. These developments include galvanoelectric, thermoelectric, elastic properties, 1/f noise, and higher current momenta. Anderson localization and harmonic generation in composites in the vicinity of the percolation threshold. The book describes how one can find effective characteristics such as conductivity, dielectric permittivity, magnetic permeability with knowledge of the distribution of different components constituting an inhomogeneous medium. Considered are a wide range of recent studies dedicated to the elucidation of physical properties of macroscopically disordered systems. Aimed at researchers and advanced students, it contains a straightforward set of useful tools which will allow the reader to derive the basic physical properties of complicated systems together with their corresponding qualitative characteristics and functional dependencies.



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