

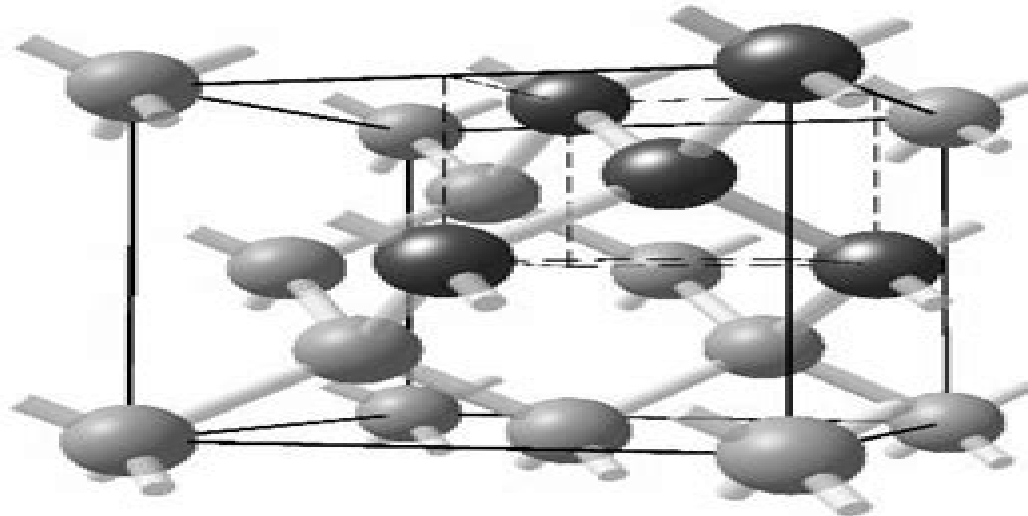
## Chapter 1

# PHYSICAL PROPERTIES OF SEMICONDUCTORS

### 1.0 Introduction

Valence electrons in metals are loosely bound to their parent atoms so that even a very small electric field is sufficient to free them and enable conduction. Therefore, the *valence band* and the *conduction band* in energy diagram of metals overlap. On the other hand, bonds between atoms in insulators are strong. A comparatively large amount of energy (typically more than 3 eV) is needed to free an electron. In terms of energy-band picture, the valence band and the conduction band are separated by a rather large *energy gap* (*forbidden gap*). All energy states in the valence band of an insulator are occupied by electrons and all states in the conduction band are completely empty.

Covalent bonds between atoms in semiconductors are moderately strong. At absolute zero temperature ( $T=0$  K), all electrons are bound to their parent atoms. There are no free electrons left that would enable electric current to flow. In the energy



**Figure 1.1a.** Unit face-centered crystal cell of silicon (after [Blakemore74, Kittel76]).

# Physical Properties Of Semiconductors

**Sadao Adachi**



## Physical Properties Of Semiconductors:

Physical Properties of Semiconductors Charles M. Wolfe, Nick Holonyak, Gregory E. Stillman, 1989      *Handbook on Physical Properties of Semiconductors* Sadao Adachi, 2004-04-30 The aim of this 3 volume reference is to present accurate reliable and up to date information on the physical properties of group IV elemental semiconductors Vol 1 III V compound semiconductors Vol 2 and II VI semiconductors Vol 3 The data on the physical properties of each material are organized in the same way throughout these volumes to facilitate searching for information The physical properties considered in these volumes can be classified into 12 groups structural properties thermal properties elastic properties phonons and lattice vibronic properties collective effects and related properties energy band structure energy band gaps energy band structure electron and hole effective mass electronic deformation potential electron affinity and Schottky barrier height optical properties elastooptic electrooptic and nonlinear optical properties and carrier transport properties An extensive bibliography is included for those who wish to find additional information      **Physical Properties of III-V Semiconductor Compounds** Sadao Adachi, 1992-11-10 The objective of this book is two fold to examine key properties of III V compounds and to present diverse material parameters and constants of these semiconductors for a variety of basic research and device applications Emphasis is placed on material properties not only of InP but also of InAs GaAs and GaP binaries      **Handbook on Physical Properties of Semiconductors: Group-IV semiconductors** Sadao Adachi, 2004      **Handbook on Physical Properties of Semiconductors: III-V compound semiconductors** Sadao Adachi, 2004      **Handbook on Physical Properties of Semiconductors: II-VI compound semiconductors** Sadao Adachi, 2004      Two-Dimensional Semiconductors Jingbo Li, Zhongming Wei, Jun Kang, 2020-02-26 In depth overview of two dimensional semiconductors from theoretical studies properties to emerging applications Two dimensional 2D materials have attracted enormous attention due to their exotic properties deriving from their ultrathin dimensions 2D materials such as graphene transition metal dichalcogenides transition metal oxides black phosphorus and boron nitride exhibit versatile optical electronic catalytic and mechanical properties thus can be used in a wide range of applications including electronics optoelectronics and optical applications Two Dimensional Semiconductors Synthesis Physical Properties and Applications provides an in depth view of 2D semiconductors from theoretical studies properties to applications taking into account the current state of research and development It introduces various preparation methods and describes in detail the physical properties of 2D semiconductors including 2D alloys and heterostructures The covered applications include but are not limited to field effect transistors spintronics solar cells photodetectors light emitting diode sensors and bioelectronics Highly topical 2D materials are a rapidly advancing field that attracts increasing attention Concise overview covers theoretical studies preparation methods physical properties potential applications the challenges and opportunities Application oriented focuses on 2D semiconductors that can be used in various applications such as field effect transistors solar cells sensors and bioelectronics

Highly relevant newcomers as well as experienced researchers in the field of 2D materials will benefit from this book **Two Dimensional Semiconductors Synthesis Physical Properties and Applications** is written for materials scientists semiconductor and solid state physicists electrical engineers and readers working in the semiconductor industry **Fundamentals of Semiconductors** Peter YU, Manuel Cardona, 2010-04-07 Excellent bridge between general solid state physics textbook and research articles packed with providing detailed explanations of the electronic vibrational transport and optical properties of semiconductors The most striking feature of the book is its modern outlook provides a wonderful foundation The most wonderful feature is its efficient style of exposition an excellent book Physics Today Presents the theoretical derivations carefully and in detail and gives thorough discussions of the experimental results it presents This makes it an excellent textbook both for learners and for more experienced researchers wishing to check facts I have enjoyed reading it and strongly recommend it as a text for anyone working with semiconductors I know of no better text I am sure most semiconductor physicists will find this book useful and I recommend it to them Contemporary Physics Offers much new material an extensive appendix about the important and by now well established deep center known as the DX center additional problems and the solutions to over fifty of the problems at the end of the various chapters *Transition Metal Impurities In Semiconductors* Victor N Fleurov, K A Kikoin, 1994-08-31 This book discusses the theory of the electron states of transition metal impurities in semiconductors in connection with the general theory of isoelectronic impurities It contains brief descriptions of the experimental data available for transition metal impurities belonging to iron palladium and platinum groups and for rare earth impurities in elemental semiconductors III IV II VI and IV VI compounds and in several oxide compounds TiO<sub>2</sub> BaTiO<sub>3</sub> SrTiO<sub>3</sub> Also included are applications of the theory to the optical electrical and resonance properties of semiconductors doped by the transition metal impurities The book presents a theory unifying previously proposed ligand field and band descriptions of transition metal impurities It describes the theory in the context of the general theory of neutral impurities in semiconductors and demonstrates the capabilities of this description to explain the basic experimental properties of semiconductors doped by transition metal impurities A detailed discussion of various experimental results and their theoretical interpretation is carried out This book comprises three parts The first two parts consider several exactly solvable models and describe numerical techniques All the models and simulations constitute a general pattern describing transition metal and rare earth impurities in semiconductors The final part uses this theory in order to address various experimentally observed properties of these systems **Semiconductor Nanoscale Devices: Materials and Design Challenges** Ashish Raman, Prabhat Singh, Naveen Kumar, Ravi Ranjan, 2025-03-14 Semiconductor Nanoscale Devices Materials and Design Challenges provides a comprehensive exploration of nanoscale technologies and semiconductor device design focusing on innovative materials and advanced applications It bridges classical and quantum concepts offering insights into foundational materials device architectures and future technologies like biosensors 6G

communication and photovoltaics The book is organized into three sections foundational concepts methodologies and advancements and next generation applications It emphasizes practical design analytical modeling and optimization for real world applications making it a valuable resource for professionals and researchers Key Features Comprehensive coverage of nanoscale semiconductor device design challenges and innovations Focus on advanced materials and methodologies for cutting edge technologies Practical insights into measurement techniques and device optimization In depth exploration of emerging applications like 6G biosensors and photovoltaics

*Handbook of II-VI Semiconductor-Based Sensors and Radiation Detectors* Ghenadii Korotcenkov, 2023-04-20 Three volumes book Handbook of II VI Semiconductor Based Sensors and Radiation Detectors is the first to cover both chemical sensors and biosensors and all types of photodetectors and radiation detectors based on II VI semiconductors It contains a comprehensive and detailed analysis of all aspects of the application of II VI semiconductors in these devices The first volume Materials and Technologies of a three volume set describes the physical chemical and electronic properties of II VI compounds which give rise to an increased interest in these semiconductors Technologies that are used in the development of various devices based on II VI connections such as material synthesis deposition characterization processing and device fabrication are also discussed in detail in this volume It covers also topics related to synthesis and application of II VI based nanoparticles and quantum dots as well their toxicity biocompatibility and biofunctionalization

**Investigation of Physical Properties of Semiconductors** MAX E. CASPARI, 1960 Research effort was devoted to the investigation of materials which may have interesting semiconducting properties at high temperatures In particular solid solutions and compounds of metals and tungsten trioxide were investigated It was found that lead forms solid solutions with tungsten trioxide over a wide composition range but has metallic electrical properties Copper tungstate and a compound containing a small amount of silver in tungsten trioxide had interesting semiconducting properties Aluminum boride was a semiconductor with a large activation energy Coupled with the preparation chemical analysis and determination of electrical properties of these compounds a crystal structure determination of triclinic copper tungstate was initiated A study of the Faraday effect at microwave frequencies on n and p type germanium and silicon was carried out over a wide temperature range as a function of the static magnetic field leading to information regarding the effective masses life times and mobilities of the charge carriers Author

**Optical Properties of Semiconductors** G. Martinez, 1992-11-30 It is widely recognized that an understanding of the optical properties of matter will give a great deal of important information relevant to the fundamental physical properties This is especially true in semiconductor physics for which due to the intrinsic low screening of these materials the optical response is quite rich Their spectra reflect indeed as well electronic as spin or phonon transitions This is also in the semiconductor field that artificial structures have been recently developed showing for the first time specific physical properties related to the low dimensionality of the electronic and vibronic properties with this respect the quantum and fractional quantum Hall effects

are among the most well known aspects The associated reduced screening is also a clear manifestation of these aspects and as such favors new optical properties or at least significantly enhances some of them For all these reasons it appeared necessary to try to review in a global way what the optical investigation has brought today about the understanding of the physics of semiconductors This volume collects the papers presented at the NATO Advanced study Institute on Optical Properties of Semiconductors held at the Ettore Majorana Centre Erice Sicily on March 9th to 20th 1992 This school brought together 70 scientists active in research related to optical properties of semiconductors There were 12 lecturers who provided the main contributions

Springer Handbook of Condensed Matter and Materials Data Werner Martienssen, Hans Warlimont, 2006-09-21 Springer Handbook of Condensed Matter and Materials Data provides a concise compilation of data and functional relationships from the fields of solid state physics and materials in this 1200 page volume The data encapsulated in 914 tables and 1025 illustrations have been selected and extracted primarily from the extensive high quality data collection Landolt B r nstein and also from other systematic data sources and recent publications of physical and technical property data Many chapters are authored by Landolt B r nstein editors including the prominent Springer Handbook editors W Martienssen and H Warlimont themselves The Handbook is designed to be useful as a desktop reference for fast and easy retrieval of essential and reliable data in the lab or office References to more extensive data sources are also provided in the book and by interlinking to the relevant sources on the enclosed CD ROM Physicists chemists and engineers engaged in fields of solid state sciences and materials technologies in research development and application will appreciate the ready access to the key information coherently organized within this wide ranging Handbook From the reviews this is the most complete compilation I have ever seen When I received the book I immediately searched for data I never found elsewhere and I found them rapidly No doubt that this book will soon be in every library and on the desk of most solid state scientists and engineers It will never be at rest Physicalia Magazine

**Scientific and Technical Aerospace Reports**, 1978-04

**Handbook on Physical Properties of Ge, Si, GaAs and InP** Adolfas Dargys, Jurgis Kundrotas, 1994

**Semiconductors and Semimetals**, 2014-05-14 Semiconductors and Semimetals

**Nuclear Science Abstracts**, 1971

Quantum Physics of Semiconductor Materials and Devices Debdeep Jena, 2022 Aimed at upper level undergraduate students and graduate students in Electrical Engineering Physics Applied Physics Materials Science and Engineering this textbook covers the quantum physics of semiconductors including their practical applications in various areas and their future potential

**Semiconductor Nanostructures for Optoelectronic Devices** Gyu-Chul Yi, 2012-01-13 This book presents the fabrication of optoelectronic nanodevices The structures considered are nanowires nanorods hybrid semiconductor nanostructures wide bandgap nanostructures for visible light emitters and graphene The device applications of these structures are broadly explained The book deals also with the characterization of semiconductor nanostructures It appeals to researchers and graduate students

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