

Practice Problems- Band Theory of solids and Semiconductors

1. Refer to the class notes on band structure of solid. In the case of periodically placed delta function potential, show that the wave function for a particle in the periodic delta function potential can be written in the form

$$\psi(x) = C[\sin(kx) + e^{-iKa} \sin(k(a-x))], \quad 0 \leq x \leq a.$$

2. Find the energy at the top of the first allowed band, for the case $\beta = 5$, correct to three significant digits. For the sake of argument, assume $a/a = 1$.
3. Find the Fermi energy of copper metal. The electron density in copper is $8.5 \times 10^{28} \text{electrons/m}^3$.

[Ans. 7.04 eV]

4. An electron beam strikes a crystal of cadmium sulfide (CdS). Electrons scattered by the crystal move at a velocity of $4.4 \times 10^5 \text{ m/s}$. Calculate the energy of the incident beam. Express your result in eV. CdS is a semiconductor with a band gap, E_g , of 2.45 eV.
(Hint: $E_{\text{incident}} = E_{\text{emitted}} + E_{\text{scattered}}$).

5. The number of electron-hole pairs in intrinsic germanium (Ge) is given by:

$$n_i = 9.7 \times 10^{15} \times T^{3/2} \times e^{\frac{-E_g}{2kT}} \text{ cm}^{-3}$$

($E_g = 0.72 \text{ eV}$)

- (a) What is the density of pairs at $T = 20 \text{ deg-C}$?
 - (b) Will undoped Ge be a good conductor at 200 deg-C ? If so, why?
6. If no electron-hole pairs were produced in germanium (Ge) until the temperature reached the value corresponding to the energy gap, at what temperature would Ge become conductive? ($E_{\text{gap}} = 3/2kT$)
 7. Given $\mu_p = 470 \text{ cm}^2/\text{V.s}$ for Si, what is the hole drift velocity at $\mathcal{E} = 10^3 \text{ V/cm}$. What is τ_{avg} and what is the average distance traveled between collisions, i.e., the mean free path ? (Ans. mean free path = 22nm).
 8. What is the hole diffusion constant in a piece of silicon doped with $3 \times 10^{15} \text{ cm}^{-3}$ of donors and $7 \times 10^{15} \text{ cm}^{-3}$ of acceptors at 300 K? at 400 K? [Ans. $7.6 \text{ cm}^2/\text{V.s}$]

Semiconductors Their Theory Practice

Thomas S. Miller



Semiconductors Their Theory Practice:

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Semiconductors W.M. Jr. Coughran,Julian Cole,Peter Lloyd,Jacob K. White,2012-12-06 Semiconductor and integrated circuit modeling are an important part of the high technology chip industry whose high performance low cost microprocessors and high density memory designs form the basis for supercomputers engineering workstations laptop computers and other modern information appliances There are a variety of differential equation problems that must be solved to facilitate such modeling This two volume set covers three topic areas process modeling and circuit simulation in Volume I and device modeling in Volume II Process modeling provides the geometry and impurity doping characteristics that are prerequisites for device modeling device modeling in turn provides static current and transient charge characteristics needed to specify the so called compact models employed by circuit simulators The goal of these books is to bring together scientists and mathematicians to discuss open problems algorithms to solve such and to form bridges between the diverse disciplines involved **The Story of Semiconductors** John W. Orton,2008-12-11 The book provides an overview of the fascinating spectrum of semiconductor physics devices and applications presented from a historical perspective It covers the development of the subject from its inception in the early nineteenth century to the recent millennium Written in a lively

informal style it emphasizes the interaction between pure scientific push and commercial pull on the one hand and between basic physics materials and devices on the other It also sets the various device developments in the context of systems requirements and explains how such developments met wide ranging consumer demands It is written so as to appeal to students at all levels in physics electrical engineering and materials science to teachers lecturers and professionals working in the field as well as to a non specialist scientific readership **Semiconductors and Semimetals** ,1981-09-02

Semiconductors and Semimetals *Semiconductor Laser Theory* Prasanta Kumar Basu,Bratati Mukhopadhyay,Rikmantra Basu,2015-06-17 Developed from the authors classroom tested material Semiconductor Laser Theory takes a semiclassical approach to teaching the principles structure and applications of semiconductor lasers Designed for graduate students in physics electrical engineering and materials science the text covers many recent developments including diode lasers u

Making a Semiconductor Superpower Dong-Won Kim,2023-09-29 This book provides real stories about the South Korean semiconductor community It explores the lives and careers of six influential semiconductor engineers who all studied at Korea Advanced Institute of Science and Technology KAIST under the mentorship of Dr Kim Choong Ki the most influential semiconductor professor in South Korea during the last quarter of the twentieth century Kim s students became known as Kim s Mafia because of the important positions they went on to hold in industry government and academia This book will be of interest to semiconductor engineers and electronics engineers historians of science and technology and scholars and students of East Asian studies They were called Kim s Mafia Kim Choong Ki himself wouldn t have put it that way But it was true what semiconductor engineers in South Korea whispered about his former students They were everywhere Kim was the first professor in South Korea to systematically teach semiconductor engineering From 1975 when the nation had barely begun producing its first transistors to 2008 when he retired from teaching Kim trained more than 100 students effectively creating the first two generations of South Korean semiconductor experts Source IEEE Spectrum October 2022 [Compact Models for Integrated Circuit Design](#) Samar K. Saha,2018-09-03 Compact Models for Integrated Circuit Design Conventional Transistors and Beyond provides a modern treatise on compact models for circuit computer aided design CAD Written by an author with more than 25 years of industry experience in semiconductor processes devices and circuit CAD and more than 10 years of academic experience in teaching compact modeling courses this first of its kind book on compact SPICE models for very large scale integrated VLSI chip design offers a balanced presentation of compact modeling crucial for addressing current modeling challenges and understanding new models for emerging devices Starting from basic semiconductor physics and covering state of the art device regimes from conventional micron to nanometer this text Presents industry standard models for bipolar junction transistors BJTs metal oxide semiconductor MOS field effect transistors FETs FinFETs and tunnel field effect transistors TFETs along with statistical MOS models Discusses the major issue of process variability which severely impacts device and circuit performance in advanced technologies and requires statistical compact models Promotes

further research of the evolution and development of compact models for VLSI circuit design and analysis Supplies fundamental and practical knowledge necessary for efficient integrated circuit IC design using nanoscale devices Includes exercise problems at the end of each chapter and extensive references at the end of the book Compact Models for Integrated Circuit Design Conventional Transistors and Beyond is intended for senior undergraduate and graduate courses in electrical and electronics engineering as well as for researchers and practitioners working in the area of electron devices However even those unfamiliar with semiconductor physics gain a solid grasp of compact modeling concepts from this book

Advanced Semiconductors Shadia Ikhmayies, 2025-08-21 This book presents comprehensive reviews on the synthesis characterization properties and applications of advanced semiconducting materials It explores modern inorganic organic and hybrid semiconductors and semiconductor physics through density functional theory Topics include morphology dependent properties in inorganic semiconductors and methods for tuning the electron transport properties of nanotube semiconductors Readers will also find discussions on earth abundant and environmentally friendly chalcogenide nanomaterials for photovoltaics the use of chalcogenides and oxide semiconductors in photoelectrochemical reactions and insights into defect formation during ion implantation in diamond and c BN thin films A thermomechanical response model for photothermal 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 Symposium Proceedings Innovative Teaching Practices Janina Morska, Alan Rogerson, 2023-06-14

This volume contains the papers presented at the International Symposium Innovative Teaching Practices held on August 14 18 2023 in The Queen's College Oxford University The Symposium was organized by The Mathematics Education for the Future Project an international philanthropic project founded in 1986 and dedicated to innovation in mathematics science computer and statistics education *Publications of the National Institute of Standards and Technology ... Catalog* National Institute of Standards and Technology (U.S.), 1975 **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 NBS Special Publication ,1974 **FinFET Devices for VLSI Circuits and Systems** Samar K. Saha,2020-07-15 To surmount the continuous scaling challenges of MOSFET devices FinFETs have emerged as the real alternative for use as the next generation device for IC fabrication technology The objective of this book is to provide the basic theory and operating principles of FinFET devices and technology an overview of FinFET device architecture and manufacturing processes and detailed formulation of FinFET electrostatic and dynamic device characteristics for IC design and manufacturing Thus this book caters to practicing engineers transitioning to FinFET technology and prepares the next generation of device engineers and academic experts on mainstream device technology at the nanometer nodes Semiconductors and the Information Revolution John W. Orton,2009-06-17 Semiconductors and the Information Revolution sets out to explain the development of modern electronic systems and devices from the viewpoint of the semiconductor materials germanium silicon gallium arsenide and many others which made them possible It covers the scientific understanding of these materials and its intimate relationship with their technology and many applications It began with Michael Faraday took off in a big way with the invention of the transistor at Bell Labs in 1947 and is still burgeoning today It is a story to match any artistic or engineering achievement of man and this is the first time it has been presented in a style suited to the non specialist It is written in a lively non mathematical style which brings out the excitement of discovery and the fascinating interplay between the demands of system pull and technological push It also looks at the nature of some of the personal interactions which helped to shape the modern technological world An introductory chapter illustrates just how dependent we are on modern electronic systems and explains the significance of semiconductors in their development It also provides in as painless a way as possible a necessary understanding of semiconductor properties in relation to these applications The second chapter takes up the historical account and ends with some important results emerging from the Second World War including its effect on the organisation of scientific research Chapter three describes the world shaking discovery of the transistor and some of the early struggles to make it commercially viable including the marketing of the first transistor radio In chapter four we meet the integrated circuit which gave shape to much of our modern life in the form of the personal computer and which gave rise to a famously long running patent war Later chapters cover the application of compound semiconductors to light emitting devices such as LEDs and lasers and light detecting devices such as photocells We learn how these developments led to the

invention of the CD player and DVD recorder how other materials were applied to the development of sophisticated night vision equipment fibre optical communications systems solar photovoltaic panels and flat panel displays Similarly microwave techniques essential to our modern day love of mobile phoning are seen to depend on clever materials scientists who not for the first time invented new semiconductors with just the right properties Altogether it is an amazing story and one which deserves to be more widely known Read this book and you will be rewarded with a much deeper understanding and appreciation of the technological revolution which shapes so many aspects of our lives A historical account of the development of semiconductor physics devices and applications from the nineteenth century to the present day Coverage of the importance of material quality and its relation to the physics of the devices Presented in a strictly non mathematical and anecdotal way to appeal to a wide audience Provides the broad sweep of science history

Invention of Integrated Circuits Arjun N. Saxena, 2009 This book is the first to give an authoritative and comprehensive account of the invention of Integrated Circuits ICs from an insider who had participated and contributed from the beginning of their invention and advancement to the Ultra Large Scale ICs ULSICs of today It reads like a mystery novel to engross the reader but it is not based on fiction it gives documented facts of the invention of ICs analyzes the patents and highlights additional details and clarifications of their history

Publications of the National Bureau of Standards ... Catalog United States. National Bureau of Standards, 1978

Foundations of Computer Science and Frontiers in Education: Computer Science and Computer Engineering Hamid R. Arabnia, Leonidas Deligiannidis, Soheyla Amirian, Farid Ghareh Mohammadi, Farzan Shenavarmasouleh, 2025-05-24 This book constitutes the proceedings of the 20th International Conference on Foundations of Computer Science FCS 2024 and the 20th International Conference on Frontiers in Education FECS 2024 held as part of the 2024 World Congress in Computer Science Computer Engineering and Applied Computing in Las Vegas USA during July 22 to July 25 2024 The 10 FECS 2024 papers included were carefully reviewed and selected from 43 submissions FCS 2024 received 172 submissions and accepted 31 papers for inclusion in the proceedings The papers have been organized in topical sections as follows Foundations of computer science frontiers in education novel studies and assessment results frontiers in educations tools frontiers in education student retention teaching and learning methods curriculum design and related issues and poster position papers

Publications of the National Bureau of Standards United States. National Bureau of Standards, 1974

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