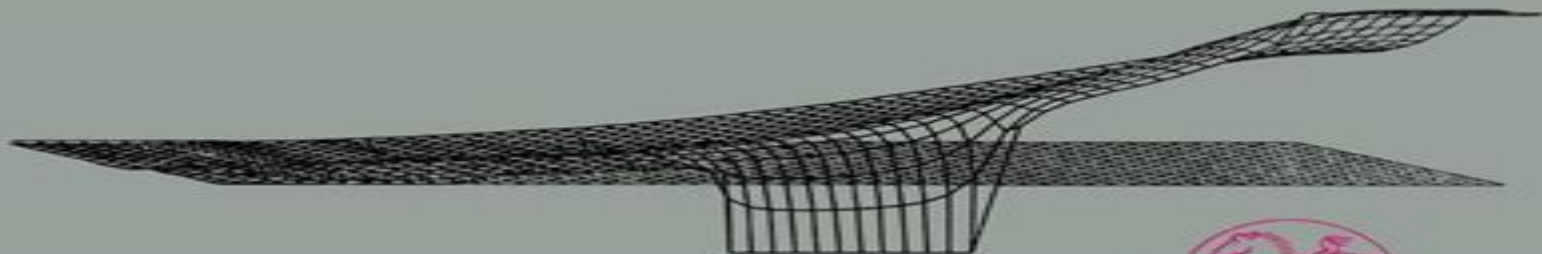


**Computational
Microelectronics**
Edited by S. Selberherr

**Carlo Jacoboni
Paolo Lugli**

**The
Monte Carlo Method
for Semiconductor
Device Simulation**



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The Monte Carlo Method For Semiconductor Device Simulation Computational Microelectronics

Carlo Jacoboni, Paolo Lugli



The Monte Carlo Method For Semiconductor Device Simulation Computational Microelectronics:

The Monte Carlo Method for Semiconductor Device Simulation Carlo Jacoboni, Paolo Lugli, 1989-10-30 This volume presents the application of the Monte Carlo method to the simulation of semiconductor devices reviewing the physics of transport in semiconductors followed by an introduction to the physics of semiconductor devices [The Monte Carlo Method for Semiconductor Device Simulation](#)

[The Monte Carlo Method for Semiconductor Device Simulation](#) Carlo Jacoboni, Paolo Lugli, 2012-12-06 The application of the Monte Carlo method to the simulation of semiconductor devices is presented A review of the physics of transport in semiconductors is given followed by an introduction to the physics of semiconductor devices The Monte Carlo algorithm is discussed in great details and specific applications to the modelling of semiconductor devices are given A comparison with traditional simulators is also presented **Hierarchical Device Simulation** Christoph Jungemann, Bernd Meinerzhagen, 2003-06-05

This monograph is the first on physics based simulations of novel strained Si and SiGe devices It provides an in depth description of the full band monte carlo method for SiGe and discusses the common theoretical background of the drift diffusion hydrodynamic and Monte Carlo models and their synergy *Physics of Semiconductor Devices* Massimo Rudan, 2017-09-27 This textbook describes the basic physics of semiconductors including the hierarchy of transport models and connects the theory with the functioning of actual semiconductor devices Details are worked out carefully and derived from the basic physical concepts while keeping the internal coherence of the analysis and explaining the different levels of approximation Coverage includes the main steps used in the fabrication process of integrated circuits diffusion thermal oxidation epitaxy and ion implantation Examples are based on silicon due to its industrial importance Several chapters are included that provide the reader with the quantum mechanical concepts necessary for understanding the transport properties of crystals The behavior of crystals incorporating a position dependent impurity distribution is described and the different hierarchical transport models for semiconductor devices are derived from the Boltzmann transport equation to the hydrodynamic and drift diffusion models The transport models are then applied to a detailed description of the main semiconductor device architectures bipolar MOS CMOS including a number of solid state sensors The final chapters are devoted to the measuring methods for semiconductor device parameters and to a brief illustration of the scaling rules and numerical methods applied to the design of semiconductor devices **Physics of Semiconductor Devices** K. N. Bhat, A. Dasgupta, 2004 Contributed papers of the workshop held at IIT Madras in 2003

Handbook of Optoelectronic Device Modeling and Simulation Joachim Piprek, 2017-10-10 Optoelectronic devices are now ubiquitous in our daily lives from light emitting diodes LEDs in many household appliances to solar cells for energy This handbook shows how we can probe the underlying and highly complex physical processes using modern mathematical models and numerical simulation for optoelectronic device design analysis and performance optimization It reflects the wide availability of powerful computers and advanced commercial software which have opened the door for non specialists to perform sophisticated modeling and

simulation tasks The chapters comprise the know how of more than a hundred experts from all over the world The handbook is an ideal starting point for beginners but also gives experienced researchers the opportunity to renew and broaden their knowledge in this expanding field

Advanced Physics of Electron Transport in Semiconductors and Nanostructures

Massimo V. Fischetti, William G. Vandenberghe, 2016-05-20 This textbook is aimed at second year graduate students in Physics Electrical Engineering or Materials Science It presents a rigorous introduction to electronic transport in solids especially at the nanometer scale Understanding electronic transport in solids requires some basic knowledge of Hamiltonian Classical Mechanics Quantum Mechanics Condensed Matter Theory and Statistical Mechanics Hence this book discusses those sub topics which are required to deal with electronic transport in a single self contained course This will be useful for students who intend to work in academia or the nano micro electronics industry Further topics covered include the theory of energy bands in crystals of second quantization and elementary excitations in solids of the dielectric properties of semiconductors with an emphasis on dielectric screening and coupled interfacial modes of electron scattering with phonons plasmons electrons and photons of the derivation of transport equations in semiconductors and semiconductor nanostructures somewhat at the quantum level but mainly at the semi classical level The text presents examples relevant to current research thus not only about Si but also about III V compound semiconductors nanowires graphene and graphene nanoribbons In particular the text gives major emphasis to plane wave methods applied to the electronic structure of solids both DFT and empirical pseudopotentials always paying attention to their effects on electronic transport and its numerical treatment The core of the text is electronic transport with ample discussions of the transport equations derived both in the quantum picture the Liouville von Neumann equation and semi classically the Boltzmann transport equation BTE An advanced chapter Chapter 18 is strictly related to the tricky transition from the time reversible Liouville von Neumann equation to the time irreversible Green s functions to the density matrix formalism and classically to the Boltzmann transport equation Finally several methods for solving the BTE are also reviewed including the method of moments iterative methods direct matrix inversion Cellular Automata and Monte Carlo Four appendices complete the text

Semiconductor Equations

Peter A. Markowich, Christian A. Ringhofer, Christian Schmeiser, 2012-12-06 In recent years the mathematical modeling of charge transport in semi conductors has become a thriving area in applied mathematics The drift diffusion equations which constitute the most popular model for the simulation of the electrical behavior of semiconductor devices are by now mathematically quite well understood As a consequence numerical methods have been developed which allow for reasonably efficient computer simulations in many cases of practical relevance Nowadays research on the drift diffusion model is of a highly specialized nature It concentrates on the exploration of possibly more efficient discretization methods e g mixed finite elements streamline diffusion on the improvement of the performance of nonlinear iteration and linear equation solvers and on three dimensional applications The ongoing miniaturization of semiconductor devices has prompted a shift of the focus of

the modeling research lately since the drift diffusion model does not account well for charge transport in ultra integrated devices Extensions of the drift diffusion model so called hydrodynamic models are under investigation for the modeling of hot electron effects in submicron MOS transistors and supercomputer technology has made it possible to employ kinetic models semiclassical Boltzmann Poisson and Wigner Poisson equations for the simulation of certain highly integrated devices

Simulation of Semiconductor Processes and Devices 2004 Gerhard Wachutka, Gabriele Schrag, 2012-12-06 This volume contains the proceedings of the 10th edition of the International Conference on Simulation of Semiconductor Processes and Devices SISPAD 2004 held in Munich Germany on September 2 4 2004 The conference program included 7 invited plenary lectures and 82 contributed papers for oral or poster presentation which were carefully selected out of a total of 151 abstracts submitted from 14 countries around the world Like the previous meetings SISPAD 2004 provided a world wide forum for the presentation and discussion of recent advances and developments in the theoretical description physical modeling and numerical simulation and analysis of semiconductor fabrication processes device operation and system performance The variety of topics covered by the conference contributions reflects the physical effects and technological problems encountered in consequence of the progressively shrinking device dimensions and the ever growing complexity in device technology

Compound Semiconductor Device Modelling Christopher M. Snowden, Robert E. Miles, 2012-12-06 Compound semiconductor devices form the foundation of solid state microwave and optoelectronic technologies used in many modern communication systems In common with their low frequency counterparts these devices are often represented using equivalent circuit models but it is often necessary to resort to physical models in order to gain insight into the detailed operation of compound semiconductor devices Many of the earliest physical models were indeed developed to understand the unusual phenomena which occur at high frequencies Such was the case with the Gunn and IMPATI diodes which led to an increased interest in using numerical simulation methods Contemporary devices often have feature sizes so small that they no longer operate within the familiar traditional framework and hot electron or even quantum mechanical models are required The need for accurate and efficient models suitable for computer aided design has increased with the demand for a wider range of integrated devices for operation at microwave millimetre and optical frequencies The apparent complexity of equivalent circuit and physics based models distinguishes high frequency devices from their low frequency counterparts Over the past twenty years a wide range of modelling techniques have emerged suitable for describing the operation of compound semiconductor devices This book brings together for the first time the most popular techniques in everyday use by engineers and scientists The book specifically addresses the requirements and techniques suitable for modelling GaAs InP ternary and quaternary semiconductor devices found in modern technology

Advanced Physical Models for Silicon Device Simulation Andreas Schenk, 2012-12-06 Device simulation has two main purposes to understand and depict the physical processes in the interior of a device and to make reliable predictions of the behavior of an anticipated new device generation

Towards these goals the quality of the physical models is decisive. The introductory chapter of this book contains a critical review on models for silicon device simulators which rely on moments of the Boltzmann equation. With reference to fundamental experimental and theoretical work an extensive collection of widely used models is discussed in terms of physical accuracy and application results. This review shows that the quality and efficiency of the physical models which have been developed for the purpose of numerical simulation over the last three decades is sufficient for many applications. Nevertheless the basic understanding of the microscopic processes as well as the uniqueness and accuracy of the models are still unsatisfactory. Hence the following chapters of the book deal with the derivation of physics based models from a microscopic level also using new approaches of tailored quantum mechanics. Each model is compared with experimental data and applied to a number of simulation examples. The problems when starting from first principles and making the models suitable for a device simulator will also be demonstrated. We will show that demands for rapid computation and numerical robustness require a compromise between physical soundness and analytical simplicity and that the attainable accuracy is limited by the complexity of the problems.

The Drift Diffusion Equation and Its Applications in MOSFET Modeling

Wilfried Hänsch, 2012-12-06 To be perfect does not mean that there is nothing to add but rather there is nothing to take away. Antoine de Saint Exupéry. The drift diffusion approximation has served for more than two decades as the cornerstone for the numerical simulation of semiconductor devices. However the tremendous speed in the development of the semiconductor industry demands numerical simulation tools that are efficient and provide reliable results. This makes the development of a simulation tool an interdisciplinary task in which physics, numerical algorithms and device technology merge. For the sake of an efficient code there are trade offs between the different influencing factors. The numerical performance of a program that is highly flexible in device types and the geometries it covers certainly cannot compare with a program that is optimized for one type of device only. Very often the device is sufficiently described by a two dimensional geometry. This is the case in a MOSFET for example if the gate length is small compared with the gate width. In these cases the geometry reduces to the specification of a two dimensional device. Here again the simplest geometries which are planar or at least rectangular surfaces will give the most efficient numerical codes. The device engineer has to decide whether this reduced description of the real device is still suitable for his purposes.

Nitride Semiconductor Devices Joachim Piprek, 2007-06-27 This is the first book to be published on physical principles, mathematical models and practical simulation of GaN based devices. Gallium nitride and its related compounds enable the fabrication of highly efficient light emitting diodes and lasers for a broad spectrum of wavelengths ranging from red through yellow and green to blue and ultraviolet. Since the breakthrough demonstration of blue laser diodes by Shuji Nakamura in 1995 this field has experienced tremendous growth worldwide. Various applications can be seen in our everyday life from green traffic lights to full color outdoor displays to high definition DVD players. In recent years nitride device modeling and simulation has gained importance and advanced software tools are

emerging Similar developments occurred in the past with other semiconductors such as silicon where computer simulation is now an integral part of device development and fabrication This book presents a review of modern device concepts and models written by leading researchers in the field It is intended for scientists and device engineers who are interested in employing computer simulation for nitride device design and analysis

Theory and Simulation Methods for Electronic and Phononic Transport in Thermoelectric Materials Neophytos Neophytou, 2020-03-16 This book introduces readers to state of the art theoretical and simulation techniques for determining transport in complex band structure materials and nanostructured geometry materials linking the techniques developed by the electronic transport community to the materials science community Starting from the semi classical Boltzmann Transport Equation method for complex band structure materials then moving on to Monte Carlo and fully quantum mechanical models for nanostructured materials the book addresses the theory and computational complexities of each method as well as their advantages and capabilities Presented in language that is accessible to junior computational scientists while including enough detail and depth with regards to numerical implementation to tackle modern research problems it offers a valuable resource for computational scientists and postgraduate researchers whose work involves the theory and simulation of electro thermal transport in advanced materials

Simulation of Semiconductor Processes and Devices 2007 Tibor Grasser, 2007-09-18 This volume contains the proceedings of the 12th International Conference on Simulation of Semiconductor Processes and Devices SISPAD 2007 held September 2007 in Vienna Austria It provides a global forum for the presentation and discussion of recent advances and developments in the theoretical description physical modeling and numerical simulation and analysis of semiconductor fabrication processes device operation and system performance

Springer Handbook of Semiconductor Devices Massimo Rudan, Rossella Brunetti, Susanna Reggiani, 2022-11-10 This Springer Handbook comprehensively covers the topic of semiconductor devices embracing all aspects from theoretical background to fabrication modeling and applications Nearly 100 leading scientists from industry and academia were selected to write the handbook s chapters which were conceived for professionals and practitioners material scientists physicists and electrical engineers working at universities industrial R D and manufacturers Starting from the description of the relevant technological aspects and fabrication steps the handbook proceeds with a section fully devoted to the main conventional semiconductor devices like e g bipolar transistors and MOS capacitors and transistors used in the production of the standard integrated circuits and the corresponding physical models In the subsequent chapters the scaling issues of the semiconductor device technology are addressed followed by the description of novel concept based semiconductor devices The last section illustrates the numerical simulation methods ranging from the fabrication processes to the device performances Each chapter is self contained and refers to related topics treated in other chapters when necessary so that the reader interested in a specific subject can easily identify a personal reading path through the vast contents of the handbook

Intrinsic Point Defects, Impurities, and Their Diffusion in Silicon

Peter Pichler,2004-06-02 This book contains the first comprehensive review of intrinsic point defects impurities and their complexes in silicon Besides compiling the structures energetic properties identified electrical levels and spectroscopic signatures and the diffusion behaviour from investigations it gives a comprehensive introduction into the relevant fundamental concepts **Modelling of Interface Carrier Transport for Device Simulation** Dietmar

Schroeder,2013-03-09 This book represents a comprehensive text devoted to charge transport at semiconductor interfaces and its consideration in device simulation by interface and boundary conditions It contains a broad review of the physics modelling and simulation of electron transport at interfaces in semiconductor devices Particular emphasis is put on the consistent derivation of interface or boundary conditions for semiconductor device simulation The book is of interest with respect to a wide range of electronic engineering activities as process design device design process characterization research in microelectronics or device simulator development It is also useful for students and lecturers in courses of electronic engineering and it supplements the library of technically oriented solid state physicists The deepest roots of this book date back to the mid seventies Being a student of electrical engineering who was exposed for the first time to the material of semiconductor device electronics I was puzzled by noticing that much emphasis was put on a thorough introduction and understanding of the basic semiconductor equations while the boundary conditions for these equations received very much less attention Until today on many occasions one could get the impression that boundary conditions are unimportant accessories they do not stand on their own besides the bulk transport equations although it is clear that they are of course a necessary complement of these *Deterministic Solvers for the Boltzmann Transport Equation* Sung-Min

Hong,Anh-Tuan Pham,Christoph Jungemann,2011-07-31 The book covers all aspects from the expansion of the Boltzmann transport equation with harmonic functions to application to devices where transport in the bulk and in inversion layers is considered The important aspects of stabilization and band structure mapping are discussed in detail This is done not only for the full band structure of the 3D k space but also for the warped band structure of the quasi 2D hole gas Efficient methods for building the Schrödinger equation for arbitrary surface or strain directions gridding of the 2D k space and solving it together with the other two equations are presented *Computational Electronics* Karl Hess,J.P. Leburton,U.

Ravaioli,2013-03-14 Large computational resources are of ever increasing importance for the simulation of semiconductor processes devices and integrated circuits The Workshop on Computational Electronics was intended to be a forum for the discussion of the state of the art of device simulation Three major research areas were covered conventional simulations based on the drift diffusion and the hydrodynamic models Monte Carlo methods and other techniques for the solution of the Boltzmann transport equation and computational approaches to quantum transport which are relevant to novel devices based on quantum interference and resonant tunneling phenomena Our goal was to bring together researchers from various disciplines that contribute to the advancement of device simulation These include Computer Science Electrical Engineering

Applied Physics and Applied Mathematics The success of this multidisciplinary formula was proven by numerous interactions which took place at the Workshop and during the following three day Short Course on Computational Electronics The format of the course including a number of tutorial lectures and the large attendance of graduate students stimulated many discussions and has proven to us once more the importance of cross fertilization between the different disciplines

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