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The Drift Diffusion Equation and Its Applications in MOSFET Modeling
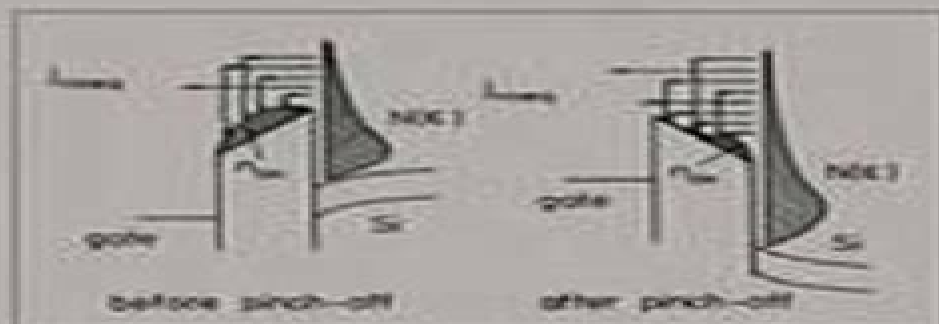
Drift Diffusion Equation And Its Applications In Mosfet Modeling

Dietmar Schroeder

Drift Diffusion Equation And Its Applications In Mosfet Modeling:

The Drift Diffusion Equation and Its Applications in MOSFET Modeling Wilfried Hänsch,1991-09-04 To be perfect does not mean that there is nothing to add but rather there is nothing to take away Antoine de Saint Exupery 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

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 Exupery 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

Quasi-hydrodynamic Semiconductor Equations Ansgar Jüngel,2011-04-27 In this book a hierarchy of macroscopic models for semiconductor devices is presented Three classes of models are studied in detail isentropic drift diffusion equations energy transport models and quantum hydrodynamic equations The derivation of each of the models is shown including physical discussions Furthermore the corresponding mathematical problems are analyzed using modern techniques for nonlinear partial differential equations The equations are discretized employing mixed finite element methods Also

numerical simulations for modern semiconductor devices are performed showing the particular features of the models Modern analytical techniques have been used and further developed such as positive solution methods local energy methods for free boundary problems and entropy methods The book is aimed at applied mathematicians and physicists interested in mathematics as well as graduate and postdoc students and researchers in these fields **Transport Equations for Semiconductors** Ansgar Jüngel,2009-03-17 This volume presents a systematic and mathematically accurate description and derivation of transport equations in solid state physics in particular semiconductor devices *Analysis and Simulation of Heterostructure Devices* Vassil Palankovski,Rüdiger Quay,2012-12-06 Communication and information systems are subject to rapid and highly so phisticated changes Currently semiconductor heterostructure devices such as Heterojunction Bipolar Transistors HBTs and High Electron Mobility Transis tors HEMTs are among the fastest and most advanced high frequency devices They satisfy the requirements for low power consumption medium integration low cost in large quantities and high speed operation capabilities in circuits In the very high frequency range cut off frequencies up to 500 GHz 557 have been reported on the device level HEMTs and HBTs are very suitable for high efficiency power amplifiers at 900 MHz as well as for data rates higher than 100 Gbitfs for long range communication and thus cover a broad range of appli cations To cope with explosive development costs and the competition of today s semicon ductor industry Technology Computer Aided Design TCAD methodologies are used extensively in development and production As of 2003 III V semiconductor HEMT and HBT micrometer and millimeter wave integrated circuits MICs and MMICs are available on six inch GaAs wafers SiGe HBT circuits as part of the CMOS technology on eight inch wafers are in volume production Simulation tools for technology devices and circuits reduce expensive technological efforts This book focuses on the application of simulation software to heterostructure devices with respect to industrial applications In particular a detailed discussion of physical modeling for a great variety of materials is presented *Nanostructure Design* Ehud Gazit,Ruth Nussinov,2008-08-05 As one of the fastest growing fields of research in the 21st century nanotechnology is sure to have an enormous impact on many aspects of our lives Nanostructure Design Methods and Protocols serves as a major reference for theoretical and experimental considerations in the design of biological and bio inspired building blocks the physical characterization of the formed structures and the development of their technical applications The chapters contributed by leading experts are divided into two sections the first of which covers experimental aspects of nanostructure design and the second delves into computational methods As a volume of the highly successful Methods in Molecular BiologyTM series this collection pulls together cutting edge protocols written in a step by step readily reproducible format certain to guide researchers to the desired results Comprehensive and essential Nanostructure Design Methods and Protocols uses biological principles and vehicles on design to aid scientists in the great challenges still ahead *Nanotechnology for Electronics, Photonics, and Renewable Energy* Anatoli Korkin,Predrag S. Krstić,Jack C. Wells,2010-12-14 Tutorial lectures given by world renowned researchers have

become one of the important traditions of the Nano and Giga Challenges NGC conference series 1 Soon after preparations had begun for the rst forum NGC2002 in Moscow Russia the organizers realized that publication of the lectures notes would be a va able legacy of the meeting and a signi cant educational resource and knowledge base for students young researchers and senior experts Our rst book was p lished by Elsevier and received the same title as the meeting itself Nano and Giga 2 Challenges in Microelectronics Our second book Nanotechnology for Electronic 3 4 Materials and Devices based on the tutorial lectures at NGC2004 in Krakow 5 Poland the third book from NGC2007 in Phoenix Arizona and the current book 6 from joint NGC2009 and CSTC2009 meeting in Hamilton Ontario have been published in Springer s Nanostructure Science and Technology series Hosted by McMaster University the meeting NGC CSTC 2009 was held as a joint event of two conference series Nano and Giga Challenges Nano Giga Forum and Canadian Semiconductor Technology Conferences CSTC bringing together the networks and expertise of both professional forums Informational electronics and photonics renewable energy solar systems fuel cells and batteries and sensor nano and bio technologies have reached a new stage in their development in terms of engineering limits to cost effective impro ment of current technological approaches The latest miniaturization of electronic devices is approaching atomic dimensions   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 *Classical to Quantum Transport in Multi-Dimensional Field Effect Transistors* Naveen Kumar,Prateek Kumar,Ankit Dixit,Prabhat Singh,2025-09-30 Classical to Quantum Transport in Multi Dimensional Field Effect Transistors offers a wide range of topics with attractive images and informative explanations It begins with an exploration of the fundamentals of field effect transistor FET functioning emphasizing how behavior is governed by classical models As the semiconductor industry pushes the boundaries of miniaturization and performance Multi Dimensional Field Effect Transistors MuDFETs and emerging material platforms are redefining the foundations of modern electronics This book offers a deep and insightful journey through the evolving landscape of advanced FET architectures from classical conduction models to quantum and ballistic transport regimes Authored by experts across academia and research institutions this book offers in depth discussions on Multi Dimensional and Junctionless FETs Design innovations enabling superior control scaling and performance 2D Materials Transition Metal Dichalcogenides TMDCs Harnessing atomically thin semiconductors for next generation device engineering Nanosheet Transistors Unlocking new dimensions in charge transport and quantum confinement Charge transport mechanisms from classical semiclassical to ballistic regimes in nanosheet and nanowire FETs Tunnel Field Effect Transistor TFET Based Biosensors Cutting edge developments in label free ultra sensitive detection for healthcare and environmental monitoring Integration of FET platforms in nonlinear and quantum photonics using silicon nitride waveguides Whether you re exploring the quantum limits of device physics or developing real world sensing solutions this collection bridges theory and application in one compelling volume With contributions from leading researchers and technologists this book serves as a vital reference for academics graduate students and professionals working in nanoelectronics semiconductor devices biosensors and photonic field **Numerical Methods in Electromagnetics** W.H.A. SCHILDERS,E.J.W. TER MATEN,2005-04-04 This special volume provides a broad overview and insight in the way numerical methods are being used to solve the wide variety of problems in the electronics industry Furthermore its aim is to give researchers from other fields of application the opportunity to benefit from the results wich have been obtained in the electronics industry Complete survey of numerical methods used in the electronic industry Each chapter is selfcontained Presents state of the art applications and methods Internationally recognised authors **Simulation of Semiconductor Devices and Processes, Vol. 5** Siegfried Selberherr,Hannes Stippel,Ernst Strasser,1993 Hierarchical Device Simulation Christoph Jungemann,Bernd Meinerzhagen,2012-12-06 This book summarizes the research of more than a decade Its early motivation dates back to the eighties and to the memorable talks Dr C Moglestue FHG Freiburg gave on his Monte Carlo solutions of the Boltzmann transport equation at the NASECODE conferences in Ireland At that time numerical semiconductor device modeling basically implied the application of the drift diffusion model On the one hand those talks

clearly showed the potential of the Monte Carlo model for an accurate description of many important transport issues that cannot adequately be addressed by the drift diffusion approximation On the other hand they also clearly demonstrated that at that time only very few experts were able to extract useful results from a Monte Carlo simulator With this background Monte Carlo research activities were started in 1986 at the University of Aachen RWTH Aachen Germany Different to many other Monte Carlo research groups the Monte Carlo research in Aachen took place in an environment of active drift diffusion and hydrodynamic model development **Pseudomorphic HEMT Technology and Applications** R.L. Ross,Stefan P. Svensson,Paolo Lugli,2012-12-06 PHEMT devices and their incorporation into advanced monolithic integrated circuits is the enabling technology for modern microwave millimeter wave system applications Although still in its infancy PHEMT MIMIC technology is already finding applications in both military and commercial systems including radar communication and automotive technologies The successful team in a globally competitive market is one in which the solid state scientist circuit designer system engineer and technical manager are cognizant of those considerations and requirements that influence each other s function This book provides the reader with a comprehensive review of PHEMT technology including materials fabrication and processing device physics CAD tools and modelling monolithic integrated circuit technology and applications Readers with a broad range of specialities in one or more of the areas of materials processing device physics circuit design system design and marketing will be introduced quickly to important basic concepts and techniques The specialist who has specific PHEMT experience will benefit from the broad range of topics covered and the open discussion of practical issues Finally the publication offers an additional benefit in that it presents a broad scope to both the researcher and manager both of whom must be aware and educated to remain relevant in an ever expanding technology base Extended Irreversible Thermodynamics David Jou,Jose Casas-Vazquez,Georgy Lebon,2012-12-06 Modern technology strives towards higher speed higher power and higher miniaturiza tion In these conditions the classical transport equations must be updated in order to incorporate memory non local and non linear effects These effects have been studied by starting from microscopic models which are specific to particular systems and whose solution requires mathematical approximations and boundary conditions The aim of extended irreversible thermodynamics is to complement such microscopic analyses with a macroscopic framework which could play with respect to the generalized trans port equations incorporating the aforementioned effects a role similar to the one played by classical thermodynamics with respect to the classical transport equations Such a macroscopic framework is particularly useful for comparing the results obtained from various microscopic models for placing some restrictions on the range of validity of different approximations and for settling a discussion on some basic concepts that arise unavoidably in a formalism that crosses the frontiers of the local equilibrium theory Extended irreversible thermodynamics is not at all in conflict with the classical theory of non equilibrium thermodynamics and rational thermodynamics but must be viewed as a relevant extension of the scope of these descriptions For the student or the

researcher it may be stimulating to go beyond the classical theories and to enter a of new ideas new applications and new problems **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 **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 deriva tion of interface or boundary conditions for semiconductor device simula tion The book is of interest with respect to a wide range of electronic engineering activities as process design device design process character ization 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 understand ing 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   High-Frequency Bipolar Transistors Michael Reisch,2012-12-06 This book provides a rather comprehensive presentation of the physics and modeling of high frequency bipolar transistors with particular emphasis given to silicon based devices I hope it will be found useful by those who do as well as by those who intend to work in the field as it compiles and extends material presented in numerous publications in a coherent fashion I ve worked on this project for years and did my best to avoid errors De spite all efforts it is possible that something has been overlooked during copy editing and proof reading If you find a mistake please let me know Michael Reisch Kempten December 2002 Notation It is intended here to use the most widely employed notation in cases where the standard textbook notation is different from the SPICE notation the latter is used In order to make

formulas more readable model parameters represented in SPICE by a series of capital letters are written here as one capital letter with the rest in the form of a subscript e g XCJC is used here instead of the XCJC used in the SPICE input Concerning the use of lower case and capital letters the following rules are applied Time dependent large signal quantities are represented by lower case let ters The variables t v and p therefore denote time dependent current voltage and power values

    Design, Simulation and Construction of Field Effect Transistors Dhanasekaran Vikraman,Hyun-Seok Kim,2018-07-18 In recent years research on microelectronics has been specifically focused on the proposition of efficient alternative methodologies and materials to fabricate feasible integrated circuits This book provides a general background of thin film transistors and their simulations and constructions The contents of the book are broadly classified into two topics design and simulation of FETs and construction of FETs All the authors anticipate that the provided chapters will act as a single source of reference for the design simulation and construction of FETs This edited book will help microelectronics researchers with their endeavors and would be a great addition to the realm of semiconductor physics   *Physics And Modeling Of Tera- And Nano-devices* Maxim V Ryzhii,Victor Ryzhii,2008-04-28 Physics and Modeling of Tera and Nano Devices is a compilation of papers by well respected researchers working in the field of physics and modeling of novel electronic and optoelectronic devices The topics covered include devices based on carbon nanotubes generation and detection of terahertz radiation in semiconductor structures including terahertz plasma oscillations and instabilities terahertz photomixing in semiconductor heterostructures spin and microwave induced phenomena in low dimensional systems and various computational aspects of device modeling Researchers as well as graduate and postgraduate students working in this field will benefit from reading this book   *Simulation of Semiconductor Devices and Processes* Siegfried Selberherr,Hannes Stippel,Ernst Strasser,2012-12-06 The Fifth International Conference on Simulation of Semiconductor Devices and Processes SISDEP 93 continues a series of conferences which was initiated in 1984 by K Board and D R J Owen at the University College of Wales Swansea where it took place a second time in 1986 Its organization was succeeded by G Baccarani and M Rudan at the University of Bologna in 1988 and W Fichtner and D Aemmer at the Federal Institute of Technology in Zurich in 1991 This year the conference is held at the Technical University of Vienna Austria September 7 9 1993 This conference shall provide an international forum for the presentation of out standing research and development results in the area of numerical process and de vice simulation The miniaturization of today s semiconductor devices the usage of new materials and advanced process steps in the development of new semiconduc tor technologies suggests the design of new computer programs This trend towards more complex structures and increasingly sophisticated processes demands advanced simulators such as fully three dimensional tools for almost arbitrarily complicated geometries With the increasing need for better models and improved understand ing of physical effects the Conference on Simulation of Semiconductor Devices and Processes brings together the simulation community and the process and device en gineers who need reliable numerical

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