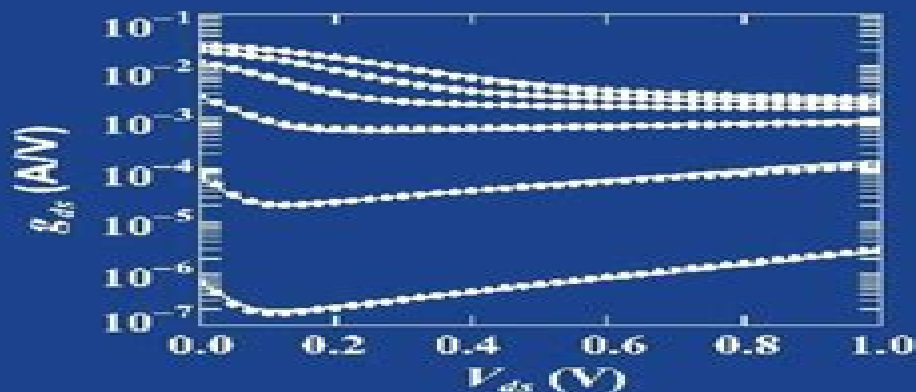


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MOSFET MODELING FOR VLSI SIMULATION

Theory and Practice



Narain Arora

World Scientific

Mosfet Modeling For Vlsi Simulation Theory And Practice

Narain D. Arora



Mosfet Modeling For Vlsi Simulation Theory And Practice:

Mosfet Modeling For Vlsi Simulation: Theory And Practice Narain Arora, 2007-02-14 A reprint of the classic text this book popularized compact modeling of electronic and semiconductor devices and components for college and graduate school classrooms and manufacturing engineering over a decade ago The first comprehensive book on MOS transistor compact modeling it was the most cited among similar books in the area and remains the most frequently cited today The coverage is device physics based and continues to be relevant to the latest advances in MOS transistor modeling This is also the only book that discusses in detail how to measure device model parameters required for circuit simulations The book deals with the MOS Field Effect Transistor MOSFET models that are derived from basic semiconductor theory Various models are developed ranging from simple to more sophisticated models that take into account new physical effects observed in submicron transistors used in today's 1993 MOS VLSI technology The assumptions used to arrive at the models are emphasized so that the accuracy of the models in describing the device characteristics are clearly understood Due to the importance of designing reliable circuits device reliability models are also covered Understanding these models is essential when designing circuits for state of the art MOS ICs

MOSFET Models for VLSI Circuit Simulation Narain D. Arora, 2012-12-06 Metal Oxide Semiconductor MOS transistors are the basic building block of MOS integrated circuits I C Very Large Scale Integrated VLSI circuits using MOS technology have emerged as the dominant technology in the semiconductor industry Over the past decade the complexity of MOS ICs has increased at an astonishing rate This is realized mainly through the reduction of MOS transistor dimensions in addition to the improvements in processing Today VLSI circuits with over 3 million transistors on a chip with effective or electrical channel lengths of 0.5 microns are in volume production Designing such complex chips is virtually impossible without simulation tools which help to predict circuit behavior before actual circuits are fabricated However the utility of simulators as a tool for the design and analysis of circuits depends on the adequacy of the device models used in the simulator This problem is further aggravated by the technology trend towards smaller and smaller device dimensions which increases the complexity of the models There is extensive literature available on modeling these short channel devices However there is a lot of confusion too Often it is not clear what model to use and which model parameter values are important and how to determine them After working over 15 years in the field of semiconductor device modeling I have felt the need for a book which can fill the gap between the theory and the practice of MOS transistor modeling This book is an attempt in that direction

BSIM4 and MOSFET Modeling for IC Simulation Weidong Liu, Chenming Hu, 2011 This book presents the art of advanced MOSFET modeling for integrated circuit simulation and design It provides the essential mathematical and physical analyses of all the electrical mechanical and thermal effects in MOS transistors relevant to the operation of integrated circuits Particular emphasis is placed on how the BSIM model evolved into the first ever industry standard SPICE MOSFET model for circuit simulation and CMOS technology

development The discussion covers the theory and methodology of how a MOSFET model or semiconductor device models in general can be implemented to be robust and efficient turning device physics theory into a production worthy SPICE simulation model Special attention is paid to MOSFET characterization and model parameter extraction methodologies making the book particularly useful for those interested or already engaged in work in the areas of semiconductor devices compact modeling for SPICE simulation and integrated circuit design Mosfet Modeling For Circuit Analysis And Design Carlos Galup-montoro,Marcio Cherem Schneider,2007-02-27 This is the first book dedicated to the next generation of MOSFET models Addressed to circuit designers with an in depth treatment that appeals to device specialists the book presents a fresh view of compact modeling having completely abandoned the regional modeling approach Both an overview of the basic physics theory required to build compact MOSFET models and a unified treatment of inversion charge and surface potential models are provided The needs of digital analog and RF designers as regards the availability of simple equations for circuit designs are taken into account Compact expressions for hand analysis or for automatic synthesis valid in all operating regions are presented throughout the book All the main expressions for computer simulation used in the new generation compact models are derived Since designers in advanced technologies are increasingly concerned with fluctuations the modeling of fluctuations is strongly emphasized A unified approach for both space matching and time noise fluctuations is introduced Bipolar transistor and MOSFET device models Kunihiro Suzuki,2016-03-02 Continuous efforts to develop new semiconductor devices enable device manufacturers to make significant improvements in the information technology sector Bipolar transistors and MOSFETS are two special electronic device components that are used to construct very large scale integrated VLSI circuits allowing engineers to create powerful machines that are power efficient VLSI device characterization depends largely on semiconductor device modeling which is based on physical and electronic principles Bipolar transistor and MOSFET device models is a textbook that describes basic functions and characterization models of these two types of transistors Readers will learn about the processes employed to derive these models which will help them understand the modeling process Chapters in this text cover the fundamentals of semiconductor devices the pn junction high and low injection region models for bipolar transistors and different MOSFET models such as channel doping models and gated SOI models Key features of this book include step by step easy to understand presentation of model information on innovative semiconductor devices an overview of model derivation assumptions approximations and limitations novel experimental information on semiconductor parameters such as gate fringe capacitance silicided source drain resistance and threshold voltage shift Bipolar transistor and MOSFET device models is an essential learning resource for advanced students and professional engineers involved in semiconductor device modeling and fabrication divisions *Compact Hierarchical Bipolar Transistor Modeling With Hicum* Michael Schroter,Anjan Chakravorty,2010-11-25 Compact Hierarchical Bipolar Transistor Modeling with HiCUM will be of great practical benefit to professionals from the process development modeling

and circuit design community who are interested in the application of bipolar transistors which include the SiGe C HBTs fabricated with existing cutting edge process technology The book begins with an overview on the different device designs of modern bipolar transistors along with their relevant operating conditions while the subsequent chapter on transistor theory is subdivided into a review of mostly classical theories brought into context with modern technology and a chapter on advanced theory that is required for understanding modern device designs This book aims to provide a solid basis for the understanding of modern compact models Latest Advances in Electrothermal Models Krzysztof Górecki, Paweł Górecki, 2021-03-17

This book is devoted to the latest advances in the area of electrothermal modelling of electronic components and networks It contains eight sections by different teams of authors These sections contain the results of a electro thermal simulations of SiC power MOSFETs using a SPICE like simulation program b modelling thermal properties of inductors taking into account the influence of the core volume on the efficiency of heat removal c investigations into the problem of inserting a temperature sensor in the neighbourhood of a chip to monitor its junction temperature d computations of the internal temperature of power LEDs situated in modules containing multiple power LEDs taking into account both self heating in each power LED and mutual thermal couplings between each diode e analyses of DC DC converters using the electrothermal averaged model of the diode transistor switch including an IGBT and a rapid switching diode f electrothermal modelling of SiC power BJTs g analysis of the efficiency of selected algorithms used for solving heat transfer problems at nanoscale h analysis related to thermal simulation of the test structure dedicated to heat diffusion investigation at the nanoscale The Physics and Modeling of Mosfets Mitiko Miura-Mattausch, 2008

This volume provides a timely description of the latest compact MOS transistor models for circuit simulation The first generation BSIM3 and BSIM4 models that have dominated circuit simulation in the last decade are no longer capable of characterizing all the important features of modern sub 100nm MOS transistors This book discusses the second generation MOS transistor models that are now in urgent demand and being brought into the initial phase of manufacturing applications It considers how the models are to include the complete drift diffusion theory using the surface potential variable in the MOS transistor channel in order to give one characterization equation Physics And Modeling Of Mosfets, The: Surface-potential Model Hisim Tatsuya Ezaki, Hans

Jurgen Mattausch, Mitiko Miura-mattausch, 2008-06-03 This volume provides a timely description of the latest compact MOS transistor models for circuit simulation The first generation BSIM3 and BSIM4 models that have dominated circuit simulation in the last decade are no longer capable of characterizing all the important features of modern sub 100nm MOS transistors This book discusses the second generation MOS transistor models that are now in urgent demand and being brought into the initial phase of manufacturing applications It considers how the models are to include the complete drift diffusion theory using the surface potential variable in the MOS transistor channel in order to give one characterization equation

Junctionless Field-Effect Transistors Shubham Sahay, Mamidala Jagadesh Kumar, 2019-02-27 A comprehensive one

volume reference on current JLFET methods techniques and research Advancements in transistor technology have driven the modern smart device revolution many cell phones watches home appliances and numerous other devices of everyday usage now surpass the performance of the room filling supercomputers of the past Electronic devices are continuing to become more mobile powerful and versatile in this era of internet of things IoT due in large part to the scaling of metal oxide semiconductor field effect transistors MOSFETs Incessant scaling of the conventional MOSFETs to cater to consumer needs without incurring performance degradation requires costly and complex fabrication process owing to the presence of metallurgical junctions Unlike conventional MOSFETs junctionless field effect transistors JLFETs contain no metallurgical junctions so they are simpler to process and less costly to manufacture JLFETs utilize a gated semiconductor film to control its resistance and the current flowing through it Junctionless Field Effect Transistors Design Modeling and Simulation is an inclusive one stop reference on the study and research on JLFETs This timely book covers the fundamental physics underlying JLFET operation emerging architectures modeling and simulation methods comparative analyses of JLFET performance metrics and several other interesting facts related to JLFETs A calibrated simulation framework including guidance on SentaurusTCAD software enables researchers to investigate JLFETs develop new architectures and improve performance This valuable resource Addresses the design and architecture challenges faced by JLFET as a replacement for MOSFET Examines various approaches for analytical and compact modeling of JLFETs in circuit design and simulation Explains how to use Technology Computer Aided Design software TCAD to produce numerical simulations of JLFETs Suggests research directions and potential applications of JLFETs Junctionless Field Effect Transistors Design Modeling and Simulation is an essential resource for CMOS device design researchers and advanced students in the field of physics and semiconductor devices

Electronics Michael Olorunfunmi Kolawole, 2020-06-15 This book gives clear explanations of the technical aspects of electronics engineering from basic classical device formulations to the use of nanotechnology to develop efficient quantum electronic systems As well as being up to date this book provides a broader range of topics than found in many other electronics books This book is written in a clear accessible style and covers topics in a comprehensive manner This book's approach is strongly application based with key mathematical techniques introduced helpful examples used to illustrate the design procedures and case studies provided where appropriate By including the fundamentals as well as more advanced techniques the author has produced an up to date reference that meets the requirements of electronics and communications students and professional engineers Features Discusses formulation and classification of integrated circuits Develops a hierarchical structure of functional logic blocks to build more complex digital logic circuits Outlines the structure of transistors bipolar JFET MOSFET or MOS CMOS their processing techniques their arrangement forming logic gates and digital circuits optimal pass transistor stages of buffered chain sources and types of noise and performance of designed circuits under noisy conditions Explains data conversion processes choice of the converter types and inherent errors

Describes electronic properties of nanomaterials the crystallites size reduction effect and the principles of nanoscale structure fabrication Outlines the principles of quantum electronics leading to the development of lasers masers reversible quantum gates and circuits and applications of quantum cells and fabrication methods including self assembly quantum dot cellular automata and tunneling superconducting circuits and describes quantum error correction techniques Problems are provided at the end of each chapter to challenge the reader's understanding *Intelligent Nanomaterials* Ashutosh Tiwari, Yogendra Kumar Mishra, Hisatoshi Kobayashi, Anthony P. F. Turner, 2016-10-11 Overall this book presents a detailed and comprehensive overview of the state of the art development of different nanoscale intelligent materials for advanced applications Apart from fundamental aspects of fabrication and characterization of nanomaterials it also covers key advanced principles involved in utilization of functionalities of these nanomaterials in appropriate forms It is very important to develop and understand the cutting edge principles of how to utilize nanoscale intelligent features in the desired fashion These unique nanoscopic properties can either be accessed when the nanomaterials are prepared in the appropriate form e g composites or in integrated nanodevice form for direct use as electronic sensing devices In both cases the nanostructure has to be appropriately prepared carefully handled and properly integrated into the desired application in order to efficiently access its intelligent features These aspects are reviewed in detail in three themed sections with relevant chapters Nanomaterials Fabrication and Biomedical Applications Nanomaterials for Energy Electronics and Biosensing Smart Nanocomposites Fabrication and Applications **Soft Errors** Jean-Luc Autran, Daniela Munteanu, 2017-12-19 Soft errors are a multifaceted issue at the crossroads of applied physics and engineering sciences Soft errors are by nature multiscale and multiphysics problems that combine not only nuclear and semiconductor physics material sciences circuit design and chip architecture and operation but also cosmic ray physics natural radioactivity issues particle detection and related instrumentation *Soft Errors From Particles to Circuits* addresses the problem of soft errors in digital integrated circuits subjected to the terrestrial natural radiation environment one of the most important primary limits for modern digital electronic reliability Covering the fundamentals of soft errors as well as engineering considerations and technological aspects this robust text Discusses the basics of the natural radiation environment particle interactions with matter and soft error mechanisms Details instrumentation developments in the fields of environment characterization particle detection and real time and accelerated tests Describes the latest computational developments modeling and simulation strategies for the soft error rate estimation in digital circuits Explores trends for future technological nodes and emerging devices *Soft Errors From Particles to Circuits* presents the state of the art of this complex subject providing comprehensive knowledge of the complete chain of the physics of soft errors The book makes an ideal text for introductory graduate level courses offers academic researchers a specialized overview and serves as a practical guide for semiconductor industry engineers or application engineers **Electromigration In Ulsi Interconnections** Cher Ming Tan, 2010-06-25 Electromigration in ULSI

Interconnections provides a comprehensive description of the electromigration in integrated circuits. It is intended for both beginner and advanced readers on electromigration in ULSI interconnections. It begins with the basic knowledge required for a detailed study on electromigration and examines the various interconnected systems and their evolution employed in integrated circuit technology. The subsequent chapters provide a detailed description of the physics of electromigration in both Al and Cu based Interconnections in the form of theoretical, experimental and numerical modeling studies. The differences in the electromigration of Al and Cu based interconnections and the corresponding underlying physical mechanisms for these differences are explained. The test structures, testing methodology, failure analysis methodology and statistical analysis of the test data for the experimental studies on electromigration are presented in a concise and rigorous manner. Methods of numerical modeling for the interconnect electromigration and their applications to the understanding of electromigration physics are described in detail with the aspects of material properties, interconnection design and interconnect process parameters on the electromigration performances of interconnects in ULSI further elaborated upon. Finally, the extension of the studies to narrow interconnections is introduced and future challenges on the study of electromigration are outlined and discussed.

Logic Non-volatile Memory: The Nvm Solutions For Ememory Charles Ching-hsiang Hsu, Yuan-tai Lin, Ching-sung Yang, 2014-03-18. Would you like to add the capabilities of the Non Volatile Memory NVM as a storage element in your silicon integrated logic circuits and as a trimming sector in your high voltage driver and other silicon integrated analog circuits? Would you like to learn how to embed the NVM into your silicon integrated circuit products to improve their performance? This book is written to help you. It provides comprehensive instructions on fabricating the NVM using the same processes you are using to fabricate your logic integrated circuits. We at our eMemory company call this technology the embedded Logic NVM. Because embedded Logic NVM has simple fabrication processes, it has replaced the conventional NVM in many traditional and new applications including LCD driver, LED driver, MEMS controller, touch panel controller, power management unit, ambient and motion sensor controller, micro controller unit, MCU security ID setting tag, RFID, NFC, PC camera controller, keyboard controller and mouse controller. The recent explosive growth of the Logic NVM indicates that it will soon dominate all NVM applications. The embedded Logic NVM was invented and has been implemented in users' applications by the 200 employees of our eMemory company who are also the authors and author assistants of this book. This book covers the following Logic NVM products: One Time Programmable (OTP) memory, Multiple Times Programmable (MTP) memory, Flash memory and Electrically Erasable Programmable Read Only Memory (EEPROM). The fundamentals of the NVM are described in this book, which include the physics and operations of the memory transistors, the basic building block of the memory cells and the access circuits. All of these products have been used continuously by the industry worldwide. In depth, readers can attain expert proficiency in the implementation of the embedded Logic NVM technology in their products.

Advanced Ultra Low-Power Semiconductor Devices Shubham

Tayal, Abhishek Kumar Upadhyay, Shiromani Balmukund Rahi, Young Suh Song, 2023-10-30 **ADVANCED ULTRA LOW POWER SEMICONDUCTOR DEVICES** Written and edited by a team of experts in the field this important new volume broadly covers the design and applications of metal oxide semiconductor field effect transistors This outstanding new volume offers a comprehensive overview of cutting edge semiconductor components tailored for ultra low power applications These components pivotal to the foundation of electronic devices play a central role in shaping the landscape of electronics With a focus on emerging low power electronic devices and their application across domains like wireless communication biosensing and circuits this book presents an invaluable resource for understanding this dynamic field Bringing together experts and researchers from various facets of the VLSI domain the book addresses the challenges posed by advanced low power devices This collaborative effort aims to propel engineering innovations and refine the practical implementation of these technologies Specific chapters delve into intricate topics such as Tunnel FET negative capacitance FET device circuits and advanced FETs tailored for diverse circuit applications Beyond device centric discussions the book delves into the design intricacies of low power memory systems the fascinating realm of neuromorphic computing and the pivotal issue of thermal reliability Authors provide a robust foundation in device physics and circuitry while also exploring novel materials and architectures like transistors built on pioneering channel dielectric materials This exploration is driven by the need to achieve both minimal power consumption and ultra fast switching speeds meeting the relentless demands of the semiconductor industry The book's scope encompasses concepts like MOSFET FinFET GAA MOSFET the 5 nm and 7 nm technology nodes NCFET ferroelectric materials subthreshold swing high k materials as well as advanced and emerging materials pivotal for the semiconductor industry's future

Mixed Analog-digital VLSI Devices and Technology Yannis Tsividis, 2002 Improve your circuit design potential with this expert guide to the devices and technology used in mixed analog digital VLSI chips for such high volume applications as hard disk drives wireless telephones and consumer electronics The book provides you with a critical understanding of device models fabrication technology and layout as they apply to mixed analog digital circuits You will learn about the many device modeling requirements for analog work as well as the pitfalls in models used today for computer simulators such as Spice Also included is information on fabrication technologies developed specifically for mixed signal VLSI chips plus guidance on the layout of mixed analog digital chips for a high degree of analog device matching and minimum digital to analog interference This reference book features an intuitive introduction to MOSFET operation that will enable you to view with insight any MOSFET model besides thorough discussions on valuable large signal and small signal models Filled with practical information this first of its kind book will help you grasp the nuances of mixed signal VLSI device models and layout that are crucial to the design of high performance chips

Circuit Design for Modern Applications A. Andrew Roobert, M. Venkatesh, Shiromani Balmukund Rahi, G. Lakshmi Priya, Samuel Tensingh, 2025-02-05 This book offers a clear exploration of cutting edge semiconductor circuit technologies and their practical applications It covers topics like advanced

transistor design low power consumption techniques and high performance circuit design Circuit Design for Modern Applications explores the recent innovations in semiconductor technology Bandgap reference circuits quad model transistors voltagecontrolled oscillators LDO regulators power amplifiers low noise amplifiers operational amplifiers low power CNTFET based quaternary multipliers and STT MRAM based cache memory for multicore systems are discussed It points out the difficulties in designing CMOS analog and RF circuits for mmWave applications and looks into newly developed field effect transistors for an alternate solution Innovative devices such as III V material based HEMTs and junctionless FETs are discussed The book also looks at creative ways to improve circuit performance and energy efficiency which is a useful resource for academics researchers and industry experts working in semiconductors This book will help the readers to stay on the cutting edge of contemporary circuit design technologies covering various topics from fundamental circuit design to high performance circuits

Electrical Modeling and Design for 3D System Integration Er-Ping Li, 2012-03-19 New advanced modeling methods for simulating the electromagnetic properties of complex three dimensional electronic systems Based on the author s extensive research this book sets forth tested and proven electromagnetic modeling and simulation methods for analyzing signal and power integrity as well as electromagnetic interference in large complex electronic interconnects multilayered package structures integrated circuits and printed circuit boards Readers will discover the state of the technology in electronic package integration and printed circuit board simulation and modeling In addition to popular full wave electromagnetic computational methods the book presents new more sophisticated modeling methods offering readers the most advanced tools for analyzing and designing large complex electronic structures Electrical Modeling and Design for 3D System Integration begins with a comprehensive review of current modeling and simulation methods for signal integrity power integrity and electromagnetic compatibility Next the book guides readers through The macromodeling technique used in the electrical and electromagnetic modeling and simulation of complex interconnects in three dimensional integrated systems The semi analytical scattering matrix method based on the N body scattering theory for modeling of three dimensional electronic package and multilayered printed circuit boards with multiple vias Two and three dimensional integral equation methods for the analysis of power distribution networks in three dimensional package integrations The physics based algorithm for extracting the equivalent circuit of a complex power distribution network in three dimensional integrated systems and printed circuit boards An equivalent circuit model of through silicon vias Metal oxide semiconductor capacitance effects of through silicon vias Engineers researchers and students can turn to this book for the latest techniques and methods for the electrical modeling and design of electronic packaging three dimensional electronic integration integrated circuits and printed circuit boards

Operation and Modeling of the MOS Transistor Yannis Tsividis, Colin McAndrew, 2011 The MOS Metal Oxide Semiconductor transistor is the most important building block of modern silicon integrated circuits This book fills an important gap in the literature by presenting a unified treatment of the operation and

modeling of the MOS transistor that is complemented with extensive intuitive discussions The MOS transistor is the dominant VLSI Very Large Scale Integration device and understanding of this device is mandatory for those people planning a career in device physics and modeling as well as in circuit design Especially important for university courses there is a logical systematic and progressive description that starts with semiconductor fundamentals and builds up to a comprehensive understanding of the basics of MOS transistors For practicing professionals there are details of nuances observed in MOS transistor behavior and various approaches to modeling these are presented Detailed derivations are given for modeling dc currents charges for large signal operation small signal operation at low frequencies and high frequencies and noise

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