

Designing of Tunnel FET and FinFET using Sentaurus TCAD and Finding their Characteristics

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ABSTRACT– In this paper, a FinFET and Tunnel FET (TFET) are designed and implemented using Sentaurus TCAD. Due to numerous advantages, the TFET and FinFET have been proposed as a possible alternative to the conventional metal oxide semiconductor FET (MOSFET). A phenomenal performance has been achieved using FinFET technology up to a 7 nm feature size. A detailed observation is made on FinFET and TFET regarding various effects such as short channel effects, quantum tunneling effect and characteristics like electric field, voltage and current, on-current, doping concentrations, energy band diagrams etc. FinFET technology can be used for designing different low power CMOS digital circuits and memory-based circuits. On the contrary, TFET based synthesized circuits are known for their high sensitivity, for which they are suitable for sensing applications, especially biosensors.

Keywords: Trigate Fin-FET, Tunnel FET, Doping concentrations, Energy band Diagram, Electric field.

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1. INTRODUCTION

There are a lot of new technologies booming in the recent years. The MOSFET's are now slowly replaced by other FET devices, such as Tunnel-FET (TFET) and FinFET [1] [2]. TFET and FinFET have better performance than MOSFET in low power supply devices in most cases. FinFET is basically a Multi-gate MOSFET structure. On scaling the MOS-FET, the size is reduced to 100 nm variation, due to which subthreshold-Swing has increased, and I-off current has also increased. Which is why, we are approaching alternate technologies. In MOSFET, limiting the subthreshold swing to 60mV/decade due to thermal Boltzmann tail of carries, whereas it does not affect the TFET devices [3] [4].

On restricting the Size of the MOSFET, it results in the increase of large Short Channel effects. Whereas, TFET works well in this scenario and shows better performance using Quantum Tunneling effect. There are many different types of devices in FinFET and TFET, including single-gate FinFET, double-

gate FinFET, triple-gate FinFET, and many more [6]. A planar TFET has higher electric field effect, has better ON current and decreased subthreshold-swing than other TFET devices. There are many drawbacks to this device's also. In TFET, the ON current is very less and there are ambipolar effects. Whereas in FinFET, it has high parasitic capacitances, it's hard to manage the varying Threshold voltage (V_{th}). Both of them put to gather, have high fabricating cost compared to that of MOSFET.

While modelling the device, the structures are placed on Silicon on Insulator (SOI) to avoid any sort of leakage. There are two different types of device modelling such as 2D and 3D, which will result in analyzing the various structures. These devices are modelled in Sentaurus TCAD software for further analyzes. TCAD allows to study the device structure and various other parameter in the Software.

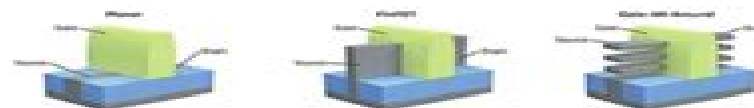


Figure 1. Types of FET devices [4]

FinFET has vertical channel which looks like a fin, whereas, MOSFET has a horizontal channel. In FIN-FET the channel is covered with a Silicon layer. The TFET device has P-I-N-junction, and works on-the band to band Tunneling. On giving some bias to drain, the conduction band of the channel is shoved below the valence band of the source part.

Sentaurus Tcad User Guide Finfet

**Manoj Singh Gaur,Mark
Zwolinski,Vijay Laxmi,D.
Boolchandani,Virendra Sing,Adit Singh**

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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 3D TCAD Simulation for CMOS Nanoelectronic Devices Yung-Chun Wu, Yi-Ruei Jhan, 2017-06-19 This book demonstrates how to use the Synopsys Sentaurus TCAD 2014 version for the design and simulation of 3D CMOS complementary metal oxide semiconductor semiconductor nanoelectronic devices while also providing selected source codes Technology Computer Aided Design TCAD Instead of the built in examples of Sentaurus TCAD 2014 the practical cases presented here based on years of teaching and research experience are used to interpret and analyze simulation results of the physical and electrical properties of designed 3D CMOSFET metal oxide semiconductor field effect transistor nanoelectronic devices The book also addresses in detail the fundamental theory of advanced semiconductor device design for the further simulation and analysis of electric and physical properties of semiconductor devices The design and simulation technologies for nano semiconductor devices explored here are more practical in nature and representative of the semiconductor industry and as such can promote the development of pioneering semiconductor devices semiconductor device physics and more practically oriented approaches to teaching and learning semiconductor engineering The book can be used for graduate and senior undergraduate students alike while also offering a reference guide for engineers and experts in the semiconductor industry Readers are expected to have some preliminary knowledge of the field *Spacer Engineered FinFET Architectures* Sudeb Dasgupta, Brajesh Kumar Kaushik, Pankaj Kumar Pal, 2017-06-26 This book focusses on the spacer engineering aspects of novel MOS based device circuit co design in sub 20nm technology node its process complexity variability and reliability issues It comprehensively explores the FinFET tri gate architectures with their circuit SRAM suitability and tolerance to random statistical variations Handbook of Computer Networks and Cyber Security Brij B. Gupta, Gregorio Martinez Perez, Dharma P. Agrawal, Deepak Gupta, 2019-12-31 This handbook introduces the basic principles and fundamentals of cyber security towards establishing an understanding of how to protect computers from hackers and adversaries The highly informative subject matter of this handbook includes various concepts models and terminologies along with examples and illustrations to demonstrate substantial technical details of the field It motivates the readers to exercise better protection and defense mechanisms to deal with attackers and mitigate the situation This handbook also outlines some of the exciting areas of future research where the existing approaches can be implemented Exponential

increase in the use of computers as a means of storing and retrieving security intensive information requires placement of adequate security measures to safeguard the entire computing and communication scenario With the advent of Internet and its underlying technologies information security aspects are becoming a prime concern towards protecting the networks and the cyber ecosystem from variety of threats which is illustrated in this handbook This handbook primarily targets professionals in security privacy and trust to use and improve the reliability of businesses in a distributed manner as well as computer scientists and software developers who are seeking to carry out research and develop software in information and cyber security Researchers and advanced level students in computer science will also benefit from this reference

Advanced Field-Effect Transistors Dharmendra Singh Yadav, Shiromani Balmukund Rahi, Sukeshni Tirkey, 2023-12-22 Advanced Field Effect Transistors Theory and Applications offers a fresh perspective on the design and analysis of advanced field effect transistor FET devices and their applications The text emphasizes both fundamental and new paradigms that are essential for upcoming advancement in the field of transistors beyond complementary metal oxide semiconductors CMOS This book uses lucid intuitive language to gradually increase the comprehension of readers about the key concepts of FETs including their theory and applications In order to improve readers learning opportunities Advanced Field Effect Transistors Theory and Applications presents a wide range of crucial topics Design and challenges in tunneling FETs Various modeling approaches for FETs Study of organic thin film transistors Biosensing applications of FETs Implementation of memory and logic gates with FETs The advent of low power semiconductor devices and related implications for upcoming technology nodes provide valuable insight into low power devices and their applicability in wireless biosensing and circuit aspects As a result researchers are constantly looking for new semiconductor devices to meet consumer demand This book gives more details about all aspects of the low power technology including ongoing and prospective circumstances with fundamentals of FET devices as well as sophisticated low power applications

VLSI Design and Test Manoj Singh Gaur, Mark Zwolinski, Vijay Laxmi, D. Boolchandani, Virendra Sing, Adit Singh, 2013-12-13 This book constitutes the refereed proceedings of the 17th International Symposium on VLSI Design and Test VDAT 2013 held in Jaipur India in July 2013 The 44 papers presented were carefully reviewed and selected from 162 submissions The papers discuss the frontiers of design and test of VLSI components circuits and systems They are organized in topical sections on VLSI design testing and verification embedded systems emerging technology

Nanoelectronic Devices and Applications Trupti Ranjan Lenka, Hieu Pham Trung Nguyen, 2024-07-02 Nanoelectronic Devices and Applications presents reviews on recent advances in nanoelectronic device design and new directions for their practical use The volume includes 16 edited chapters that cover novel material systems band engineering modelling and simulations fabrication and characterization techniques and their emerging applications The discussions presented in this book are based on current understandings on innovations and future trends and references are provided for advanced scholars Chapter 1 presents an overview of recent innovations and future

prospects in III nitride semiconductor technologies for RF power digital and quantum applications Chapter 2 reports new trends in GaN based optical devices for sensing and micro display applications Chapter 3 shows current interests in nanophosphors and their utilizations in improving device performance of InGaN nanowire light emitting diodes LEDs Recent studies on the effect of potential profile on the carrier transport in AlGaAs based double quantum well structures and their applications are presented in Chapter 4 The recent progress in high electron mobility transistors HEMTs is presented through Chapters 5 6 and 7 A comprehensive review on Ga₂O₃ emphasizing material properties growth approaches and its applications for next generation high power nanoelectronics the effect of dielectric layers on the characteristics of AlN Ga₂O₃ HEMTs are presented in Chapter 8 and 9 respectively Chapters 10 14 summarize the recent studies in field effect transistors FETs adopting different materials and structures Chapter 15 presents current research in 2D Tungsten Diselenide WSe₂ with special focus on the material properties device structures applications and challenges Finally Chapter 16 presents a systematic review of memristors and memristive semiconductor devices The book is intended as a primary resource for elective subjects in advanced electronics and computer engineering courses at university level Researchers and industry professionals will also learn about emerging trends and state of the art research in nanoelectronics

The Physics of Semiconductor Devices R. K. Sharma,D.S. Rawal,2019-01-31 This book disseminates the current knowledge of semiconductor physics and its applications across the scientific community It is based on a biennial workshop that provides the participating research groups with a stimulating platform for interaction and collaboration with colleagues from the same scientific community The book discusses the latest developments in the field of III nitrides materials devices compound semiconductors VLSI technology optoelectronics sensors photovoltaics crystal growth epitaxy and characterization graphene and other 2D materials and organic semiconductors

VLSI Design and Test Brajesh Kumar Kaushik,Sudeb Dasgupta,Virendra Singh,2017-12-21 This book constitutes the refereed proceedings of the 21st International Symposium on VLSI Design and Test VDAT 2017 held in Roorkee India in June July 2017 The 48 full papers presented together with 27 short papers were carefully reviewed and selected from 246 submissions The papers were organized in topical sections named digital design analog mixed signal VLSI testing devices and technology VLSI architectures emerging technologies and memory system design low power design and test RF circuits architecture and CAD and design verification

Miniaturized Transistors Lado Filipovic,Tibor Grassner,2019-06-24 What is the future of CMOS Sustaining increased transistor densities along the path of Moore's Law has become increasingly challenging with limited power budgets interconnect bandwidths and fabrication capabilities In the last decade alone transistors have undergone significant design makeovers from planar transistors of ten years ago technological advancements have accelerated to today's FinFETs which hardly resemble their bulky ancestors FinFETs could potentially take us to the 5 nm node but what comes after it From gate all around devices to single electron transistors and two dimensional semiconductors a torrent of research is being carried out in order to design the next

transistor generation engineer the optimal materials improve the fabrication technology and properly model future devices We invite insight from investigators and scientists in the field to showcase their work in this Special Issue with research papers short communications and review articles that focus on trends in micro and nanotechnology from fundamental research to applications Nanoscale Field Effect Transistors: Emerging Applications Ekta Goel, Archana

Pandey,2023-12-20 Nanoscale Field Effect Transistors Emerging Applications is a comprehensive guide to understanding simulating and applying nanotechnology for design and development of specialized transistors This book provides in depth information on the modeling simulation characterization and fabrication of semiconductor FET transistors The book contents are structured into chapters that explain concepts with simple language and scientific references The core of the book revolves around the fundamental physics that underlie the design of solid state nanostructures and the optimization of these nanoscale devices for real time applications Readers will learn how to achieve superior performance in terms of reduced size and weight enhanced subthreshold characteristics improved switching efficiency and minimal power consumption Key Features Quick summaries Each chapter provides an introduction and summary to explain concepts in a concise manner In Depth Analysis This book provides an extensive exploration of the theory and practice of nanoscale materials and devices offering a detailed understanding of the technical aspects of Nano electronic FET transistors Multidisciplinary Approach It discusses various aspects of nanoscale materials and devices for applications such as quantum computation biomedical applications energy generation and storage environmental protection and more It showcases how nanoscale FET devices are reshaping multiple industries References Chapters include references that encourage advanced readers to further explore key topics Designed for a diverse audience this book caters to students academics and advanced readers interested in learning about Nano FET devices Readership Students academics and advanced readers *Fabless Semiconductor*

Manufacturing Chinmay K. Maiti,2022-11-17 This book deals with 3D nanodevices such as nanowire and nanosheet transistors at 7 nm and smaller technology nodes It discusses technology computer aided design TCAD simulations of stress and strain engineered advanced semiconductor devices including III nitride and RF FDSOI CMOS for flexible and stretchable electronics The book focuses on how to set up 3D TCAD simulation tools from mask layout to process and device simulation including fabless intelligent manufacturing The simulation examples chosen are from the most popular devices in use today and provide useful technology and device physics insights In order to extend the role of TCAD in the More than Moore era the design issues related to strain engineering for flexible and stretchable electronics have been introduced for the first time

Physics of Semiconductor Devices V. K. Jain,Abhishek Verma,2013-11-27 The purpose of this workshop is to spread the vast amount of information available on semiconductor physics to every possible field throughout the scientific community As a result the latest findings research and discoveries can be quickly disseminated This workshop provides all participating research groups with an excellent platform for interaction and collaboration with other members of their respective scientific

community This workshop s technical sessions include various current and significant topics for applications and scientific developments including Optoelectronics VLSI ULSI Technology Photovoltaics MEMS Sensors Device Modeling and Simulation High Frequency Power Devices Nanotechnology and Emerging Areas Organic Electronics Displays and Lighting Many eminent scientists from various national and international organizations are actively participating with their latest research works and also equally supporting this mega event by joining the various organizing committees **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 **Advanced VLSI Design and**

Testability Issues Suman Lata Tripathi,Sobhit Saxena,Sushanta Kumar Mohapatra,2020-08-18 This book facilitates the VLSI interested individuals with not only in depth knowledge but also the broad aspects of it by explaining its applications in different fields including image processing and biomedical The deep understanding of basic concepts gives you the power to develop a new application aspect which is very well taken care of in this book by using simple language in explaining the concepts In the VLSI world the importance of hardware description languages cannot be ignored as the designing of such dense and complex circuits is not possible without them Both Verilog and VHDL languages are used here for designing The current needs of high performance integrated circuits ICs including low power devices and new emerging materials which can play a very important role in achieving new functionalities are the most interesting part of the book The testing of VLSI circuits becomes more crucial than the designing of the circuits in this nanometer technology era The role of fault simulation algorithms is very well explained and its implementation using Verilog is the key aspect of this book This book is well organized into 20 chapters Chapter 1 emphasizes on uses of FPGA on various image processing and biomedical applications Then the descriptions enlighten the basic understanding of digital design from the perspective of HDL in Chapters 2 5 The performance enhancement with alternate material or geometry for silicon based FET designs is focused in Chapters 6 and 7

Chapters 8 and 9 describe the study of bimolecular interactions with biosensing FETs Chapters 10-13 deal with advanced FET structures available in various shapes materials such as nanowire HFET and their comparison in terms of device performance metrics calculation Chapters 14-18 describe different application specific VLSI design techniques and challenges for analog and digital circuit designs Chapter 19 explains the VLSI testability issues with the description of simulation and its categorization into logic and fault simulation for test pattern generation using Verilog HDL Chapter 20 deals with a secured VLSI design with hardware obfuscation by hiding the IC's structure and function which makes it much more difficult to reverse engineer

Micro and Nanoelectronics Devices, Circuits and Systems Trupti Ranjan Lenka, Durgamadhab Misra, Arindam Biswas, 2021-09-09 The book presents select proceedings of the International Conference on Micro and Nanoelectronics Devices Circuits and Systems MNDCS 2021 The volume includes cutting edge research papers in the emerging fields of micro and nanoelectronics devices circuits and systems from experts working in these fields over the last decade The book is a unique collection of chapters from different areas with a common theme and will be immensely useful to academic researchers and practitioners in the industry who work in this field

'Advances in Microelectronics: Reviews', Vol_1 Sergey Yurish, 2017-12-24 The 1st volume of Advances in Microelectronics Reviews Book Series contains 19 chapters written by 72 authors from academia and industry from 16 countries With unique combination of information in each volume the Advances in Microelectronics Reviews Book Series will be of value for scientists and engineers in industry and at universities In order to offer a fast and easy reading of the state of the art of each topic every chapter in this book is independent and self contained All chapters have the same structure first an introduction to specific topic under study second particular field description including sensing applications Each of chapter is ending by well selected list of references with books journals conference proceedings and web sites This book ensures that readers will stay at the cutting edge of the field and get the right and effective start point and road map for the further researches and developments

Nanoelectronics Balwinder Raj, Suman Lata Tripathi, Tarun Chaudhary, Mandeep Singh, 2025-05-15 This book exhibits a unique way of explaining nanomaterials and devices and analyzing their design parameters to meet the sub nanoregime challenges for low power chip design Since process variability device sizing and power supply scaling are ongoing challenges in very large scale integration VLSI circuit designs this book highlights the conventional and novel nanomaterials devices and circuits leakage current mitigation techniques and other important trade offs along with exhaustive analysis More focus has been placed throughout the book on various trade offs for high speed and low power VLSI devices and circuits co design This book Discusses advanced nano semiconductor devices such as FinFET nanowires tunnel field effect transistors carbon nanotube field effect transistors and high electron mobility transistors Presents high performance semiconductor devices at nanoscale technology nodes for the analysis of quantum effects and their impact on circuits and systems Covers power dissipation and reduction techniques for high performance devices Explains both silicon

and non silicon devices for various applications like digital logic and analog radio frequency applications Examines the difficulties and practical design approaches for extremely low power analog integrated circuits It is primarily written for senior undergraduates graduate students and academic researchers in the fields of electrical engineering electronics and communications engineering materials science nanoscience and nanotechnology **Micro and Nanoelectronics Devices, Circuits and Systems** Koushik Guha,Samar Kanti Saha,Jacopo Iannacci,2025-07-23 This book presents select proceedings of the International Conference on Micro and Nanoelectronics Devices Circuits and Systems MNDCS 2024 The book includes cutting edge research papers in the emerging fields of micro and nanoelectronics devices circuits and systems from experts working in these fields over the last decade The book is a unique collection of chapters from different areas with a common theme It is beneficial to academic researchers and practitioners in the industry who work in this field TCAD : **Sentaurus TCAD** ,2024-11-19 Sentaurus TCAD Sentaurus TCAD TCAD Sentaurus TCAD TCAD

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