

# Preface

Almost on a daily basis, nanoelectronic metal-oxide-semiconductor (CMOS) technology and device design are introduced and explored in rapidly developing semiconductor industry. This book “3D TCAD Simulation for CMOS Nanoelectronic Devices” presents a self-contained and up-to-date critical ideas and illustrations that will help the readers to understand nano electronics device design and its background fundamental physics in detail. Along with basic concepts, the book includes numerous examples which will assist the readers to clearly understand advanced semiconductor research as well. This book will be a proper resource for graduate students doing research in CMOS Nanoelectronic Devices and also for the professional engineers working in both academia and industry. It can also serve as a reference for device research and development engineers and experts in semiconductor industry.

This book reflects the belief that in semiconductor device physics by means of illustrative problems with step-by-step TCAD solutions. This book contents are based on the **Synopsys Sentaurus TCAD 2014 version**. This book thoroughly describes the tools and models for modern nanoelectronic devices by computer simulation technology with which one shall design, develop, and optimize semiconductor device structure and process technology with respect to different important commercialized semiconductor devices and materials. By using TCAD simulation for the analysis of electric and physical properties, time consumed in expensive device fabrication can be minimized leading to effective research output and huge amount of resources and manpower could also be saved. Synopsys Sentaurus TCAD is the leader in global development of 3D TCAD Simulation for CMOS Nanoelectronic Devices. Power houses in semiconductor industry such as Intel, TSMC, Samsung, and IBM are all using the Synopsys products.

This book also considers all the basic semiconductor device physics theory along with recent advanced quantum perspective for nanoelectronic semiconductor device design. It is suggested that readers should have preliminary semiconductor knowledge before reading this book for a better understanding. This book is focused on three main subjects. Part I (Chapters 1–4) are about simulation of electrical and physical properties of Silicon CMOSFET. It starts with the designs of

2D Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) and 3D Silicon and Germanium ( $L_g = 15$  and  $10$  nm) and InGaAs FinFETs. Part II (Chapters 5–7) are about novel nano-semiconductor devices such as Junctionless FET and tunneling FET. Part III (Chapter 8) is about predicting the feasible solutions for Silicon and Germanium FET devices of ultimate minimum dimension and proving that Moore’s Law can be extended to the nanotechnology nodes. This chapter on ultra scaled devices serves as only a design guideline and in future more ab-initio and first principle based models shall be incorporated in the device physics for more accurate results which we believe will be updated in future editions of this book.

Instead of direct application of built-in library examples of Synopsys Sentaurus TCAD v. 2014, this book is based on “actual practices of teaching” and “research results” more than 40 international SCI journal papers by our research team in Taiwan National Tsing Hua University over a decade. The design and technology of this book “3D TCAD Simulation for CMOS Nanoelectronic Devices” are fairly important and practical for semiconductor industry and academic research, and it can also improve the development of foresight nanoelectronic semiconductor device. Due to limited knowledge of the author and the continuous update and development of Synopsys Sentaurus TCAD version, users are welcome to contact us via the email address of [ycwu.tcad.tw@gmail.com](mailto:ycwu.tcad.tw@gmail.com) with respect to any mistake or typing errors, or advised to refer to latest user manual of Synopsys Sentaurus TCAD.

Reader can download basic examples at our lab’s website <http://semiconductorlab.iwopop.com/>. The files are compressed as a zip format. Users should transfer to Synopsys Sentaurus TCAD Workbench under UNIX or Linux system and unzip as directories. Above examples are completely ready to run. Other examples in this book, readers can easily create from above basic examples. We tried to present all the details in a clear and concise method. Thus, readers should be able to follow the computations of all the problems in this book.

We would like to express our deep gratitude to the assistance provided by the research team members of our laboratory in writing this book and the valuable suggestions by students participating in this course over the years. We appreciate Synopsys Company technical support. Also, we would like to acknowledge the Ministry of Science and Technology (MOST) of Taiwan for continuously support, National Nano Device Laboratories (NDL) of Taiwan is greatly appreciated for its technical support in real nanoelectronic devices fabrication. National High-Performance Computing (NCHC) Center of Taiwan is also greatly appreciated for its TCAD simulation support.

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