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Text Introduces Power Circuit Designers To Simulation As It's Done At The Chip and Process Levels

Integrated Power Devices and TCAD Simulation, Yue Fu, Zhangming Li, Wai Tung Ng, Johnny K. O. Sin; CRC Press (www.crcpress.com or www.taylorandfrancis.com), hardback, 338 pages; 2014; ISBN 978-1-4665-8381-8

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TCAD is not SPICE warmed over; it is something different: not a *circuit* but a *device* and *process* simulator. This book begins with a couple of chapters of power-electronics concepts, including linear regulators, dc-dc converters, switched-capacitor converters, the PWM-switch configurations and the Ćuk variation, some additional considerations, then the isolated versions of the configurations with primary-side half- and full-bridge, and push-pull drivers plus some additional topics. SPICE circuit simulation is mentioned in passing as a prelude to pre-circuit simulation.

The second chapter continues the circuits overview with some emphasis on segmented output stages for handling a wide load range while maintaining efficiency. The third chapter is a history of the semiconductor industry and its various "levels" or causal progressions, starting with EDA and wafer tools and ending at the sixth level with marketing and sales.

Chapter four surveys power-IC technology, giving historical, industrial, and technological perspectives. After these appetizers, the main meal is brought out, starting in chapter 5 with "technology computer-aided design," or TCAD process and device simulation. "TCAD is used … to simulate semiconductor manufacturing process technology; a different set of tools is used to also study the electrical, thermal and optical properties of semiconductor devices" (p. 67.) Ion implantation, deposition, oxidation, and other processes are briefly described.

Chapter six moves on to device simulation, and various physical models or equations for solid-state processes, including "Intel's Local Field Models." Then the chapter moves on to on-chip thermal modeling. Deep-level traps in GaN material are included in trap modeling. Quantum tunneling is also included. Chapter 7 takes the reader through process steps, with plenty of cross-sectional views of the wafer showing how processes build up the IC.

Chapter 8 returns to device modeling, some diode junction equations, graphs, and doping plots. Some of the BJT effects such as the Kirk effect and second breakdown are described from a physical device standpoint, thereby complementing solid-state electronics textbooks. LDMOS is illustrated at some length.

Chapter 9 is about 3D simulation of devices. Device layouts begin to proliferate in the drawings. Interconnection is modeled: substrate, contacts, vias, metal—it's all there, though it goes by quickly. The polarization properties of III-nitride wurtzite are not left out either, and strain-induced polarization associated with GaN, InN, and AlN. By the end of chapter 10, the GaN HEMT structure is in the limelight. And then the book ends, though not before the appendices cover some details of carrier statistics and trap dynamics, then a big bibliography and finally the index.

A background in graduate solid-state electronics would be helpful in extracting the most from this book, though the typical electrical engineer should know enough to find some enlightenment in it regarding the pre-circuit aspect of electronics. Semiconductor engineering has advanced to the point where the devices—in 3D with layout, thermal, and other effects thrown in—can themselves be computer modeled, along with the processes underlying the devices. This book provides a readable engineering overview of the pre-circuit considerations.

About The Author

Dennis Feucht has been involved in power electronics for 25 years, designing motor-drives and power converters. He has an instrument background from Tektronix, where he designed test and measurement equipment and did research in Tek Labs. He has lately been doing current-loop converter modeling and converter optimization.