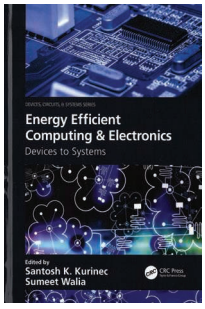
Book News

by Fernando A. Silva

Energy Efficient Computing and Electronics: Devices to Systems



By Santosh K. Kurinec and Sumeet Walia (Eds.), CRC Press, 2019, Hardback, 474 pages, ISBN: 978-1-138-71036-8.

The immense quantity of data created by ubiquitous smart devices, communication systems, and Internet of Things devices demands powerful computing and storage infrastructures. The exponential increase in big data needs future handling performance of still-to-be-developed computers, not limited by the amount of energy dissipated to store, compute, and transmit data. Moreover, for every watt of dissipated energy, more than 1 W of air-conditioning is needed to remove the generated heat. Therefore, disruptive new device concepts, sensors, circuit architectures, and new materials are needed to keep the computing power up to requested in the coming decades.

Energy Efficient Computing and Electronics: Devices to Systems discusses how to design energy-efficient electronic devices, circuits, and systems in the quest to lower computing energy consumption per bit. This timely book is divided into three sections, each including five chapters.

Digital Object Identifier 10.1109/MIE.2020.2966835
Date of current version: 25 March 2020

The first section is devoted to emerging low-power devices that are able to obtain energy-efficient device structures. Chapter 1 presents the development of a process design kit for academic use for a fin field-effect transistor (FinFET)-based framework for the 7-nm node. Chapter 2 focuses on molecular phenomena at the gate dielectric/channel interface in MOSFETs. Chapter 3 deals with the development of tunneling FETs. Chapter 4 provides introductory physics concepts for the spintronic effects (magnetoresistance, spin-transfer torque, spin Hall effect, magnetoelectric effect). Chapter 5 uses hafnium-oxide-based ferroelectric tunnel junctions to store data as a polarization state change.

Section II is devoted to loss reduction in sensors, interconnects, and gallium nitride (GaN) Schottky power diodes. Chapter 6 provides an overview of the current state of technology and scientific investigations in the field of X-ray sensors based on chromium compensated GaN for imaging systems. Chapters 7 and 8 introduce the application of vertical-cavity surface-emitting lasers to low-power optoelectronic interconnects, to reduce dissipated power while increasing speed, departing from the present copper-based interconnections. Chapter 9 investigates GaN and aluminum GaN heterostructures-based Schottky diodes with low turn-on voltage for energy-efficient 230-Vac–dc power supplies.

DISRUPTIVE NEW DEVICE CONCEPTS, SENSORS, CIRCUIT ARCHITECTURES, AND NEW MATERIALS ARE NEEDED TO KEEP THE COMPUTING POWER UP TO REQUESTED IN THE COMING DECADES.

Chapter 10 reviews the stoichiometry-controlled crystal growth technique and its application to compound semiconductor oscillation devices to extend the terahertz region.

Section III addresses aspects of systems design and related applications. Chapter 11 discusses issues related to the inherent physical noise (thermal noise, flicker noise, gate current noise, and shot noise) in low-power biosensing mixed-signal CMOS technology. Chapter 12 describes processor modeling using architecture description languages (ADLs) and presents ADL-driven methodologies for software toolkit generation, hardware synthesis exploration, and validation of programmable architectures. Chapter 13 concentrates on two highly challenging problems related to energy-efficient cloud data centers (CDCs): the minimization of the total cost of a CDC provider in a market where the bandwidth and energy cost show geographical diversity, and the minimization of the grid energy cost of a green CDC while meeting the performance of each delay-bounded request in an environment where grid price, wind speed, and solar irradiance show temporal diversity. Chapter 14 suggests an innovative way to implement neural networks combining ultralow-voltage hardware-based perceptrons and inertial neurons with analog communication links. Chapter 15 proposes a multipattern matching-based dynamic malware

detection algorithm in smartphones as an alternative to machine-learning-based methods to minimize energy consumption in smartphones.

All 15 chapters contain a detailed table of contents as well as hundreds of references. A preface, index, and table of contents are also included.

Section I Emerging Low Power Devices

1) "A FinFET-Based Framework for VLSI Design at the 7 nm Node," by Vinay Vashishtha and Lawrence T. Clark
2) "Molecular Phenomena in MOSFET Gate Dielectrics and Interfaces," by S. Arash Sheikholeslam, Hegoi Manzano, Cristian Grecu, and Andre Ivanov
3) "Tunneling Field Effect Transistors," by Amir N. Hanna and Muhammad Mustafa Hussain
4) "The Exploitation of the Spin-Transfer Torque Effect for CMOS Compatible Beyond Von Neumann Computing," by Thomas Windbacher, Alexander Makarov, Siegfried Selberherr, Hiwa Mahmoudi, B. Gunnar Malm, Mattias Ekström, and Mikael Östling
5) "Ferroelectric Tunnel Junctions as Ultra-Low-Power Computing Devices," by Spencer Allen Pringle and Santosh K. Kurinec.

Section II Sensors, Interconnects and Rectifiers

6) "X-ray Sensors Based on Chromium Compensated Gallium Arsenide," by Anton Tyazhev and Oleg Tolbanov
7) "Vertical-Cavity Surface-Emitting Lasers for Interconnects," by Werner H.E. Hofmann
8) "Low-Power Optoelectronic Interconnects on Two-Dimensional Semiconductors," by D. Keith Roper
9) "GaN-Based Schottky Barriers for Low Turn-On Voltage Rectifiers," by Nishant Darvekar and Santosh K. Kurinec
10) "Compound Semiconductor Oscillation Device Fabricated by Stoichiometry Controlled-Epitaxial Growth and Its Application to Terahertz and Infrared Imaging and Spectroscopy," by Takeo Ohno, Arata Yasuda, Tadao Tanabe, and Yutaka Oyama.

Section III Systems Design and Applications

11) "Low Power Biosensor Design Techniques Based on Information Theoretic Principles," by Nicole McFarlane
12) "Low-Power Processor Design Methodology: High-Level Estimation and Optimization via Processor Description Language," by Zheng Wang and Anupam Chattopadhyay
13) "Spatio-Temporal Multi-Application Request Scheduling in Energy-Efficient Data Centers," by Haitao Yuan, Jing Bi, and Meng-Chu Zhou
14) "Ultra-Low-Voltage Implementation of Neural Networks," by Farooq Ahmad Khanday, Nasir Ali Kant, and Mohammad Rafiq Dar
15) "Multi-Pattern Matching Based Dynamic Malware Detection in Smart Phones," by V.S. Devi, S. Roopak, Tony Thomas, and Md. Meraj Uddin.

Editor Santosh K. Kurinec earned a Ph.D. degree in physics from the University of Delhi, India, and is a professor of electrical and microelectronic engineering at Rochester Institute of Technology (RIT) in New York and visiting scholar at the IBM T.J. Watson Research Center, Yorktown Heights, New York. She received the RIT Trustee Scholarship Award in 2008 and was honored as the Engineer of the Year finalist by the Rochester Engineering Society in 2008. She is a Fellow of the IEEE, a member of the American Physical Society and New York State Academy of Sciences, an associate editor of *IEEE Transactions on Education*, and an IEEE Electron Devices Society Distinguished Lecturer. She received the 2012 IEEE Outstanding Undergraduate Teaching Award. Her current research activities include low-power FETs, nonvolatile memory, photovoltaics, and advanced integrated circuit materials and processes.

Editor Sumeet Walia is a senior lecturer and a Vice Chancellor's Fellow at RMIT University, Melbourne Australia. He earned a Ph.D. degree at RMIT in 2013 in the multidisciplinary field of functional materials and devices. Recognized as one of Asia's top 10 innovators (under 35) for his research into oxides-based energy sources and electronic memories, Dr. Walia works in electronic memories, an important step toward developing a bionic brain. He is an expert in materials engineering for nanoelectronics, sensing, and wearable devices. He is the recipient of several important awards, such as the 2017 Victorian Young Achiever for Research Impact, one of the most Innovative Engineers in Australia in 2018, and the 2018 Royal Society of Victoria—Phillip Law Award for Excellence in Physical Sciences.

Energy Efficient Computing and Electronics: Devices to Systems contains a wealth of valuable resources of paramount importance for graduate students, engineers, researchers, and scientists willing to start exploring energy-efficient designs of electronic devices, sensors, circuits, and systems. The book is also a valuable tool for graduate-level teachers and practicing professionals who need to understand and master energy-efficient revolutionary device concepts, associated circuits, and architectures that may greatly extend the practical engineering limits of future energy-efficient computation from device to system level.

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