This book offers a comprehensive review of the state of the art in innovative Beyond-CMOS nanodevices for developing novel functionalities, logic and memories dedicated to researchers, engineers and students.

It focuses on the interest of nanostructures and nanodevices (nanowires, small slope switches, 2D layers, nanostructured materials, etc.) for advanced More than Moore (RF-nanosensors-energy harvesters, on-chip electronic cooling, etc.) and Beyond-CMOS logic and memory applications. The convergence of More Moore and Beyond-CMOS, on the one hand, and the merging of More than Moore and Beyond-CMOS, on the other hand, have been widely studied in the scientific literature over recent years. This book provides a detailed review of the most recent advances in these fields which have gained a strong momentum for many applications.

The second of two books on this subject, it is primarily intended for societies, organizations and companies working in the micro/nanoelectronics and micro/nanosystems fields.

Francis Balestra joined LPCS (Laboratory of Physics of Semiconductor Devices), Grenoble INP, France in 1982, where he was involved in research on the study, characterization, modeling, and simulation of the first fully depleted silicon-on-insulator and fully inverted multi-gate MOS transistors. He now works at IMEP (Institute of Microelectronics, Electromagnetism and Photonics), also at Grenoble INP in France, and has co-authored over 150 publications in international scientific journals, 250 communications at international conferences (more than 70 invited papers and review articles), and 30 books or individual chapters.
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Microelectronics, based on complementary metal–oxide semiconductor (CMOS) technology, is the essential hardware enabler for electronic product and service innovation in key growth markets, such as communications, computing, consumer electronics, automotives, avionics, automated manufacturing, health and the environment. The global semiconductor industry underpins 16% of the world’s total economy and is growing every year. The worldwide market for electronic products is estimated to be more than $1,800 billion, and the related electronics services market more than $6,500 billion. These product and service markets are made possible by a $310 billion market for semiconductor components and an associated $90 billion market for semiconductor equipment and materials. The new era of nanoelectronics, which started at the beginning of the current millennium with the smallest patterns in state-of-the-art silicon-based devices below 100 nm, is making an exponential increase in system complexity and functionality possible.

Nanoelectronics allows the development of smart electronic systems by switching, storing, monitoring, receiving and transmitting information. In respect to its societal relevance, the ubiquitous nanoelectronics is also closely linked to the notion of ambient intelligence, which is a vision of the future where people are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognizing and responding to the presence of different individuals in a seamless way.

Since the invention of the transistor in 1947 at Bell Labs, followed by the first silicon transistor in 1954 and the concept of integrated circuits in 1958
at Texas Instruments, progress in the field of microelectronics has been
tremendous, which has revolutionized society. In these last 50 years,
dramatic advances have been achieved in the packing density of transistors.
This has resulted in the density of transistors on an integrated chip (IC)
doubling every two years (Moore’s law) since the 1970s. At the beginning of
the 1970s, the first microprocessor had only about 2,000 transistors (10 µm
gate length), the world’s first two-billion transistor processor was reported in
2008 in 65 nm CMOS technology.

The same trend can be observed for memories. The dynamic random
access memory (DRAM) capacity has been raised from 1 kb in 1970 to
several Gb at present. Several billion transistor static random access memory
(SRAM) chips have also been realized. For nonvolatile memories, 256 Gb
have been demonstrated. This increase in transistor count and memory
capacity has led to increased processing power, measured now in thousands
of millions of instructions per second (MIPS).

Moore’s law also means decreasing cost per function, the transistor price
has dropped at an average rate of about 1.5 per year (about 108 since the
beginning of the semiconductor industry).

However, according to the International Technology Roadmap for
Semiconductors and ENIAC Strategic Research Agenda, there are big
challenges to overcome in order to continue progressing in the same direction.

The minimum critical feature size of the elementary nanoelectronic
deVICES (physical gate length of the transistors) will drop into the
sub-decananometer range in the next decade. In the sub-10 nm range,
“beyond-CMOS” devices, based on nanowires, nanodots, carbon electronics
or other nanodevices, will certainly play an important role and could be
integrated onto CMOS platforms in order to pursue integration down to
nanometer structures. Silicon (Si) will remain the main semiconductor
material for the foreseeable future, but the required performance
improvements for the end of the roadmap for high performance, low and
ultra-low power applications will lead to a substantial enlargement of the
number of new materials, technologies, device and circuit architectures.

Therefore, new generations of Nanoelectronic ICs present increasingly
formidable multidisciplinary challenges at the most fundamental level (novel
materials, new physical phenomena, ultimate technological processes, novel
design techniques, etc.).
In this timeframe, performance will also derive from heterogeneity, referring to the increasing diversity of functions integrated onto CMOS platforms as envisaged in the “More than Moore (MtM)” approach.

This book, and the related book *Beyond-CMOS Nanodevices 1* (Volume 1), also published by ISTE and Wiley offer a comprehensive review of the state-of-the-art in innovative Beyond-CMOS nanodevices for developing novel functionalities, logic and memories dedicated to researchers, engineers and students.

Volume 1 particularly focuses on the interest of nanostructures and nanodevices (nanowires, small slope switches, 2D layers, nanostructured materials, etc.) for advanced MtM (RF, nanosensors, energy harvesters, on-chip electronic cooling, etc.). This book focuses on beyond-CMOS logic and memory applications.

MtM functions allow the world of digital computing and data storage to interact with the real world. MtM devices typically provide conversion of non-digital as well as non-electronic information, such as mechanical, thermal, acoustic, chemical, optical and biomedical functions, to digital data and vice versa. Clearly MtM technologies and products provide essential functional enrichment to the digital CMOS-based mainstream semiconductors. MtM has become one of the major innovation drivers for a very broad spectrum of societally relevant applications.

There has been increased interest recently for using nanoscale beyond-CMOS devices in the More Moore and MtM domains:

– miniaturization remains a major enabler for price reduction, functionality multiplication and integration with electronics;

– the CMOS technology is facing dramatic challenges for future low power, high performance and memory applications;

– nanoscale beyond-CMOS structures can improve devices’ intrinsic performance and enable new functionalities.

Nanotechnologies will also offer powerful ways to bring added value, in terms of cost, reproducibility, sensitivity, automation, analysis and new functionality in healthcare applications such as *in vitro* diagnostics or drug delivery, as well as in environment control (water, air, soil), agriculture and food, transport monitoring, ambient intelligence, defense or homeland