Special Issue on Future Trends in Nanocomputing

Message of Guest Editors

The slow but steady ending of Moore's Law indicates the end of an era in which the increase of computational performance was mainly due to technology downscaling. On the other hand, expectations on integrated circuit industry are rising with tremendous speed. The promises of deep learning, big data, internet-of-things, autonomous driving, cryptocurrencies, wearables and many others demands solutions that take todays technologies to its borders. This motivated vast amount of research on novel emerging technologies, with promising and outstanding characteristics.

This special edition presents seven invited works that focus on different aspects of the design with emerging technologies. With silicon facing barriers to the future development of traditional CMOS technology, it is now time to think ahead and look for new alternatives that can add exciting new characteristics to future applications. In this sense, new materials and substrates must be investigated. Some of them enable the development of fast and low power switching devices that represents digital state by different physical properties, such as optical excitation, magnetic field, and phase state. Associated with that, new non-von Neumann computing architectures can be explored, including computing-in-memory that minimizes the problems associated to data transfer between memory and logic units. In the following, we present a short description of the papers appearing in this Special Issue.

Ardesi, Gaeta, Beretta, Piccinini and M. Graziano focus on the requirement that promising and new nanotechnologies must be analyzed under the consideration of real physical effects. Therefore, the authors present an *ab initio* molecular dynamics simulations of field-coupled nanocomputing molecules. In contrast to common works, the authors assume that the position of atoms, and thus, the geometry of the whole structure, is not fixed but subjected to molecular vibrations. This more realistic scenario allows interesting insights into the behavior of these nanodevices and provides important feedback both from a modelling and a practical perspective.

Formigoni, Ferreira and Nacif focus on one higher level and present a survey on placement and routing for different field-coupling nanotechnologies (FCN). The authors review the operation of two main FCN and how the clock acts on the circuit control and synchronization. Finally, they described in details several strategies for the placement and routing of these devices in order to obtain optimized circuits. This is a crucial step to the advancement of the technology.

Guimarães and Câmara concentrate on circuit level studies and present digital circuits and systems based on single-electron tunneling technology. In contrast to other works, the authors discuss an actual design methodology, a mandatory requirement for advanced circuit and system design. The applicability of the proposed methodology is not only applied for combinational and sequential circuits, but also SRAM structures. The obtained results indicate the potential of large-scale circuits and systems based on this nanotechnology SET in terms of robustness, area, and power consumption.

Caballero and Vilela Neto focus on the rather surprising application of photonic crystals for nanocomputing. The authors review the most important techniques to build logic devices in photonic crystals, and thus, indicate the considerable advances that have been in recent years

for this nanotechnology. Furthermore, the authors provide a valuable comparison of the characteristics of each method, which will support future developments of photonic crystals integrated logic devices and circuit.

Reis, Niemier and Hu focus on the important and promising idea of Computing-in-memory. Therefore, the authors discuss the implications of ferroelectric FET (FeFET) device models to the design of computing-in-memory architectures. The study compares two kinds of FeFET devices that enable significant improvements in terms of energy and delay or in terms of density when compared with the standard SRAM technology. This clearly indicates the application-level benefits one can expect from this technology in the future.

Dias and Butzen survey the developments in regard to memresistors, an emerging technology that received recently wide attention. Starting from discussion on devices level, the authors present relevant models and applications. The survey focuses on several designs, e.g. on-chip memory and digital circuits, and emphasizes that memresistors meet the requirements for the implementation of neuromorphic computing.

Neutzling and Ribas concentrate on a fundamental requirement for the large-scale design of each emerging technology – the logic synthesis. Therefore, the authors review different methods for threshold logic synthesis, which is highly suitable for emerging technologies. Additionally, the authors employ experimental data to illustrate and compare the performance of the state-of-the- art logic synthesis methods, and thus, provide valuable fundamentals for future developments and applications.

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