Nanoscale Memristor Device As Synapse In Neuromorphic Systems

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Memristor and Memristive Neural Networks

Memristor and Memristive Neural Networks for Brain-Inspired Computing
Nanoscale Networking and Communications Handbook
Advances in Neural Networks - ISNN 2016
Bio-inspired Computing: Theories and Applications
Memristors
Neuromorphic Devices for Brain-inspired Computing
Memristors and Memristive Systems
Advances in Neuromorphic Hardware Exploiting Emerging Nanoscale Devices
Photo-Electroactive Non-Volatile Memories for Data Storage and Neuromorphic Computing
Advances in Memristors, Memristive Devices and Systems
Micro- and Nanoelectronics
VLSI-SoC: System-on-Chip in the Nanoscale Era
Design, Verification and Reliability
Advances in Neural Networks - ISNN 2018
Electric-Double-Layer Coupled Oxide-Based Neuromorphic Transistors
Studies
Fiber Electronics
Memristor Networks
Advances in Unconventional Computing
Advances in Non-volatile Memory and Storage Technology
Enabling Technologies for Very Large-Scale Synaptic Electronics
Memristor Technology: Synthesis and Modeling for Sensing and Security Applications
Advances in Computational Intelligence
Ferroelectricity in Doped Hafnium Oxide
Emerging Memory and Computing Devices in the Era of Intelligent Machines
Synaptic Plasticity for Neuromorphic Systems
Development of Memristor Based Circuits
Transport Phenomena in Micro- and Nanoscale Functional Materials
and Devices
Handbook of Memristor Networks
Advances in Neural Networks: Computational and Theoretical Issues
Network Science and Cybersecurity
Springer Handbook of Computational Intelligence
Emerging Non-volatile Memory Technologies
13th Chaotic Modeling and Simulation International Conference
Neural Information Processing
Recent Development in Optoelectronic Devices
Memristors for Neuromorphic Circuits and Artificial Intelligence Applications
Nanoelectronic Materials, Devices and Modeling
Advances in Neuromorphic Memristor Science and Applications

Memristor and Memristive Neural Networks

This book collects research works that exploit neural networks and machine learning techniques from a multidisciplinary perspective. Subjects covered include theoretical, methodological and computational topics which are grouped together into chapters devoted to the discussion of novelties and innovations related to the field of Artificial Neural Networks as well as the use of neural networks for applications, pattern recognition, signal processing, and special topics such as the detection and recognition of multimodal emotional expressions and daily cognitive functions, and bio-inspired memristor-based networks.

Providing insights into the latest research interest from a pool of international experts coming from different research fields, the volume becomes valuable to all those with any interest in a holistic approach to implement believable, autonomous, adaptive and context-aware Information Communication Technologies.

Memristive Devices for Brain-Inspired Computing

Nanoscale Networking and Communications Handbook

Artificial Intelligence (AI) has found many applications in the past decade due to the ever increasing computing power. Artificial Neural Networks are inspired in the brain structure and consist in the interconnection of artificial neurons through artificial synapses. Training these systems requires huge amounts of data and, after the network is trained, it can recognize unforeseen data and provide useful information. The so-called Spiking Neural Networks behave similarly to how the brain functions and are very energy efficient. Up to this moment, both spiking and conventional neural networks have been implemented in software programs running on conventional computing units. However, this approach requires high computing power, a large physical space and is energy inefficient. Thus, there is an increasing interest in developing AI tools directly implemented in hardware. The first hardware demonstrations have been based on CMOS circuits for neurons and specific communication protocols for synapses. However, to further increase training speed and energy efficiency while decreasing system size, the combination of CMOS neurons with memristor synapses is being explored. The memristor is a resistor with memory which behaves similarly to biological synapses. This book explores the state-of-the-art of neuromorphic circuits implementing neural networks with memristors for AI applications.

Advances in Neural Networks - ISNN 2016

This comprehensive handbook serves as a professional reference as well as a practitioner's guide to today's most complete and concise view of nanoscale networking and communications. It offers in-depth coverage of theory, technology, and practice as they relate to established technologies and recent advancements. It explores practical solutions to a wide range of nanoscale networking and communications issues. Individual chapters, authored by leading experts in the field, address the immediate and long-term challenges in the authors' respective areas of expertise.

Bio-inspired Computing: Theories and Applications

As CMOS scaling is approaching the fundamental physical limits, a wide range of new nanoelectronic materials and devices have been proposed and explored to extend and/or replace the current electronic devices and circuits so as to maintain progress with respect to speed and integration density. The major limitations, including low carrier mobility, degraded
subthreshold slope, and heat dissipation, have become more challenging to address as the size of silicon-based metal oxide semiconductor field effect transistors (MOSFETs) has decreased to nanometers, while device integration density has increased. This book aims to present technical approaches that address the need for new nanoelectronic materials and devices. The focus is on new concepts and knowledge in nanoscience and nanotechnology for applications in logic, memory, sensors, photonics, and renewable energy. This research on nanoelectronic materials and devices will be instructive in finding solutions to address the challenges of current electronics in switching speed, power consumption, and heat dissipation and will be of great interest to academic society and the industry.

**Memristors**

This book reports on the latest advances in and applications of memristors, memristive devices and systems. It gathers 20 contributed chapters by subject experts, including pioneers in the field such as Leon Chua (UC Berkeley, USA) and R.S. Williams (HP Labs, USA), who are specialized in the various topics addressed in this book, and covers broad areas of memristors and memristive devices such as: memristor emulators, oscillators, chaotic and hyperchaotic memristive systems, control of memristive systems, memristor-based min-max circuits, canonic memristors, memristive-based neuromorphic applications, implementation of memristor-based chaotic oscillators, inverse memristors, linear memristor devices, delayed memristive systems, flux-controlled memristive emulators, etc. Throughout the book, special emphasis is given to papers offering practical solutions and design, modeling, and implementation insights to address current research problems in memristors, memristive devices and systems. As such, it offers a valuable reference book on memristors and memristive devices for graduate students and researchers with a basic knowledge of electrical and control systems engineering.

**Neuromorphic Devices for Brain-inspired Computing**

This book offers a balanced and comprehensive guide to the core principles, fundamental properties, experimental approaches, and state-of-the-art applications of two major groups of emerging non-volatile memory technologies, i.e. spintronics-based devices as well as resistive switching devices, also known as Resistive Random Access Memory (RRAM). The first section presents different types of spintronic-based devices, i.e. magnetic tunnel junction (MTJ), domain wall, and skyrmion memory devices. This section describes how their developments have led to various promising applications, such as microwave oscillators, detectors, magnetic logic, and neuromorphic engineered systems. In the second half of the book, the underlying device physics supported by different experimental observations and modelling of RRAM devices are presented with memory array level implementation. An insight into RRAM desired properties as synaptic element in neuromorphic computing platforms from material and algorithms viewpoint is also discussed with specific example in automatic sound classification framework.

**Memristors and Memristive Systems**

Explains current co-design and co-optimization methodologies for building hardware neural networks and algorithms for machine learning applications. This book focuses on how to build energy-efficient hardware for neural networks with learning capabilities—and provides co-design and co-optimization methodologies for building hardware neural networks that can learn. Presenting a complete picture from high-level algorithm to low-level implementation details, Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design also covers many fundamentals and essentials in neural networks (e.g., deep learning), as well as hardware implementation of neural networks. The book begins with an overview of neural networks. It then discusses algorithms for utilizing and training rate-based artificial neural networks. Next comes an introduction to various options for executing neural networks, ranging from general-purpose processors to specialized hardware, from digital accelerator to analog accelerator. A design example on building energy-efficient accelerator for adaptive dynamic programming with neural networks is also presented. An examination of fundamental concepts and popular learning algorithms for spiking neural networks follows that, along with a look at the hardware for spiking neural networks. Then comes a chapter offering readers three design examples (two of which are based on conventional CMOS, and one on emerging nanotechnology) to implement the learning algorithm found in the previous chapter. The book concludes with an outlook on the future of neural network hardware. Includes cross-layer survey of hardware accelerators for neuromorphic algorithms. Covers the co-design of architecture and algorithms with emerging devices for much-improved computing efficiency. Focuses on the co-design of algorithms and hardware, which is especially critical for using emerging devices, such as traditional memristors or diffusive memristors, for neuromorphic computing. Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design is an ideal resource for researchers, scientists, software engineers, and hardware engineers dealing with the ever-increasing requirement on power consumption and response time. It is also excellent for teaching and training undergraduate and graduate students about the latest generation neural networks with powerful learning capabilities.

**Advances in Neuromorphic Hardware Exploiting Emerging Nanoscale Devices**

This book provides a comprehensive overview of current research on memristors, memcapacitors and, meminductors. In addition to an historical overview of the research in this area, coverage includes the theory behind memristive circuits, as well as memcapacitance, and meminductance. Details are shown for recent applications of memristors for resistive random access memories, neuromorphic systems and hybrid CMOS/memristor circuits. Methods for the simulation of memristors are demonstrated and an introduction to neuromorphic modeling is provided.
Memristive Devices for Brain-Inspired Computing: From Materials, Devices, and Circuits to Applications—Computational Memory, Deep Learning, and Spiking Neural Networks reviews the latest in material and devices engineering for optimizing memristive devices beyond storage applications and toward brain-inspired computing. The book provides readers with an understanding of four key concepts, including materials and device aspects with a view of current materials systems and their remaining barriers, algorithmic aspects comprising basic concepts of neuroscience as well as various computing concepts, the circuits and architectures implementing those algorithms based on memristive technologies, and target applications, including brain-inspired computing, computational memory, and deep learning. This comprehensive book is suitable for an interdisciplinary audience, including materials scientists, physicists, electrical engineers, and computer scientists. Provides readers an overview of four key concepts in this emerging research topic including materials and device aspects, algorithmic aspects, circuits and architectures and target applications Covers a broad range of applications, including brain-inspired computing, computational memory, deep learning and spiking neural networks Includes perspectives from a wide range of disciplines, including materials science, electrical engineering and computing, providing a unique interdisciplinary look at the field

Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design

This book constitutes the refereed proceedings of the 15th International Symposium on Neural Networks, ISNN 2018, held in Minsk, Belarus in June 2018. The 98 revised regular papers presented in this volume were carefully reviewed and selected from 214 submissions. The papers cover many topics of neural network-related research including intelligent control, neurodynamic analysis, bio-signal, bioinformatics and biomedical engineering, clustering, classification, forecasting, models, algorithms, cognitive computation, machine learning, and optimization.

Photo-Electroactive Non-Volatile Memories for Data Storage and Neuromorphic Computing

Physical implementation of the memristor at industrial scale sparked the interest from various disciplines, ranging from physics, nanotechnology, electrical engineering, neuroscience, to intelligent robotics. As any promising new technology, it has raised hopes and questions; it is an extremely challenging task to live up to the high expectations and to devise revolutionary and feasible future applications for memristive devices. The possibility of gathering prominent scientists in the heart of the Silicon Valley given by the 2011 International Joint Conference on Neural Networks held in San Jose, CA, has offered us the unique opportunity of organizing a series of special events on the present status and future perspectives in neuromorphic memristor science. This book presents a selection of the remarkable contributions given by the leaders of the field and it may serve as inspiration and future reference to all researchers that want to explore the extraordinary possibilities given by this revolutionary concept.

Advances in Memristors, Memristive Devices and Systems

This two-volume set (CCIS 1159 and CCIS 1160) constitutes the proceedings of the 14th International Conference on Bio-Inspired Computing: Theories and Applications, BIC-TA 2019, held in Zhengzhou, China, in November 2019. The 122 full papers presented in both volumes were selected from 197 submissions. The papers in the two volumes are organized according to the topical headings: evolutionary computation and swarm intelligence; bioinformatics and systems biology; complex networks; DNA and molecular computing; neural networks and artificial intelligence.

Micro- and Nanoelectronics

Computing systems are undergoing a transformation from logic-centric towards memory-centric architectures, where overall performance and energy efficiency at the system level are determined by the density, performance, functionality and efficiency of the memory, rather than the logic sub-system. This is driven by the requirements of data-intensive applications in artificial intelligence, autonomous systems, and edge computing. We are at an exciting time in the semiconductor industry where several innovative device and technology concepts are being developed to respond to these demands, and capture shares of the fast growing market for AI-related hardware. This special issue is devoted to highlighting, discussing and presenting the latest advancements in this area, drawing on the best work on emerging memory devices including magnetic, resistive, phase change, and other types of memory. The special issue is interested in work that presents concepts, ideas, and recent progress ranging from materials, to memory devices, physics of switching mechanisms, circuits, and system applications, as well as progress in modeling and design tools. Contributions that bridge across several of these layers are especially encouraged.

VLSI-SoC: System-on-Chip in the Nanoscale Era - Design, Verification and Reliability

This edited Volume Memristors - Circuits and Applications of Memristor Devices is a collection of reviewed and relevant research chapters, offering a comprehensive overview of recent developments in the field of Engineering. The book comprises single chapters authored by various researchers and edited by an expert active in the physical sciences, engineering, and technology research areas. All chapters are complete in itself but united under a common research study topic. This publication aims at providing a thorough overview of the latest research efforts by international authors on physical sciences, engineering, and technology, and open new possible research paths for further novel developments.

Advances in Neural Networks - ISNN 2018
This book highlights the main advances in fiber electronics, like fiber-shaped solar cells, batteries, supercapacitors, sensors, light-emitting devices, memristors and communication devices from the standpoints of material synthesis, structure design and property enhancement. It focuses on revealing the separation and transport mechanisms of charges, establishing transport equations for electrons and ions, and emphasizing integration methods in fiber devices. In closing, it reviews emerging applications based on fiber devices that could accelerate their large-scale production in the near future. Given its scope, the book offers a valuable resource for scientists, engineers, graduate students and undergraduate students in a wide variety of fields such as advanced materials, energy, electrochemistry, applied physics, nanoscience and nanotechnology, polymer science and engineering and biomedical science. It also benefits many non-specialist industrialists who are working to promote new technologies.

**Electric-Double-Layer Coupled Oxide-Based Neuromorphic Transistors Studies**

The unconventional computing is a niche for interdisciplinary science, cross-bred of computer science, physics, mathematics, chemistry, electronic engineering, biology, material science and nanotechnology. The aims of this book are to uncover and exploit principles and mechanisms of information processing in and functional properties of physical, chemical and living systems to develop efficient algorithms, design optimal architectures and manufacture working prototypes of future and emergent computing devices. This second volume presents experimental laboratory prototypes and applied computing implementations. Emergent molecular computing is presented by enzymatic logical gates and circuits, and DNA nano-devices. Reaction-diffusion chemical computing is exemplified by logical circuits in Belousov-Zhabotinsky medium and geometrical computation in precipitating chemical reactions. Logical circuits realised with solitons and impulses in polymer chains show advances in collision-based computing. Photo-chemical and memristive devices give us a glimpse on hot topics of a novel hardware. Practical computing is represented by algorithms of collective and immune-computing and nature-inspired optimisation. Living computing devices are implemented in real and simulated cells, regenerating organisms, plant roots and slime mould. The book is the encyclopedia, the first ever complete authoritative account, of the theoretical and experimental findings in the unconventional computing written by the world leaders in the field. All chapters are self-contains, no specialist background is required to appreciate ideas, findings, constructs and designs presented. This treatise in unconventional computing appeals to readers from all walks of life, from high-school pupils to university professors, from mathematicians, computers scientists and engineers to chemists and biologists.

**Fiber Electronics**

The primary aim of this book is to discuss various aspects of nanoscale device design and their applications including transport mechanism, modeling, and circuit applications. Provides a platform for modeling and analysis of state-of-the-art devices in nanoscale regime, reviews issues related to optimizing the sub-nanometer device performance and addresses simulation aspect and/or fabrication process of devices. Also, includes design problems at the end of each chapter.

**Memristor Networks**

This book provides readers with a single-source guide to fabricate, characterize and model memristor devices for sensing applications. The authors describe a correlated, physics-based model to simulate and predict the behavior of devices fabricated with different oxide materials, active layer thickness, and operating temperature. They discuss memristors from various perspectives, including working mechanisms, different synthesis methods, characterization procedures, and device employment in radiation sensing and security applications.

**Advances in Unconventional Computing**

An important part of the colossal effort associated with the understanding of the brain involves using electronics hardware technology in order to reproduce biological behavior in silico'. The idea revolves around leveraging decades of experience in the electronics industry as well as new biological findings that are employed towards reproducing key behaviors of fundamental elements of the brain (notably neurons and synapses) at far greater speed-scale products than any software-only implementation can achieve for the given level of modelling detail. So far, the field of neuromorphic engineering has proven itself as a major source of innovation towards the 'silicon brain' goal, with the methods employed by its community largely focused on circuit design (analogue, digital and mixed signal) and standard, commercial, Complementary Metal-Oxide Silicon (CMOS) technology as the preferred 'tools of choice' when trying to simulate or emulate biological behavior. However, alongside the circuit-oriented sector of the community there exists another community developing new electronic technologies with the express aim of creating advanced devices, beyond the capabilities of CMOS, that can intrinsically simulate neuron- or synapse-like behavior. A notable example concerns nanoelectronic devices responding to well-defined input signals by suitably changing their internal state ('weight'), thereby exhibiting 'synapse-like' plasticity. This is in stark contrast to circuit-oriented approaches where the 'synaptic weight' variable has to be first stored, typically as charge on a capacitor or digitally, and then appropriately changed via complicated circuitry. The shift of very much complexity from circuitry to devices could potentially be a major enabling factor for very-large scale 'synaptic electronics', particularly if the new devices can be operated at much lower power budgets than their corresponding 'traditional' circuit replacements. To bring this promise to fruition, synergy between the well-established practices of the circuit-oriented approach and the vastness of possibilities opened by the advent of novel nanoelectronic devices with rich internal dynamics is absolutely essential and will create the opportunity for radical innovation in both fields. The result of such synergy can be of potentially staggering impact to the progress of our efforts to both simulate the brain and ultimately understand it. In this Research Topic, we wish to provide an overview of what
contributes state-of-the-art in terms of enabling technologies for very large scale synaptic electronics, with particular stress on innovative nanoelectronic devices and circuit/system design techniques that can facilitate the development of very large scale brain-inspired electronic systems

**Advances in Non-volatile Memory and Storage Technology**

This book constitutes the refereed proceedings of the 13th International Symposium on Neural Networks, ISNN 2016, held in St. Petersburg, Russia in July 2016. The 84 revised full papers presented in this volume were carefully reviewed and selected from 104 submissions. The papers cover many topics of neural network-related research including signal and image processing; dynamical behaviors of recurrent neural networks; intelligent control; clustering, classification, modeling, and forecasting; evolutionary computation; and cognition computation and spiking neural networks.

**Enabling Technologies for Very Large-Scale Synaptic Electronics**

Summary: "As memristors are not yet on the market, the development of memristor emulators and memristor based circuits is very important for real and practical engineering applications. The objectives of this book are to review the basic concepts of the memristor, describe state-of-the-art memristor based circuits and to stimulate further research and development in this area."--Preface.

**Memristor Technology: Synthesis and Modeling for Sensing and Security Applications**

Photo-Electroactive Non-Volatile Memories for Data Storage and Neuromorphic Computing summarizes advances in the development of photo-electroactive memories and neuromorphic computing systems, suggests possible solutions to the challenges of device design, and evaluates the prospects for commercial applications. Sections covers developments in electro-photoactive memory, and photonic neuromorphic and in-memory computing, including discussions on design concepts, operation principles and basic storage mechanism of optoelectronic memory devices, potential materials from organic molecules, semiconductor quantum dots to two-dimensional materials with desirable electrical and optical properties, device challenges, and possible strategies. This comprehensive, accessible and up-to-date book will be of particular interest to graduate students and researchers in solid-state electronics. It is an invaluable systematic introduction to the memory characteristics, operation principles and storage mechanisms of the latest reported electro-photoactive memory devices. Reviews the most promising materials to enable emerging computing memory and data storage devices, including one- and two-dimensional materials, metal oxides, semiconductors, organic materials, and more Discusses fundamental mechanisms and design strategies for two- and three-terminal device structures Addresses device challenges and strategies to enable translation of optical and optoelectronic technologies

**Advances in Computational Intelligence**

This book contains extended and revised versions of the best papers presented at the 24th IFIP WG 10.5/IEEE International Conference on Very Large Scale Integration, VLSI-SoC 2016, held in Tallinn, Estonia, in September 2016. The 11 papers included in the book were carefully reviewed and selected from the 36 full papers presented at the conference. The papers cover a wide range of topics in VLSI technology and advanced research. They address the latest scientific and industrial results and developments as well as future trends in the field of System-on-Chip (SoC) Design.

**Ferroelectricity in Doped Hafnium Oxide**

This book covers a range of models, circuits and systems built with memristor devices and networks in applications to neural networks. It is divided into three parts: (1) Devices, (2) Models and (3) Applications. The resistive switching property is an important aspect of the memristors, and there are several designs of this discussed in this book, such as in metal oxide/organic semiconductor nonvolatile memories, nanoscale switching and degradation of resistive random access memory and graphene oxide-based memristor. The modelling of the memristors is required to ensure that the devices can be put to use and improve emerging application. In this book, various memristor models are discussed, from a mathematical framework to implementations in SPICE and verilog, that will be useful for the practitioners and researchers to get a grounding on the topic. The applications of the memristor models in various neuromorphic networks are discussed covering various neural network models, implementations in A/D converter and hierarchical temporal memories.

**Emerging Memory and Computing Devices in the Era of Intelligent Machines**

Ferroelectricity in Doped Hafnium Oxide: Materials, Properties and Devices covers all aspects relating to the structural and electrical properties of HfO2 and its implementation into semiconductor devices, including a comparison to standard ferroelectric materials. The ferroelectric and field-induced ferroelectric properties of HfO2-based films are considered promising for various applications, including non-volatile memories, negative capacitance field-effect-transistors, energy storage, harvesting, and solid-state cooling. Fundamentals of ferroelectric and piezoelectric properties, HfO2 processes, and the impact of dopants on ferroelectric properties are also extensively discussed in the book, along with phase transition, switching kinetics, epitaxial growth, thickness scaling, and more. Additional chapters consider the modeling of ferroelectric phase transformation, structural characterization, and the differences and similarities between HfO2 and standard ferroelectric
materials. Finally, HfO2 based devices are summarized. Explores all aspects of the structural and electrical properties of HfO2, including processes, modelling and implementation into semiconductor devices Considers potential applications including FeCaps, FeFETs, NCFETs, FTJs and more Provides comparison of an emerging ferroelectric material to conventional ferroelectric materials with insights to the problems of downscaling that conventional ferroelectrics face

**Synaptic Plasticity for Neuromorphic Systems**

This Handbook presents all aspects of memristor networks in an easy to read and tutorial style. Including many colour illustrations, it covers the foundations of memristor theory and applications, the technology of memristive devices, revised models of the Hodgkin-Huxley Equations and ion channels, neuromorphic architectures, and analyses of the dynamic behaviour of memristive networks. It also shows how to realise computing devices, non-von Neumann architectures and provides future building blocks for deep learning hardware. With contributions from leaders in computer science, mathematics, electronics, physics, material science and engineering, the book offers an indispensable source of information and an inspiring reference text for future generations of computer scientists, mathematicians, physicists, material scientists and engineers working in this dynamic field.

**Development of Memristor Based Circuits**

This two-volume set LNCS 7902 and 7903 constitutes the refereed proceedings of the 12th International Work-Conference on Artificial Neural Networks, IWANN 2013, held in Puerto de la Cruz, Tenerife, Spain, in june 2013. The 116 revised papers were carefully reviewed and selected from numerous submissions for presentation in two volumes. The papers explore sections on mathematical and theoretical methods in computational intelligence, neurocomputational formulations, learning and adaptation emulation of cognitive functions, bio-inspired systems and neuro-engineering, advanced topics in computational intelligence and applications

**Transport Phenomena in Micro- and Nanoscale Functional Materials and Devices**

Micro- and Nanoelectronics: Emerging Device Challenges and Solutions presents a comprehensive overview of the current state of the art of micro- and nanoelectronics, covering the field from fundamental science and material properties to novel ways of making nanodevices. Containing contributions from experts in both industry and academia, this cutting-edge text: Discusses emerging silicon devices for CMOS technologies, fully depleted device architectures, characteristics, and scaling Explains the specifics of silicon compound devices (SiGe, SiC) and their unique properties Explores various options for post-CMOS nanoelectronics, such as spintronic devices and nancionic switches Describes the latest developments in carbon nanotubes, iii-v devices structures, and more Micro- and Nanoelectronics: Emerging Device Challenges and Solutions provides an excellent representation of a complex engineering field, examining emerging materials and device architecture alternatives with the potential to shape the future of nanotechnology.

**Handbook of Memristor Networks**

The book “Recent Developments in Optoelectronic Devices” is about the latest developments in optoelectronics. This book is divided into three categories: light emitting devices, sensors, and light harvesters. This book also discusses the theoretical aspects of device design for iridium complexes as organic light emitting diodes (OLEDs), strategies for developing novel nanostructured materials, silicon-rich oxide (SRO) electroluminescent devices, and multifunctional optoelectronic devices developed on resistive switching effects. The worldwide participation of authors has contributed to the unifying effect of science. Furthermore, interested readers will also find information on the screen printed technology using semiconductor devices, nonlinear phenomena in quantum devices, experimental set up of optoelectronics flexible logic gate to realize logic operations, autonomous vehicles, and the latest developments in perovskites as solar cells.

**Advances in Neural Networks: Computational and Theoretical Issues**

Explore the cutting-edge of neuromorphic technologies with applications in Artificial Intelligence In Neuromorphic Devices for Brain-Inspired Computing. Artificial Intelligence, Perception, and Robotics, a team of expert engineers delivers a comprehensive discussion of all aspects of neuromorphic electronics designed to assist researchers and professionals to understand and apply all manner of brain-inspired computing and perception technologies. The book covers both memristic and neuromorphic devices, including spintronic, multi-terminal, and neuromorphic perceptual applications. Summarizing recent progress made in five distinct configurations of brain-inspired computing, the authors explore this promising technology’s potential applications in two specific areas: neuromorphic computing systems and neuromorphic perceptual systems. The book also includes: A thorough introduction to two-terminal neuromorphic memristors, including memristive devices and resistive switching mechanisms Comprehensive explorations of spintronic neuromorphic devices and multi-terminal neuromorphic devices with cognitive behaviors Practical discussions of neuromorphic devices based on chalcogenide and organic materials In-depth examinations of neuromorphic computing and perceptual systems with emerging devices Perfect for materials scientists, biochemists, and electronics engineers, Neuromorphic Devices for Brain-Inspired Computing: Artificial Intelligence, Perception, and Robotics will also earn a place in the libraries of neurochemists, neurobiologists, and neurophysiologists.
Network Science and Cybersecurity

Advances in Nonvolatile Memory and Storage Technology, Second Edition, addresses recent developments in the non-volatile memory spectrum, from fundamental understanding, to technological aspects. The book provides up-to-date information on the current memory technologies as related by leading experts in both academia and industry. To reflect the rapidly changing field, many new chapters have been included to feature the latest in RRAM technology, STT-RAM, memristors and more. The new edition describes the emerging technologies including oxide-based ferroelectric memories, MRAM technologies, and 3D memory. Finally, to further widen the discussion on the applications space, neuromorphic computing aspects have been included. This book is a key resource for postgraduate students and academic researchers in physics, materials science and electrical engineering. In addition, it will be a valuable tool for research and development managers concerned with electronics, semiconductors, nanotechnology, solid-state memories, magnetic materials, organic materials and portable electronic devices. Discusses emerging devices and research trends, such as neuromorphic computing and oxide-based ferroelectric memories Provides an overview on developing nonvolatile memory and storage technologies and explores their strengths and weaknesses Examines improvements to flash technology, charge trapping and resistive random access memory

Springer Handbook of Computational Intelligence

The three-volume set of LNCS 11953, 11954, and 11955 constitutes the proceedings of the 26th International Conference on Neural Information Processing, ICONIP 2019, held in Sydney, Australia, in December 2019. The 173 full papers presented were carefully reviewed and selected from 645 submissions. The papers address the emerging topics of theoretical research, empirical studies, and applications of neural information processing techniques across different domains. The second volume, LNCS 11954, is organized in topical sections on image processing by neural techniques; learning from incomplete data; model compression and optimisation; neural learning models; neural network applications; and social network computing.

Emerging Non-volatile Memory Technologies

This book focuses on essential synaptic plasticity emulations and neuromorphic computing applications realized with the aid of three-terminal synaptic devices based on ion-coupled oxide-based electric-double-layer (EDL) transistors. To replicate the robust, plastic and fault-tolerant computational power of the human brain, the emulation of essential synaptic plasticity and computation of neurons/synapse by electronic devices are generally considered to be key steps. The book shows that the formation of an EDL at the dielectric/channel interface that slightly lags behind the stimuli can be attributed to the electrostatic coupling between ions and electrons; this mechanism underlies the emulation of short-term synaptic behaviors. Furthermore, it demonstrates that electrochemical doping/dedoping processes in the semiconducting channel by penetrated ions from electrolyte can be utilized for the emulation of long-term synaptic behaviors. Lastly, it applies these synaptic transistors in an artificial visual system to demonstrate the potential for constructing neuromorphic systems. Accordingly, the book offers a unique resource on understanding the brain-machine interface, brain-like chips, artificial cognitive systems, etc.

13th Chaotic Modeling and Simulation International Conference

The Springer Handbook for Computational Intelligence is the first book covering the basics, the state-of-the-art and important applications of the dynamic and rapidly expanding discipline of computational intelligence. This comprehensive handbook makes readers familiar with a broad spectrum of approaches to solve various problems in science and technology. Possible approaches include, for example, those being inspired by biology, living organisms and animate systems. Content is organized in seven parts: foundations; fuzzy logic; rough sets; evolutionary computation; neural networks; swarm intelligence and hybrid computational intelligence systems. Each Part is supervised by its own Part Editor(s) so that high-quality content as well as completeness are assured.

Neural Information Processing

Network Science and Cybersecurity introduces new research and development efforts for cybersecurity solutions and applications taking place within various U.S. Government Departments of Defense, industry and academic laboratories. This book examines new algorithms and tools, technology platforms and reconfigurable technologies for cybersecurity systems. Anomaly-based intrusion detection systems (IDS) are explored as a key component of any general network intrusion detection service, complementing signature-based IDS components by attempting to identify novel attacks. These attacks may not yet be known or have well-developed signatures. Methods are also suggested to simplify the construction of metrics in such a manner that they retain their ability to effectively cluster data, while simultaneously easing human interpretation of outliers. This is a professional book for practitioners or government employees working in cybersecurity, and can also be used as a reference. Advanced-level students in computer science or electrical engineering studying security will also find this book useful.

Recent Development in Optoelectronic Devices

This book covers all major aspects of cutting-edge research in the field of neuromorphic hardware engineering involving emerging nanoscale devices. Special emphasis is given to leading works in hybrid low-power CMOS-Nanodevice design. The book offers readers a bidirectional (top-down and bottom-up) perspective on designing efficient bio-inspired hardware. At the
nanodevice level, it focuses on various flavors of emerging resistive memory (RRAM) technology. At the algorithm level, it addresses optimized implementations of supervised and stochastic learning paradigms such as: spike-time-dependent plasticity (STDP), long-term potentiation (LTP), long-term depression (LTD), extreme learning machines (ELM) and early adoptions of restricted Boltzmann machines (RBM) to name a few. The contributions discuss system-level power/energy/parasitic trade-offs, and complex real-world applications. The book is suited for both advanced researchers and students interested in the field.

Memristors for Neuromorphic Circuits and Artificial Intelligence Applications

Transport Phenomena in Micro- and Nanoscale Functional Materials and Devices offers a pragmatic view on transport phenomena for micro- and nanoscale materials and devices, both as a research tool and as a means to implant new functions in materials. Chapters emphasize transport properties (TP) as a research tool at the micro/nano level and give an experimental view on underlying techniques. The relevance of TP is highlighted through the interplay between a micro/nanocarrier’s characteristics and media characteristics: long/short-range order and disorder excitations, couplings, and in energy conversions. Later sections contain case studies on the role of transport properties in functional nanomaterials. This includes transport in thin films and nanostructures, from nanogranular films, to graphene and 2D semiconductors and spintronics, and from read heads, MRAMs and sensors, to nano-oscillators and energy conversion, from figures of merit, micro-coolers and micro-heaters, to spincaloritronics. Presents a pragmatic description of electrical transport phenomena in micro- and nanoscale materials and devices from an experimental viewpoint Provides an in-depth overview of the experimental techniques available to measure transport phenomena in micro- and nanoscale materials Features case studies to illustrate how each technique works Highlights emerging areas of interest in micro- and nanomaterial transport phenomena, including spintronics

Nanoelectronic Materials, Devices and Modeling

Using memristors one can achieve circuit functionalities that are not possible to establish with resistors, capacitors and inductors, therefore the memristor is of great pragmatic usefulness. Potential unique applications of memristors are in spintronic devices, ultra-dense information storage, neuromorphic circuits and programmable electronics. Memristor Networks focuses on the design, fabrication, modelling of and implementation of computation in spatially extended discrete media with many memristors. Top experts in computer science, mathematics, electronics, physics and computer engineering present foundations of the memristor theory and applications, demonstrate how to design neuromorphic network architectures based on memristor assemblies, analyse varieties of the dynamic behaviour of memristive networks and show how to realise computing devices from memristors. All aspects of memristor networks are presented in detail, in a fully accessible style. An indispensable source of information and an inspiring reference text, Memristor Networks is an invaluable resource for future generations of computer scientists, mathematicians, physicists and engineers.

Advances in Neuromorphic Memristor Science and Applications

One of the most striking properties of biological systems is their ability to learn and adapt to ever changing environmental conditions, tasks and stimuli. It emerges from a number of different forms of plasticity, that change the properties of the computing substrate, mainly acting on the modification of the strength of synaptic connections that gate the flow of information across neurons. Plasticity is an essential ingredient for building artificial autonomous cognitive agents that can learn to reliably and meaningfully interact with the real world. For this reason, the neuromorphic community at large has put substantial effort in the design of different forms of plasticity and in putting them to practical use. These plasticity forms comprise, among others, Short Term Depression and Facilitation, Homeostasis, Spike Frequency Adaptation and diverse forms of Hebbian learning (e.g. Spike Timing Dependent Plasticity). This special research topic collects the most advanced developments in the design of the diverse forms of plasticity, from the single circuit to the system level, as well as their exploitation in the implementation of cognitive systems.

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