

Preface

Progress in the field of semiconductor electronics continues to have profound influence on human society. In particular, this has led to an unprecedented growth in the information communication technology field, as well as virtually every other field of engineering and technology. Hence, the demand for faster, low cost, and more efficient information processing systems continues to increase at a high rate. Typical trending is primarily driven by the quest to create a ubiquitously connected world and the realization of the Internet of things. Since the establishment of Moore's law in the 1960s, device evolution can be mainly traced by incessant micro-sizing to reach higher processing speed and to facilitate the production of sizeable packing densities at lower fabrication costs. Particularly, "memory" constitutes nowadays more than 60% of the modern processor area, which makes it a major target for device miniaturization. Microprocessors today provide unmatched computing power owing to state-of-art Complementary Metal-Oxide-Semiconductor (CMOS) technology. Nonetheless, further projection of the current CMOS design to satisfy the growing needs for higher processing capacity and larger data size while miniaturizing device scale has now reached its practical limits. Key challenges arise from extending the performance capstone of actual devices in terms of leakage current, power consumption, and switching speed, when the main constraint is often attributed to structure, outside the peculiar capabilities of the CMOS material itself. Hence, technological breakthroughs pushing forward novel device configurations are highly desirable to achieve new scalable platforms that would outperform the classic CMOS design or to extend the lifetime of CMOS in a hybrid technology. Nowadays, researchers in the field of micro- or nanoelectronics are focusing their attention on (Resistive Random Access Memory) RRAM technology as a viable alternative to early CMOS-based approach for device miniaturization.

Memristor devices have a high potential in replacing some of the current technologies used for nonvolatile memory. However, there are still momentous challenges to overcome before this happens. Decisive factors are the integration and reliability of the device, which are substantial for industrial manufacturing. Device implementation currently waits for robust material processing and uniformity

of engineered interfaces, since the device characteristics, such as retention, endurance, and switching speed are immensely affected by the fabrication process. The reliability of the memristor device also needs to be taken into consideration before it can be used at large scale. Testing the device and characterizing its failure modes with respect to temperature, read, and write cycles are so important from a quality control point of view. Another imposed challenge is to have in-depth understanding of the switching mechanism, which will allow for further structural and performance optimization of the device. Developing robust device models that truly reflect the operation of memristors and integrate them with electronic design automation tools is another major challenge. The described challenges have focused the attention of researchers across the various domains related to memristor, which span device fabrication through applications. The intensive research effort over the past few years, in particular, has resulted in many promising solutions that are shaping memristors into a viable future technology.

This book is organized into six chapters with references globally listed at the end. Each chapter carries brief introduction of the work undertaken and is followed by the detailed analysis.

Chapter 1 provides detailed background about the memristor device and delivers an extensive overview of the recent advancements and characteristics of memristive devices.

In Chap. 2, sol-gel/drop-coated micro-thick memristors with different electrode and oxide materials are investigated and developed for low-power sensing.

Chapter 3 reports on a novel crossbar nano-thick memristors comprising an insulator HfO_2 layer, an Hf-metal capping acting as oxygen getter, and top/bottom Pd electrodes, having an asymmetric stack configuration: Pd/Hf/ HfO_2 /Pd. Moreover, the electrical characteristics of the fabricated devices were investigated in terms of the device key parameters, such as the active area, and the oxide/capping layer thicknesses.

Chapter 4 presents the fabrication and characterization of novel crossbar microwire-based device consisting of Nb/NbO/Pt structure exhibiting 1000 times conductivity change with an effective continuum of resistance levels.

Chapter 5 presents the novel radiation sensing concept utilizing the capabilities of the developed TiO_2 micro-thick memristors. Memristive-based secure communication approaches are also provided.

In Chap. 6, a framework is provided to model anionic memristor devices and the effects of oxide thickness, active material type, and device temperature are investigated.

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