Reconfigurable Materials and Devices for Neuromorphic Computing Focus Topic
Room Hall B - Session RM-TuP
Reconfigurable Materials and Devices for Neuromorphic Computing Poster Session

RM-TuP1 Selector-less Crossbar Array through Self-rectifying Characteristic of Pt/HfO_2/Ti Memristor*, Yong Kim, S.Y. Ryu, W.H. Jeong,* Seoul National University of Science and Technology, Republic of Korea*; K.-S. Min,* Kookmin University, Republic of Korea*; B.J. Choi,* Seoul National University of Science and Technology, Republic of Korea

DRAM and flash memory currently being used as working memory devices must be configured with transistors. For this reason, it has been reached the limits of scaling, power consumption and fabrication cost. In order to overcome these limits, next-generation memory devices have been developed and materials/device structures have been studied actively. Memristor could be used as a nonvolatile memory with simple crossbar array (CBA) structure. Although CBA structure is possible to innovatively overcome the scaling limits, it has major problem, so called sneak path current. It is caused by cross talking near the selected cell and typically solved by adding an additional selector device (e.g., diode, transistor, etc.). Recently, self-rectifying memristor could be enabled by bilayer stack, which could much simplifying the CBA structure: selector-less CBA. We fabricated the 10x10 and 30x30 CBA as selector-less memristor device using the potential barrier between each stack of the fabricated MIM structure.

In this study, we have acquired the self-rectifying characteristics for CBA structure using the Pt/HfO_2/Ti device. The device was fabricated 10x10 and 30x30 CBA patterned with 2 – 20 µm of electrode size. The top/bottom electrodes were deposited using electron beam evaporator and the dielectric material was deposited by atomic layer deposition (ALD). HfO_2 layer grown by ALD plays the role of switching layer in memristor. The thickness of the switching layer was quite thin, which eliminates the need for electroforming process. In addition, we obtained the self-rectifying characteristic that does not permit the fluent current conduction under negative bias through the potential barrier between Pt and HfO_2 layer.

As a result of electrical properties, this device follows an interface-type switching mechanism in which the current value decreased as the electrode size decreased. By inserting Al_2O_3 layer of 1 - 2nm, it was confirmed that switching occurs in HfO_2/Ti interface. The size of the formed conductive region was changed through the positive bias and the stability of the rectifying function was verified by applying the negative bias up to -3V. We confirmed the uniformity of memristor cells randomly chosen among 10x10 and 30x30 CBA and verified the device-to-device variability. Cycle-to-cycle variability was also obtained from these cells through a switching of more than 100 cycles. Finally, the AC measurement was applied to explore the possibility of fabricated device as a synaptic device.

RM-TuP2 Electron Beam Induced Current Microscopy of Interfacial Barrier Effects in Al_2O_3/TiO_x Resistive Switches*, Brian Hoskins,* National Institute of Standards and Technology (NIST)*; G. Adam,* National Institute for R&D in Microtechnologies (IMT Bucharest), Romania*; E. Strelcov,* National Institute of Standards and Technology (NIST)/University of Maryland*; A. Kolmakov, N.B. Zhitenev,* National Institute of Standards and Technology (NIST)*; D. Strukov,* University of California at Santa Barbara*; J. McClelland,* National Institute of Standards and Technology (NIST)

Resistive switching devices (ReRAM) represent a broad class of two-terminal continuously tunable resistors including memristors, phase change memory (PCM), valence change memory (VCM), and electrochemical metallization cells (ECM). Though these devices, especially PCM, are increasingly being commercialized by industry for use in next generation memories, they are also all actively studied for use as synaptic weights in next generation hardware-accelerated neuromorphic networks.

We have previously investigated Electron Beam Induced Current Microscopy as a means of reliably characterizing resistive switches. In that investigation, we observed surprising electronic effects, such as internal secondary electron emission, in addition to more traditional electron-hole pair separation, and we broke those up into constituent currents based on their origin through Monte-Carlo modeling of the electron beam-matter interaction.

Now, armed with a new understanding of the physics of EBIC imaging, we study the impact of manufacturing variations on resistive switches by continuously tuning the thickness of an Al_2O_3 interfacial barrier. Shifts in the apparent ratios of internal secondary electron emission from the top electrode to the bottom electrode and vice versa appear to indicate a continuous tuning of the apparent filament diameter as both a function of the injected current and the interfacial barrier thickness. This yields an apparent reduction in the current density, the primary effect of which is a reduction in the device damage from forming and a suppression of parasitic leakage currents imaged in devices without interfacial barriers.

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