Accepted Manuscript

Switching characteristics of microscale unipolar Pd/Hf/HfO2/Pd memristors

Heba Abunahla, Maguy Abi Jaoude, Curtis J. O'Kelly, Yasmin Halawani, Mahmoud Al-Qutayri, Said F. Al-Sarawi, Baker Mohammad

PII: S0167-9317(17)30350-7
DOI: doi:10.1016/j.mee.2017.10.010
Reference: MEE 10643

To appear in: *Microelectronic Engineering*

Received date: 30 May 2017
Revised date: 20 September 2017
Accepted date: 13 October 2017

Please cite this article as: Heba Abunahla, Maguy Abi Jaoude, Curtis J. O'Kelly, Yasmin Halawani, Mahmoud Al-Qutayri, Said F. Al-Sarawi, Baker Mohammad , Switching characteristics of microscale unipolar Pd/Hf/HfO2/Pd memristors. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Mee(2017), doi:10.1016/j.mee.2017.10.010

Switching Characteristics of Microscale Unipolar Pd/Hf/HfO_2/Pd Memristors

Heba Abunahla[1*], Maguy Abi Jaoude[2], Curtis J. O'Kelly[1], Yasmin Halawani[1], Mahmoud Al-Qutayri[1], Said F. Al-Sarawi[3] and Baker Mohammad[1]

[1]Department of Electrical and Computer Engineering, Khalifa University of Science and Technology, Abu Dhabi, 127788, UAE
[2]Department of Applied Mathematics and Sciences, Khalifa University of Science and Technology, Abu Dhabi, 127788, UAE
[3]Centre for Biomedical Engineering, School of Electrical and Electronic Engineering, The University of Adelaide, SA 5000, Australia

*Correspondence to [heba.abunahla@kustar.ac.ae]

ABSTRACT

In this paper, we investigate the switching behavior of nano-thick microscale Pd/Hf/HfO_2-10nm/Pd memristors. Several key electrical characteristics such as the forming voltage and the SET/RESET *I-V* parameters are studied as a function of the device size, the hafnium-capping thickness and the environmental temperature. The fabricated stack exhibits a unipolar switching behavior that is characteristic of two interfacial oxide and buffer layers consisting of the same transition metal. The average forming voltage value decreases oppositely to the microscale device area while it increases with the Hf-capping layer thickness. The unipolar memristive switching behavior is found to be polarity-dependent due to diverse contributions of the top Hf-buffer layer and the bottom Pd electrode to the switching mechanism. Joule heating effects involving thermophoresis and diffusion are concluded to be predominantly governing the ON/OFF switching events in the positive polarity. Synergistic electric field effects are found to additionally control the unipolar switching behavior in the negative mode. The respective key roles of the top Hf-buffer layer and the bottom Pd electrode in the asymmetric unipolar memristive switching are elucidated at the molecular level according to well-established transport phenomena reported for oxygen vacancies. Given the importance of heat in controlling the conductance state of the proposed stack, the memristor's electrical sensitivity to changes in the ambient temperature is preliminarily investigated for potential temperature sensing applications.

Keywords: HfO_2; unipolar; size effect; capping thickness; switching mechanism; temperature effect

Introduction

The interest in modeling[1-3], fabrication and characterization[4-6] of memristors has significantly increased since the realization of the first physical device was announced by HP labs in 2008[7]. Nanoscale memristors are indeed widely accepted as promising candidates for the advancement of future universal memory and the development of intelligent computing systems, owing to their enhanced scalability, low power consumption and relatively fast ON/OFF switching compared to the classic RRAM technology[8]. Beyond computing applications, the unique and chaotic *I-V* response of some memristors has paved the way for their potential integration in hardware security[9-12]. Other emerging applications have explored the use of microscale memristive devices for biological and