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Resistive switching, endurance and retention properties of ZnO/HfO_2 bilayer heterostructure memory device

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Abstract

This work reports the fabrication of resistive memory device with a bilayer ZnO/HfO_2 structure. Highly stable and uniform bipolar resistance switching (RS) characteristics were attained when HfO_2 interfacial layer is introduced in ZnO device. The bilayer device attains good resistive switching with increased resistance ON-OFF ratio of the order of $\sim 10^2$, better dc endurance of > 10^2 cycles and retention of $>10^4$s at room temperature. X-ray Photoelectron Spectroscopy (XPS) investigation is also done and it is confirmed that oxygen vacancies in ZnO thin film are responsible for improved resistance switching. The current-voltage (I–V) relationship reveals that switching behavior of these devices is mainly dominated by Space-Charge-Limited-Current mechanism (SCLC) regulated due to localized oxygen vacancies. Effect of temperature on the electrical conductivity has also been investigated to analyze the behavior of Low Resistance States (LRS) and High Resistance States (HRS). The findings imply that the bilayer ZnO/HfO_2 device structure is a promising one for upcoming non-volatile memory applications.

Introduction

With the advancement in IC technology, device sizes are shrinking all the time, making it difficult to support MOORE's law prediction [1]. Memory is one of the most important section of any IC which is required for storing and processing vast amount of information and it plays an important part in the newer technologies like IoT, big data, block chain etc. There is a high demand for creating new memories and computing devices that can beat the upcoming shortage of storage space [2,3]. Among the new trends in the memory sector, the non-volatile type resistive random-access memory (RRAM) have drawn significant attention due to its great stability, ease of fabrication, fast programming, low production cost, simple metal-insulator-metal (MIM) heterostructure, and reduced power consumption [4,5].

In spite of these advantages, there are some limitations in terms of operating voltage and reliability that have been continuously pointed out by researchers. The common insulating materials in RRAM are ZnO [6], HfO_2 [7], Al_2O_3 [8], NiO [9] etc. Among these, ZnO have shown a great potential as it has a wide bandgap, low cost, and excellent chemical stability [10]. Although there are reports available on ZnO-based RRAM but there is a lot of scope for improvement in some areas like it has a wide resistance range, non-uniformity in SET and RESET voltage, higher