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Resistive switching characteristics of HfO_2 based bipolar nonvolatile RRAM cell

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ABSTRACT

Non-volatile memory (NVM) will play a significant role in the progress of the next-generation of electronic products due to the physical limitations of the conventionally used flash memory. In this paper, switching properties of Cu/HfO_2/Pt/Si resistive random access memory device were successfully demonstrated. Semiconductor parameter analyzer (model no. B1500A Agilent) was used for the measurement of the resistive switching characteristics of the fabricated device. It has been observed that the device shows the bipolar mode of switching operation. The temperature dependence of electrical conductivity for low resistance state and high resistance state was also measured in the range from 300 K to 450 K. The switching behaviour of the proposed device explained on the basis of conduction filaments formed in HfO_2.

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1. Introduction

The memory which is used for storing data and program is a main component in any computer system. All recognizable computing platforms such as computer, cell phone, digital cameras, portable electronic gadget and large super-computer use storage systems for storing data, either temporarily or permanently as per their requirement [1]. Uses of nonvolatile memory (NVM) are constantly increasing, due to the huge demand of portable and consumer electronic gadgets, such as memory card, USB storage and smart phone, where NVM is used as a main component. Existing charge storage based non-volatile memory technologies like flash memories have now reached to its physical limits [2]. To overcome the limitations of traditional memories and to bring advancement in new technologies like internet of things (IOT) and big data applications, the memories should be dense, power efficient and robust. Hence nano-scale memories which do not work on charge storing magneto-resistive random access memory (MRAM) [3], ferroelectric random access memory (FeRAM) [4], resistive random access memory (RRAM) [5] and phase change random access memory (PCRAM) [6] have drawn a significant interest of researchers for future non-volatile memories. RRAM is a potential candidate for future memories due to its modest components, extraordinary compactness, low power, and exceptional scalability [7]. In recent years, the resistive switching properties in different types of metal oxides such as HfO_x [8], TiO_x [9], TaO_x [10], AlO_x [11], NiO_x [12] and ZrO_x [13] etc. have been largely observed and investigated. Among the various materials proposed for RRAM, HfO_x is potential candidate due to its superior electrical performance and exceptional compatibility with existing CMOS technology [14–15]. The HfO_2 based metal-oxide RRAM have been preferred by many researchers due to its fast operational speed, high integration, low power consumption, and high compatibility with advanced complementary metal-oxide semiconductor technologies [16–17].

Basic resistive switching memory cell as shown in Fig. 1, consists of an insulating/resistive material layer sandwiched between two conductive electrodes. Depending on the polarity of voltage the resistive switching behaviour of RRAM is divided as unipolar switching or bipolar switching. In unipolar switching, resistive switching is induced by a voltage of same polarity but a different magnitude (as shown in Fig. 2). On the other hand, in bipolar switching resistive switching is induced by a voltage of opposite

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