Neutral Oxygen Beam Surface Treatment Enabled Resistive Switching Characteristics in ZnO-based Conducting Bridge Random Access Memory

WPI-AIMR, Tohoku Univ.[1], IFS, Tohoku Univ.[2]

°Firman Mangasa Simanjuntak[1], Takeo Ohno[1], and Seiji Samukawa[1,2]

E-mail: simanjuntak.firman.mangasa.a1@tohoku.ac.jp, samukawa@ifs.tohoku.ac.jp

Introduction: The conventional flash (non-volatile) and dynamic random access (volatile) technologies have been widely used for secondary and system memories, respectively; however, these technologies have met their scalability limit. Conducting bridge random access memory (CBRAM) as an emerging memory technology may overcome the scaling issue; moreover, it has potential as a universal memory for both secondary and system data storage application.[1)] The CBRAM mechanism relies upon the voltage induces ionic drift; results in the formation and rupture of metallic bridge accumulation that behaves as an electrical switch.[2)] However, such ionic drift is often difficult to control and leads to a deterioration switching performance and even a disability to show switching behavior. In this work, we developed a simple method by utilizing neutral beam oxidation (NBO) surface treatment[3)] to induce switching behavior in ZnO-based CBRAM devices. ZnO material is often overlooked as a candidate for a reliable storage layer due to its *n*-type nature. The high concentration of donor defects contributes to the occurrence of high leakage current in switching devices. Consequently, the effective thickness of ZnO switching layer is usually very thick (55 nm and above) to compensate sufficient resistance.[1),2)] The effective thickness of the ZnO switching layer need to be reduced in order to compete with another oxide system.[4)]

Experimental: 25 nm thick of ZnO films were deposited onto ITO/glass substrates using conventional RF sputtering. The deposited films were irradiated with neutral oxygen beam for various times. In order to fabricate sandwich device structure, 100 nm thick of circular Cu top electrodes were deposited onto the ZnO/ITO structure; patterned using a metal shadow mask with 150 µm in diameter. A semiconductor device analyzer was used to measure the electrical characteristics of the devices.

Results: Devices made without NBO irradiation shows very high leakage current; thus, no switching characteristic was observed as shown in Fig. 1(a). Interestingly, obvious switching characteristic was found after the NBO irradiation (Fig. 1(b)). We successfully fabricate reliable Cu/ZnO/ITO devices made with only 25 nm thick of switching layer, which is considered very thin in ZnO-based switching memory. This result shows that the NBO surface treatment technique offers a promising method to fabricate high dense CBRAM devices.

1) F. M. Simanjuntak et al., *Nanoscale Res. Lett.* **11**, 368 (2016).
2) F. M. Simanjuntak et al., *Nanotechnology* **28**, 38LT02 (2017).
3) T. Ohno et al., *Results Phys.* **8**, 169 (2018).
4) T. Ohno et al., *Appl. Phys. Lett.* **106**, 173110 (2015).

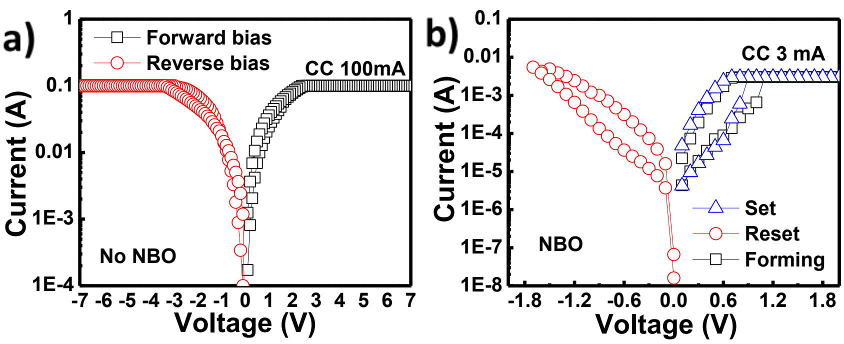

Figure 1. Typical *I-V* curves of Cu/ZnO/ITO devices (a) without and (b) with surface treatment of neutral oxygen beam.