RF Sputtering Pressure Controlled Switching Characteristics of ZnO-based Flexible-Transparent Resistive Memory Devices

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Introduction: Flexible and transparent resistive memory devices have been widely investigated due to their potential use in wearable electronics.[1)] The mechanism of resistive memory is controlled by the formation and rupture of the conducting filament inside the storage layer.[2)] ZnO is one of the most promising storage layer materials for fabricating such memory devices; ZnO is highly transparent in visible light, low cost and environment-friendly.[3)] Various device design and techniques have been proposed in order to improve the ZnO-based resistive memory.[4)] However, based on our knowledge, the importance of sputtering pressure as a processing parameter in fabricating the memory device is still overlooked. In this work, we found that the switching characteristics are significantly influenced by the sputtering pressure.

Experimental: 30 nm thick of ZnO films were deposited onto ITO/PEN substrates using conventional RF sputtering. The deposited films were deposited with various sputtering chamber pressure while the Ar/O_2 ratio was maintained at 2/1 ratio. 300 nm thick of circular AZO 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. X-ray diffraction and atomic force microscope were used to investigate the crystal structure and the surface topography of the grown films, respectively. X-ray photoemission spectroscopy was used to evaluate the defects in the films.

Results: Devices made with lower sputtering pressure show higher pristine resistance (Fig.1). It is found that the memory characteristics can be tuned by controlling the pressure; low-pressure device exhibits write-once-read-many-times memory (WORM) while mid and high devices exhibit reproducible switching memory (RSM) characteristic. The device made with high pressure, however, require multi-step forming process and low On/Off ratio as compared to the low-pressure device. We successfully fabricate both WORM and RSM AZO/ZnO/ITO flexible & transparent devices. This result shows that the sputtering pressure is one of the main processing parameters that cannot be simply overlooked.

1) F. M. Simanjuntak et al., *Nanoscale Res. Lett.* **11**, 368 (2016).
2) T. Ohno et al., *Appl. Phys. Lett.* **106**, 173110 (2015).
3) F. M. Simanjuntak et al., *Appl. Phys. Lett.* **108**, 183506 (2016).
4) F. M. Simanjuntak et al., *Nanotechnology* **28**, 38LT02 (2017).

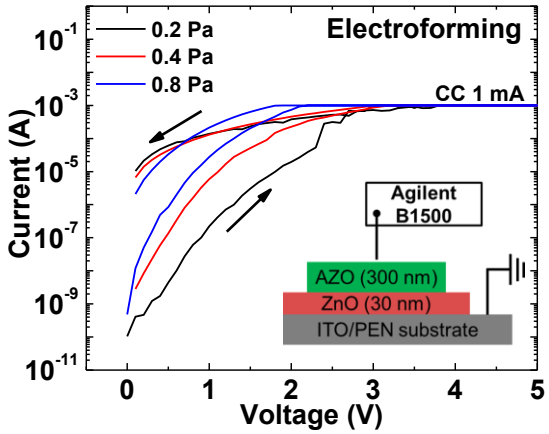

Figure 1. Electroforming process of AZO/ZnO/ITO devices fabricated with various sputtering pressure.