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/O2 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).
4) F. M. Simanjuntak et al., Nanotechnology 28, 38LT02 (2017).

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