Resistive switching in self-organized TiO₂ nano-channels for resistive random access memory

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The key challenge of the non-volatile memory is its scalability [1]. To develop such next generation highly scalable resistive switching memory devices, the efficacy of 50 keV Ar⁺-ion irradiation to fabricate self-organized TiO₂ nano-channel-based structures at an ion fluence of 5×10^{16} ions/cm² was investigated. Given the structural modification of the TiO₂ layer with increasing ion fluence by x-ray diffraction, we will discuss the formation of nano-channels between voids by transmission electron microscopy (TEM). We will show the evolution of near surface oxygen-deficient region by *in-situ* energy-filtered TEM at a threshold ion fluence of 5×10^{16} ions/cm² (Figure 1) in consistence with our x-ray photoelectron spectroscopy results.

Figure 1: Cross-sectional TEM of TiO₂/Pt/Ti/SiO₂/Si after ion irradiation at a fluence of 5×10^{16} ions/cm² shows evolution of nano-channels (rectangular yellow dashed line) surrounded by bigger voids

Moreover, electron density modification after ion irradiation determined by using x-ray reflectivity with the help of Parratt's algorithm [2] will be discussed. We will also discuss the

origin of local resistive switching behavior using conductive atomic force microscopy (c-AFM), and verify its practical application by measuring current-voltage (I-V) characteristics after fabricating two-terminal Pt/TiO_x/TiO₂/Pt devices (figure 2). These experimental results will be discussed in the light of oxygen vacancy migration through the self-organized nano-channels in TiO₂ layers.

Figure 2: Local resistive switching of the sample irradiated at an ion-fluence of 5×10^{16} ions/cm² acquired using complementary I-V spectroscopy mode of c-AFM

References

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