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**MS-8-P-2427 Electrical Characteristics of Resistive Switching Devices Observed by TEM and Atom Probe Tomography**

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Metal-Insulator-Transition (M-I-T) is the basis of electrical or thermal-driven phase change of oxide layer. Some oxides can change their conductivity from insulator to metal above certain current density. Although M-I-T is not fully understood at present, it can be used as a switching device for the solution of sneak leakage problem. In order to apply the bipolar switching materials as the active layer of Resistive-switching Random Access Memory (RRAM), selection device which can minimize the sneak leakage current is needed. Among various candidates, we chose Nb-oxide for the selection device because of its compatibility with semiconductor structure. We have elucidated the mechanism of M-I-T of the amorphous NbO2 layer by using in-situ Transmission Electron Microscopy (TEM) technique combined with Atom Probe Tomography (APT).
At first, we have prepared the sandwich-type stack consisting of top-electrode (TE)/Nb-oxide/bottom-electrode (BE) as shown in Fig. 1. Then, I-V curves were measured by using the in-situ probing system which can reveal the microstructural change simultaneously. APT was sequentially used to achieve compositional change in three-dimensions.
During the mild operation of Icompliance < 10 µA, forming voltage was gradually approached to stable level of Vth = 0.6 V, while a threshold switching (TS) was distinctly measured. Reverse bias could reset forming step. No crystallization was, however, observed during the operation. This means that the TS of amorphous Nb-oxide is not caused by distinct crystallization but by charge injection. APT analysis after switching operation could reveal that cyclic fatigue could lead to the compositional change of Nb-oxide layer into the insulating NbO2 and metallic NbOx. This compositional redistribution is likely to enhance the reliability of the device.
On the contrary, the severe operation of Icompliance > 100 µA caused the filament formation of NbO2 layer. Conductive paths in the NbO2 layer were competitively formed by intense operations. The present result demonstrates that the resistive switching of NbO2 relies on different mechanisms with respect to applied current. This could be confirmed by the followed in-situ heating experiment and electron energy loss spectroscopy analysis.

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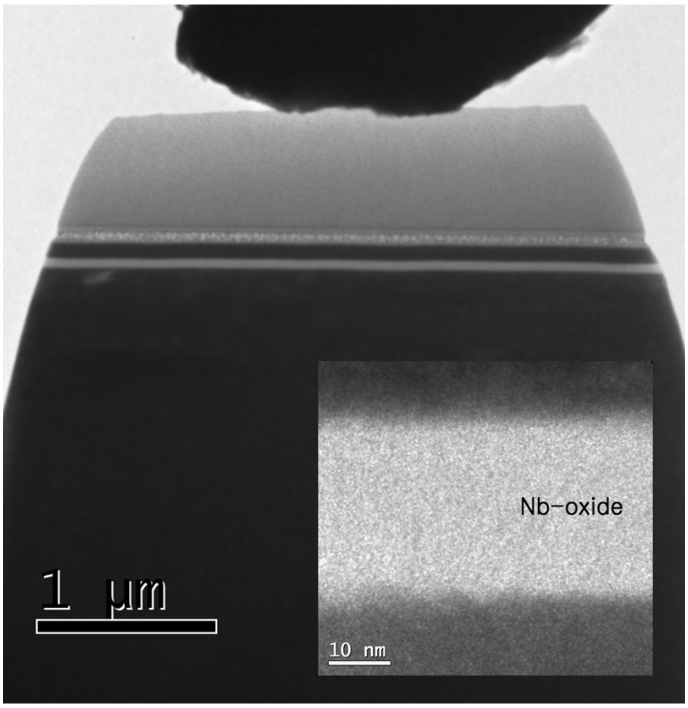


Fig. 1: Image for the in-situ probing experiment. Switching layer consisting of TE/Nb-oxide/BE stack is shown in inset image. The Nb-oxide layer could be sustained amorphous phase even after cyclic I-V measurements.

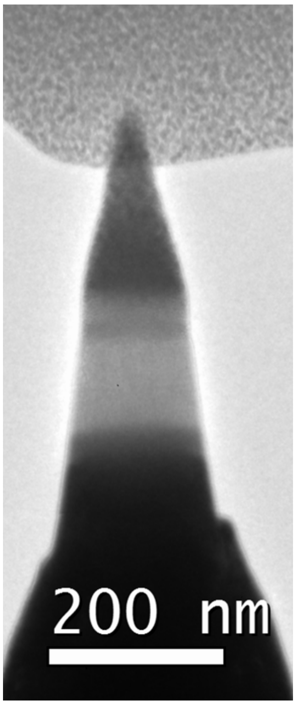


Fig. 2: Tip-shaped sample prepared by using FIB for the combinatory analysis of electrical probing and APT. After I-V measurement, sample was moved to APT chamber to analyse the elemental distribution of Nb-oxide.

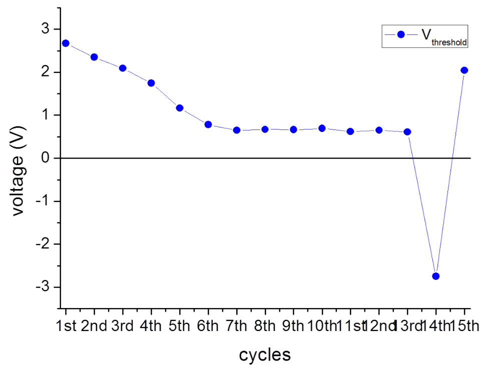


Fig. 3: Threshold voltage alteration during M-I-T cycles. Compliance current was set to 0.5 µA.