

## **Set voltage improvement of resistive switching in $\text{MnO}_x$ using oxygen annealing**

**Min Kyu Yang<sup>1,2</sup>, Jae-Wan Park<sup>1</sup>, Tae Kuk Ko<sup>2</sup> and Jeon-Kook Lee<sup>1\*</sup>**

<sup>1</sup>Thin Film Materials Research Center, Korea Institute of Science and Technology,

<sup>2</sup>Department of Electrical and Electronic Engineering, Yonsei University

Resistive memory switching devices based on transition metal oxides are now emerging as a candidate for non-volatile memories. However, for the development of resistive memory devices using transition metal oxides, improvements of several memory switching properties are required. In this letter, we report one of the ways to minimize the distribution of memory switching parameters by oxygen annealing at Ti- $\text{MnO}_x$  interfaces. From x-ray photoelectron spectroscopy measurements, we observe that change in  $\text{Mn}^{+4}/\text{Mn}^{+3}$  ratio at the  $\text{MnO}_x$  surface by oxygen-annealing. We can conclude that the excess of oxygen by oxygen annealing of  $\text{MnO}_x$  film leads to an increase of  $\text{Mn}^{4+}$  content at the  $\text{MnO}_x$  surface. The effect of oxygen annealing on the improvement of distribution of  $V_{\text{set}}$  and  $R_{\text{off}}$  resistive switching is discussed.