# Multilevel resistive switching memory based on two-dimensional materials using simple solution process

**Gwang Hyuk Shin**, Choon-Ki Kim, Gyeong Sook Bang, Byung Chul Jang, Myung Hun Woo, Yang-Kyu Choi, and Sung-Yool Choi

School of Electrical Engineering, Korea Advanced Institute of Science and Technology (KAIST), 34141 Daejeon, Korea
Sungyool.choi@kaist.ac.kr

**Abstract** Resistive switching memory has attracted great attention due to easy fabrication with simple structure as well as outstanding non-volatile memory performance including fast switching speed and low power consumption.[1-3] As a method of maximizing information storage density, the multi-level cell application (MLC) is one of the most promising solutions. The MLC in resistive switching memory has been widely reported in various materials such as polymers and binary metal oxides.[4-6] However, an MLC operation based on only two dimensional materials has not been demonstrated yet. Here, we report the multilevel resistive switching memory based on graphene oxide (GO) and $MoS_2$ using simple solution process. $MoS_2$ nanosheets, which is exfoliated by Li intercalation process, were successfully embedded between two GO thin films using a spin-coating process. The GO/$MoS_2$/GO stacks result in significant On/Off current ratio increases from ~$10^2$ for GO-only devices to > $10^4$ for devices with $MoS_2$ nanosheet. Excellent multilevel non-volatile memory performance including >$10^4$ s retention time, >$10^2$ endurance cycle without severe degradation, and at least four multiple resistance states were also demonstrated. Furthermore, we systematically investigated the resistive switching mechanism that trapped space charges in $MoS_2$ deep trap sites determine the number of resistance states which could be modulated by electrical bias. These results indicate that $MoS_2$ nanosheets could be utilized as good charge storage materials enabling the MLC operation.

## References

[1] Hwang, C. S. et al., Adv. Electron. Mater., 1 (2015) 1400056.

[2] Jeong, D. S. et al., Rep. Prog. Phys., 75 (2012) 076502.

[3] Yang, J. J. et al., Nat. Nanotechnol., 3 (2008) 429-433.

[4] Yoon, J.H. et al., Adv. Mater., 27 (2015) 3811-3816.

[5] Choi, S.J. et al., Adv. Mater., 11 (2011) 3272-3277.

[6] Hwang, S.K. et al, Nano Letter , 12 (2012) 2217-2221.