Supporting Information

SWITCHING POWER UNIVERSALITY IN UNIPOLAR RESISTIVE SWITCHING MEMORIES

Jongmin Kim[1], Kyooho Jung[1,2], Yongmin Kim[1,3], Yongcheol Jo[1], Sangeun Cho[1], Hyeonseok Woo[1], Seongwoo Lee[1], A. I. Inamdar[1], Jinpyo Hong[4], Jeon-Kook Lee[5], Hyungsang Kim[1], Hyunsik Im[1]

[1]Division of Physics and Semiconductor Science, Dongguk University, Seoul 100-715, Republic of Korea. [2]R&D Division, Flash Integration Technology Team, SK-Hynix, 2091 Gyeongchung daero Bubal-eub, Icheon-si Gyeonggi-do, Republic of Korea. [3]LED Product & Technology, LED Business, Samsung Electronics Co., Ltd, San #24 Nongseo-dong, Giheung-gu, Yongin-city, Gyeonggi-do, 446-711, Republic of Korea. [4]Department of Physics, Hanyang University, Seoul 133-791, Republic of Korea. [5]Center for Opto-Electronic Materials and Devices, Korea Institute Science & Technology (KIST), Seoul 136-791, Republic of Korea.

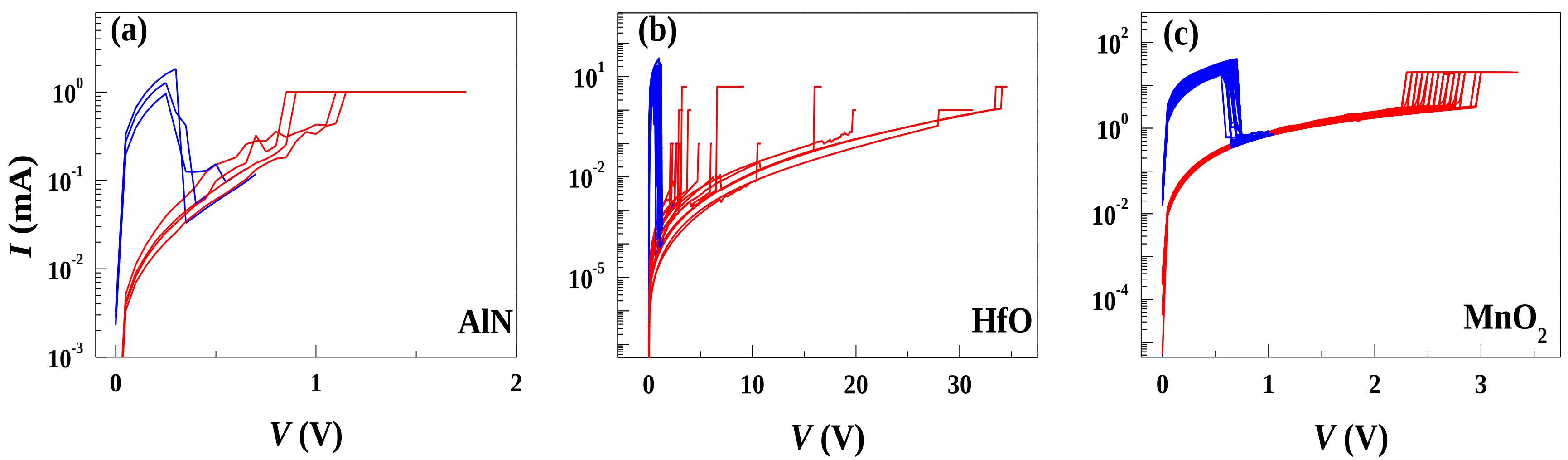

Fig. S1. Representative resistive switching current-voltage curves for (a) Ti/AlN/Ti, (b) Pt/HfO/Ti and (c) Ti/MnO_2/Pt devices.

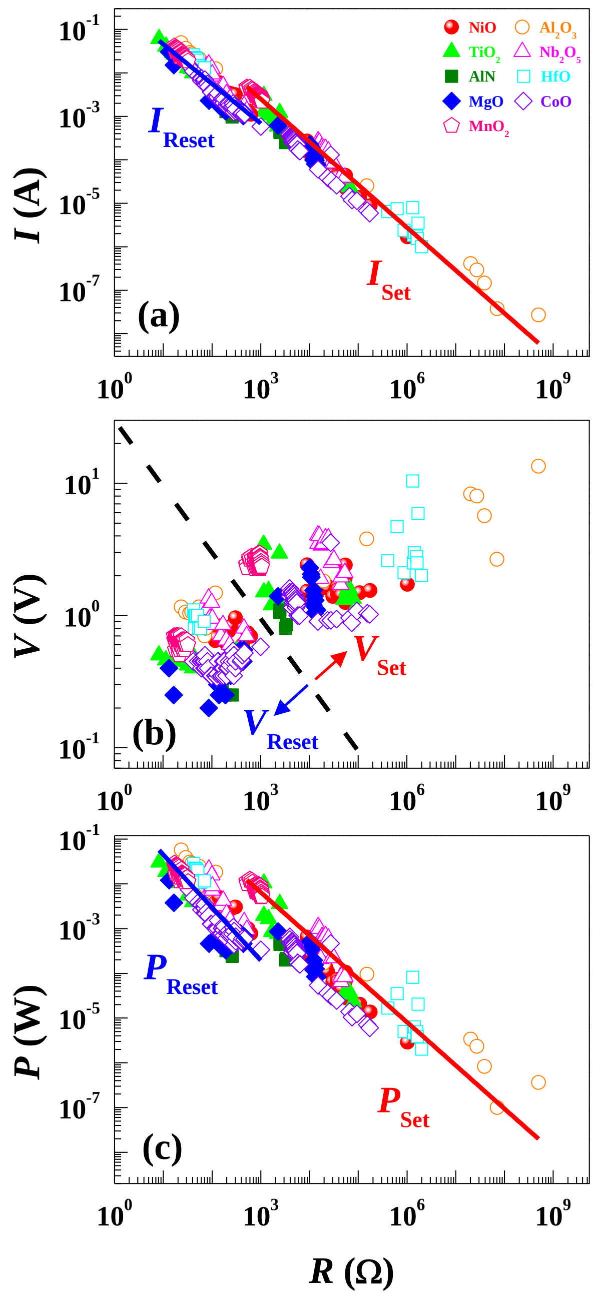

Fig. S2. (a) Switching current *I*, (b) switching voltage *V* and (c) switching power *P* as a function of switching resistance *R* for the Set and Reset processes. The solid lines represent the least-squares fitting curves using a $R^{-\beta}$ power-law.

Material	β_{Set}	β_{Reset}
NiO	0.92±0.219	0.93±0.232
Al_2O_3	0.68±0.429	1.49±0.193
TiO_2	1.20±0.133	1.16±0.128
Nb_2O_5	2.03±0.552	1.55±0.509
HfO	0.93±0.878	1.76±0.618
MgO	1.10±0.224	1.10±0.849
CoO	1.17±0.251	1.05±0.074
MnO_2	0.98±0.076	1.35±0.079
Average	1.15±0.363	1.35±0.350

Table. S1. Extracted exponent β values for individual RS devices. RS devices with a large number of switching cycles are used. The average value of the individually obtained β parameters is comparable to the β value obtained from the full least-squares fitting, validating the power-law relation between switching power and switching resistance.

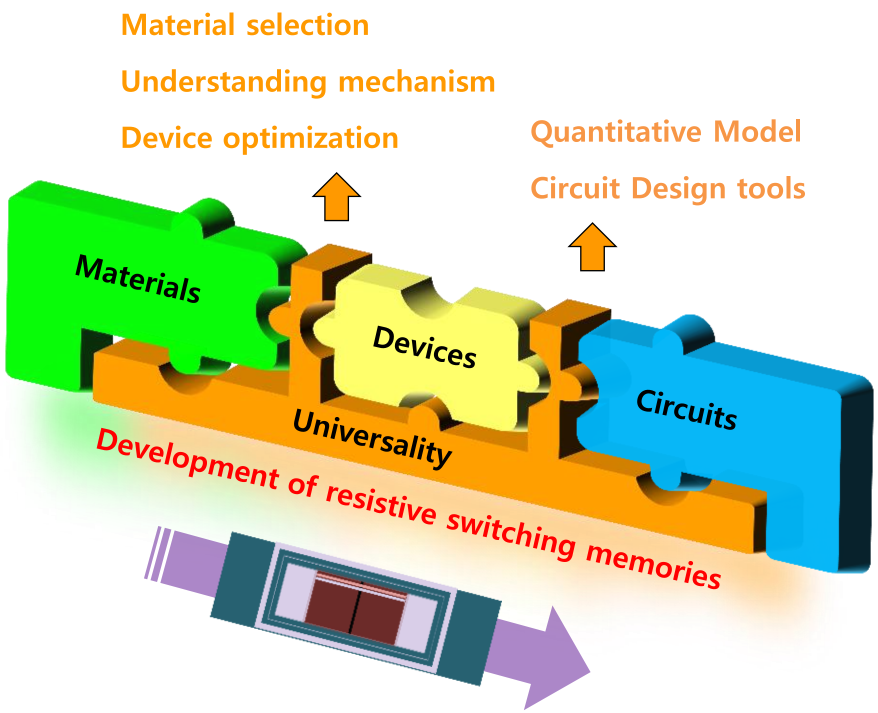

Fig. S3. Importance of quantitative universality for the development of resistive switching memories.
The quantitative universality of device parameters in various resistive switching devices can provide a deeper understanding of the correlation between materials, devices and circuits, regardless of different process integration schemes used in the ReRAM industry.