

Bifunctional Complementary Type Ferroelectric Memory Circuit with both P- and N-channel MoTe₂

Sungjae Hong

Ji Hoon Park, Seongil Im

Department of Physics, Yonsei University, 50, Yonsei-ro, Seodaemun-gu, Seoul, South Korea

hsj7562@yonsei.ac.kr

Two dimensional (2D) semiconductors such as transition metal dichalcogenides (TMDs) have extensively been studied, resultantly displaying their great potentials in many devices and applications [1-5]. In the present work, we report ferroelectric nonvolatile memory (FeNVM) field effect transistors (FETs) using p-channel MoTe₂ and organic P(VDF-TrFE) polymer, and furthermore a complementary type memory cell is demonstrated coupling p- and n-channel MoTe₂ FETs. A top-gate p-FET with P(VDF-TrFE) and a bottom-gate n-FET with Al₂O₃ dielectric are integrated as one cell. Such a complementary type cell is in fact more desirable research path in respect of power consumption but rare to find in 2D-based memory reports. We select MoTe₂ among many other 2D semiconductors, because p-type MoTe₂-based ferroelectric memory is not reported yet, and also because it is relatively easy to obtain both p- and n-channel from the homogeneous MoTe₂. The integrated device operates as a complementary metal oxide semiconductor (CMOS) inverter in a small voltage range from 0 to ~2.5 V as well, but primarily works as a ferroelectric nonvolatile memory circuit when p-channel with top P(VDF-TrFE) ferroelectric polymer is biased with high voltages over the coercive electric field (E_c) of the polymer. The bottom-gate n-channel transistor operates as a switching device in the FeNVM cell, allowing voltage output signals during device operations. We conclude that our complementary type FeNVM cell is practical and novel enough to report as a first demonstration based on MoTe₂.

References

- [1] B. Radisavljevic, A. Radenovic, J. Brivio, V. Giacometti, A. Kis, *Nat. Nanotechnol.* 6 (2011) 147
- [2] J. Ahn, P. J. Jeon, S. R. A. Raza, A. Pezeshki, S. W. Min, D. K. Hwang, S. Im, *2D Mater.* 3 (2016) 045011
- [3] J. Y. Lim, A. Pezeshki, S. Oh, J. S. Kim, Y. T. Lee, S. Yu, D. K. Hwang, G. H. Lee, H. J. Choi, S. Im, *Adv. Mater.* 29 (2017) 1701798
- [4] A. Lipatov, P. Sharma, A. Gruverman, A. Sinitiskii, *ACS Nano* 9 (2015) 8089
- [5] X. Zhang, J. Grajal, J. L. Vazquez-Roy, U. Radhakrishna, X. Wang, W. Chern, L. Zhou, Y. Lin, P. C. Shen, X. Ji, X. Ling, A. Zubair, Y. Zhang, H. Wang, M. Dubey, J. Kong, M. Dresselhaus, T. Palacios, *Nature* 566 (2019) 368

Figures

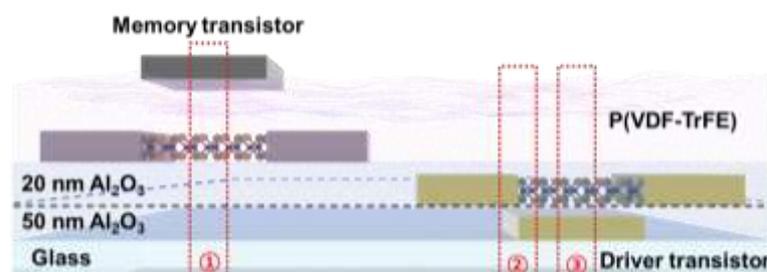


Figure 1: 3D scheme of integrated bifunctional complementary type MoTe₂ memory cell

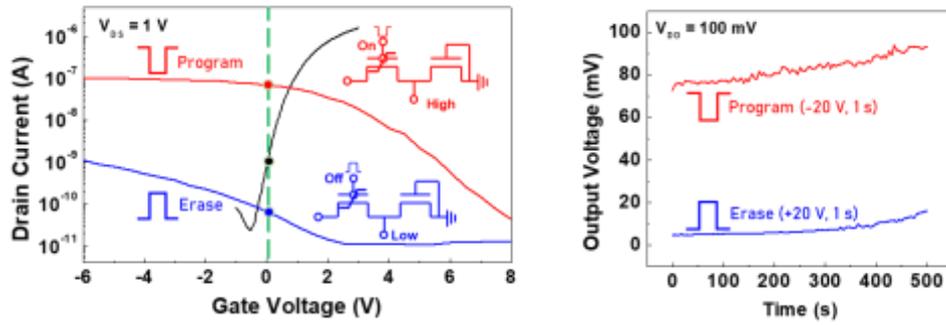


Figure 2: The current-voltage characteristics of p- and n-type MoTe₂ transistors and the retention curve of the memory cell

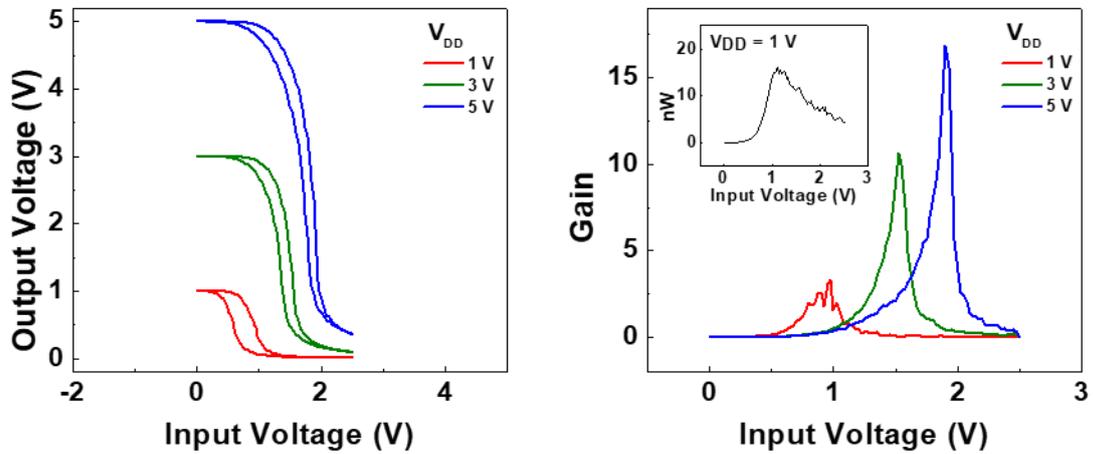


Figure 3: The voltage transfer curve and gain (inset power consumption) of the complementary type cell in CMOS operation regime.