Emerging Device Applications of 2D Materials

Steven J. Koester
University of Minnesota, ECE Department, 200 Union St. SE, Minneapolis, USA
skoester@umn.edu

Two-dimensional (2D) materials, crystalline materials characterized by strong in-plane bonds and weak out-of-plane bonds, have been intensively studied for the better part of the past two decades. 2D materials have many remarkable properties, but the applications for which they are best suited remains an open question. In this talk, I will describe the efforts in our group to identify new applications for 2D materials, with a focus on the ones where their unique properties can best be utilized. I will first discuss our work on graphene and how its high mobility, monolayer thickness and unique band structure can enable a new class of high-speed, non-volatile tuning elements [1] and compact read heads for magnetic storage [2]. I will also describe the characteristics of selected 2D semiconductors, including transition metal dichalcogenides (TMDCs) and black phosphorus, and show how their properties can be used to realize ultra-scaled dynamic memories [3], and ultra-low power and reconfigurable electronic circuits. Finally, I will show recent results [4] on semi-metallic contacts to the TMDC, WS_2, that provide strong evidence that 2D materials have tremendous potential to realize high-performance MOSFETs for VLSI logic circuits with ultimate scalability.

References

[1] J. Wen, V. R. S. K. Chaganti, and S. J. Koester, IEEE Elect. Dev. Lett., vol. 43 (2022), pp. 820-823.

[2] J. Hu, G. Stecklein, D. A. Deen, Q. Su, P. A. Crowell, and S. J. Koester, IEEE Trans. Elect. Dev., vol. 66 (2019), pp. 5003-5010.

[3] C. U. Kshirsagar, W. Xu, Y. Su, M. C. Robbins, C. H. Kim, and S. J. Koester, ACS Nano, vol. 10 (2106), pp. 8457–8464.

[4] L. Jin, and S. J. Koester, IEEE Elect. Dev. Lett., vol. 43 (2022), pp. 639-642.

Figures

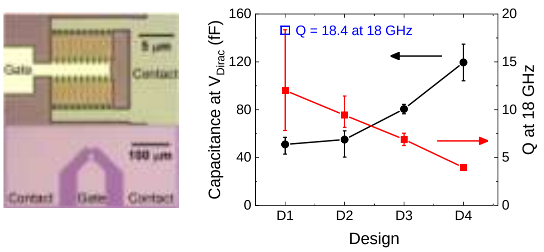

Figure 1: High-speed graphene varactor showing high-Q at 18 GHz. [1].

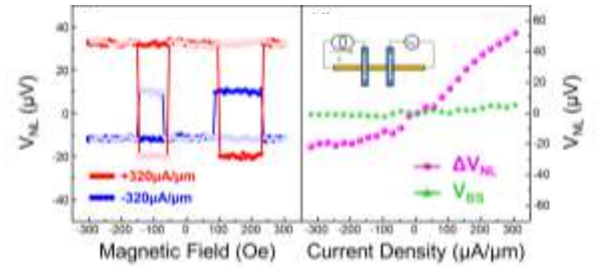

Figure 2: Results from narrow graphene spin valves showing low background signal [2].

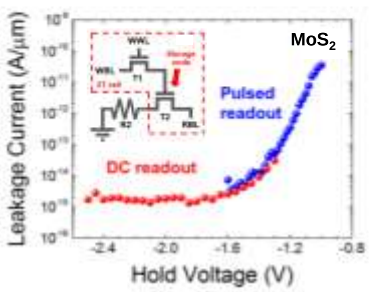

Figure 3: Results showing long retention time in MoS_2 two-transistor DRAM [3].

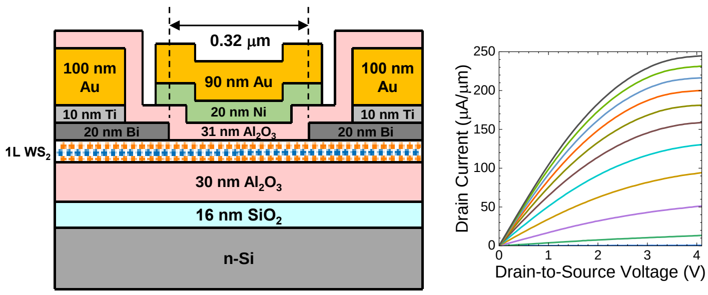

Figure 4: Dual-gated, single-layer CVD-grown WS_2 MOSFET with Bi contacts. [4].