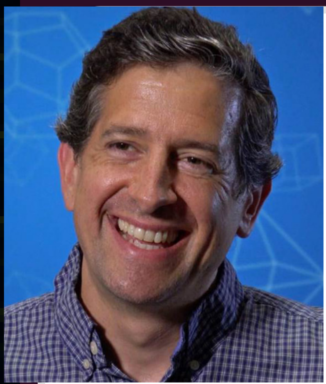
Oral Session C1 (Thursday, February 15)

Chair: Shunsuke Fukami, Tohoku University

Keynote Talk



9: 00 - 9 : 40

Daniel C. Worledge

IBM Research

Spin-transfer-torque MRAM: the next revolution in memory

Spin-Transfer-Torque MRAM (STT-MRAM) was invented at IBM by John Slonczewski in the early 1990s, using a spin-polarized current, instead of a magnetic field, to write a magnetic free layer in a magnetic tunnel junction. The discovery of perpendicular magnetic anisotropy in thin CoFeB/MgO layers at IBM and independently by Tohoku University enabled a dramatic reduction in the switching current, and opened the way to practical perpendicular magnetic tunnel junctions for dense STT-MRAM.

This talk will provide an overview of STT-MRAM, including the two basic building blocks described above. I'll give an introduction to the physics of spin-transfer torque and applications of STT-MRAM. Then I will review why perpendicular magnetic anisotropy is advantageous for STT-MRAM compared to in-plane anisotropy. I will discuss the research at IBM in 2009 that led to our discovery of perpendicular anisotropy in thin CoFeB/MgO layers, and our use of these layers to make the first practical perpendicular magnetic tunnel junctions and the first demonstration of reliable writing in STT-MRAM [1]. Finally I will review our recent results on methods to lower the switching current of STT-MRAM by using optimized magnetic materials and double magnetic tunnel junctions, including our recent demonstration of reliable 250 ps switching [2].

References

[1] D. C. Worledge et al., "Switching distributions and write reliability of perpendicular spin torque MRAM", 2010 International Electron Devices Meeting, pp. 12.5.1 (2010)

[2] C. Safranski et al., "Reliable Sub-Nanosecond Switching in Magnetic Tunnel Junctions for MRAM Applications", IEEE Transactions on Electron Devices, 69, p7180 (2022)

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Keynote Talk

9: 40 - 10 : 20

Evgeny Y. Tsymbal

Department of Physics and Astronomy, University of Nebraska-Lincoln (UNL)

Antiferromagnetic tunnel junctions for spintronics

Antiferromagnetic (AFM) spintronics has emerged as a subfield of spintronics, where an AFM Néel vector is used as a state variable. Due to being robust against magnetic perturbations, producing no stray fields, and exhibiting ultrafast dynamics, antiferromagnets can serve as promising functional materials for spintronic applications. To realize this potential, efficient electric control and detection of the AFM Néel vector are required. This keynote talk features fundamental properties of AFM tunnel junctions (AFMTJs) as spintronic devices where such electric control and detection can be realized [1]. We emphasize critical requirements for observing a large tunneling magnetoresistance (TMR) effect in AFMTJs with collinear [2] and noncollinear [3,4] AFM electrodes, such as crystallinity of the junction, AFM metals exhibiting momentum-dependent spin polarization [2,3], and/or AFM metals supporting Néel spin currents [5]. We further discuss the unique property of non-collinear antiferromagnets to sustain virtually 100% spin polarization [4], the possibility of magnetic tunnel junctions (MTJs) with a single ferromagnetic electrode [6], and spin torques that are capable of Néel vector switching [5]. Overall, AFMTJs have potential to become a new standard for spintronics providing larger magnetoresistive effects, few orders of magnitude faster switching speed, and much higher packing density than conventional MTJs.

References

1. Pal, B. et al. Josephson diode effect from Cooper pair momentum in a topological semimetal. Nat. Phys. 18, 1228-1233 (2022).
2. Kim, J.-K. et al. Intrinsic supercurrent non-reciprocity coupled to the crystal structure of a van der Waals Josephson barrier. Nat. Commun. accepted (2024).
3. Sivakumar, P. K. et al. Long-range Phase Coherence and Second Order ϕ_0-Josephson Effect in a Dirac Semimetal 1T-$PtTe_2$ submitted (2024).
4. Jeon, K.-R. et al. Zero-field polarity-reversible Josephson supercurrent diodes enabled by a proximity-magnetized Pt barrier. Nat. Mater. 21, 1008-1013 (2022).