Manipulation of magnetic skyrmions for memory and logic applications

O. Boulle

Spintec, Grenoble, France

Contact@E-mail (Century Gothic 10)

Skyrmions are topological spin textures which hold great promise as nanoscale bits of information in memory and logic devices [1]. The recent demonstration of room temperature skyrmions [2,3] as well as their current induced motion in industry compatible sputtered thin films have lifted important roadblocks toward the realization of skyrmion based devices. However, their development is impeded by a too low current induced velocity (about 100 m/s) [4] as well as the skyrmion Hall effect, namely a motion transverse to the current direction due to their topological charge which can lead to their annihilation in tracks. Antiferromagnetic (AF) skyrmions allow these limitations to be lifted owing to their vanishing magnetization and net zero topological charge, promising fast dynamics without skyrmion Hall effect. In this presentation, I will address the stabilization and current induced manipulation of skyrmion in compensated synthetic antiferromagnetic (SAF). I will first show that skyrmions can be stabilized at room temperature in Pt/Co/Ru based compensated SAFs and nucleated using local current injection or ultrafast laser pulses [5]. I will then show that SAF skyrmions can be moved by current at velocities over 900 m/s without skyrmion Hall effect. Micromagnetic simulations and analytical models using experimental parameters show that this enhanced skyrmion velocity can be explained by the compensation of the topological charges as well as an enhanced spin orbit torque in the synthetic antiferromagnet. I will conclude the talk with recent results on the electrical nucleation and detection of a skyrmion in magnetic tunnel junctions, which is another important milestone for skyrmion based devices [6]. Our results open important paths toward the realization of logic and memory devices based on the fast manipulation of skyrmions.

References

[1] A. Fert, V. Cros, and J. Sampaio, Nat. Nanotechnol. 8, 152 (2013).
[2] O. Boulle, Nature Nano., 11, 449 (2016)
[3] A. Fert, N. Reyren and V. Cros, Nat Rev Mater 2, 17031 (2017).
[4] R. Juge et al., Phys. Rev. Appl. 12, 044007 (2019)
[5] R. Juge et al., Nature Communication, 13, 4807 (2022)
[6] J. Urrestarazu Larranaga et al., arXiv:2308.00445 (2023)