Two-Pulse Magnetic Field Free Switching Scheme for Advanced Perpendicular SOT-MRAM

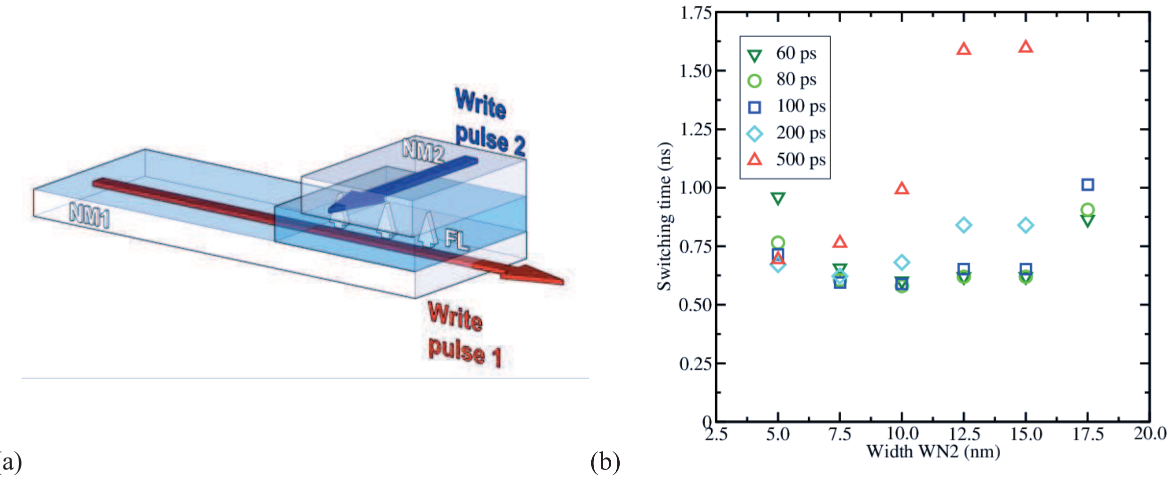
Roberto Orio[1], Alexander Makarov[2], Wolfgang Goes[3], Johannes Ender[1], Simone Fiorentini[1], and Viktor Sverdlov[1]

[1] *Christian Doppler Laboratory for Nonvolatile Magnetoresistive Memory and Logic at the*
[2] *Institute for Microelectronics, TU Wien, Austria*
[3] *Silvaco Europe Ltd., Cambridge, United Kingdom*

The continuous increase in performance and speed of modern integrated circuits is steadily supported by miniaturization of CMOS devices. However, a rapid increase of stand-by power due to leakages becomes a pressing issue. To reduce the energy consumption particularly in CPUs, one can replace the SRAM in hierarchical multi-level processor memory structures with a non-volatile memory. The development of an electrically addressable non-volatile memory combining high speed and high endurance is essential to achieve this goal [1]. Spin-orbit torque magnetoresistive random access memory (SOT-MRAM) combines non-volatility, high speed, and high endurance and is thus perfectly suited for applications in caches. However, its development is still hindered by the need of an external magnetic field for deterministic switching of perpendicularly magnetized layers [2].

We demonstrate that a magnetic field free two-pulse switching scheme previously suggested to accelerate switching of afree layer (FL) of a rectangular form [3] is also suitable for switching of symmetric perpendicularly magnetized layers. The memory cell is shown in Fig.1a: It includes a perpendicularly magnetized FL on top of a heavy metal wire (NM1). Another heavy metal wire (NM2) overlaps partly and serves to apply the second consecutive perpendicular current pulse of the same current density, with a duration T_2. The first pulse puts the magnetization in-plane, while the second pulse running under a part of the free layer tilts the magnetization in this part to create an in-plane stray magnetic field. This in-plane magnetic field acts on the rest of the free layer and completes the switching deterministically

Fig.1b shows the switching time averaged over 20 realizations as a function of the second pulse duration T_2 when the first pulse is 100ps short as a function of the overlap of NM2 with a 25nm×25nm FL. The fast (~0.5ns), deterministic, and magnetic field free switching of a perpendicularly magnetized recording layer is achieved for non-complete overlap between 20% to 70%. The switching scheme is extremely robust with respect to pulse duration fluctuations and pulse synchronization failure as it yields a large confidence window with respect to T_2 fluctuations (Fig.1b). The optimal overlap NM2 with the free layer is found to be around 30-50%



(a) (b)

Figure 1: (a) Two-pulse switching scheme applied to the perpendicularly polarized square magnetic FL; (b) Switching time averaged over 20 realization as function of the overlap, for several second pulse

References

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