Low and fast magnetization dynamic driven by spin transfer torque in nanopillar spinvalve with strong perpendicular anisotropty

Stéphane Mangin

Institut Jean Lamour, CNRS, Nancy Universite´, UPV Metz, Vandoeuvre le`s Nancy, France
stephane.mangin@ijl.nancy-universite.fr

As predicted by L. Berger and J. Slonczewski [1] when a current of polarized electrons enters a ferromagnet the current exert a torque on the ferromagnet magnetization. This torque can lead to magnetization switching between two stable configurations which was later demonstrated in nanopillar spin-valve structures [2]. The ability of a spin-polarized current to reverse the magnetization orientation of nanomagnets should enable a range of magnetic devices such spin transfer magnetic random access memories (ST-MRAM). However, several advances are needed to realize practical devices [3]. One key point is the reduction of the currents required to switch magnetization while maintaining the thermal stability of the free layer. The study of the effect of both spin polarized current and thermal activation on magnetization dynamic as then been performed. Nanopillar spin valves 70 nm x 140 nm made of [Co/Ni] and [Co/Pd multilayers showing perpendicular anisotropy were prepared. In such geometry one can observe that the critical current scales with the height of the anisotropy energy barrier and critical currents as low as 120 μA is achieved in quasi-static room-temperature measurements of a 45-nm diameter device [4]. Moreover fast switching has been observed using short current pulses down to 300 ps [5,6] and thermally activated process gave rise to telegraph noise [7]. Fast magnetization precession could also be observed [8]

We will also present results on the switching field distribution obtained by measuring the switching field of more that 1000 hysteresis loop for different injected current values. The results were treated in the light of a simple model of thermal activation over an energy barrier, first introduced by Néel and Brown [9]. The fitting of the switching field distribution using the Kurkijärvi expression [10] derivated from the Neel brown model permits to deduce the switching field distribution and the spin-current-dependent energy barrier [11].

The study of the switching field distribution confirm that domain nucleation and growth need to be taken into account to fully explain the experimental observation as it can be seen on figure 1 [12]

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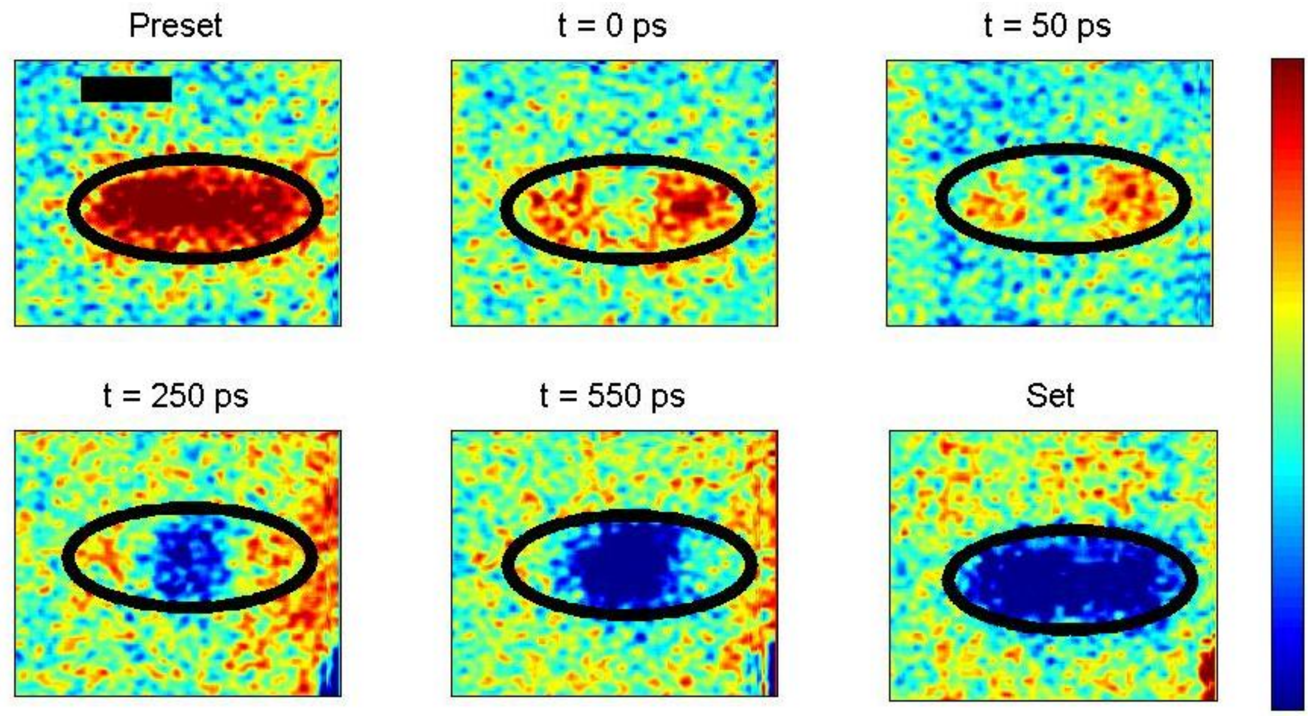
Figures



Experimental STXM images of the magnetic contrast in a 100 × 300 nm2 ellipsoidal nanopillar spin valve. Images (a)–(e) have been taken at different times during the CIMS reversal based on the setup shown in Fig. 1. Image (a) is the initial state, and (f) is the final state. The color scale corresponds to the perpendicular component of the free-layer magnetization, fromparallel (P)(red) to antiparallel (AP)(blue) with respect to the reference layer.