Magnetic switching and excitations due to spin polarized current in NiFe and CoFe based nanopillars

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The effect of a spin polarized current on the magnetic behavior of deep sub-micron spin-valve nanopillars is of considerable interest for new magneto-electronic applications or for preventing abnormal behavior in advanced CPP read heads. Several spin-valve structures consisting of NiFe, CoFe or laminated free layers were deposited and patterned in nanopillars of diameters ranging from 0.1 to 0.28μm. The transport measurements carried out with current densities varying from 5.10^6 to 10^8 A/cm^2 have evidenced several contributions to the spin polarized current. In a first regime of moderate current densities, the spin polarized current is acting as an effective field, whose amplitude and sign is directly proportional to the injected current. This current induced effective field allows to switch the magnetization of the free layer without any external field. It is at the origin of the R(I) loops observed experimentally. The influence of the composition and thickness of the magnetic layer on this effective field was studied.

For larger current densities, the Oersted field becomes large enough to induce the formation/annihilation of vortex states during the hysteresis loop. In this regime, the spin-polarized current creates a strong asymmetry in the vortex behavior that cannot be ascribed to a simple effective field but rather to a spin torque contribution. Another signature of the spin torque at larger current densities, is the observation of steady precessional modes in the hysteresis loops in some samples in particular ranges of DC current and applied magnetic field (see Fig.1). This abnormal behavior was predicted by Li and Zhang in their spin torque model [1].

To interpret these spin transfer effects, a new micromagnetic simulation model was developed from Li and Zhang's study [1] by adding to the spin torque term the extra term at the origin of the effective field contribution. The simulation results of this model will be compared to the experimental results.

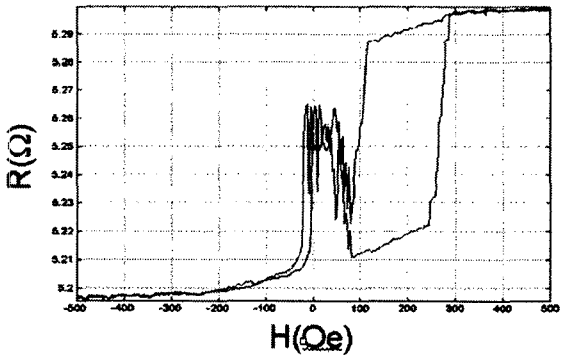

Fig.1: Hysteresis loop of a CPP spin-valve nanopillar measured at a DC current of 6mA. A very large noise due to current driven excitations is observed between -30Oe and 80Oe.

[1] Z.Li and S.Zhang, Phys.Rev.B68, 024404 (2003).