12: Spintronics: Characterisation of perpendicular anisotropy MRAM cells

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Magnetic memories (MRAM) are non-volatile emerging technology with the potential to become the standard solution for high performance non-volatile memories. To move towards the 20nm technology nodes, systems with perpendicular magnetization are the ideal solution. Indeed, using MTJs with Perpendicular Magnetic Anisotropy (PMA) is interesting in several respects: i) it allows increasing the density of memory cells on a wafer since no elliptical shape is required to stabilize the anisotropy direction, contrary to the planar systems, ii) PMA energy is usually much larger than shape anisotropy that can be obtained in planar MTJs, allowing longer memory retention at small size; iii) for a given retention time, the critical current density to write information by Spin Transfer Torque (STT) switching is strongly reduced, provided the Gilbert damping remains low enough. Perpendicular anisotropy materials must be integrated in magnetic tunnel junctions. These junctions have typical magneto resistance signals of 100%. In a nonvolatile memory element, the low resistance is associated to a bit '0' and the high-resistance to a '1' bit. Switching between these two states can be achieved by spin transfer torque with pulses of 2-5MA/cm^2 current density.

The aim of this practical work is to electrically characterize the current densities necessary to write the desired memory state using phase diagrams. Electrical tests will be done using DC current and pulses of 10-100ns. Methods to determine the thermal stability and write error rates will be reviewed on devices nano-fabricated to dot sizes of 50 to 200 nm in diameter.

The practical work will be based at the Institute of Nanosciences and Cryogenics (INAC) at CEA Grenoble. Studies level requested to follow this practical: Master of Science in Physics, Material's Science or Nanotechnology.

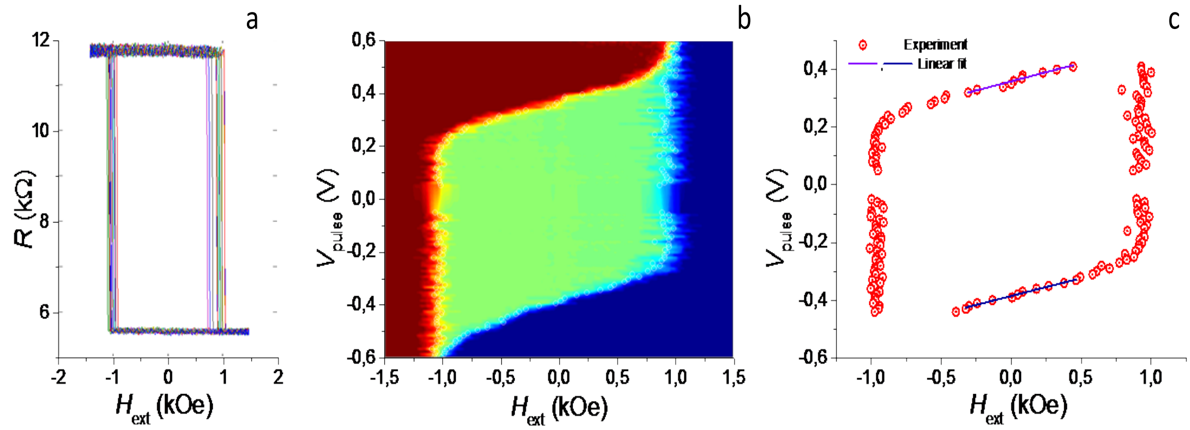

Figure 1: Left: A Magneto-Resistive (MR) hysteresis cycle measured on an perpendicular anisotropy tunnel junction showing the variation of the resistance when the magnetizations of the pinned and free layer switch from parallel P (low resistance) to antiparallel AP (high resistance). Middle: a phase diagram plot of the same junction when applying current pulses. The color code shows the resistance state, blue for low and red for high resistance, with green being the bi-stable region that can be used for a memory cell. Right: Fitting and the phase diagram allows access to spin torque switching efficiency, depending on the material parameters of the cell.

References: http://www.spintec.fr