NEW WRITE SCHEMES FOR MAGNETIC NON-VOLATILE MEMORIES: THERMALLY ASSISTED AND SPIN TRANSFER WRITING

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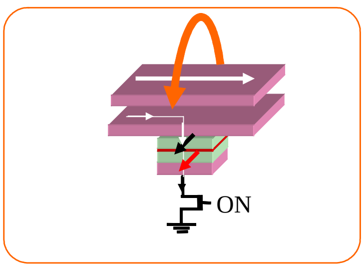
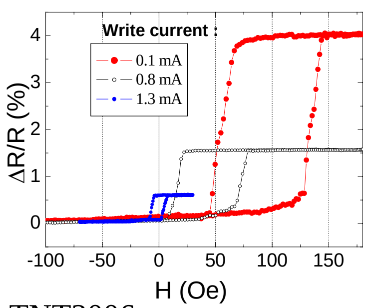
Magnetic Random Access Memories will probably become a major area of applications of spin electronics. However, the R&D in MRAM started almost 10 years ago and MRAM chips are not yet on the market due to write selectivity issues which still need to be fixed in an efficient way in terms of density and energy consumption. In this study, we have investigated two new ways to selectively write in MRAM cells i.e. switch the magnetization of the soft layer in current perpendicular to plane (CPP) spin-valve nanopillars of the form F/NM/R/AF. F is a ferromagnetic soft layer (typically NiFe 5nm), NM is a non-magnetic spacer layer made of Cu (fully metallic stack) or Alumina (magnetic tunnel junction) typically 4nm thick, R is a reference ferromagnetic layer of pinned magnetization (CoFe 3nm), AF is an antiferromagnetic pinning layer (IrMn 8nm). The diameter of the pillars are in the range 70-150nm.

The first method is based on a thermally assisted write scheme: A short pulse of current (typical width~1ns) is sent through the pillar for the write process. This pulse heats the free layer of the pillar and reduces its switching field (See Fig.1). A weak DC field is simultaneously applied on the structure, which allows switching the magnetization in the desired direction. A particularly interesting embodiment consists in using an exchange biased soft layer with a relatively low Néel temperature (~180°C). The heating allows to unpin the magnetization of the free layer and switch it. The dot then cools down and its magnetization freezes in the new direction (Fig.1). This write technique is very promising for Magnetic Random Access Memories since it offers perfect write selectivity, solves the issue of superparamagetic limit and even allows multilevel storage.

The second method is based on the spin torque exerted by a spin polarized current flowing through a magnetic nanostructure on its magnetization. This effect predicted by Slonczewski and Berger in 1996 was later on observed in Co/Cu/Co sandwiches. We showed that it also exists in much more complex structures such as the CPP spin-valves developed for magnetoresistive heads used in computer disk drives (Fig.2). While in heads this effect is a source of noise and should be reduced, in the context of MRAM or magnetic logic gates, it can be used as a very efficient new write scheme offering also perfect write selectivity.





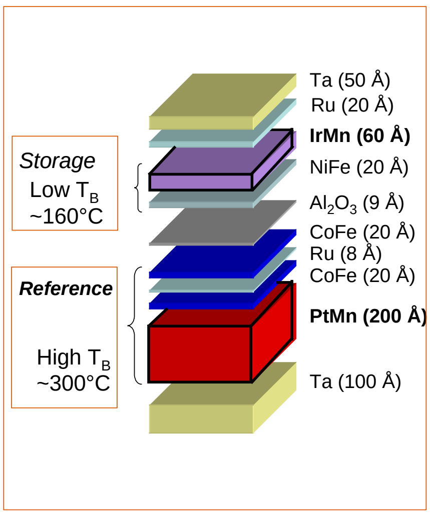


Fig.1 : Illustration of the principle of operation of a Thermally Assisted Magnetic_RAM

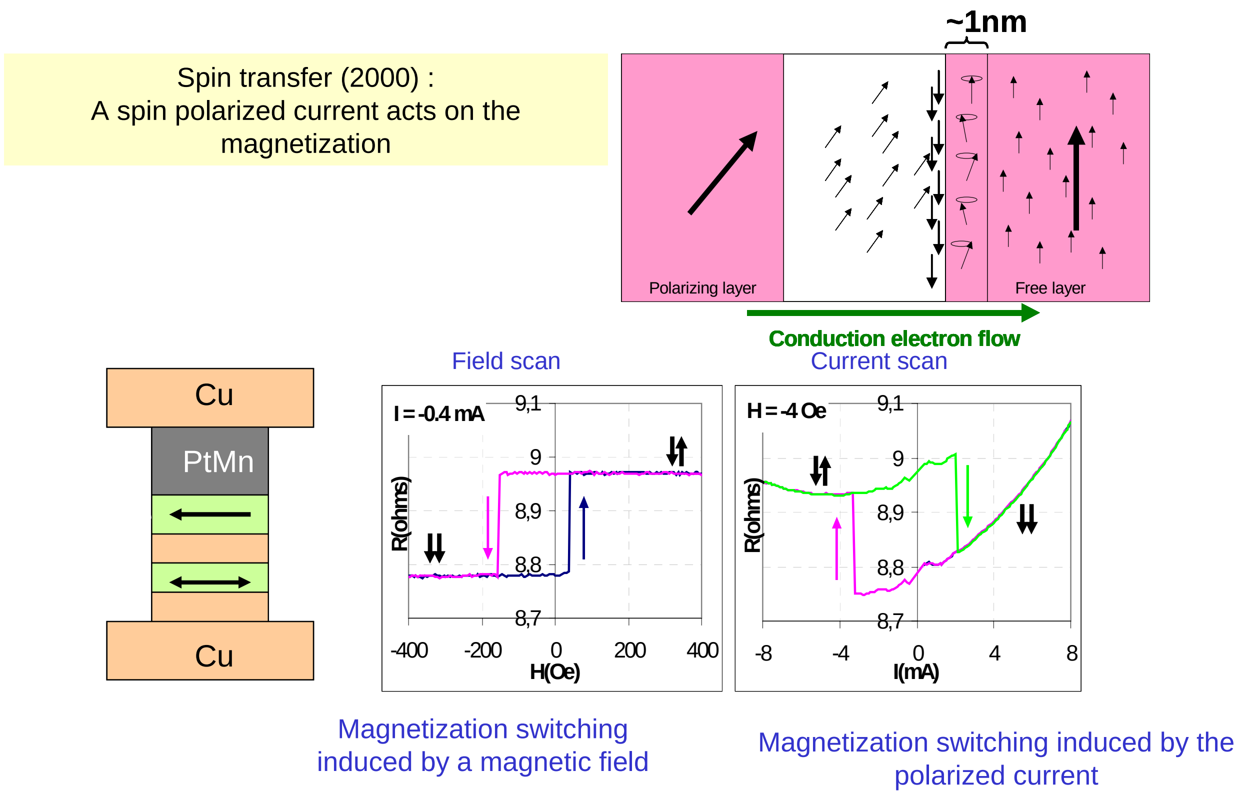


Fig.2 : In a pillar of composition Cu/CoFe 3nm/Cu 4nm/CoFe 2.5nm/PtMn 20nm, the magnetization of the unpinned CoFe layer can be switched either by an external field or by a current flowing perpendicular to the plan of the layers.