Journées Nationales en Nanosciences et en Nanotechnologies

ISTRADE

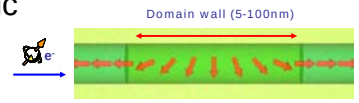
Innovative Spin TRAnsfer DEvices

(appel P-Nano 2007)

Coordinator: D.Ravelosona, Institut d'Electronique Fondamentale, UMR 8622, Université Paris Sud, France

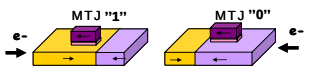
ISTRADE Objectives

- Investigate and use spin transfer torque effect in magnetic domain walls (DWs) to extend and enhance the fundamental understanding of this new scientific topic



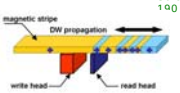
reasonable currents can move DWs in "tracks" (J~10 ^{7} A/cm^2)

- Network progress in the basic understanding of the science will be used to demonstrate the feasibility of nanodevices for applications such as Spin RAMs, magnetic logic and high frequency devices.



Spin RAM with DW writing

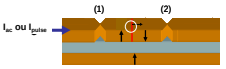
S. Parkin et al., Science 320, 190 (2008)



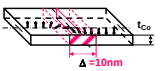
Solid state hard disk (>1 Tera bits/inch^2 ?)

ISTRADE Deliverables

- To obtain low DC and RF threshold current density to move DWs in spin valves with **perpendicular anisotropy** combined with artificial pinning positions using **3 different approaches**:



→ High polarized systems
→ Very narrow domain wall
→ Very low Ms materials

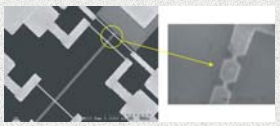


Narrow 1 D Bloch DW moving in the free layer of a perpendicular spin valve

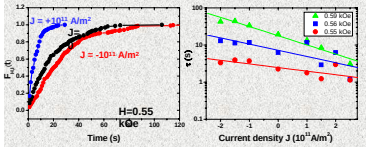
- To study the scalability of current induced domain wall motion down to 30 nm
- To demonstrate the proof of concept of a STT multi level cell memory and logic device

Institut d'Electronique Fondamentale, Université Paris Sud, Orsay

D.Ravelosona, C.Burrowes, S. Park, M.Ngoc, N.Vernier, C.Chappert



Nanodevices with 2 successive constrictions



Probability of depinning under current in CoNi

NRJ barrier under current

$$\tau = \tau_0 Exp\left(\frac{E(H,J)}{k_B T}\right)$$

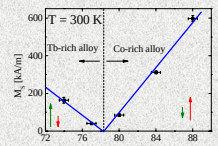
E(H,J)= E(H)-σJ

Task in the network:

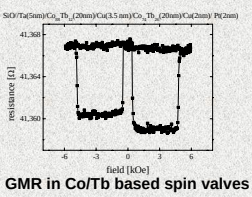
- Highly polarized spin valves (CoNi,CoFeB,…)
- Well defined artificial pinning positions down to 100nm
- DC/RF current induced DW propagation
- Kerr microscopy

Laboratoire Physique des Matériaux, Université Henri-Poincaré, Nancy

S. Mangin, M. Gottwald, M. Hehn, S. Andrieu, F. Montaigne



Controlable magnetization



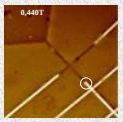
GMR in Co/Tb based spin valves

Task in the network:

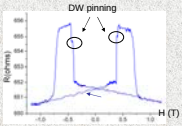
- Ferrimagnetic materials with low M_S (TbCo alloy, Tb/Co multilayers)
- Wires down to 100nm in size
- DC current induced DW propagation

Laboratoire Nanostructure et Magnetisme, INAC/CEA, Grenoble

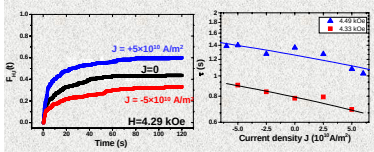
J.P. Attane, A. Mihai, L. Vila, A. Marty, Y.Samson



MFM image: pinning on an intrinsic defect



GMR showing DW Pinning on an intrinsic defect



Probability of depinning under current in FePt

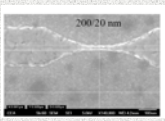
NRJ barrier under current

$$\tau = \tau_0 Exp\left(\frac{E(H,J)}{k_B T}\right)$$

E(H,J)= E(H)-σJ

Task in the network:

- Materials with very narrow DW ~5nm (FePt, FePd,..)
- Wires down to 30 nm
- DC and pulse current induced DW propagation
- MFM measurements



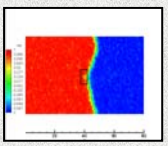
Narrow constriction realized by ebeam lithography

SPINTEC, CEA-INAC ,CNRS/UJF/ INP, Grenoble

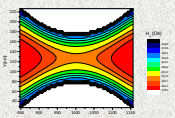
H.Szambolics, F. Garcia Sanchez, L. Buda-Prejbeanu,

Task in the network:

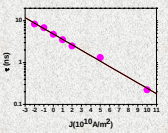
- Micromagnetic simulations



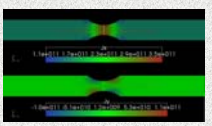
Effect of thermal fluctuations on the depinning process of a domain wall (FePt)



Dipolar field generated at a constriction by the hard layer in CoNi based spin valves



Energy barrier under current (FePt)



Current lines at a constriction

Main result: the non adiabatic contribution β has been determined in FePt (domain wall width Δ~1nm) and CoNi (Δ~10nm) from the probabilities of depinning under current. β is found to not depend on the domain wall width [β(FePt=0.05) and β(CoNi)=0.03] and to be close to the damping parameter. (Nature Physics 2009)

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