SYMS 1 Magnetic Switching I

Time: Monday 15:00–16:45 Room: HSZ 04

Invited Talk SYMS 1.1 Mon 15:00 HSZ 04

Manipulation of magnetization by spin transfer: switching, microwave generation — •Albert Fert[1], O. Boulle[1], V. Cros[1], M. Elsen[1], J. Grollier[1], A. Hamzic[1], H. Jaffrés[1], M. AlHajDarwish[2], J. Bass[2], H. Kurt[2], W. P. Pratt[2], J. Barnas[3], I. Gimtra[3], I. Weymann[3], R. Giraud[4], G. Faini[4], and A. Lamaitre[4] — [1]Unité Mixte de Physique CNRS/Thales, 91767 Palaiseau, France — [2]Michigan State University, East Lansing, MI, USA — [3]Poznan University, Poland — [4]LPN/CNRS, Marcoussis, France

The magnetization of a ferromagnetic body can be manipulated without applying any magnetic field, only by transferring some quantity of spin angular momentum from a spin-polarized electrical current. The first part of the lecture introduces the concept of spin transfer and describes basic experiments we performed on pillar-shaped metallic pillars and tunnel junctions. Specific experiments giving more insight on the microscopic mechanism will also be presented, for example experiments in which the switching currents can be inverted by the introduction of impurities with selected spin dependent scattering cross-section. The second part of the talk summarizes the theoretical model developed for the calculation of the spin torque and its application to several problems: inversion or tuning of the switching currents by impurity scattering, generation of microwave oscillations at zero field, etc. I will conclude with some work on the problem of the synchronization of spin transfer oscillators, an important challenge for the future applications to microwave generation.

Invited Talk SYMS 1.2 Mon 15:45 HSZ 04

Spin-torque effects in single-crystalline Fe nanomagnets and nanopillars — •Daniel E. Bürgler, Henning Dassow, Ronald Lehndorff, Matthias Buchmeier, Peter A. Grünberg, and Claus M. Schneider — Institut für Festkörperforschung und cni - Center of Nanoelectronic Systems for Information Technology, Forschungszentrum Jülich GmbH

We report on current-induced magnetization switching (CIMS) and microwave excitations in single-crystalline Fe nanomagnets and nanopillars. Fe(14)/Cr(0.9)/Fe(10)/Ag(6)/Fe(2) [thicknesses in nm] multilayers are prepared by molecular beam epitaxy. The middle Fe layer is magnetically hardened due to AF interlayer coupling across the Cr spacer. The topmost Fe layer is decoupled and acts as free layer. Nanomagnets and nanopillars with diameters of about 150 nm are patterned by optical and e-beam lithography. The CPP-GMR is 2.6% at RT and 5.6% at 4 K. Clearly different GMR curves for the field along the easy and hard axes of Fe(001) indicate the single-crystalline nature of the nanostructures. Hysteretic CIMS occurs at current densities larger than 2×10^7 A/cm^2. The critical current density and the switching behavior are different for the field applied along easy and hard axes. In nanopillars, CIMS appears for both current polarities and is related to the switching of the top or middle Fe layer, respectively, and to the different spin scattering asymmetries of Fe/Cr and Fe/Ag interfaces. High-frequency spectroscopy reveals magnetic GHz excitations in the nanomagnets with a rich dependence of the excitation frequency on the DC current, field strength and direction, again with clearly different easy and hard axis behaviors.

Invited Talk SYMS 1.3 Mon 16:15 HSZ 04

Current-induced spin-transfer torque and spin dynamics in spin-valve structures — •Jozef Barnas[1,2], Martin Gmitra[1], Vitaly Dugaev[3], and Albert Fert[4] — [1]Department of Physics, Adam Mickiewicz University, Poznan, Poland — [2]Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland — [3]Instituto Superior Tecnico, Lisbon, Portugal — [4]Unite Mixte de Physique CNRS/THALES, Orsay, France

A unified description of the current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) and current-induced magnetic switching (CIMS) in spin-valve structures has been worked out in terms of a macroscopic model. The description is based on the classical spin diffusion equation for the distribution function and on the relevant boundary conditions for the longitudinal and transverse components of the spin current. The description explains experimentally observed correlations between normal/inverse CPP-GMR and normal/inverse CIMS.

Time evolution of the CIMS and spin dynamics due to spin-transfer torque have been analyzed in terms of a macrospin model by solving the relevant Landau-Lifshitz-Gilbert equation. Current-induced transition to steady precessional modes in zero magnetic field has been found in some asymmetrical structures. Conditions for the occurrence of such precessional modes and the relevant phase diagram have also been found.