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CV-04. Memory properties in a Landau-Lifshitz hysteresis model for thin ferromagnetic sheets. B. Van de Wiele¹, L. Dupre² and F. Olyslager¹. *INTEC, Ghent University, Ghent, Belgium; 2. EELAB, Ghent University, Ghent, Belgium*

The paper deals with a 2D-numerical model for the evaluation of the electromagnetic hysteretic behavior of thin magnetic sheets when applying a uni-directional magnetic field. The time variation of the magnetization vector M in each space point obeys the Landau-Lifshitz equation [1]. The effective field is the result of several contributions: the applied field, the magnetostatic field, the anisotropy field and the exchange field. In the numerical scheme, the magnetization dynamics is calculated analytically by keeping the effective field constant during each time step, which guaranties the time independence of the magnitude of M . In order to drastically improve the computational cost, the magnetostatic field is evaluated exactly at each time point using Fast Fourier Transforms, while the anisotropy field calculations are assuming a cubic atomic structure. Microstructural features, such as grain size and crystallographic texture, are introduced in the micromagnetic model by dividing the geometry in subregions, each with its own magnetic preferable directions. Macroscopic magnetization loops are reconstructed by considering in the micromagnetic model on the one hand the total magnetization in the cross section of the sheet and on the other hand the applied magnetic field. In the paper, numerical experiments are presented aiming at low frequency applications. The presented micromagnetic model is used to study magnetic memory material properties. When a time varying magnetic field with local minima and maxima is applied, numerical experiments reveal that (1) minor hysteretic loops in the resulting macroscopic magnetization are indeed closed (2) the closed minor loops are completely erased from the memory and (3) the magnetic domain structure at the starting point of a minor loop is recovered exactly when this loop is closed.

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CV-05. Computation of switching rates by Landau-Lifshitz simulation: filtering U-turns. S. Wang¹ and P.B. Visscher¹. *MINT Center and Physics Department, University of Alabama, Tuscaloosa, AL, USA*

Magnetic switching rates are often computed from an Arrhenius-Neel formula proportional to $\exp[-E/kT]$, where E is an energy barrier. In principle, such formulas can be derived by statistical methods from the Landau-Lifshitz equation of micromagnetics. Attempts to check the Arrhenius-Neel formula by counting switches in an LL simulation have been complicated by the problem of multiple crossings and U-turns in the presence of noise — the result

has been found to depend sensitively on how a “switch” is defined, even for relatively high barriers. By studying actual noisy switching trajectories such as that shown in the figure, we have found a simple algorithm for identifying U-turns (false switches in which the magnetization jumps immediately back to the original energy well) and thereby counting actual switches, that does not depend sensitively on arbitrary parameters. This will be applied to calculation of switching rates of current interest, such as MRAM elements and spin-torque devices.

Fig. 1. Planar projection of a short trajectory (showing a false switch or U-turn) of the magnetization for a thin film with demag field and in-plane anisotropy; theta is the angle from the normal direction, phi is the azimuthal angle in the film plane.

CV-06. Size effects in submicronic dots of [Co/Pt]/NiFe with competing out-of-plane and easy plane anisotropy. L.D. Buda-Prejbeanu¹, J. Tousseint², B. Rodmacq¹ and B. Dieny¹. *SPINTEC, CEA / CNRS/ URA2512, Grenoble, France; 2. Laboratoire Louis Neel, CNRS, Grenoble, France*

Recent spintronic components consist of a whole stack of coupled magnetic layers and the efficiency of the final device is assured by the optimization of each ingredient. For example of the RF oscillator [1] uses a perpendicular spin polarizer to inject electrons with out-of-plane spin in an in-plane soft magnetic layer. Fully three-dimensional micromagnetic simulations were carried out in order to analyze the magnetization distribution of the a perpendicular spin polarizer consisting of [Co/Pt](12nm) / [NiFe](2nm). We focused on square dots with a lateral size below 300nm and variable material parameters. Single square dots of NiFe with a thickness of 2nm submitted to a saturating out-of-plane field relax in zero field to an in-plane vortex-like magnetic state. By adding the [Co/Pt] multilayer with strong out-of-plane anisotropy, this multilayer being separated from the NiFe layer by a non-magnetic decoupling spacer, the magnetization of the NiFe partially reorients out-of-plane because of the stray field issued from the [Co/Pt]. However, this stray field alone is not enough to overcome the NiFe easy plane shape anisotropy so that the reorientation is only partial bringing the mean value of the out-of-plane magnetization from 0.03 to 0.10. Fully reorient the magnetization out-of-plane, the average exchange stiffness constant of the [Co/Pt] multilayer considered in the simulation as an homogeneous material, has to be adjusted as a function of the dot size. For dots 100nm wide, the out-of plane saturation of the NiFe thin film is reached for an exchange constant around 10^{-12} J/m while for dots of 200nm the exchange constant has to be twice larger. The magnetization distortion of the NiFe film is important to consider for the proper operation of the device.

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CV-07. Guiding center approximation to gyroscopic motion in micromagnetics. A. Prabhakar¹. *Electrical Engineering, Indian Institute of Technology, Chennai, India*

Magnetic sensors design for high frequency operations require dynamic micromagnetic simulations that solve the Landau-Lifshitz-Gilbert equation

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ABSTRACTS