Tuning writing magnetic fields in multi-state storage media

R. Morales[1,2], M. Kovylina[3], Z-P. Li[4], M. Erekhinsky[4], J. E. Villegas[5], A. Labarta[3], X. Batlle[3], and Ivan K. Schuller[4]

[1]Dpto. de Química-Física, Universidad del País Vasco, 48940 Leioa, Spain.
[2]IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Spain.
[3]Departament de Física Fonamental and Institut de Nanociència i Nanotecnologia, Universitat de Barcelona, 08028 Barcelona, Catalonia, Spain
[4]Physics Department, University of California San Diego, La Jolla 92093 CA, USA
[5] Unité Mixte de Physique CNRS/Thales, Université Paris Sud, 91405 Orsay, France

Contact e-mail: rafael_morales@ehu.es

Antiferromagnetic/ferromagnetic (AF/FM) bilayers exhibiting both negative and positive exchange bias have been proposed as multi-state storage media [1]. In such media the same magnetic region or element can store more than two digits. Thus, a track length comprising 8 magnetic elements stores up to 2^8 = 256 bytes in regular media, whilst in a threefold multi-state system it could store up to 3^8 = 6561 combinations, that could be called Tits (Ternary Digits). A multi-state digit is defined by the remanent magnetization (M_s) of the magnetic element. M_s is determined by the external field (H_{FC}) applied while cooling the AF/FM bilayer through the AF Néel temperature. A low H_{FC} yields a FM hysteresis loop with negative exchange bias providing a state with the highest M_s value (Fig. 1, H_{FC} = 0.5 kOe). High H_{FC} leads to a loop with positive exchange bias giving a digit with the lowest M_s (Fig. 1, H_{FC} = 5.0 kOe). States in-between can be defined either by a fractional value of M_s or even by a null remanence, by applying intermediate cooling fields (Fig. 1, H_{FC} = 2.0 kOe).

The minimum H_{FC} necessary to obtain positive exchange bias establishes the magnetic field required for multi-state storage writing. In continuous thin films it depends on structural parameters. However, we demonstrate in this work that this minimum H_{FC} yielding positive exchange bias can be tuned by patterning the continuous bilayer. It will be showed that both dots and antidots nanostructures reduce the writing magnetic field of all multi-states. The writing magnetic field decreases either as the dot size decreases or as the antidot density increases. [2,3] These findings are explained upon energy considerations of buried and bare pinned uncompensated spins in the AF.

Work supported by U.S. DOE, Spanish MICINN (MAT2009-08667 and FIS2008-06249), Catalan DURSI (2009SGR856), U.S. Air Force Office for Scientific Research, and IKERBASQUE Basque Foundation for Science.

References

[1] I. V. Roshchin, O. Petracic, R. Morales, Z.-P. Li, X. Batlle, I. K. Schuller, US Patent Number 7,764,454.

[2] Z.-P. Li, R. Morales, and I. K. Schuller, *Appl. Phys. Lett*. **94** (2009) 142503

[3] M. Kovylina, M. Erekhinsky, R. Morales, J. E. Villegas, I. K. Schuller, A. Labarta, and X. Batlle, *Appl. Phys. Lett.* **95** (2009) 152507

Figures

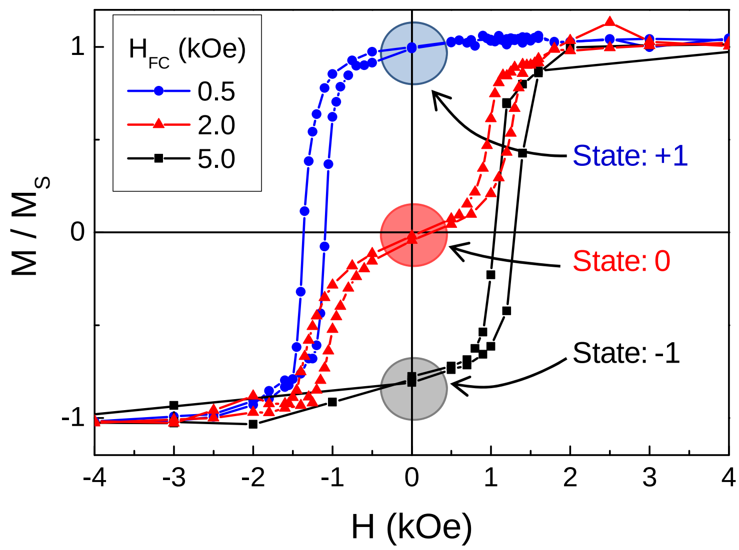

Figure 1. Three hysteresis loops of a continuous FeF_2/Ni bilayer for different cooling fields. These cooling fields defined a threefold multi-state.