Tailoring the magnetization states in thickness modulated $NdCo_5$ films with perpendicular magnetic anisotropy.

A. Hierro-Rodríguez[1,2], R. Cid[1,2], G. Rodríguez-Rodríguez[1,2], M. Vélez[1], J.I. Martín[1,2], L.M. Álvarez-Prado[1,2] and J.M. Alameda[1,2]

[1] Universidad de Oviedo, C/Calvo Sotelo s/n, 33007, Oviedo, Spain
[2] Centro de Investigación en Nanomateriales y Nanotecnología – CINN (CSIC – Universidad de Oviedo – Principado de Asturias), Parque Tecnológico de Asturias, 33428 Llanera, Spain
hierroaurelio@uniovi.es

Magnetic materials with out-of-plane magnetic anisotropy have a great interest nowadays due to their applications in order to develop new high density magnetic storage medias. In the case of rare earth-transition metal alloys (RE-TM), these materials are also interesting from fundamental research point of view due to its complex magnetic behavior. One of the most interesting magnetic structures that appear in this kind of samples are the so called “Magnetic Stripe Domains”, which existence is due to competition between magnetostatic energy, perpendicular and in plane anisotropy and exchange interaction [1, 2].

In order to tailor the magnetic properties of these RE-TM alloys and get a better understanding of their magnetization processes we have used nanolithography techniques [3] to nanostructure these kind of samples. In particular, we have prepared $NdCo_5$ films with periodic thickness modulations in “battlement-like” structures (Fig.1) by electron beam lithography and dry etching techniques.

These battlement-like structures allow to study how the stripe domains configuration evolves as a function of the thickness of the magnetic film and the width of the battlements, while the exchange interaction between the different regions of the nanostructure is present. In order to develop this experiment we have prepared samples with battlement period from 2 μm to 500 nm and a battlement deep from 10 to 30 nm. Magnetic characterization has been made by magnetic force microscopy (MFM) technique with in-plane magnetic field application capabilities. Thus, MFM images sequences have been measured to analyze how the magnetization configuration evolves as a function of magnetic field.

The experiments show that there are two different magnetization behavior regimes. In the first one large battlement periods result in the existence of a great number of stripe domains both in the upper and lower regions of the nanostructured sample, and although both areas are exchange coupled, the magnetic behavior of each region seems to be decoupled, being even possible to obtain stripes configured in a perpendicular geometry (Fig.2a).
The other regime is observed when the battlement period is small compared with the stripe domain characteristic period and then the magnetization of the film becomes coupled again in the upper and lower battlement regions (Fig.2b).

References

[1] R. Cid, G. Rodríguez-Rodríguez, , L.M. Álvarez-Prado, J. Díaz and J.M. Alameda, JMMM, **316** (2007) E446.
[2] L. M. Álvarez-Prado, G. T. Pérez, R. Morales, F. H. Salas, and J. M. Alameda, PRB, **56** (1997) 3306.
[3] , J Nogués, Kai Liu, J.L Vicent and Ivan K Schuller, JMMM, **256**, 1-3 (2003) 449.

Figures

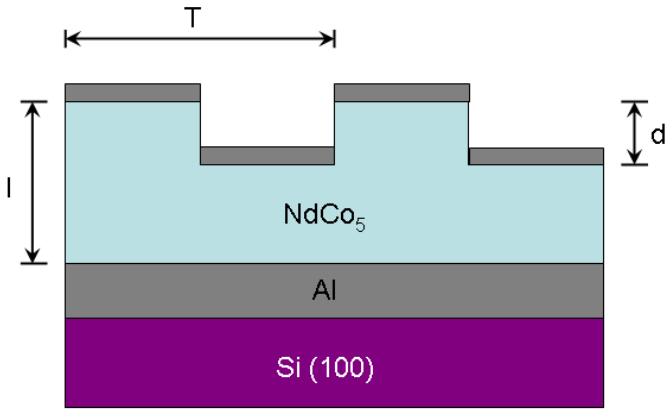

Fig.1 Sketch of a battlement - like structure in a $NdCo_5$ film. The period (T) and etching depth (d) are indicated.

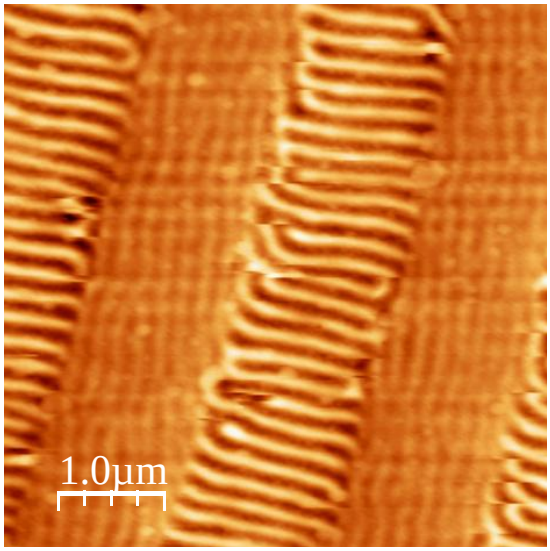

Fig.2a MFM image of battlement like structure with a period of 2µm. Decoupled state: at certain external field, measuring the in-plane hard axis loop, the stripes of both regions of the nanostructure are perpendicular to each other.

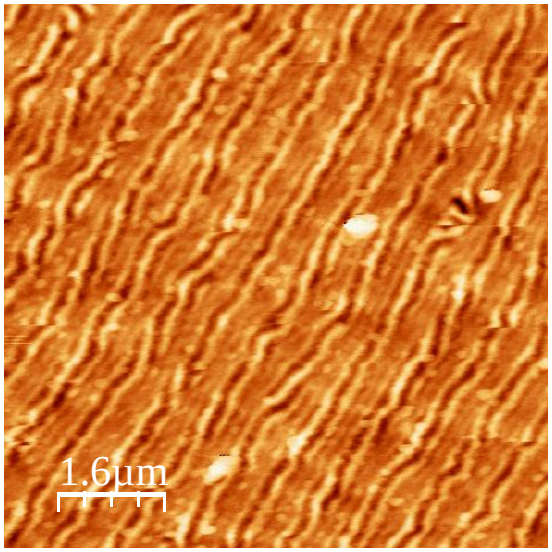

Fig.2b MFM image of battlement like structure with a period of 500nm. Coupled state: The magnetization in both regions of the nanostructure rotates together upper and lower.