TEMPERATURE DEPENDENCE OF THE ANTIFERROMAGNETIC COUPLING IN AMORPHOUS Co_XSi_{1-X} / Si MULTILAYERS

L. Zárate[1], *C. Quirós*[1], *M. Vélez*[1], *N. Yaacoub*[2] , *C. Meny*[2], *A. Pérez-Junquera, J. I. Martín*[1] *and J. M. Alameda*[1]

[1] *Depto. de Física, Universidad de Oviedo, Avda. Calvo Sotelo s/n, 33007 Oviedo, Spain.*
[2] *IPCMS-GEMME, CNRS-UMR 7504, 23 rue du Loess, F-67037 Strasbourg Cedex, France*

lzaratep@condmat.uniovi.es

Nanostructured magnetic materials have been intensively studied lately due to the interesting properties they present when at least one of their geometrical dimensions are reduced to the nanometric scale. The most simple nanostructure is a thin film with nanometric thickness. Multilayers built by thin film blocks have shown interesting properties like giant magnetoresistance (GMR) with a great impact in technology industry, but also present optical, magnetic and other properties different than bulk materials which in one hand are very useful to develop new materials with selected properties and, on the other hand, give important information about fundamental physical interactions.

In this work, amorphous $((Co_xSi_{1-x})_{5\ nm}$ / $(Si)_d)\times n$ multilayers have been prepared by co-sputtering on Si substrates in order to study the presence of antiferromagnetic coupling between the magnetic layers. The magnetically active layer thickness has been kept fixed at 5 nm, and the Si spacing layer thickness, d, has been varied between 2 and 15 nm, while the number of periods, n, is 10 or 6. The structure of the multilayers has been characterized by X-ray reflectometry and SUPREX software[1] has been used to fit parameters. The multilayer structure is well defined with very low cumulative roughness values around 0.8 nm. It also reveals a clear asymmetry between the Si-on Co and Co-on-Si interfaces in the analyzed multilayers, where the first interface can be described by diffusion while in the other interface an intermediate $CoSi_y$ compound of about 0.5-0.7 nm is formed.

Bulk magnetometry and magneto-optical transverse Kerr effect (MOTKE) measurements show that the films have in-plane uniaxial magnetic anisotropy and that the Co_xSi_{1-x} layers are antiferromagnetically coupled for Si layer thicknesses lower than 8 nm in the amorphous compositions (Fig.1). The magnetic field required to switch between antiparallel and parallel configurations is as low as 3 Oe [2]. These results are in contrast with those found in polycrystalline Co/Si multilayers, which show no clear evidence of antiferromagnetic coupling [3].

Temperature dependent measurements using MOTKE show that the AF coupling can only be observed in a temperature range close to the Curie temperature of the multilayers. As temperature is reduced, the coercive field of the individual Co_xSi_{1-x} layers increases so that they are not soft enough to be reversed by the weak AF coupling. Moreover, results obtained in Co_xSi_{1-x} /Si /Co_xSi_{1-x} trilayers show different temperature behaviours for the switching process corresponding to the AF state formation and the one corresponding to the ferromagnetic alignment at saturation (fig.2).

Also, zero-field-cooled and field-cooled magnetization measurements have been carried out using a SQUID magnetometer in the temperature range 5-300K and in applied fields up to 5 Tesla in order to analyze the role of the possible superparamagnetic contributions.

References:

[1] 24 E. E. Fullerton, I. K. Schuller, H. Vanderstraeten, and Y.Bruynseraede, Phys. Rev. B **45**, 9292 (1992).

[2] C. Quirós, J. I. Martín, L. Zárate, M. Vélez, and J. M. Alameda, Phys. Rev. B **71**, 024423 (2005)

[3] P. J. Grundy, J. M. Fallon, and H. J. Blythe, Phys. Rev. B **62**, 9566 (2000)

Figures:

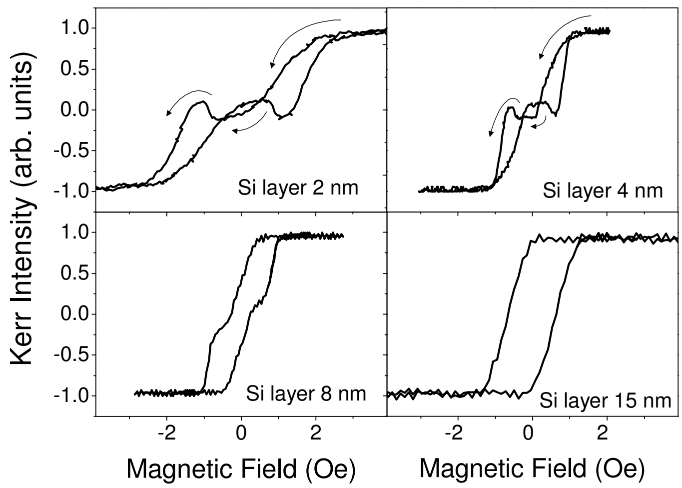

Fig.1. MOTKE hysteresis loops along the easy axis of $Co_{0.74}Si_{0.26}$ – based multilayers for different Si spacer thicknesses. Curved arrows indicate the sense of the loop.

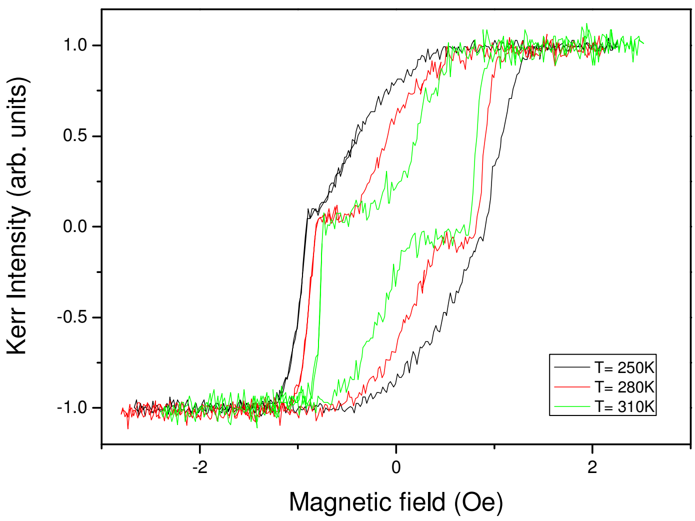

Fig.2. Temperature dependence of antiferromagnetic coupling in a 5nm $Co_{0.74}Si_{0.26}$ /3nm Si /5nm $Co_{0.74}Si_{0.26}$ trilayer . Note that behaviours are different when creating the AF and the F states, being much more sensible to temperature the first one .