Modulated Exchange Coupling across Rare-Earth Layers in Gd_XCo_{1-X}/Gd/Gd_YCo_{1-Y} Trilayers

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Magnetic systems formed by nanometric-scale-thick layers have attracted much attention both for technological applications ~~and from a fundamental~~ point of view as they can show interesting magnetic properties and artificially induced stable configurations that are absent in bulk materials or single thin films[1], opening new ways for the design of novel devices.

In particular, rare earth (RE) – transition metal (TM) amorphous alloy multilayers are a family of great interest due to their fundamental characteristics. These alloys present antiferromagnetic coupling between the magnetic moments of the RE and TM ions, which also have different dependences with temperatures. Consequently a compensation temperature (T_{comp}) compositionally dependent is usually found, resulting that the net magnetization of the alloy is aligned with either the RE or TM as the temperature is below or over T_{comp}[2].

In this work exchange coupling between two Gd-Co amorphous alloy layers of different compositions across an interlayer of Gd of variable thickness has been studied. In particular, the compositions of the trilayers are $Gd_{28}Co_{72}$/Gd/$Gd_{12}Co_{88}$ and have been chosen in such way that both alloys had their T_{comp} far away from the temperature range of measurement (from 20K to 300K), being one of them dominated by Gd ($Gd_{28}Co_{72}$) and the other one by the Co sublattice ($Gd_{12}Co_{88}$), (see Fig. 1).

The trilayers were obtained by dc magnetron co-sputtering on quartz substrates and present an in-plane well-defined uniaxial anisotropy. The Gd-Co layers have a thickness of 500Å, while the thickness of the Gd interlayer was varied from 0Å to 300Å. The samples have a 100Å Cu capping to prevent oxidation. Magnetic characterization has been performed by transverse magneto-optical Kerr effect (T-MOKE) measuring on both sides of the trilayers illuminating the whole sample with visible light. T-MOKE signal is then only sensitive to the Co magnetic moments, and penetration depth is about 400Å so that only one layer is measured at a time. It has allowed us to analyze the magnetization reversal process within each layer and then, to compare the behaviour with that of Gd_XCo_{1-X}/Gd_YCo_{1-Y} bilayers[3].

It has been found that the exchange coupling between $Gd_{28}Co_{72}$ and $Gd_{12}Co_{88}$ layers can be actually modulated by varying the thickness of the Gd interlayer. Thus, as Gd layer thikness is increased, the strength of the coupling is reduced so that the temperature necessary to decouple the layers becomes lower, being 135K the value of this decoupling temperature for the 300Å-thick Gd layer case. Moreover, the interplay between this modulated exchange coupling through the 4f moments and the creation (or annihilation) of the domain wall across the thickness present at saturation (see fig.1) results in the observation of a rich variety of behaviours in the magnetization reversal processes as the temperature is varied (see fig. 2).

References:

[1] S.M. Valvidares, L.M. Álvarez-Prado, J.I. Martín, J.M. Alameda, Physical Review, B **64** (2001) 134423.
[2] P. Hansen, in *Book of Magnetic Materials*, edited by K.H.J. Buschow (Elsevier, Amsterdam, 1991), vol. 6, p.289.
[3] R.Morales, J.I. Martín, and J.M. Alameda, Physical Review B, **70** (2004) 174440.

Figures:

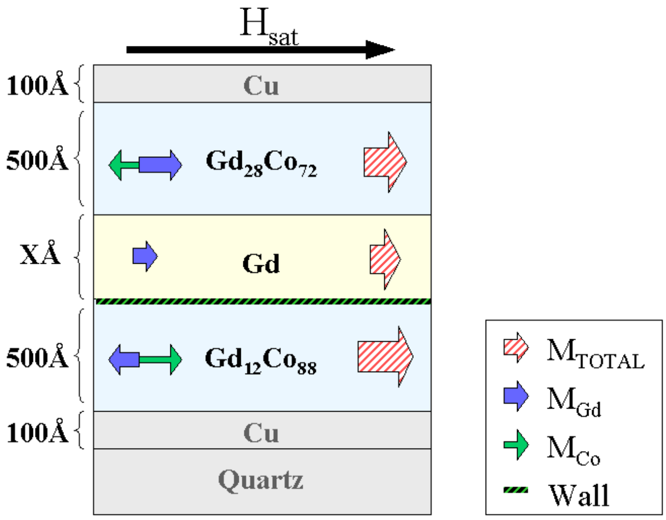

Fig. 1. Sample sketch where total magnetic moment of each monolayer is represented, as well as the magnetic moment of Gd and Co sublattices.

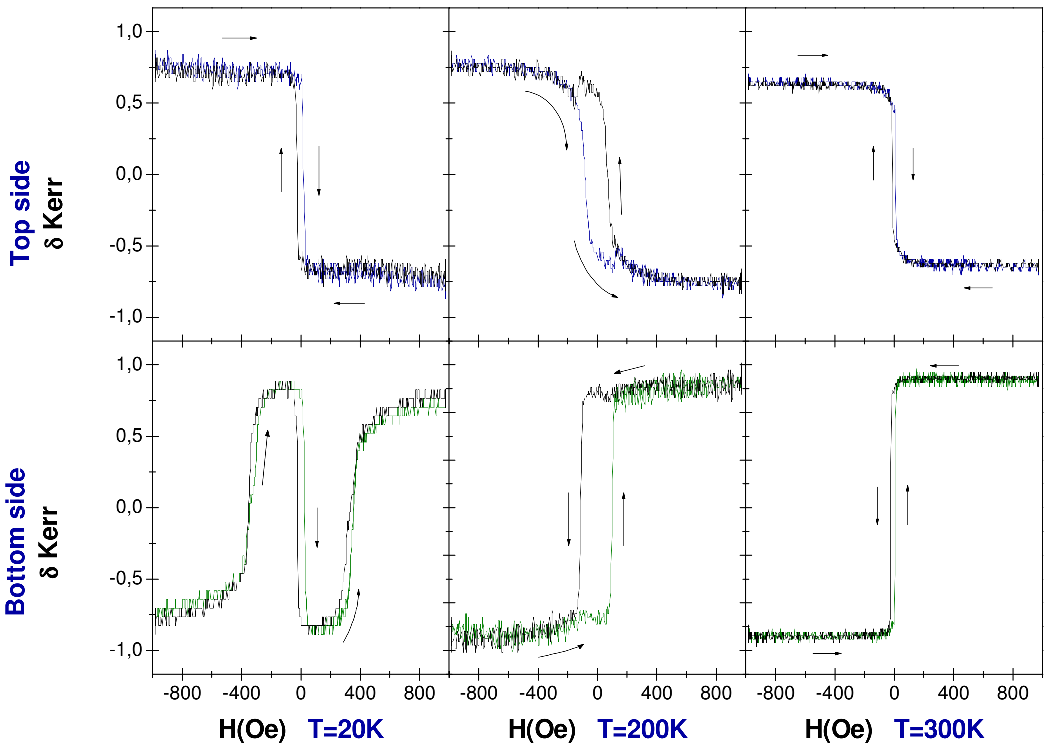

Fig. 2. T-MOKE hysteresis loops along the easy axis of both sides of $Gd_{28}Co_{72}/Gd/Gd_{12}Co_{88}$ with 35Å Gd interlayer. Note that T-MOKE signal is only sensitive to Co moments. Arrows indicate the sense of the loop.