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BILINEAR AND BIQUADRATIC COUPLING IN Fe/Cr/Fe/MgO (100) THIN FILMS GROWN BY DC-SPUTTERING

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Abstract – Nanometric samples of Fe/Cr/Fe on MgO (100) were prepared by DC sputtering and experimental measurements were performed by MOKE and FMR. The measurements showed that the sample with Cr thickness of 15 Å presents bilinear and biquadratic coupling between the Fe layers. These results were confirmed by numerical calculations. We are currently preparing new samples, varying the thickness of the Cr spacer and the deposition temperature, in order to verify the variation of the coupling (intensity and sign) between the ferromagnetic layers.

The observation of magnetic coupling between nanometric ferromagnetic films, separated by a nonmagnetic spacer layer, aroused great interest in scientific research on the behavior of magnetic multilayers, in both the theoretical and experimental point of view. By the end of the 80's, P. Grünberg and A. Fert demonstrated the existence of antiferromagnetic coupling [1] and giant magnetoresistence effect in Fe/Cr magnetic multilayers, respectively. Later, S. Parkin [2] has shown that the exchange coupling alternated in sign (positive/negative) according to the thickness of the Cr spacer layer. He also found that the effect decreases in magnitude as the thickness of the nonmagnetic spacer increases. The system may present two types of coupling: the bilinear coupling and biquadratic coupling.

The theoretical prediction and the experimental investigation of these phenomena are crucial for practical applications such as, magnetic recording media, magnetoresistive sensors (for automotive industry) and magnetoresistive random access memories (MRAM). However, the versatility and eficiency, of the above cited devices, strongly depend on the understanding and knowledge of the physical phenomena involved in their construction and operation.

We have prepared trilayers of Fe/Cr/Fe grown on MgO (100) substrate by DC magnetron sputtering. The argon pressure (working pressure) during the deposition was kept at 2.2 mtorr and a Cr (001) buffer layer (100 Å thick) was deposited at 600 ºC onto the MgO, in accordance with Ref. [3]. After that, the trilayer composed of Fe (45Å)/ Cr (t)/ Fe (45Å) was grown at 150 ºC. Finally, in order to protect the sample from oxidation, a cap-layer of Cr (30Å) was grown at the same temperature. The magnetic properties were measured by magneto-optical Kerr effect (Moke), ferromagnetic resonance (FMR) and Magnetoresistence (MR).

The measurements showed that the sample with 15 Å Cr presents bilinear and biquadratic coupling between the Fe layers. These results were confirmed by numerical calculations. However, the other sample (20 Å Cr) do not present any coupling between the Fe layers. This can be seen from the MOKE (Fig.1 and Fig. 2) and FMR (Fig. 3) measurements and from the numerical calculations as well, which clearly show the behavior of two uncoupled films. We are currently preparing new samples, varying the thickness of the Cr spacer and the deposition temperature, in order to verify the variation of the coupling (intensity and sign) between the ferromagnetic layers.

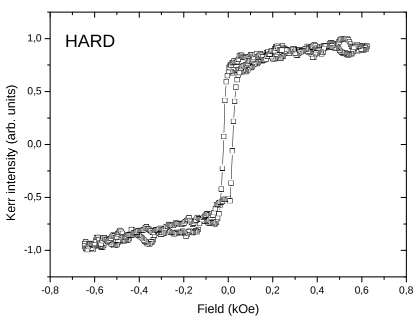

Figure 1: Normalized magnetization versus external magnetic field along the hard-axis.

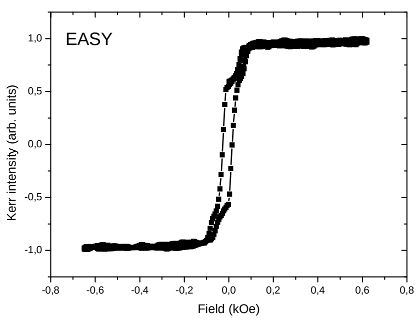

Figure 2: Normalized magnetization versus external magnetic field along the easy-axis.

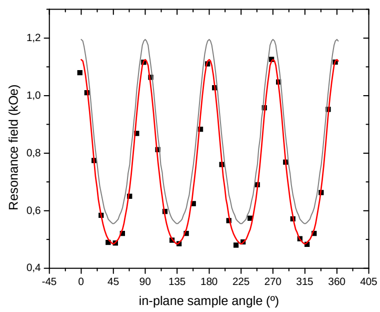

Figure 3: Resonance field versus in-plane field angle for FMR measurements.

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