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Oscillatory behavior of Exchange Bias Field in NiFe/IrMn/Co System

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Abstract –The coupling effect between two adjacent exchange bias systems in NiFe(3nm)/IrMn(t)/Co(3nm) trilayers structure was studied. The exchange bias field values from the bottom NiFe/IrMn (H_{EB}^b) and the top IrMn/Co (H_{EB}^t) interfaces show different behaviors. On the dependence of IrMn spacer thickness, H_{EB}^b increases in the range from 3nm to 7 nm and it is kept almost constant for thicker IrMn spacer, while H_{EB}^t decreases in an oscillatory behavior. These results could be evidencing that the exchange bias effect at the interfaces are modified by the exchange interaction coupling between the FM layers.

The exchange bias effect (EB) has been generally considered as an interfacial effect, implying that only interfacial spins are responsible for the unidirectional pinning of the magnetization at the ferromagnetic (FM) layer. However, there have been a number of experimental evidences about the influence of AF bulk effects over EB. In addition, it was found that EB is strongly dependent on the thickness of the antiferromagnetic (AF) layer even for large thicknesses [1], and besides, EB can persist even when a nonmagnetic spacer was inserted between AF and FM layers [2]. In FM/AF/FM trilayers, a bulk characteristic of EB would imply that the action of EB from one AF/FM (or FM/AF) interface could propagate up to the other.

Si<111>/Cu(10nm)/NiFe(3nm)/IrMn(t)/Co(3nm)/Ru(3nm) multilayers (*t*=3, 5, 7, 10, 15, 20, 40 and 60 nm) were prepared by magnetron sputtering. During the deposition, the operating Ar pressure was kept at 3 mTorr and the substrates were at room temperature. The samples were prepared under an applied magnetic field of 480 Oe in order to set the unidirectional anisotropy. Magnetization measurements were performed using a vibrating sample magnetometer (VSM).

The H_{EB} vs IrM(t) observed in Fig. 1 show that the exchange bias field (H_{EB}^b) at the bottom NiFe(3nm)/IrMn(t) interface is more intense than the exchange bias intensity (H_{EB}^t) at the IrMn(t)/Co(3nm) top interface, but the outstanding result is the oscillatory behavior at the IrMn/Co interface. Probably, the coupling between the two FM layers oscillates when the AF thickness is changed; this can be expected if the interlayer coupling is mediated by the exchange interaction through the antiferromagnetic layer, which influences EB at the IrMn/Co interface. In addition, we think that EB is intensifying the interlayer coupling, which is present even for spacer thickness about 60 nm.

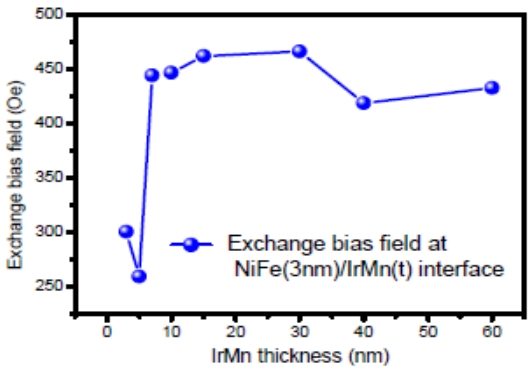

Figure 1: Exchange bias field as a function of IrMn spacer thickness at the NiFe(3nm)/IrMn(t) bottom interface in NiFe(3nm)/IrMn(t)/Co(3nm) trilayer structure.

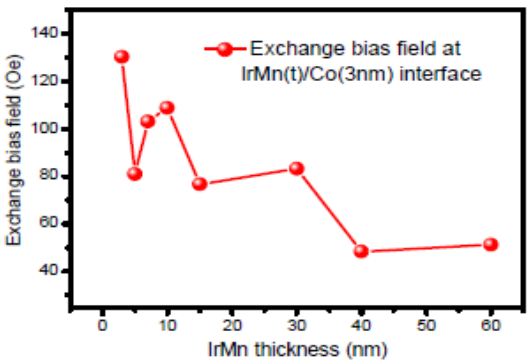

Figure 2: Exchange bias field as a function of IrMn spacer thickness at the IrMn(t)/Co(3nm) top interface in NiFe(3nm)/IrMn(t)/Co(3nm) trilayer structure.

[1] R. Morales, Zhi-Pan Li, J. Olamit, Kai Liu, J. M. Alameda and Ivan K. Schuller. Phys. Rev. Lett. 102, 097201 (2009).
[2] Miguel Tafur, W. Alayo, Y. T. Xing, E. Baggio Saitovitch and V. P. Nascimento. J. Phys. D: Appl. Phys. 42, --- (2009).