Study of the exchange bias behavior on the applied field cooling in ferromagnetic/antiferromagnetic bilayers based $La_{1-x}Ca_xMnO_3$ system

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We studied the exchange bias effect in a ferromagnetic/ antiferromagnetic interface based on the lanthanum manganite system doped with Ca: $La_{1-x}Ca_xMnO_3$ (LCMO). We grew F-LCMO/AF-LCMO bilayers by using a DC sputtering technique at high oxygen pressure on (001) $SrTiO_3$ single-crystal substrates. From magnetization loops and thermal demagnetization curves we found that the exchange bias field magnitude H_{ex} increases with the decreasing of temperature and it depends on the magnitude of applied cooling field, H_{FC}. We also noted that transition temperature of the bilayer in magnetization curves as function of temperature reveal a dependence on H_{FC}.

Keywords: Magnetic bilayers, sputtering, interfaces, manganite, exchange bias,
Work supported by the Excellence Center of Novel Materials CENM and Colciencias.

In modern applications, the key to modifying and controlling magnetic properties is based on designing magnetic structures with properties governed by the interface region [1]. Exchange bias is a phenomena associated to the exchange anisotropy created at the interface between an AF and an F material [2], which manifests itself as a shift of the ferromagnetic hysteresis loop [3] when the sample is field cooled through the Neel temperature, T_N, of the antiferromagnetic phase [4]. Exchange bias materials, in thin-film form, have been the most widely studied type of system. Moreover, materials in thin-film form have been the basis of many interesting phenomena related to exchange bias, such as AF thickness, interface disorder, or orientation dependence of Hex, to name a few. We grew in-situ F-LCMO/AF-LCMO bilayers by using a sputtering technique at high oxygen pressure (PO_2 = 3.5mbar) and at a substrate temperature of 850 °C on (001) oriented $SrTiO_3$ substrates. We first grew the AF-layer on the substrate with a given AF thickness, t_{AF}, and then the ferromagnetic layer on the AF-layer, with a given F thickness, t_f. with 1/6 and 6/1 thickness ratio. For the magnetic characterization, we used a Physical Property Measuring System, PPMS, from Quantum DesignTM with a Vibrating-Sample Magnetometer (VSM), obtaining isothermal magnetic hysteresis loops between 5-100K for different H_{FC} and magnetization curves as functions of temperature for different field cooling (100 Oe -1000 Oe). From the magnetic hysteresis loops at 5K, we obtained Hex for different cooling fields (H_{FC} = 100, 200, 300, 400, 500, 600, 700, 800, 1000 Oe). As noted in Figure 1a, the Exchange Bias field tends to increase linearly to H_{FC} = 400 Oe, and thereafter it decreases – revealing that there is an applied cooling field that maximizes the effect.

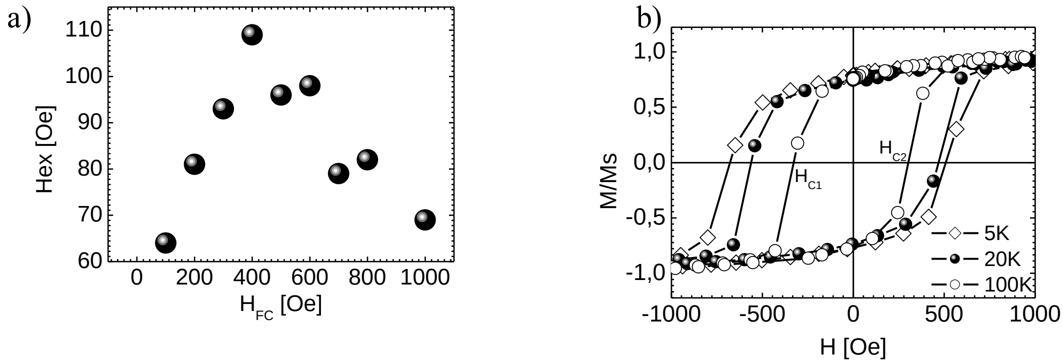

Fig. 1 a) Exchange bias, Hex, dependence on H_{FC}, obtained from magnetic hysteresis loops at 5K. b) Magnetic hysteresis loops at T = 5, 20, and 100 K for a field of 400 Oe.

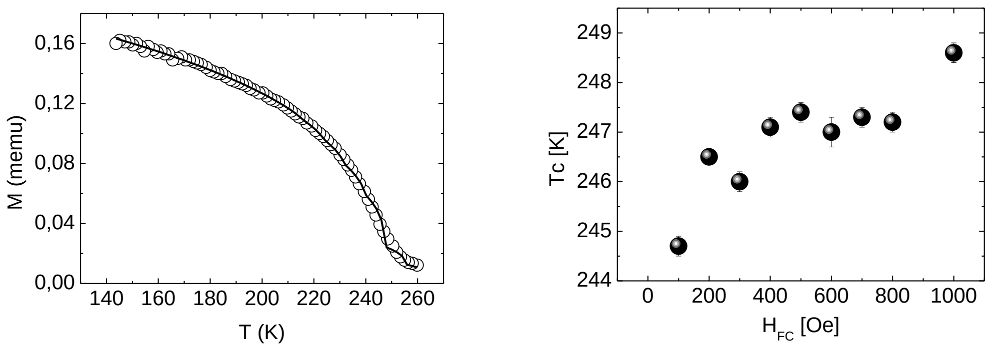

Fig. 2 a) Comparison of experimental M(T) data for a H_{FC} = 400 Oe (open circle) and the least-square fitting result (line) according to a Gaussian distribution [5]; for clarity only, a fraction of the actual data set is displayed. b) Tc obtained from the Gaussian fit for different applied cooling fields.

[1] R.L. Stamps, J. Phys. D: Appl. Phys. Lett. **33**, R247 (2000).
[2] J. Nougués, Ivan K. Shuller. J. Magn. Magn. Mater. **192** 205 (1998)
[3] M. Grimsditch, A. Hoffman, P. Vavassori, Hongtao Shi and D. Lederman. Phys. Rev.Lett. **90** 257201-1 (2003)
[4] I. Panagiotopouslos, C. Christides, M. Pissas and D. Niarchos. Phys. Rev. B **60** 485 (1999)
[5] G. Campillo, A. Berger, J. Osorio, J. E. Pearson, S. D. Bader, E. Baca and P. Prieto. J. Magn. Magn. Mater. **237** 61-68 (2001).

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