Double hysteresis loop driven by exchange coupling in Cr_2O_3/Pt/Co positive exchange coupled thin film system

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In exchange bias systems, when the antiferromagnet is multi-domain state, usually a single hysteresis loop with averaged exchange bias (H_{ex}) is observed. However, sometimes a double hysteresis loop with local H_{ex} is observed. The double hysteresis loop was explained in terms of the lateral ferromagnetic (FM) and antiferromagnetic (AFM) domain size [1]. When the FM domain size is smaller than or comparable to the AFM domain size, such a double hysteresis loop will be obtained. In Cr_2O_3/spacer/Co perpendicular exchange coupling system, a perpendicular exchange bias switching was achieved by using magnetoelectric effect of Cr_2O_3[2,3] or using positive exchange bias phenomena[4]. During such a switching, both the single and double hysteresis loop has been observed depend on the sample structure; when Pt spacer was used, single hysteresis loop was observed[2,4], while when Cr spacer was used, double hysteresis loop was observed[3]. In this study, we investigated the AFM multi-domain state of the Cr_2O_3/Pt/Co thin film system exhibiting positive exchange bias and observed both the single and double hysteresis loop, by changing Pt spacer thickness or measurements temperature. Our results indicate the single/double hysteresis loop state can be controlled by changing H_{ex} magnitude, even if the sample structure keep unchanged. We consider the conditions to obtain the double hysteresis loop state in terms of the energy of the system; there's competition of energy to form domain wall in Co layer and to align Co parallel to Cr interface spin against exchange coupling. Larger H_{ex} make the latter energy increase, which become driving force to make domain wall in Co layer, results in the observation of the double hysteresis loop. That is, in other word, the AFM domain can be imprinted to neighbor FM domain if the H_{ex} magnitude is sufficiently large. Such a FM domain size control would have important role for the design of device applications.

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