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REORIENTATION OF EXCHANGE BIAS WITH VARYING TEMPERATURE AND COOLING FIELD IN FERROMAGNETIC/ANTIFERROMAGNETIC BILAYERS

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강자성/반강자성 이층구조에서 온도와 자기장에 따른 교환 바이어스의 재배열

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1. INTRODUCTION

Understanding the exchange bias mechanism in the interface between a ferromagnet (FM) and an antiferromagnet (AFM) has been an almost half-century old problem after the first discovery by Meiklejohn and Bean in 1956 [1]. Tremendous efforts have been devoted to clarify the physics of the exchange bias since the exchange biased system provides us a new kind of interesting physical system having interface where the two differently ordered magnetic systems meet. Despite several experimental and theoretical reports concerning positive exchange bias [2-3], the clear origin involving these phenomena has not yet been clarified mainly due to the unknown spin structure and the unknown exchange interaction at the FM/AFM interface. We systematically investigate exchange bias H_E and coercivity H_C of the Fe/Cr(100) bilayer structure with varying the temperature or varying the cooling field strength H_{FC}.

2. EXPERIMENT

The samples having the structure of 4-nm Fe/t_{Cr}-nm Cr bilayer thin films where t_{Cr} was varied from 3.2 nm to 16.2 nm, were prepared on MgO(100) substrate by dc magnetron sputtering at Ar sputtering pressure of 2mTorr and base pressure better than 5.0×10^{-9} Torr. Substrates were heated to 600°C during 30 min prior to deposition and kept to be 600°C during the growth of Cr(100) layer on MgO (100) substrate and then cooled to the ambient temperature for the growth of Fe layer which is capped with 3 nm Pt to prevent oxidation. An *in situ* magnetic field of about 300 Oe was applied along the MgO[100] orientation in the film plane during sample deposition to induce magnetic anisotropy in this orientation. Structure properties were characterized by the high-angle xrd diffraction, the x-ray ϕ scan and the rocking curve. Magnetic hysteresis loops were measured with varying temperature 5 K to 350 K or varying cooling field strength 0 T to 5T using a superconducting quantum interference device magnetometer.

3. RESULTS AND DISCUSSION

We have discovered that exchange bias is reoriented from negative to positive direction with increasing the temperature from 5 K

to 350 K at a constant cooling field or with increasing the cooling field strength from 0 T to 5 T at a constant temperature in the Fe/Cr(100) bilayer as shown in Fig. 1. Interestingly, in case of temperature-induced reorientation, right coercivity H_{RC} of hysteresis loop is reduced and left coercivity H_{LC} saturate to a constant value with decreasing temperatue less than 90 K, while in case of cooling field-induced reorientation, H_{RC} is kept to be a constant value and H_{LC} is gradually decreased with increasing the cooling field. Coercivity variation seems to be directly connected with the reorientation of exchange bias. This phenomenon can be explained qualitatively with a competition of FM-AFM antiferromagnetic exchange interaction and AFM-cooling field ferromagnetic interaction with varying the temperature or with varying the cooling field strength, with the assumption that at strong cooling field or temperature above the Néel temperature T_N, direction of AFM spins is governed by the cooling field direction, while weak cooling field or temperature less than T_N, direction of AFM spins is governed by the interface coupling in the FM/AFM bilayer with antiferromagnetic interface coupling.

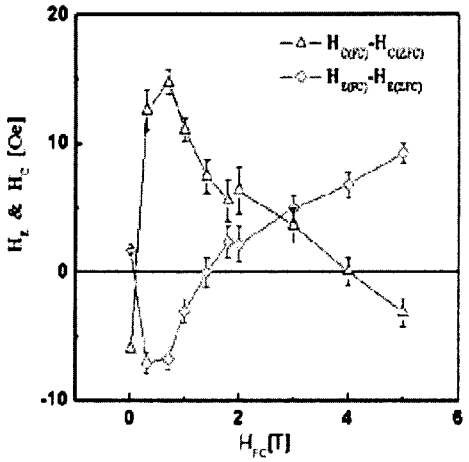

Fig. 1. Exchange bias H_E and Coercivity H_C vs. Cooling field strength H_{FC} in the Fe/Cr(100) bilayer with Cr layer 16.2 nm thick

4.ACKNOWLEDGEMENT

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