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Formation of a CoFe(001) texture in FeZr-inserted multilayer-based stacks with perpendicular magnetic anisotropy

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$[NM/Co]_n$ multilayers (NM and n denote a non-magnetic material and the number of iteration), where strong perpendicular magnetic anisotropy (PMA) is originated from the interface effects, have some distinct advantages, over $L1_0$ materials, of an easy fabrication due to a close-packed growth plane and a simple stack design allowing for many different types of material systems. However, $[NM/Co]_n$ multilayers have the two main problems of a low post-annealing stability and a difficulty of forming a CoFe(001) texture essential for high tunneling magnetoresistance. The authors recently reported new [Pt/Co] multilayers with an inverted structure that exhibit strong PMA and a high post-annealing stability up to 500°C [1, 2], thus providing an important step of relieving, if not solving, the first problem. This study deals with the second problem by inserting an amorphous FeZr layer with a high crystallization temperature between the [Pt/Co] multilayers and CoFeB/MgO layers. The PMA stack consisted of the following: Si substrate (wet-oxidized)/Ta (5)/Pt (10)/Ru (30)/[Pt (0.25)/Co (0.5)]6/FeZr (1)/CoFeB (1)/MgO (3)/Ru (3) (all thicknesses are in nm). Because Ta was previously used for a similar purpose [3, 4], the stack with Ta, instead of FeZr, was also considered for comparison. The stacks were fabricated by using a UHV sputter. The alloy targets with compositions of $Co_{20}Fe_{60}B_{20}$ and $Fe_{50}Zr_{50}$ (in at.%) were used to deposit the CoFeB and FeZr layers, respectively.

Preliminary experiments using thick FeZr thin films (10 or 100 nm) indicate that FeZr has a crystallization temperature higher than 500°C and is magnetic with a very small saturation magnetization of 35 emu/cc. Figure 1 shows x-ray diffraction patterns for the FeZr-free (upper panel) and FeZr-inserted (lower panel) stacks after annealing at 400°C. In order to amplify the x-ray signal, the thicknesses of CoFeB and MgO were increased to 10 nm. In both samples, CoFeB is amorphous in the as-deposited state, indicated by no obvious crystalline peaks related to CoFe (data not shown). After annealing, crystalline peaks related to CoFe are clearly visible in both samples but their locations are different. A strong close-packed CoFe(110) peak is seen in the FeZr-free sample, with two additional weak peaks related to CoFe(111) and CoFe(210), indicating that the crystallization initiated from the $[Pt/Co]_6$/CoFeB interface. In the FeZr-inserted sample, however, a single peak related to CoFe(001) is only observed, indicating the template effect from MgO(001). These results clearly demonstrate that the FeZr layer with its high crystallization temperature is effective in suppressing the crystallization from the close-packed muitilayers side and thus promoting the formation of the desirable CoFe(001) texture. Furthermore, the PMA properties are only slightly affected by the insertion of FeZr both in the as-deposited state and after annealing (data not shown). This is in a significant contrast with the results observed for the Ta-inserted stacks where the PMA properties greatly deteriorate with the insertion of Ta layer. Recently, Cuchet *et al*. reported the appearance of an in-plane anisotropy component in their PMA stack at Ta thicknesses as low as 0.5～0.6 nm due to the magnetic decoupling between multilayers and CoFeB across the Ta layer [3]. A similar result was also obtained in this study. Obviously, the observed PMA properties in the FeZr-inserted stack result from the fact that FeZr is magnetic, thus allowing for almost a complete magnetic coupling between $[Pt/Co]_6$ and CoFeB.

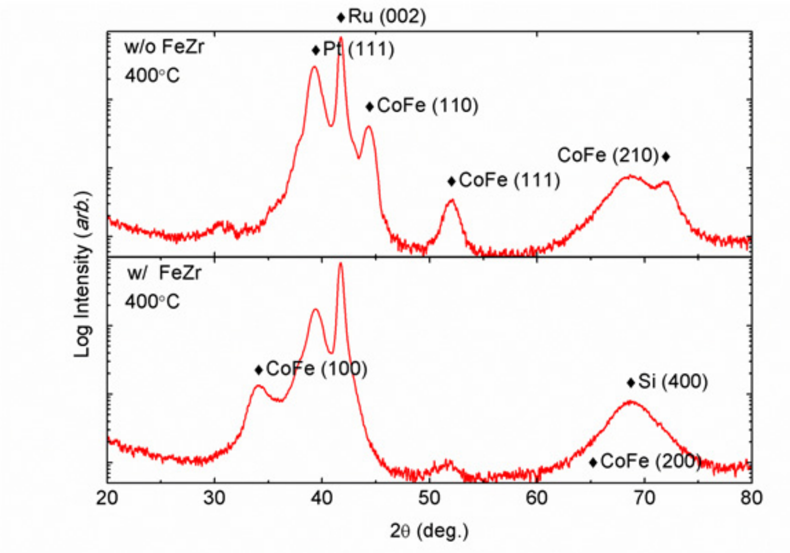

Fig 1. X-ray diffraction patterns for the FeZr-free (upper panel) and FeZr-inserted (lower panel) stacks after annealing at 400°C.

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