Perpedicular Magnetic Anisotropy in Sputtered CoFeB/Pd Multilayer

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Magnetic tunnel junctions (MTJs) with perpendicular magnetic anisotropy (PMA) have been receiving interest due to the expectation of reduced critical current density for magnetization switching [1]. To develop PMA in MTJs, L10 ordered material (FePt, CoPt) or alloy of transition metal and rare earth material is suggested. Other type of PMA structure is a ferromagnetic/novel metal multilayer system such as $(Co/Pt)_n$ and $(Co/Pd)_n$. up to now. Even though PMA and related properties have been widely studied in this system, crystalline ferromagnetic materials such as Co, Fe and CoFe were the main concern for the research. In this study, amorphous CoFeB, which is a main stream in in-plane MTJs due to large tunnel magnetoresistance(TMR) with MgO barrier, was used as ferromagnetic material to develop PMA. Dependence of PMA on metal layer thickness was quite large and number of bilayer repetition (N), type of underlayer had also an effect on the PMA.

Amorphous CoFeB and Pd were deposited by ultra-high vacuum(UHV) magnetron sputtering on the thermally oxidized (100)Si wafers. Before the deposition of CoFeB/Pd multilayer, underlayers were deposited to facilitate PMA of this system. Number of bilayer repetition(N) was varied from 2 to 20 and magnetic property was measured by vibrating sample magnetometer(VSM) at room temperature. To analyze the structure and surface morphology dependence of PMA, X-ray diffration(XRD) and Atomic Probe Microscope (AFM) were used.

Fig. 1 shows the coercivity(Hc) and total magnetic moment of CoFeB/Pd multilayer with Pd underlayer when magnetic filed was applied to the perpendicular direction of film plane. PMA was observed to 0.4 nm and thinner CoFeB. Squarness of hysteresis loop was closed to 1 for these samples. When thickness over 0.5 nm CoFeB deposited, In-plane magnetic anisotropy (IMA) was developed. Inversed-linear dependence of Hc and thickness of ferromagnetic layer, which can be also found out in the Fig. 1, has been reported in $(Co/Pt)_n$ and $(Co/Pd)_n$ system, while the critical thickness of transition from PMA to IMA was quite small (0.5 nm) compared to 0.8 nm of $(Co/Pd)_n$ system [2]. Total magnetic moment of multilyer was linearly increased with thicker CoFeB. In the higher N (repetition times) cases, Hc was almost constant (115 Oe) for $N < 15$, but it decreased rapidly for $N > 15$ samples (Fig. 2). This behavior can be attributed to formation of perpendicularly aligned domain state due to increased magnetostatic energy.

References

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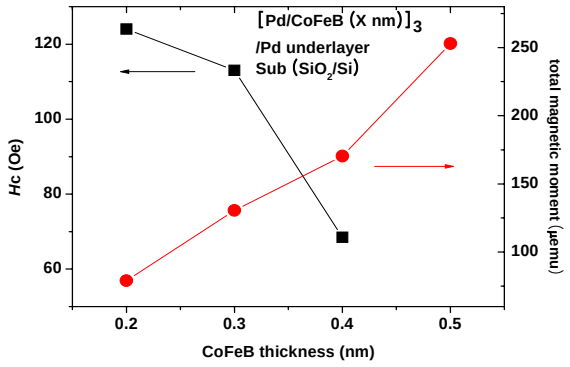

Fig. 1. Variation of coercivity and total magnetic moment of (CoFeB/Pd)3 depending on the thickness of CoFeB layer.

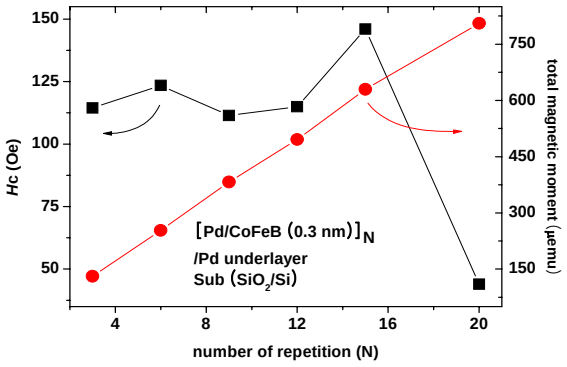

Fig. 2. Variation of coercivity and total magnetic moment depending on the number of (CoFeB/Pd) bilayer repetition.