Large Perpendicular Anisotropy of a Thick CoFeB Layer in an MgO/CoFeB/Pd Unit Structure

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Magnetic structures with a perpendicular magnetic anisotropy (PMA) have attracted a lot of research interest. This is mainly because the magnetic tunnel junctions (MTJs) with a perpendicular magnetic anisotropy (perpendicular MTJs) have the important advantage of a smaller critical current density for current induced magnetization switching (CIMS) over MTJs with an in-plane anisotropy (in-plane MTJs). Recently, the present authors reported a significantly stronger PMA (H_c=1050 Oe) in a unit structure of MgO/CoFeB/Pd with a CoFeB thickness of 2 nm [1]. The CoFeB thickness of 2 nm is considered to be at least enough for a full spin polarization, as was frequently demonstrated in the in-plane MTJs. However, in the MgO/CoFeB/Pd unit structure, it is desirable to further increase the thickness of the CoFeB. This is due to the crystallization of the CoFeB (an amorphous phase in the as-deposited state) during annealing starts to occur from the Pd side as well as in the MgO side. This problem can be reduced, if not avoided completely, by increasing the thickness of the CoFeB, which is the aim of this study.

The unit structure investigated in this study is a thermally oxidized substrate of Si/ MgO (2 nm) /CoFeB (1.5-3.5 nm) /Pd (10 nm) /Ta (3 nm). The unit structure was deposited using a magnetron sputtering system that had two separate chambers with different base pressures of 2×10^{-8} Torr and 2×10^{-9} Torr. During the deposition, the samples were transported from chamber to chamber with a UHV robotic system, so that the vacuum was not broken during this process.

As a result, a large perpendicular magnetic anisotropy is formed in an MgO/CoFeB/Pd unit structure for an MgO-based magnetic tunnel junction with a large CoFeB thickness of 3 nm. The values of the out-of-plane coercivity and the perpendicular anisotropy energy are 1180 Oe and 2.7×10^6 erg/cc, respectively. The important factors for a strong perpendicular anisotropy are the CoFeB composition and the annealing conditions. The thick CoFeB layer is expected to reduce the template effect from the Pd layer during the annealing, therefore increasing the tunneling magnetoresistance of the MgO-based magnetic tunnel junction.

Reference

[1] J. H. Jung, S. H. Lim, and S.-R. Lee, Appl. Phys. Lett. 96, 042503 (2010).