Large interfacial perpendicular magnetic anisotropy in epitaxial $Fe_{80}Al_{20}/MgAl_2O_4$ heterostructures

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Large perpendicular magnetic anisotropy (PMA) is a key requirement for magnetic tunnel junction (MTJ) based memory devices. PMA at ferromagnet (FM)/oxide interfaces is generally used to compensate thermal instabilities arising with the downsizing of MTJs. Recently, strong PMA has been reported in $Co_2FeAl/MgAl_2O_4(001)$ heterostructures [1]. Microstructure investigation revealed large PMA in the structure that was attributed to a reduced lattice strain due to the use of $MgAl_2O_4$ and the effect of strengthening of the Fe-O hybridization at the interface due to diffusion of Al into the barrier [2]. In this study, we investigated the interfacial PMA using a Fe-Al alloy instead of Co_2FeAl. We found enhanced effective PMA energy K_{eff} up to 1.1 MJ/m^3 in $Fe_{80}Al_{20}$ in contact with an $MgAl_2O_4$ barrier.

The following structures were deposited on an MgO(001) single crystal substrate using a magnetron sputtering system with a base pressure of 4×10^{-7} Pa: MgO//Cr (40)/$Fe_{80}Al_{20}$ (t_{FeAl})/Mg (0.2)/$Mg_{40}Al_{60}$ (0.7)/oxidation /Ru (2) (thickness in nm). The MgO substrate and Cr buffer were annealed at 750°C for 1 h. Fe-Al was deposited by co-sputtering. The barrier (oxide of Mg/MgAl) was formed using an oxygen plasma. Stacks were annealed for 30 min *ex-situ* at temperature T_{ann}.

In Fig. 1, K_{eff} for a t_{FeAl} = 0.8 nm film (a) and interface anisotropy K_i (b) vs. T_{ann} evaluated by magnetization curves are plotted. At T_{ann} = 450°C, the largest PMA of K_{eff} = 1.1 MJ/m^3 ($K_{eff} \cdot t_{Fe}$ = 0.9 mJ/m^2) is observed, comparable to electron beam-evaporated Fe/MgO heterostructures [3]. K_i reaches around 2.8 mJ/m^3 at 450°C and is strongly temperature dependent. Using scanning transmission electron microscopy imaging, the interface was found to be smooth and lattice-matched although significant Al diffusion into $MgAl_2O_4$ was confirmed. Therefore, the large PMA can be attributed to the creation of effective Fe-O hybridization at the Fe-Al/$MgAl_2O_4$ interface through the atomic rearrangement. This work was partly supported by the ImPACT Program of Council for Science, Technology and Innovation, Japan, and JSPS KAKENHI 16H06332 and 16H03852.

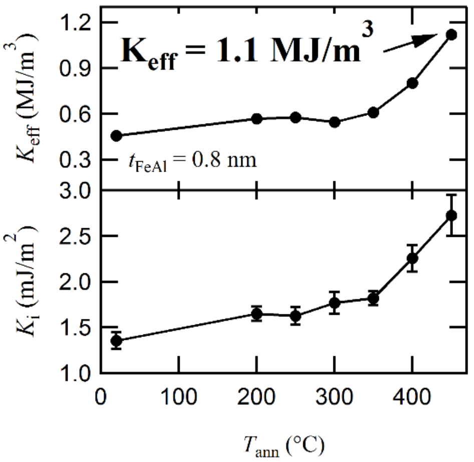

Fig. 1. K_{eff} and K_i vs. T_{ann} of $Fe_{80}Al_{20}/MgAl_2O_4$ stacks.

Reference: [1] H. Sukegawa *et al.*, Appl. Phys. Lett. **110**, 112403 (2017). [2] J.P. Hadorn *et al.*, Acta Mater. **145**, 306 (2018). [3] J.W. Koo *et al.*, Appl. Phys. Lett. **103**, 192401 (2013).