Extended Study on Perpendicular Magnetic Anisotropy in Fe/MgO interfaces

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Perpendicularly magnetized magnetic tunnel junctions (p-MTJs) with a large perpendicular magnetic anisotropy (PMA) are of particular importance to develop high-density spin-torque-transfer magnetic random access memories (STT-MRAMs). Especially, p-MTJs with CoFeB electrode are considered as a promising candidate for a basic component of the high density STT-MRAM, due to a relatively high tunnel magnetoresistance (TMR) ratio, high thermal stability at low dimensions and a low switching current [1]. Recently, we achieved a large PMA of 14 Merg/cm^3 in Fe/MgO bilayer structures based on a unique growth process [2]. The PMA energy density is higher than that in CoFeB/MgO, and the microscopic mechanism was also studied by using x-ray magnetic circular dichroism measurements [3].

In the present study, we performed extended experimental works in the PMA of Fe/MgO bilayer structures. The epitaxially grown samples of MgO(100)-subs.//MgO/Cr/Fe(3–7 monolayer)/MgO were prepared by molecular beam epitaxy, and their magnetic properties were characterized with a vibrating sample magnetometer. The PMA energy density as a function of post-annealing temperature took a maximum around 400˚C, and the temperature of the maximum PMA increased with the Fe layer thickness. For the sample of 7 monolayer in Fe layer thickness, a typical perpendicular magnetization curve was observed even at the high annealing temperature of 500˚C. On the other hand, large PMA (~10Merg/cc) was achieved at a relatively low annealing temperature (250˚C) for the sample with 3 monolayer Fe. The relationship between K_{eff}・t_{Fe} and t_{Fe} suggests structural degradation below 4 monolayer in Fe thickness, where K_{eff} is the effective PMA energy density and t_{Fe} is the Fe layer thickness. Related results such as annealing temperature dependence of coercive force will also be presented.

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