$Mg_xAl_{1-x}O_y$ バリア層を有する Fe_3O_4 トンネル磁気抵抗素子の作製

Fabrication of Fe_3O_4 magnetic tunnel junctions with $Mg_xAl_{1-x}O_y$ barrier layer

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【Introduction】 The Fe_3O_4 has been expected to be half metal, which have 100% spin polarization, from the ab initio calculations[1]. Many research groups investigated the magnetic tunnel junctions (MTJs) with Fe_3O_4 electrodes to obtain very high TMR, however, the reported values of TMR ratio were not so high; about 20%. Although the reason has not been clear, it could be attributed to the interface between Fe_3O_4 and tunnel barrier. So far, the MgO and amorphous AlO_x were employed as tunnel barrier due to easy to fabricate the junctions. Since Fe_3O_4 has spinel structure, the difference of the crystal structure could disturb the spin transport in the MTJs. Recently, Sukegawa et al. developed the MTJs with $MgAl_2O_4$ tunnel barrier layers[2], which has spinel structure. In this study, we fabricated the Fe_3O_4-MTJ with $Mg_xAl_{1-x}O_y$ tunnel barrier and investigated the crystal structure and the magneto-transport characteristics.

【Experiments】 Samples were fabricated by the reaive MBE system. The sample structures were MgO(100) / Fe_3O_4 / $Mg_xAl_{1-x}O_y$ / Fe / Au. The $Mg_xAl_{1-x}O_y$ layer was formed by reactive deposition at a T_{sub} of 100℃ in an O_2 atmosphere of 4×10^{-4} Pa, and annealed at 150℃ in vacuum. The epitaxial growth was observed by RHEED and crystal structure was investigated by STEM. The films were fabricated into MTJs of 10x10 by photolithography, ion milling and sputtering.

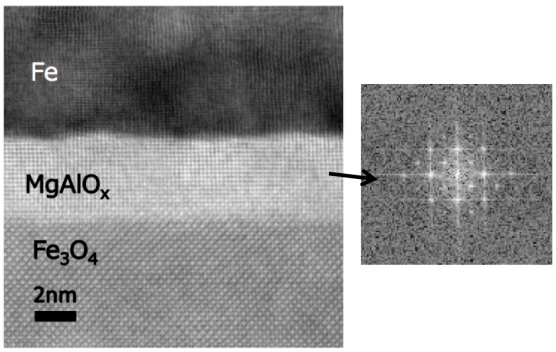

Fig.1 STEM image and FTT of $Fe_3O_4/Mg_xAl_{1-x}O_y$/Fe.

【Results】 We fabricated the $Mg_xAl_{1-x}O_y$ of 30nm for various x and observed RHEED. x=0.5 exhibited streak pattern, meaning epitaxial growth, however, x=0.33 corresponding to $MgAl_2O_4$ spinel exhibited halo pattern which means the amorphous films. Fig.2 shows the cross sectional TEM image and FFT of Fe_3O_4 / $Mg_xAl_{1-x}O_y$ / Fe. Epitaxial growths were confirmed, which was consistent with RHEED pattern, and the spinel type structure of $Mg_xAl_{1-x}O_y$ was indicated by FFT image. As shown in Fig. 2, the MTJs shows nonlinear I-V characteristics, however, the TMR ratio was +3%, which was inconsistent with ab initio calculations.

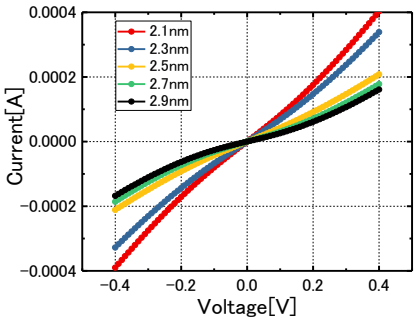

Fig2. I-V curves for MTJ with various thickness of barrier layers .

[1] A. Yanase and K. Shiratori, J. Phys. Soc. Jpn 53, 312 (1984)
[2] H. Sukegawa et al., Appl. Phys. Lett. 96, 212505 (2010)

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