Large tunnel magnetoresistance in $Co_2FeAl/MgAl_2O_4/Co_2FeAl$ junctions free from the band folding effect

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Magnetic tunnel junctions (MTJs) with a spinel $MgAl_2O_4$ barrier have recently attracted attention due to the observation of large tunnel magnetoresistance (TMR) ratios [1]. All MTJs exhibiting large TMR ratios use a *cation-disordered* barrier with a half unit cell of $MgAl_2O_4$ to prevent TMR reduction by the band-folding effect [2,3]. Recently, we reported the fabrication of lattice-matched Heusler electrode Co_2FeAl (CFA)/CoFe insertion/cation-disordered $MgAl_2O_4$/CoFe junctions and observed a relatively large TMR ratio up to 281% at room temperature (RT) [4]. However, a large TMR ratio (exceeding 200%) using cation-ordered spinel barrier was yet to be achieved. In this talk, we show a large TMR ratio up to 342% at RT using a *cation-ordered* $MgAl_2O_4$ barrier and highly spin-polarized CFA top- and bottom-electrodes.

MTJ multilayers were fabricated by magnetron sputtering on an MgO(001) substrate. The stacking structure is as follows: MgO substrate//Cr (40)/CoFe (5)/CFA (5)/CoFe (0.5)/Mg (0.45)/$Mg_{19}Al_{81}$ (d_{MgAl} = 0.75)/oxidation/CFA (5)/annealing at T_{CFA}/IrMn (12)/Ru (12), (thickness in nm). The barrier was formed by oxygen plasma oxidation. To tune the bottom-CFA/Mg-Al-O interface structure, a CoFe layer was inserted. TMR and resistance area (*RA*) were characterized using dc four probe method at RT. High-resolution annular dark-field scanning transmission electron microscopy (ADF-STEM) and nano-electron beam diffraction (NBD) were carried out for microstructural analysis.

In Fig. 1, the RT TMR curve of an MTJ with the largest TMR ratio (T_{CFA} = 550°C, TMR ratio = 342%) is shown. The ADF-STEM and NBD images suggest the formation of cation-ordered spinel barrier and highly *B*2-ordered CFA layers due to the high T_{CFA}. Especially a very high *B*2 order was confirmed for the top-CFA layer. The large TMR ratio in an ordered spinel barrier MTJ may be attributed to the high spin polarization of CFA layers, especially the top-CFA layer, which can effectively suppress the band-folding effect. This result shows the capability of the ordered spinel barrier for high performance MTJ applications. This work was partly funded by ImPACT Program of Council for Science, Technology and Innovation.

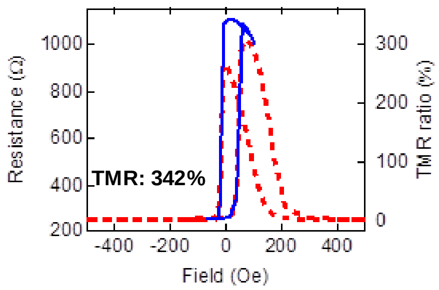

Fig.1. TMR curve of a $CFA/MgAl_2O_4/CFA$ MTJ with cation-ordered barrier, blue solid line shows a minor loop.

References: [1] H. Sukegawa *et al*., Phys. Rev. B **86**, 184401 (2012). [2] H. Sukegawa *et al*., Appl. Phys. Lett. **96**, 212505 (2010). [3] Y. Miura *et al*., Phys. Rev. B **86**, 024426 (2012). [4] T. Scheike *et al*., Appl. Phys. Lett. **105**, 242407 (2014).