# Underlayer dependence of magnetoresistance effect in tunnel junctions with $Co_2Fe_{0.4}Mn_{0.6}Si$ electrodes

○Mingling Sun[1,2], Shigeki Takahashi[3], Takahide Kubota[2,4], Yoshiaki Sonobe[3], Koki Takanashi[2,4]

(1. Grad. School of Eng., Tohoku Univ., 2. IMR, Tohoku Univ.,

3. Samsung R&D Institute Japan, 4. CSRN, Tohoku Univ.)

E-mail: sunml2010@imr.tohoku.ac.jp

Spin transfer torque magnetoresisitive random access memory (STT-MRAM) is being developed as a candidate for the next generation memories. For the development of giga-bit-class STT-MRAM, perpendicularly magnetized magnetic tunnel junctions (MTJs) with high tunnel magnetoresistance (TMR) ratio is an urgent requirement. $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) is one of popular Heusler alloys with high spin polarization. Perpendicular magnetization was reported in ultra-thin CFMS films deposited onto a Pd underlayer [1, 2]. In addition, $Co_2FeAl$ films onto Ru or Cr underlayers were also investigated for the perpendicularly magnetized films [3]. The material choice for the underlayer is crucial for the perpendicular magnetic anisotropy (PMA) of the Heusler alloys, in addition, the interdiffusion between the underlayer material and the Heusler alloy is also a concern, which may affect the TMR ratio in MTJs. In this study, TMR effects have been investigated in 3 series of CFMS/MgO/CoFe MTJs deposited on Pd, Ru and Cr underlayers.

The stacking structure of samples is as follows: MgO (100) substrate / underlayer / CFMS ($t_{CFMS}$) / MgO (2 nm) / $Co_{50}Fe_{50}$ (5 nm) / $Ir_{22}Mn_{78}$ (10 nm) / capping layer. The thicknesses of the CFMS layer were 30, 10, 5, 3, and 0.8 nm. Pd, Ru and Cr were chosen as underlayers. After the deposition process, the layered films were patterned into pillar shapes by photolithography combined with Ar ion etching and a lift-off process. Annealing was done by a vacuum furnace with an applied magnetic field of 1 T. The annealing temperatures were in a range of 200ºC – 500ºC. TMR effects were measured at room temperature.

For samples with a 30-nm-thick CFMS layer annealed at 400ºC, the TMR ratio was about 120% which was independent of the underlayer materials. The TMR ratios for the Ru and Cr underlayers slightly increased by further annealing at 450ºC, while for the Pd underlayer decreased significantly. On the other hand, for samples with a 5-nm-thick CFMS layer, the TMR ratios for the Pd underlayer sample was less than 1% irrespective of annealing temperature, while those for Ru and Cr underlayers remain higher than 100% even after the annealing at 400ºC. These results imply that the Pd diffusion causes the decrease of TMR ratio. Results for other CFMS thicknesses will also be shown and discussed in the presentation.

**References**

[1] T. Kamada *et al.*, *IEEE Trans. Magn.* **50**, 2600304 (2014).

[2] T. Kubota *et al.*, *Mater. Trans.* **57**, 773 (2016).

[3] Z. Wen *et al.*, *Adv. Mater.* **26**, 6483–6490 (2014).