Tunnel magnetoresistance effects of Co$_2$(Fe-Mn)Si/MgO/Co$_{50}$Fe$_{50}$ magnetic tunnel junctions using Pd buffer layer

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Co$_2$(Fe-Mn)Si (CFMS) Heusler alloy is one of well-known materials with high spin polarization, which promotes giant tunnel magneto resistance (TMR) effect in MgO based magnetic tunnel junctions (MTJs) at room temperature [1]. It was also reported that Pd under layer is effective for the achievement of perpendicular magnetization of CFMS films [2]. Although perpendicularly magnetized CFMS films are attractive for spin-transfer-torque magnetoresistance memory (STT-MRAM) applications [3], Pd atoms may easily diffuse into the CFMS layer by annealing process. Such an interdiffusion probably causes deterioration of TMR ratio, however, studies on TMR effect using Pd-buffered Heusler alloys are sparse. Thus, in this work, we investigated TMR effects of MTJs using CFMS Heusler alloys deposited onto Pd buffer layer.

The stacking structure of the MTJs was as follows: MgO sub. / Cr (80 nm) / Pd (5 nm) / Co$_2$Fe$_{0.4}$Mn$_{0.6}$Si ($t_{\text{CFMS}}$ nm) / MgO (2 nm) / Co$_{50}$Fe$_{50}$ (5 nm) / Ir-Mn (10 nm) / Ta (7 nm), in which the Co$_2$Fe$_{0.4}$Mn$_{0.6}$Si layer thicknesses, $t_{\text{CFMS}}$ were 10, 5, and 3 nm. The metallic layers were deposited using an ultrahigh-vacuum sputtering system with a base pressure less than 2 × 10$^{-7}$ Pa, and the MgO layer was deposited using electron beam evaporation system. In-situ post-annealing process was done after the deposition of Cr buffer (CFMS layer) at 700°C (400°C) for 1 hour. The deposition temperature for the Pd layer was 350°C; and other layers were deposited at an ambient temperature. The MTJ multilayers were patterned into junctions by photolithography combined with Ar ion etching and a lift-off process.

The TMR ratio of MTJs with a 10 nm-thick Co$_2$Fe$_{0.4}$Mn$_{0.6}$Si layer was 55% at room temperature. With decreasing $t_{\text{CFMS}}$, TMR ratios decreased and the value was about 1% for $t_{\text{CFMS}} = 3$ nm. The decrease of TMR ratio probably attributes interdiffusion of Pd atoms. TMR ratios and RA values of the MTJs including some other thicknesses of CFMS layers will also be discussed at the presentation.

References