Perpendicular magnetic tunnel junction with strained Mn-based synthetic ferrimagnets

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The Mn-based alloys have been attractive attention as electrode materials for perpendicular magnetic tunnel junctions (p-MTJ) in magneto-resistive random access memory (MRAM) [1]. This is because their high perpendicular magnetic anisotropy (PMA) and small magnetization is beneficial to shrink MTJ size toward increasing recording capacity over 16 Gbits. Recently we developed the growth technique of ultrathin MnGa films and MnGa-based p-MTJs with high PMA, however maximum TMR ratio were still below 20% [2-5]. One of the solution for achieving both high TMR ratio and low magnetization is to use synthetic ferrimagnet structure with CoFe-based insertion layer. In this presentation we propose new synthetic ferrimagnets composed of strained MnGa and CoFe-based insertion layer. The stacking structure is MgO(sub.)/Cr(40)/CoGa(30)/MnGa(3)/CoGa(t_{CoGa}=0, 0.4)/Fe(0.4)/MgO(2.4).CoFeB(1)/Ta(3)/Ru(5) (thickness is in nm), which were grown at room temperature using an ultrahigh-vacuum sputtering system. The micro-fabrication of devices was performed by a conventional photolithography and Ar ion milling. The MTJs were annealed at optimized temperature so as to obtain maximum TMR ratio. Figure 1 shows the room temperature TMR curve of the MTJs with t_{CoGa}=0 and 0.4 nm. Here, the MTJs with t_{CoGa}=0 was not annealed because the annealing at the temperature over 200℃ decreased the TMR ratio. The shape of the TMR curve indicated ferromagnetic coupling between MnGa and Fe layer, as reported in the thick-MnGa/Fe bilayer [6,7]. On the other hand, the inverted TMR curve was observed in the MTJs with t_{CoGa}=0.4 nm, implying that the MnGa and Fe layers coupled antiferromagentically [7]. In addition, the TMR increased up to 33% with the annealing at 250℃. These results suggest that the ultrathin CoGa spacer between the MnGa and the Fe layers induces the antiferromagnetic coupling for synthetic ferrimagnet and increases the thermal endurance of the Mn-based MTJs.This work was partially supported by the ImPACT program and KAKENHI (17K14103).

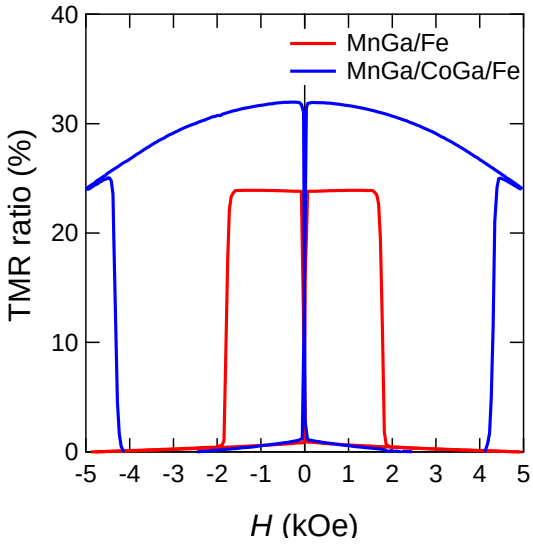

Figure1 The room temperature TMR curves of the MTJs with t_{CoGa}= 0 and 0.4 nm, which were not annealed and annealed at 250 ℃, respectively.

[1] S. Mizukami et al, Phys. Rev. Lett. 106, 117201 (2011).

[2] K.Z. Suzuki *et al.*, Jpn. J. Appl. Phys. (RC) **55**, 010305 (2016).

[3] K. Z. Suzuki *et al.*, Sci. Rep. **6**, 30249 (2016).

[4] K.Z. Suzuki et al., Appl. Phys. Lett. 112, 062402 (2018)

[5] K Z Suzuki et al., J. Phys. D: Appl. Phys. 51 235001 (2018)

[6] T. Kubota et al., Appl. Phys. Express 5 043003(2012)

[7] Q. L. Ma et al., Phys. Rev. Lett. 112, 157202(2014)