Voltage-induced perpendicular magnetic anisotropy change and switching in Ta/$(Co_xFe_{100-x})_{80}B_{20}$ multilayers

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CoFeB/MgO-based magnetic tunnel junctions (MTJs) with voltage-induced perpendicular magnetic anisotropy (PMA) change are considered as a promising low-power spintronic devices with high tunneling magnetoresistance (TMR) ratio. The enhancement of voltage effect on PMA is crucial to improve the write error rate for voltage-driven dynamic magnetization switching [1]. Several studies tried to increase the voltage effect by investigating the dependence of underlayer materials [2] and insulating materials [3]. However, the dependence of the voltage effect on the composition of CoFeB alloy in Ta/CoFeB/MgO multilayers has not been investigated yet. In this study, we investigated the voltage effect on PMA with different compositions of Ta/$(Co_xFe_{100-x})_{80}B_{20}$ multilayer (x = 0, 10, 31, 51) through the TMR effect.

The films with bottom contact / Ta(5 nm) / $(Co_xFe_{100-x})_{80}B_{20}$ (1.0 nm) / MgO / $(Co_{70}Fe_{30})_{80}B_{20}$ (3.0 nm) / Ta (5 nm) / Ru (7 nm) were deposited by sputtering on thermally oxidized Si substrates. We selected the $(Co_xFe_{100-x})_{80}B_{20}$ compositions of x = 0, 10, 31, 51, which was calibrated by X-ray fluorescence analysis. The films were micro-fabricated into 800-nm-diameter circular MTJs.

Figure 1 shows annealing temperature dependence of the voltage effect with various compositions. The voltage effect on PMA was evaluated from the bias voltage dependence of *R-H* curves under the in-plane magnetic field. The highest voltage effect of 50 – 55 fJ/(Vm) was obtained at x = 31 after 250°C-annealing, which is twice larger than that at x = 0. The treatment of high temperature annealing (> 300°C) degrades the voltage effect. From these results, it is clear that the CoFeB composition and annealing treatment are important parameters to obtain high voltage effect on PMA. In the presentation, we will present the write error rate of the voltage-driven magnetization switching using perpendicularly magnetized MTJs with optimized free layer.

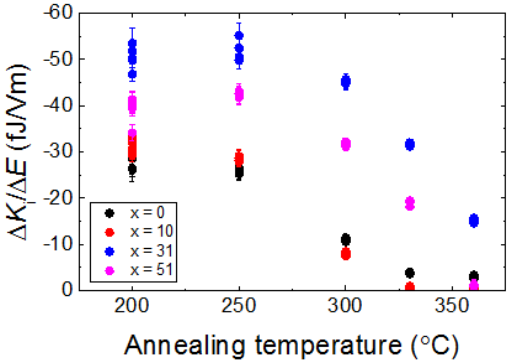

Fig. 1 Annealing temperature dependence of voltage effect with various composition.

This work was supported by ImPACT Program of Council for Science, Technology and Innovation, and a Grants-in-Aid for Scientific Research (JP16H05977).

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