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Propose of a Novel Pole Type Structures in Perpendicular MRAM for High Gb/Chip

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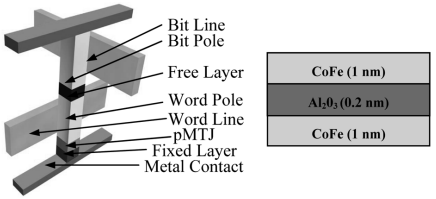
Magnetoresistive random access memory (MRAM) is not supposed to value on the field of commercial non-volatile memory nowadays. Normal MRAM has a big huddle that have to solve for high capacity device. For high capacity, normal MRAM is to have scalability. Normal MRAM need the huge current density as downsize of the cell. So normal MRAM is cannot downsize for high capacity device. This problem is due to structures of normal MRAM.

This Paper suggested novel design of MRAM for high capacity by using perpendicular magnetic tunnel junction (pMTJ) [1]. Fig. 1(a) is suggested novel design of MRAM. It called pole type perpendicular MRAM (PTP MRAM). PTP MRAM have additional pole that is high permeability material beside free layer. Because of it used high permeability pole, it have strong switching field for switched free layer without big additional current. Fig. 2 is showed results of magnetic field intensity with the current density of 8×10^7 A/cm^2 ~ 6×10^8 A/cm^2 on normal MRAM system and PTP MRAM system. The graph presents that PTP MRAM have strong field than normal MRAM on the same current density. So PTP MRAM is able to scalabilty for high capacity.This paper presents the write opertaion on PTP MRAM with supplying two method of current. This paper used 3 dimensional FEM for optimal design of PTP MRAM.



(a) **A PTP MRAM cell** **(b) A pMTJ**

Fig. 1. Simplified structures of a PTP MRAM cell and pMTJ.

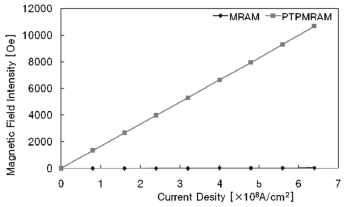


Fig. 2. Magnetic field intensity by current density.

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Study on Exchange-Biased Perpendicular Magnetic Tunnel Junction Based on Pd/Co Multilayers

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Magnetic tunnel junctions (MTJs) with perpendicular anisotropy can increase the memory density of magnetic random access memory (MRAM) by avoiding the magnetization curling phenomena in the low aspect ratio scheme [1]. In the previous study, we obtained tunneling magneto-resistance (TMR) ratio of 12.6% at R.T. in a pseudo perpendicular magnetic tunnel junction (pMTJ) but a very low TMR ratio in the top exchange biased (TEB)-pMTJ [2]. In this study, we fabricated the bottom exchange biased (BEB)-pMTJ based on Co/Pd multilayers and investigated the effect of multilayer structures, such as underlayer materials and number of bilayers, on the magnetoresistance and perpendicular exchange coupling of the BEB-pMTJs. SiO_2/Pd 9/(Co 0.2/Pd 0.7)x/Co 0.5/Al 1.6 + oxidation/Co 0.5/(Pd 0.7/Co 0.2)3/IrMn 8/Pd 2 stacks and SiO_2/underlayer/IrMn 8/Pd 0~0.7/(Co 0.2/Pd 0.7)n/Co 0.5/Al 1.6 + oxidation/Co 0.5/(Pd 0.7/Co 0.2)3/Pd 2 (numbers in nm) stacks were sputter-deposited on Si substrates for the TEB-pMTJ and the BEB-pMTJ, respectively.

When we used the Pd as an underlayer in the BEB-pMTJ stack, the TMR ratio increased a little compared with the TEB-pMTJ. However, the perpendicular exchange coupling and perpendicular anisotropy decreased because the IrMn induced the in-plane anisotropy. To improve the TMR ratio and perpendicular exchange coupling in the BEB-pMTJ, we modified the multilayer structure and the materials, such as underlayer materials, Pd insertion in between the IrMn and the bottom (Co/Pd)n layer, and the number of bilayers in the bottom (Co/Pd)n. Although the perpendicular anisotropy increased as the number of bilayers increased, the perpendicular exchange coupling with the IrMn was not observed in this stack. The perpendicularly exchange coupled pMTJ with the moderate TMR was obtained using the buffer layer of (Pd/Co)n and the exchange coupling field was 147 Oe. In summary, we could improve the TMR ratio in the BEB-pMTJ. A perpendicularly magnetized buffer layers, such as (Pd/Co)n multilayers should be used to induce the perpendicular exchange coupling with antiferromagnet such as IrMn in the BEB-pMTJ.

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