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Propose of a Novel Side Junction Structures by Using MTJ in Perpendicular MRAM for High Capacity Device

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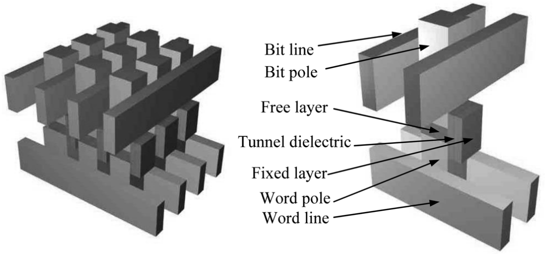
Magnetoresistive random access memory (MRAM) is not supposed to value on the field of commercial non-volatile memory nowadays. Normal MRAM has a big huddle that have to solve for high capacity device. For high capacity, normal MRAM is to have scalability. Normal MRAM need the huge current density as downsize of the cell. So normal MRAM is cannot downsize for high capacity device. This problem is due to structures of normal MRAM [1-2].

This paper suggested novel design of MRAM for high capacity by using magnetic tunnel junction (MTJ). Fig. 1 is suggested novel MRAM. It called side junction perpendicular MRAM (SJP MRAM). SJP MRAM have additional pole that is high permeability material beside free layer. Table I presents the major parameter of simulation model. One cell have a square size that 50 by 50 nm with a current density of 4~8×10^7 A/cm^2. SJP MRAM is able to scalability for high capacity because of it has strong switching field without increasing huge current. This paper used 3 dimensional FEM for optimal design of SJP MRAM.

Table I. Major parameter of SJP MRAM.

Free Layer size	50 × 50 × 30 nm (W × H × D)
Pole Size	50 × 50 × 250 nm (W × H × D)
Current Density	4 ~ 8 × 10^7 A/cm^2



(a) **Multi cells of SJP MRAM** (b) **Single cell of SJP MRAM**

Fig. 1. Simplified structures of a SJP MRAM.

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Attempt Frequency of Synthetic Antiferromagnet

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The synthetic antiferromagnet (SAF) has been used as a pinned layer in magnetic recording heads or memories in order to minimize the dipolar field and stabilize the pinned layer magnetization. Recently, SAF was adopted as a free layer in the magnetic random access memory because of its better stability. The thermal stability is characterized by the thermal relaxation time of the magnetization over an energy barrier which is described by the Arrhenius-Néel law, $\tau = f_0^{-1}\exp(E_B/k_BT)$ where f_0 is the attempt frequency, E_B is the energy barrier, and k_BT is the thermal energy. The attempt frequency is generally assumed as a constant, but is a function of many parameters such as the damping constant, the energy barrier, and so on [1]. For various symmetry of the potential landscape, theoretical equations of the attempt frequency for the magnetization in a single ferromagnet have been proposed [2-3]. Recently we confirmed that the universal theoretical equation is valid using numerical study with the stochastic Landau-Lisfhitz-Gilbert equation [4]. However, there has been no study on the attempt frequency of SAF. In this work we perform numerical simulations of the thermally activated switching of SAF and determine its attempt frequency.

Fig. 1 shows an example of the attempt frequency of SAF free layer and single free layer as a function of the damping constant. The geometry of the magnetic layer of a single cell is 60 × 20 × 2 nm^3 (length × width × thickness). In SAF, two magnetic free layer (60 × 20 × 2 nm^3) are separated by Ru spacer (0.7 nm). For the same energy barrier, SAF shows a higher attempt frequency than the single ferromagnet. It is caused by the strong coupling field due to the RKKY and magnetostatic interactions between the two ferromagnetic layers. In the presentation, we will discuss the effect of the RKKY exchange energy and the shape of nano-pillar on the attempt frequency of SAF.

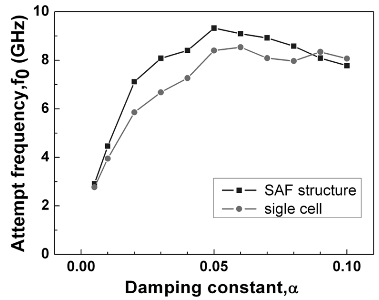

Fig. 1. The attempt frequency as a function of the damping constant.

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