구두발표 1

Optimized Flux Concentrated sutucture Design of MRAM Array for Writting Current Minimization and High Selectivity

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1. Introduction

MRAM has been interested a lot as a promising next generation non-volatile high speed and high endurance memory technology, but to archive the high density there are a few obstacles[1,2]. The most considering issue is the increasing coercivity with decreasing memory cell size. To write this small size cells, high magnetic flux density is required and many flux concentrating layer structures are introduced to increase the magnetic field without increasing the writing current because the high current density could be the source of the thermal problem and also could increase the interface effects to the other cells. Instead of the bar structure which is mostly adopted, we introduced the flux concentration island which located in between the memory cells and increase the selectivity by concentrating the flux to the memory cell which we want to write. In this paper we simulated magnetic field with given current density with finite element method. Detailed method and simulation results will be duscussed .

2. Model

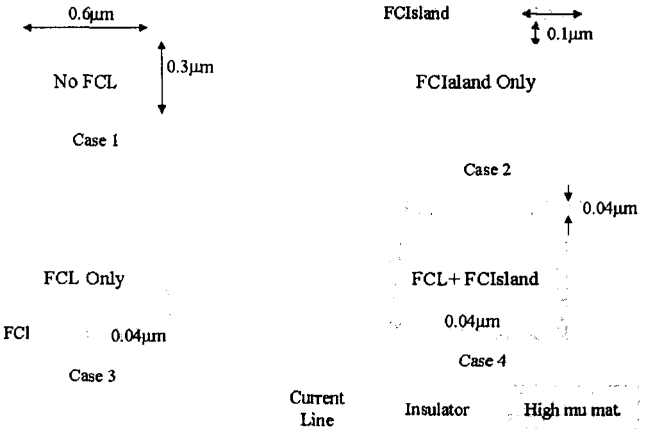
In this simulation, we used Ansys software for magnetic field simulations using finite element method (FEM). 3 by 3 MTJ (magnetic tunneling junction) memory cells and 5 by 5 MTJ cells are considered in this 3 dimensional modeling Also two perpendicular current line and flux concentration line(FCL) which covers the currant line and our flux concentration island(FCI) structures are included. Typical number of nodes are 4000 and number of meshes are 15000 with infinite boundary condition to minimize the edge effect. In this modeling we can consider two types of MTJ cell shapes, such as rectangular with corner rounding and ellipsoid.

3. Simulation Results

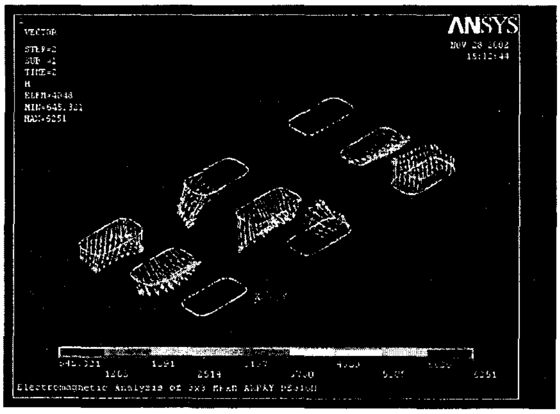
To test the modeling we first simulated the magnetic flux density when only one current line(Bit Line) is activated. 10mA bit current generates about 40 Oe magnetic fields at the memory cell as expected by experiment. Figure 1 shows four different flux concentrating structure we simulated. Flux concentrating islands (FCI) which is shown in case 2 and case 4 are located at the empty space between MTJ cells. In this paper we simulated only the square shape FCI for the simplicity, but it can be any symmetrical shape such as circle or ellipsoid. The simulated magnetic vector fields for the case 4 at the MTJ memory cell position is shown in Figure 2. The simulated strengths of magnetic vector fields at the selected center memory cells are summarized at the Table 1. Generated magnetic field from the current line is increased with either FCL or FCI. The required current to switch the magnetic memory cell with coercivity of 50 Oe is defined as required writing currrent. FCL is more efficient to minimize the writting current. The selectivity which is defiend below.

$$0.5\sqrt{((H_{x1}/H_{x0})^2+(H_{y1}/H_{y0})^2)/2}+0.5\sqrt{((H_{x2}/H_{x0})^2+(H_{y2}/H_{y0})^2)/2}$$

This shows the ratio of generated magnetic field from the current lines at the target cell and adjacent cells. Table 1 show that FCI structure is more effective to decrease the selectivity of MRAM array



Four different flux concentrating schemes for simulation



Vector plot of simulated magnetic field distribution

This table show the simulated results for four different flux conenting design

	Hx(Oe)	Hy(Oe)	Required writing Current(mA)	Selectivity (%)
Case 1	20.7	22.0	8.5	46
Case 2	21.9	27.5	7.5	42
Case 3	31.0	45.4	4.7	45
Case 4	31.1	53.5	4.5	41

4.Conculusion

For the high density MRAM array design, we suggested new flux concentrating structure and proved this structure increases the magnetic flux per unit current density and improves the selectivity from the simulated results used finite elements method. Also this FCI structure is easy to implements to real MRAM array structure

5.Reference

[1] S.Tehrani, *et.al.*, proc. of IEEE, Vol. **91** , 703 (2003)

[2] A.R. Sitaram, , *et.al.*, Symp. VLSI Tech., 15 (2003)