ESTIMATION ON CURRENT-DRIVEN DOMAIN WALL MOTION IN MAGNETIC NANOWIRE BY USE OF MAGNETIC FIELD ASSIST

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I. INTRODUCTION

A current-driven domain wall motion in magnetic nanowire with perpendicular anisotropy has been utilized in MRAM[1]. We also believe it can contribute to realize ultra-high-speed storage[2], however, larger current density is required to realize fast speed driving of domain walls. While magnetic field is simply applied normal direction to the nanowire, adjacent domain walls move opposite direction each other, *i.e.* a domain is forced to expand or compress improperly. In this study, in order to achieve reduction of required current and increase of domain wall velocity, we estimated the current-driven domain wall velocity dependence of direction and strength of applied magnetic field using a Landau–Lifshitz–Gilbert(LLG) equation with spin transfer torque term. The magnetic domain velocity was increased by use of adequate local magnetic field modulation. Our analyses indicate that in-plane component of the applied field is important for fast domain wall driving.

II. RESULTS AND DISCUSSIONS

The structure that we have used in our simulations is shown in Fig. 1. The dimensions of target nanowire are 1500 nm length, 60 nm width, and 20 nm thickness, respectively. Magnetic properties were set as follows: the saturation magnetization of 0.25 T, the uniaxial anisotropy H_k of 7.06 x 10^5 A/m, the exchange stiffness of 1.2 x 10^{-11} J/m, and the Gilbert damping constant of 0.02. The simulation cell size is 4 x 4 x 4 nm^3. We calculated the current-driven domain wall motion using a LLG equation with spin transfer torque term. In order to apply current induced spin transfer torque, current in the negative x-direction was applied. The applied current pulse is 6.4 x 10^{-6} A/cm^2 with 0.8 ns width. The white region in the figure is the magnetization toward the upward direction, while the black region indicates the magnetization toward the downward direction. To increase the domain wall velocity, pairs of permanent micromagnets were attached on top and bottom of the target nanowire for inducing local magnetic field modulation. Here, one of the calculation condition for applied field modulation is shown in Fig. 2. Figure 2 (a), (b), and (c) show x, y, and z component of the applied magnetic field modulation, by use of micromagnets with saturation magnetic flux density of 1T. In this conditions, magnetic field modulation with only in-plane components are applied to nanowire. Figure 3 shows the relationship between the moving distance of magnetic domain wall and elapsed time. By applying magnetic field modulation with in-plane component under allocated condition as shown in Fig.2, the velocity of domain wall could be improved approximately 2 times faster than that without magnetic field at the same driving current. Local magnetic field modulations seem to be effective for controlling the behavior of current-driven domain wall motion.

REFERENCES

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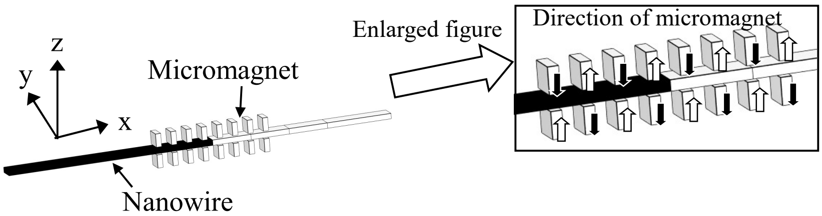

Fig. 1 Simulation model of nanowire and micromagnet.

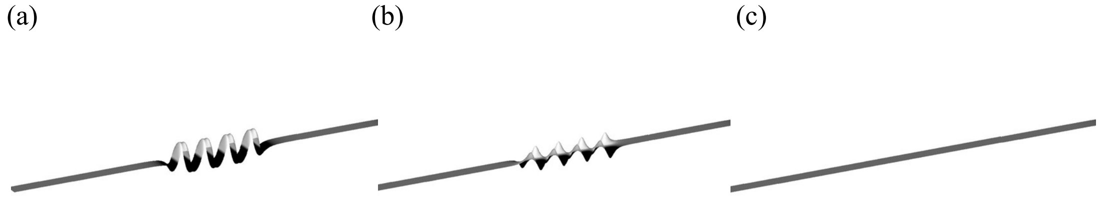

Fig. 2 (a)x, (b)y and (c)z components of the magnetic field modulation applied to the nanowire.

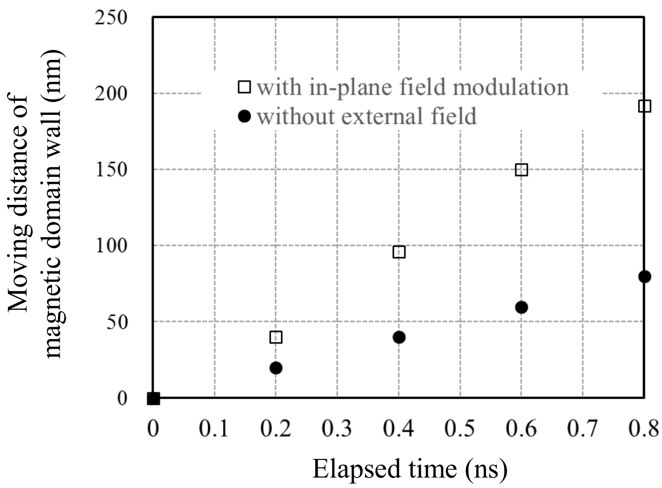

Fig. 3 Relationship between moving distance of magnetic domain wall and the elapsed time.