Magnetic Recording using Vortex-core Position in a Ferromagnetic Element

Hong-Guang Piao*, Dede Djuhana, Sang-Hyuk Lee, Je-Ho Shim, Su-Hyeong Jun, Suhk-Kun Oh, Seong-Cho Yu, and Dong-Hyun Kim

BK-21 Program and Department of Physics, Chungbuk National University, Cheongju 361-763, South Korea

In patterned ferromagnetic media, pattern size determines a recording density, where the recording density is limited basically by superparamagnetic instability [1]. Thus, to increase a recording density better than the superparamagnetic limit, multibits recording per single element has been proposed particularly using magnetic vortex core shift [2]. We have carried out micromagnetic simulation using OOMMF program [3] for circular magnetic disks in contact to four needle-shaped spikes. The diameter of circular disk has been varied from 300 to 80 nm. The thickness has been changed from 20 to 5 nm. The length and width of the four spikes has been changed from 150 to 40 nm and 50 to 13.3 nm, respectively. Material parameters of Permalloy were used with an exchange stiffness coefficient of $A = 13\times10^{-12}$ J/m and a saturation magnetization $Ms = 8.0\times10^{5}$ A/m. Micromagnetic simulation cell size is $2\times2\times5$ nm^3 and the damping constant $\alpha = 0.01$. Vortex core in the disk has been found to be shifted according to the combinational magnetization configuration of 4 spikes, as demonstrated in Fig. 1. Ultimate recording density using the proposed scheme has been investigated with changing geometry of disk and spikes, which is found to be about 1 Tb/in^2, where it seems that the stability of magnetic recording under thermal fluctuation effect has been considered to be fine.

Representative six different states depending on combinational spin configurations of four spikes are shown in the Fig. 1(a). In symmetrical combination, the vortex core is found to be at the center. Interestingly enough, we have found the vortex core position is shifted from the center of the circular ferromagnetic disk in all cases having asymmetric spike magnetization combination, as explained in the Fig. 1(b). The shift of core position is coming from the magnetostatic energy minimization due to the preferential combined flux closure including the spike magnetization.

In summary, multi-bits ultrahigh-density magnetic recording media with controlling the vortex core position is suggested and explored with micromagnetic simulation.

Reference

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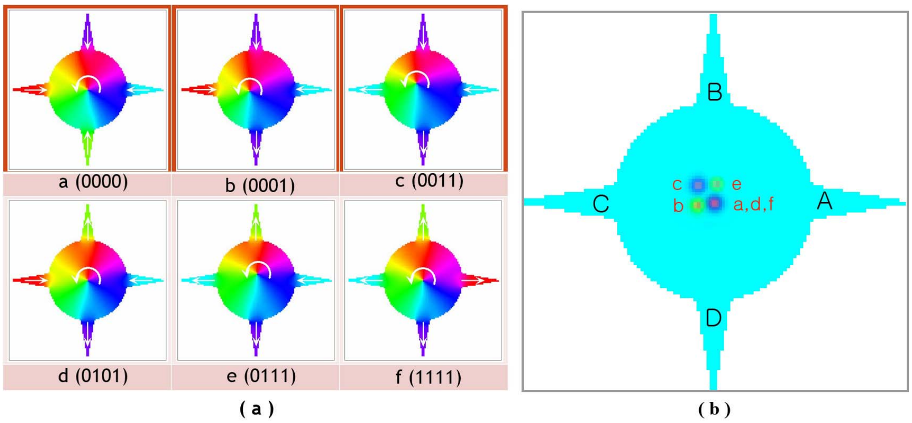

Fig. 1. (a) Simulation results for 6 different cases of spin ground configuration. Curling spins are counterclockwise. Magnetization direction of each spike is represented by either “1” or “0” corresponding to outward or inward direction, respectively. (b) Four different positions of the vortex core depending on combinational spin configurations of the four spikes.