Micromagnetic computer simulated scaling effect of s-shaped permalloy nano-element on operating fields for AND or OR logic

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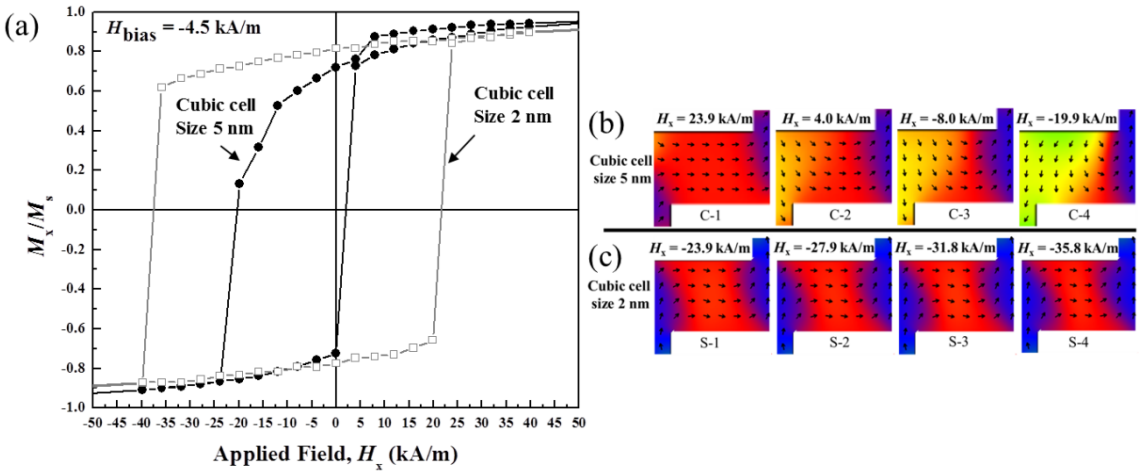
Permalloy (Py) magnetic s-shaped element was proposed for non-volatile, programmable magnetic logic device application [1]. S-state magnetization of the Py s-shaped element of length L = 200 nm was demonstrated by micromagnetic simulation for AND and OR logic with orthogonal bi-directional magnetic fields of both H_x and H_y. In this paper, we report the scaling effect of s-shaped Py nano-element on magnetic operating fields. Micromagnetic computer simulation was performed on 100 nm, 50 nm, and 30 nm long s-shaped elements to determine the operating fields. To find an optimized operating field, the coercivity for applied magnetic field in the x-direction, H_x, is obtained at different fixed H_y called H_{bias}. The optimized combination of operating fields (H_x, H_y) was found to be (27.7 ± 9.9, -16.7 ± 8.8), (37.9 ± 12.4, -25.9 ± 6.0), and (42.2 ± 8.8, -23.9 ± 4.0) in kA/m for the 100, 50, and 30 nm long s-shaped element, respectively. The allowable deviation in operating fields becomes smaller and operating fields shift to higher field as the s-element is scaled down. It is also found that the cell size of 5 nm used for simulation of the 200 nm length in [1] can be too large for modeling the 200 nm long s-shaped element, as shown by the hysteresis loops in Fig. (a) and snapshots in Fig. (b)-(c). The outcomes of the simulated results suggest that magnetic field switching of the s-shaped element may be suitable only for application on large scale and low logic density (not nanoscale and high logic density), but spin-torque switching of the s-shaped element and modification of element geometry remain to be investigated for high logic density applications.



[1] T. Hesjedal and T. Phung, Appl. Phys. Lett. **96**, 072501 (2010).