Magnetic interaction in magnetic tunnel junction array

°Hitoshi Kubota[1], Minori Goto[2], Kazuki Takahashi[2], Kay Yakushiji[1], Tomohiro Taniguchi[1], Sumito Tsunegi[1], Atsushi Sugihara[1], Akio Fukushima[1], Yoshishige Suzuki[1, 2, 3]

AIST[1], Osaka Univ.[2], CSRN-Osaka[3]

E-mail: hit-kubota@aist.go.jp

Magnetic interaction has been studied in closely-packed magnetic structures such as bit patterned media for magnetic recording[1] or magnetic random access memory[2]. In these devices, the magnetic interaction in the array should be suppressed because the interaction causes degradation of stored information. In contrast the magnetic interaction is beneficial in new computing architectures utilizing magnetic dot arrays[3,4]. Nomura et al. proposed nanomagnetic logic in which data is transferred as sequential magnetization switching through magnetic cells[4]. To read out the information from the cells, magnetic tunnel junction (MTJ) is useful because of large signal output due to tunnel magnetoresistance effect[5]. In this study we fabricated two cells of MTJ with separation of 50-600 nm and investigated magnetic interaction between the cells.

We prepared multilayers of IrMn/CoFe/Ru/CoFeB/MgO/CoFeB/MgO/Ta on thermally-oxidized Si substrates. The CoFeB sandwiched by MgO layers was free layer, which was 2.2 nm in thickness. The films were patterned into pairs of two elliptical cells with dimensions of 150 x 50 nm (left, small) and 450 nm x 150 nm (right, large), locating along the long axes. The separation between the cells were varied with 50 nm and 600 nm. Bottom and top electrodes were common to the cells. Single cell MTJs with corresponding shapes were also fabricated for comparison, which showed MR ratio of about 100% with resistance (coercivity) of about 400 Ω (140 Oe) and 60 Ω (70 Oe) in small and large cells, respectively. The resistance and MR ratios of the two-cell MTJs were well consistent with the parallel connection of small and large single MTJ cells, indicating no effect of short circuiting. When the separation was larger than 200 nm in the two-cell MTJs the MR loops showed two-step sharp switching, indicating individual switching of the cells. When the separation was 100 nm, some two-cell MTJs still show the two-step switching but others single-step switching. Further reduction of separation resulted in single-step switching observed in all the samples. The shape change of the MR curves indicates that magnetization switching in the large cells propagated to the smalls cell through the magnetic interaction in the case of 50-100 nm separation.

This work is partly supported by the Ministry of Internal Affairs and Communications.

1) O. Hellwig, et al., APL 90 (16) (2007).

2) S. Tehrani, et al., IEEE T Magn 36 (5), 2752 (2000).

3) R. P. Cowburn and M. E. Welland, Science 287 (5457), 1466 (2000).

4) H. Nomura, et al., APEX 10 (12) (2017).

5) S. Yuasa, et al., Nature Materials 3 (12), 868 (2004).