Material research for voltage-controllable spintronic device with ultralow energy consumption and synchrotron x-ray spectroscopy to reveal interfacial magnetism

Shinji Miwa : Osaka Univ.

It is important to reduce an energy consumption in IT devices for maintaining earth's environment while keeping our rich social life. To realize this, one key technology in electronics is non-volatile memory where no energy is needed to keep information. In spintronics, magnetic random access memory (MRAM), which is a kind of non-volatile memory using magnetic pole (N- and S- poles) in nano-magnets, has been developed. It is expected that the MRAM can be the only non-volatile memory which satisfies large capability, high speed, and high writing endurance. However, conventional MRAM needs electric current flow for writing, and its energy consumption is relatively large as compared to semiconductor memory device.

Voltage-controlled magnetic anisotropy in ferromagnetic ultrathin film has been found in FePt(Pd) thin films with ion-gel gating devices in 2007. After that, it has been demonstrated that such a voltage effect works in all solid device such as magnetic tunnel junction at room temperature [1]. Since magnetization direction can be controlled by the voltage effect in fast periods (down to 0.1 ns), this can be an ultimate technology for MRAM. Because the reported value of the VCMA is ten times smaller than that of the application level, a novel method to design materials showing large VCMA is highly desirable. Recently, we have revealed microscopic origins of the VCMA effect utilizing the world's largest third-generation synchrotron radiation facility SPring-8. Specifically, we have prepared epitaxial multilayer where monatomic Co or Pt layer is inserted between bcc-Fe(001) and fcc-MgO(001) which is important structure for MTJs. We found that external voltage changes orbital magnetic moment and magnetic dipole T_z term, which is correlated to the magnetic anisotropy in the systems [2,3]. Our findings enables a novel design of materials showing voltage effect larger by more than a factor of 10.

This work is a collaboration work with Y. Suzuki, F. Bonell, K. Matsuda, T. Tsukahara, T. Kawabe, K. Yoshikawa, K. Nawaoka, E. Tamura, and M. Goto of Osaka University, T. Nozaki, and S. Yuasa of AIST, M. Suzuki, T. Nakamura, Y. Kotani, and K. Toyoki of JASRI, M. Tsujikawa, and M. Shirai of Tohoku University, T. Ohkubo, and K. Hono of NIMS. A part of this work was supported by ImPACT program and JSPS-KAKENHI (JP26103002, JP15H05420).

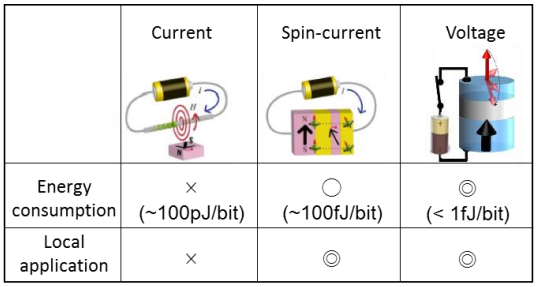

Fig. 1 Control magnetization direction

Bibliography

[1] T. Maruyama *et al.*; Nat. Nanotechnol. **4**, 158 (2009).
[2] T. Kawabe *et al.*; Phys. Rev. B in press. (arXiv:1708.08549)
[3] S. Miwa *et al.*; Nat. Commun. **8**, 15848 (2017).

External links

http://www.suzukiylab.mp.es.osaka-u.ac.jp