磁気異方性を増大させる短時間電圧パルスによる低消費電力磁化反転

Low power magnetization switching using enhancement of magnetic anisotropy with short-voltage-pulse application

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Low-power-consumption switching is a key requirement for non-volatile memories, and the switching scheme based on the voltage control of magnetic anisotropy (VCMA) [1] has been under extensive investigations. In conventional voltage-induced switching of perpendicular magnetization as illustrated in Figs. 1(a)-(c), perpendicular-anisotropy (K_{eff}) is eliminated during the voltage-pulse duration (t_p), which is a few hundreds of pico seconds. Even at such t_p, low power switching at 6 fJ/bit was demonstrated [2, 3]. Although t_p and hence write power consumption can be further reduced by the increase of the in-plane external magnetic field (H_{ext}), application of a high H_{ext} deteriorates the thermal stability factor (Δ); i.e., the data-retention time.

In this study, we propose the voltage-induced switching where t_p can be reduced by enhancing K_{eff} and its anisotropy field during t_p instead of increasing H_{ext}. The enhanced anisotropy field induces precession of magnetization around an almost-perpendicular easy axis. After turning off the voltage proximately at a half of precession period, the magnetization relaxes to the opposite equilibrium direction. We show that t_p can be as short as a few tens of pico seconds without deteriorating Δ. The results provide a guide for designing a fast and low-power consumption MRAM.

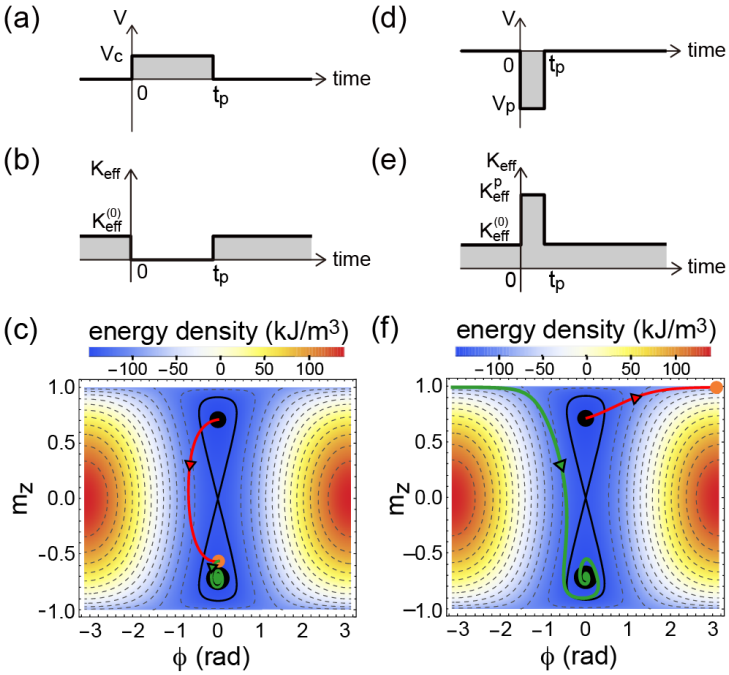

Fig. 1 (a)-(c) Conventional and (d)-(f) proposed switching schemes. (a)(d) The shape of the voltage pulse, and (b)(e) the corresponding time dependence of K_{eff}. (c)(f) The trajectories of magnetization during and after the pulse are shown by the red and green curves, respectively. m_z represents out-of-plane component of unit magnetization vector, and ϕ is azimuthal angle. H_{ext} is parallel to (ϕ, m_z) = (0, 0). The orange circles represent the magnetization direction at the end of the pulse.

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References [1] Y. Shiota et al., Nat. Mater., Vol. 11, p. 39 (2012). [2] C. Grezes *et al.*, APL **108**, 012403 (2016). [3] S. Kanai *et al.*, APL **108**, 192406 (2016).