Three-terminal spintronics devices with spin-orbit torque induced switching for ultra-low power and high-performance integrated circuits

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Spintronics memory devices with three-terminal configuration are suitable for high-speed and high-reliability applications compared with the devices with two-terminal configuration, owing to their separated current paths between the read and write operations [1)]. Spin-orbit torque (SOT)-induced magnetization switching [2,3)] is a promising scheme for the write operation of the three-terminal devices. Here we show our recent studies on the SOT-induced switching which open new possibilities of the devices and integrated circuit technologies.

The previous studies on the SOT switching build on either of two structures, both of which have the magnetic easy axis of the free layer directing orthogonal to the current: perpendicular to the plane [2)] or in-plane and orthogonal to the channel current [3)]. We have recently shown the third switching scheme with the easy axis collinear with the current [4)]. The current-induced switching originating from the SOT with Slonczewski-like symmetry has been observed in a three-terminal device with the new structure, where a Ta/CoFeB/MgO-based stack is used. Importantly, this scheme can serve as a useful tool to investigate the physics of SOT-induced switching [4)] as well as an attractive option for the application to the integrated circuits [5)]. In the presentation, we show that the new scheme allows us to unambiguously discuss the factors that determine the SOT switching current density and the difference in the dynamics between the SOT and conventional spin-transfer-torque induced magnetization switching. We also show reliable switching achieved by current pulses with the duration of 500 ps and amplitude of 1.9×10^{11} A/m^2; this feature is highly promising for high-performance integrated circuits.

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Reference

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