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Magnetization switching by two successive voltage pulses

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We reported magnetization (*M*) reversal in magnetic tunnel junction (MTJ) with Ta/ CoFeB/ MgO by the application of either electric field or current (spin transfer torque) pulse.[1,2] Here, we demonstrate a new scheme for *M* switching, in which the advantages of *E*-induced and STT switching are combined.

A stack structure, sapphire substrate/ Ta/ Ru/ Ta/ $Co_{20}Fe_{60}B_{20}$(0.9 nm)/ MgO(1.3 nm)/ $Co_{20}Fe_{60}B_{20}$(1.8 nm)/ Ta/ Ru, is sputtered and fabricated into a 40-nm-diameter MTJ between coplanar strip lines by electron beam lithography and Ar ion milling. Device is annealed at 300°C for 1 hour in vacuum (10^{-6} Torr) under magnetic field perpendicular to the plane. All magnetic layers possess perpendicular easy axis. The product of device area and resistance is 14 Ωμm^2, and tunnel magnetoresistance ratio is 125%.

Magnetic easy axis of free (top) layer switches from perpendicular to in-plane during the application of voltage pulse V_E with amplitude of +0.7 V and duration of t_E. The change of easy axis direction induces *M* precession around in-plane component of external magnetic field. The probability of V_E-induced *M* switching takes the highest value (~100%) at which t_E is nearly a half of precession period (~ 1.25 ns in the present device). The switching probability is sensitive to t_E, and that over 90% is obtained only for t_E = 1.25±0.15 ns. For the same device, we induce also STT-*M* reversal by the application of voltage pulse V_{STT} with amplitude ±0.5 V and duration of t_{STT}. The probability of V_{STT}-induced *M* switching exceeds 90% when t_{STT} is longer than ~10 ns.

We propose a new scheme for *M* switching by the application of successive two voltage pulses, V_E and V_{STT}, where we expect that *M* precession is induced by V_E and that the final *M* direction is determined by V_{STT}. Figure indicates the switching probability from as functions of t_E and t_{STT}. The result shows that one can obtain broader t_E range with high switching probability than that solely by V_E, and shorter switching time than that solely by V_{STT}.

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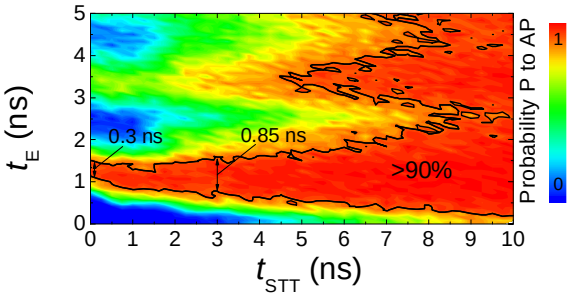

Figure: Contour mapping of magnetization switching probability from parallel (P) to anti-parallel (AP) state as functions of two successive voltage pulse durations. t_E is duration for the first voltage pulse (0.7 V) and t_{STT} for the second pulse (0.5 V).

References

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