Spin-orbit torque induced magnetization switching in Co/Pt multilayers

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Spin-orbit torque (SOT) magnetic random access memory (SOT-MRAM) devices [1-3] have attracted great attentions in recent years. When one employs it in leading-edge semiconductor integrated circuits and make them more reliable, larger magnetic anisotropy ensuring nonvolatility and large SOT generated by unit current are required for ferromagnetic switching layer at smaller dimensions. To meet these requirements, materials with perpendicular easy axis, especially those with Co/Pd and Co/Pt multilayers, are promising as they can achieve high thermal stability at smaller dimensions of less than 20 nm [4]. Recently, a significantly large current-induced effective field, corresponding to SOT, has been observed in Co/Pd and Co/Pt multilayers despite structural inversion symmetry in their stacks [5, 6], but magnetization switching has not been reported yet. In this study, we show SOT-induced switching in Co/Pt multilayer together with an evaluation of SOT.

The stacks of Ta/Pt/[Co/Pt]$_N$/Co/Ta/Capping layer are prepared on Si substrates by magneton sputtering and processed into Hall bar devices. To evaluate SOT-induced switching, a dc current is applied to the Hall bar channel under an in-plane field applied along the collinear direction to the current while monitoring the Hall resistance R_{Hall}. SOT is evaluated by a dc magnetotrasport measurement [7].

Figure shows a result of current-induced switching for a device with N = 2 under the external in-plane field $\mu_0 H_{\mathrm{ext}}$ = ±300 mT. When a dc current is applied parallel (antiparallel) to H_{ext}, switching from +z (−z) to −z (+z) is observed. From the dc magnetotrasport measurement, effective spin-Hall angle $\theta_{\mathrm{SH}}^{\mathrm{eff}}$ representing the magnitude of the SOT per unit current density is determined as 0.30, which is significantly larger than that of Pt layer previously reported [8, 9]. The obtained results suggest that Co/Pt multilayers have a potential for SOT-MRAM devices with high thermal stability and small switching current at reduced dimensions.

This work was partly supported by R&D Project for ICT Key Technology of MEXT and ImPACT Program of CSTI.

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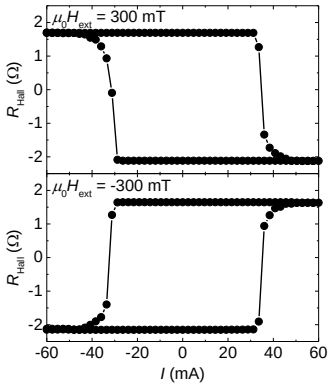

Figure. Magnetization switching induced by current under $\mu_0 H_{\mathrm{ext}}$ of ±300 mT.