ゲート誘起の構造非対称性を利用した無磁場スピン軌道トルク磁化反転

Field-free spin-orbit torque switching by utilizing gate-induced structural asymmetry

東大工 [1]，阪大産研 [2]，阪大 CSRN [3] ○長谷川 顕登 [1,2]，小山 知弘 [2,3]，千葉 大地 [2,3]

The Univ. of Tokyo [1], ISIR, Osaka Univ. [2], CSRN, Osaka Univ. [3],

°Kento Hasegawa[1,2], Tomohiro Koyama[2,3], and Daichi Chiba[2,3]

E-mail: khasegawa@g.ecc.u-tokyo.ac.jp

Spin-orbit torque (SOT) is an attractive way to control perpendicular magnetization, but the necessity of in-plane external field hinders its implementation. To date, several approaches have been proposed to overcome this issue, and one of which is use of laterally asymmetric structure [1-3]. Here, we demonstrate the field-free SOT switching by introducing an asymmetry through gate-induced oxygen migration.

The schematic drawing of our device is shown in Fig. (a). Ta(1.5 nm)/Pt(4.0 nm)/Co(0.5 nm) layers were deposited by rf-sputtering. After exposing the film to air, HfO_2 layer was formed by atomic layer deposition at 60°C, which is far below the appropriate temperature. Subsequently, the film is processed into Hall bar, and the Cr/Au gate electrode was formed to cover only $+y$ half of the wire to introduce lateral asymmetry.

As shown in the Fig. (b), anomalous Hall effect is not observed for the pristine state because the ferromagnetic Co layer turns into paramagnetic CoO_x layer by natural oxidation. However, the $+y$ side of the wire becomes ferromagnetic state with perpendicular magnetic anisotropy by applying V_g of +5 V for 8 minutes owing to the redox reaction [4]. Then, we find that this device shows deterministic current-induced magnetization switching even in the absence of the external magnetic field (Fig. (c)). The field-free SOT switching is not observed when the gate electrode covers the wire entirely, emphasizing the key role of gate-induced lateral asymmetry. Our results not only pave the way for the practical application of SOT, but also provide further insight into SOT switching in asymmetric structures.

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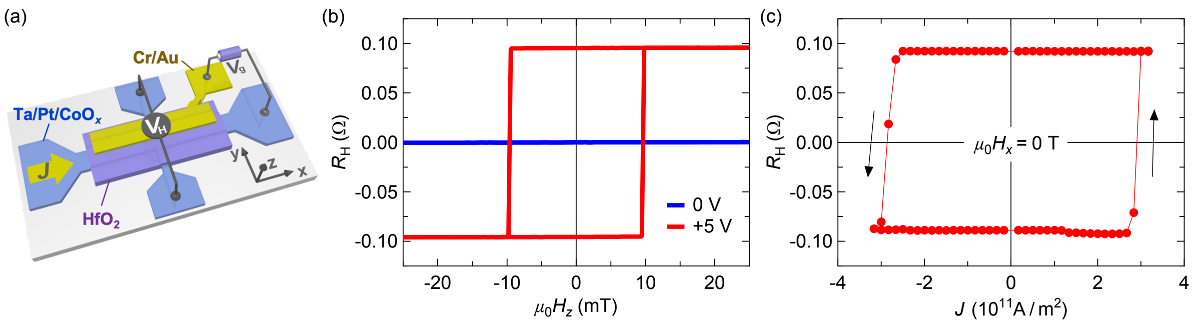

Figure. (a) Schematic illustration of the experimental setup and coordinate system. (b) Anomalous Hall loops before (0 V) and after (+5 V) applying gate voltage. (c) Current-induced magnetization switching at zero external magnetic field.

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