Pt/Co 構造におけるスピン軌道トルク：自然酸化 Co 層の影響

Spin-Orbit torque in Pt/Co system: effect of naturally oxidized Co layer

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Magnetization control via the spin-orbit torque (SOT) in a normal metal (NM)/ferromagnetic material (FM) bilayer structure has been proposed for a new writing method for MRAM devices [1]. Recently, the effect of an intentional oxidation of NM or FM layers on SOT has been reported [2,3]. In this work, we report the SOT in the Pt/Co system with oxidized Co surface. Quantitative examination of SOT revealed that the oxidation state of Co can largely enhance the SOT comparing with sample with no oxidation state.

We prepared a series of perpendicularly magnetized Pt/Co systems, in which the capping layer was not formed on top of Co layer (sample O). After the deposition, the surface of the Co layer of sample O was intentionally oxidized by air exposure. To investigate the effect of the Co surface oxidation, reference samples with MgO capping layer (sample UO), in which no oxidized Co state was confirmed, were also prepared. Figure shows the SOT induced magnetization switching curves. Compared to the sample UO, a clear reduction of the switching current density is observed in sample O even though the perpendicular magnetic anisotropy of the sample O is large compared to sample UO (inset). We performed the quantitative determination of SOT by the harmonic voltage measurements [4] and found that the two components of the SOT; the damping-like and field-like torques, are largely enhanced by the Co surface oxidization. The possible origin of the enhancement is attributed from the additional interfacial effect due to the formation of CoO layer on surface or the additional symmetry breaking related SOT due to the non-uniform oxidization along out-of-plane direction.

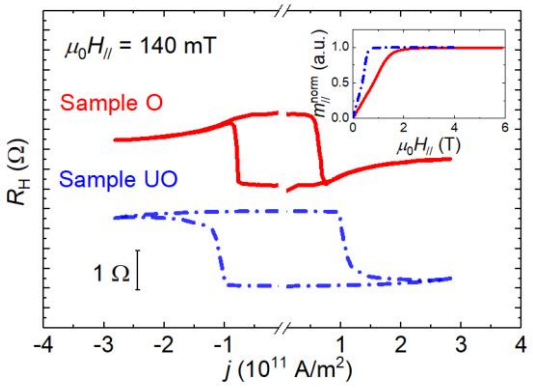

Figure: The Hall resistance R_{Hall} as a function of current density J for the sample O (solid line) and UO (dotted line). The inset shows the normalized in-plane magnetization curve.

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