Elimination of thermoelectric artifacts in spin-orbit-torque harmonics measurements

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Recent discovery of spin-orbit torque (SOT) provides a new route to control the magnetization of nano magnets, and the control of magnetization with SOT becomes a very important part of the spintronics. SOT have shown interesting features, for instance, such as unusual angular dependence, that cannot be simply explained by spin Hall effect. In order to understand SOT, it is important to quantitatively measure the magnitude, symmetry, and angular dependence of SOT. Among the several measurement schemes of SOT, harmonics measurements are frequently used for determining the magnitude of SOT because of its simplicity [1]. If a temperature gradient exists in the sample, thermoelectric artifacts can be included in the SOT harmonics measurement.

Here we have studied those thermoelectric artifacts in SOT harmonics measurements, and considered how to exclude them. The samples consisting of Ta (5 nm)/ Pt (3 nm)/ Co (0.6 nm)/ MgO (2 nm)/ Ta (2 nm) were patterned into a Hall bar geometry (5×5 **μm^2**) by ion milling and photolithography. The first and second harmonics signals are measured by a lock-in amplifier. A nominally measured Hall signal can be influenced by several artifacts such as Seebeck, Nernst, Ettingshausen, Righi-Leduc effects as well as misalignment and Ohmic offsets. It turns out that the second harmonics signals corresponding to the field-like torque and damping-like torque are contaminated by considerable thermoelectric artifacts. We have shown that those artifacts, which deteriorate a correct Hall measurement, can be eliminated by considering the current and field symmetry in the 2nd harmonics. The elimination of thermoelectric artifacts enables us to correctly measure the magnitude and angular dependence of SOT, and thereby to properly interpret the physics of SOT.

Reference

[1] Pi, U. H. et al. Appl. Phys. Lett. **97**, 162507 (2010).