Thermal detection of spin anomalous Hall effect using spin Peltier effect

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The spin Hall effect (SHE), which generates a spin current from an applied charge current in conductors, plays an important role in spintronics. Many studies have been devoted to searching materials with high charge-to-spin conversion efficiency. Recently, it was demonstrated that ferromagnetic metal can also be used for generating the spin current [1]. This phenomenon is called the spin anomalous Hall effect (SAHE) and has attracted attention because its efficiency is found to be comparable to that for commonly used paramagnetic materials.

SAHE can be measured through the spin Peltier effect (SPE) [2,3] measurement in ferromagnetic conductor/ferrimagnetic insulator systems. SPE induces a heat current from a spin current, and thus if SAHE is used to generate the spin current, the magnitude of the SPE-induced temperature modulation can be a measure of the SAHE efficiency, similarly to the SHE case [4]. The key for the measurement is to separate the SAHE contribution from the other from the transverse magnetothermoelectric phenomenon in ferromagnetic conductors, called the anomalous Ettingshausen effect (AEE), because it generates a heat current from the applied charge current with the similar symmetry to SPE [5].

In this study, we experimentally demonstrate the detection of SAHE-induced SPE by using the frequency-domain lock-in thermoreflectance (LITR) method, where the AC current-induced temperature change is measured through the reflectivity change. Since it is revealed the SPE and AEE contributions show the different frequency dependence, they can be separated; the magnitude of SPE-induced temperature change decays with increasing the frequency while that of AEE shows almost constant [6]. We performed the LITR measurement in a ferromagnetic metal/ferrimagnetic insulator junction system and confirmed that the frequency dependence of the temperature modulation magnitude decay with increasing the frequency, indicating that the SAHE contribution to SPE is dominant in the system and detectable by our method.

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