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Temperature Dependence of the Spin Hall Angle of Palladium

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In recent years, spincurrentronics has been attracting significant attention for potential future applications because of the low energy consumption of spin current.[1)] There are various methods for generating spin current, spin pumping plays one of the major roles for it.[2)] One of the potential methods for the spin current detection is the inverse spin Hall effect (ISHE), which enables converting a pure spin current to a charge current by a spin–orbit interaction. Whereas palladium (Pd) is a quite famous spin detector, the temperature dependence of the spin Hall angle of Pd has not been experimentally investigated. The purpose of this study is to clarify the temperature dependence.

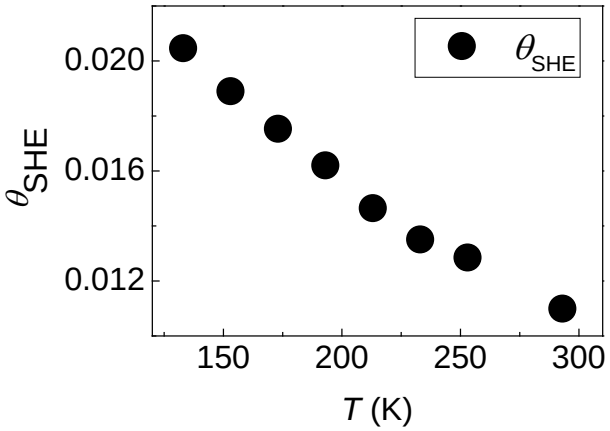

Figure 1. Temperature dependence of the spin Hall angle θ_{SHE} of Pd. The spin Hall angle decreased with an increase in the temperature.

A $Ni_{80}Fe_{20}$(Py)/Pd bilayer thin film was prepared, and a pure spin current was dynamically injected into the Pd layer. This caused the conversion of the spin current to a charge current owing to the inverse spin Hall effect. A 25-nm-thick Py film and a 5-nm-thick Pd film were prepared on an oxidized silicon substrate by electron beam evaporation. Both Py and Pd layers were rectangular with an area of 2 × 1 mm^2. The Pd layer was connected to the positive and negative ends of a nano-voltmeter. Spins from the ferromagnetic Py were injected into the Pd layer by the dynamical spin injection method. The sample system was placed at the center of a TE_{011} microwave cavity in an electron spin resonance (ESR) instrument with a frequency (f) of 9.12 GHz. An external magnetic field, H, was applied to the Py/Pd bilayer at an angle of θ_H. It was found that the spin Hall angle varies as a function of temperature, whereby the value of the spin Hall angle increases up to ca. 0.02 at 123 K as shown in Fig 1.[3)] The detail of the study will be introduced in the presentation.

1) F. J. Jedema, A. T. Filip, and B. J. van Wees: Nature (London) 410 (2001) 345.

2) Y. Tserkovnyak and A. Brataas: Phys. Rev. Lett. 88 (2002) 117601.

3) Z. Tang, Y. Kitamura, E. Shikoh, Y. Ando, T. Shinjo and M. Shiraishi: submitted to Appl. Phys. Express.