Antiferromagnetic coupling and spin Hall effect in Co / Ir-doped Cu / Co layers

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Recently, antiferromagnetic (AF) materials have attracted attention in the research field of spintronics due to its low magnetic susceptibility, lack of magnetic stray field, and fast magnetization dynamics [1]. One of the issues of AF spintronics is to establish a method to manipulate the magnetization direction of AF magnetic structure efficiently. The utilization of spin orbit torque (SOT) based on spin Hall effect (SHE) is promising for AF materials. Thus, the interaction between SOT and an AF magnetic structure has been studied using the combination of bulk AF materials and nonmagnetic materials which have strong spin orbit interaction such as Pt [2, 3]. However, in the bulk AF materials, it is difficult to control the magnetic domain structures, and the magnitude of exchange coupling, which are obstacles for systematic study on the SOT in AF materials. In contrast to the bulk AF materials, AF-coupled metallic superlattices enable us to control their exchange coupling strength by changing the thickness of nonmagnetic layer or ferromagnetic layer. Furthermore, many interfaces of metallic superlattice may lead to the enhancement of SOT.

In this study, we focus on the metallic superlattices consisting of a Ir-doped Cu (Cu-Ir) layer sandwiched by Co layers. The Co / Cu / Co system is representative materials combination showing AF coupling and giant magnetoresistance (GMR). Although pure Cu exhibits negligible SHE, it was reported that Ir impurities in Cu induced the large spin Hall angle (2.1 ± 0.6 %) [4]. Therefore, the Co / Cu-Ir / Co superlattice is expected to show both strong AF coupling and large SOT. We prepared the Co-based epitaxial metallic superlattices with Cu and Cu-Ir interlayers, called Cu sample and Cu-Ir sample, respectively, and compared their AF-coupling and SHE between the Cu sample and the Cu-Ir sample.

The Co (2 nm) / Cu or Cu-Ir (t nm) / Co (2 nm) superlattices were deposited on an Al_2O_3 (0001) substrate / buffer layer (Cr (10 nm) / Au (5 nm) / Cu (35 nm)) using a magnetron sputtering apparatus. The t dependence of AF coupling strength indicated that the first peak of AF-coupling was observed at $t \approx 0.75$ (nm) for both the Cu sample and the Cu-Ir sample. It is noted that a clear AF-coupling was observed even for the Cu-Ir sample. Then, we measured spin Hall magnetoresistance (SMR) to evaluate the SHE. Although the SMR was clearly observed for the Cu-Ir sample, there was no significant difference in the magnitude of SMR compared with that for the Cu sample. This fact suggests that the observed SMR signal was contaminated by SHE from the other layers such as a buffer layer. We will discuss possible origin for the SMR in the metallic superlattices.

[1] T. Jungwirth et al., *Nature Nano.* **11**, 231 (2016). [2] W. Zhou et al., *Phys. Rev. Mater.* **2**, 094404 (2018). [3] T. Moriyama et al., *Sci. Rep.* **8**, 14167 (2018). [4] Y. Niimi et al., *Phys. Rev. Lett.* **106**, 126601 (2011)