巨大スピンホール角材料によるスピンゼーベック発電の増大

Spin Seebeck voltage enhancement by large spin Hall angle materials

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Spin Seebeck voltage generation is an attractive technology owing to the simple structure compared to the conventional thermoelectric conversion devices. However, the generated voltage is too small for practical use still. Therefore, we tried to enhance the generated voltage by focusing on the spin Hall angle that is one of the important parameters to determine the generated voltage. Though Ta and W have the larger spin Hall angle than Pt [1,2,3], YIG/Ta and YIG/W show the smaller Spin Seebeck voltage than YIG/Pt [4]. The considerable reason of such a mismatch is the oxidation of Ta and W at the interface with YIG. Therefore, in order to decrease the oxidation, we fabricated YIG/Ta50W50 since Ta50W50 has a higher oxidation resistance than Ta and W [5].

Figure 1 is a schematic illustration of experimental configuration. We sputtered the nonmagnetic films on the sintered bulk-YIG (1mm), where the nonmagnetic films are Pt, Ta, W, Ta50W50, Ta/Ta50W50, W/Ta50W50, Ru/Ta50W50. Since the preferable thickness depends on the spin diffusion length, the nonmagnetic film thickness was changed from 3 nm to 5 nm and 7 nm. A temperature difference was applied by a pair of Peltier module, a magnetic field was swept, and the generated voltage was measured by 2 probes as shown in Fig. 1.

Figure 2 shows the Spin Seebeck coefficient $|S|$ dependence on materials. $|S|$ of YIG/Ta50W50 is the almost same as those of YIG/Pt and YIG/W, which means that Ta50W50 does not work well to restrain oxidation. But $|S|$ is affected by not only the spin Hall angle but also the spin mixing conductance at the interface with YIG. So as to separate those, YIG/Ta50W50 and YIG/W 0.4nm/Ta50W50 were compared. YIG/W 0.4nm/Ta50W50 showed the obviously larger $|S|$ than YIG/W, which indicates that Ta50W50 has the higher spin Hall angle and lower spin mixing conductance than W. In order to utilize the large spin Hall angle of Ta50W50, we fabricated YIG/Ru 0.5nm/Ta50W50 samples because Ru is hard to be oxidized. As a result, those showed the highest $|S|$ at the nonmagnetic film thickness of 5 nm.