## Pt-Ru 合金を用いたスピンゼーベック起電力 The investigation of spin Seebeck effect in Pt-Ru alloys

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Recently thermoelectric generator based on spin Seebeck effect has attracted wide attention. However, the thermoelectric conversion efficiency still needs to be improved. We found the Ru insertion between YIG and Pt improved the spin Seebeck voltage <sup>[1]</sup> and there are several considerable models of voltage increase; oxidation barrier, Rashba effect, and alloying effect, but the possibility of former two candidates was found to be low by experimental. The remained candidate is alloying effect which leads increase of the skew scattering. <sup>[2]</sup> In this investigation, we intentionally fabricated Pt-Ru alloy and studied the composition dependence on spin Seebeck coefficient (**S**) and power. SiO<sub>2</sub>/YIG (50nm)/Pt<sub>80</sub>Ru<sub>20</sub> (4.5nm) structure showed 2.09 times larger power than SiO<sub>2</sub>/YIG (50nm)/Pt (4.5nm).

The structure of sample is SiO<sub>2</sub>/YIG (50nm)/Pt<sub>100-x</sub>Ru<sub>x</sub> (4.5nm) or Pt (4.5nm) or Ru (4.5nm). as shown in Fig.1. The YIG film was fabricated by RF magnetron sputtering on thermally oxidized Si substrate. And the sample was annealed in atmosphere at 760°C for 1h. Then Pt<sub>100-x</sub>Ru<sub>x</sub> alloy layer was fabricated on the YIG by DC co-sputtering. The spin Seebeck voltage was measured by applying a temperature gradient perpendicular to plane and a magnetic field in plane, and spin Seebeck power was obtained by simple product of voltage and resistance of each sample.

Figure 2 shows the spin Seebeck power as a function of concentration x of  $Pt_{100-x}Ru_x$  alloy. By increasing Ru concentration, the power is increased as shown in Fig. 2 because Ru contributes on scattering site increase. Although the scattering site should be the highest at x=50, the Ru concentration of 20% showed the highest power instead of 50%. It is considered because the very small spin Hall angle of Ru overcomes the effect of skew scattering increase.



Fig. 1 sample structuresFig. 2 Power dependence on composition of Pt100-xRux alloy[1] F. Nakata et al.: The 41st Annual Conference on Magnetics in Japan 20aB-4(2017)[2] B. Gu, I. Sugai, T. Ziman, G. Y. Guo, N. Nagaosa, T. Seki, K.Takanashi,S.Maekawa,Phys.Rev.Lett.2010,105, 216401.