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Systematic measurements of transport properties in permalloy-based lateral spin valves

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Lateral spin valves (LSVs), in which a pure spin current can be generated in a nonmagnetic electrode, is one of the fascinating spintronic devices, potentially useful for read heads of hard disc drives. Although spin signals have been obtained successfully in a lot of previous studies, the transport mechanism has not been fully understood. For example, unexpected offset voltages appear in the measurements of spin signals. In addition, it has been demonstrated that thermal effects intricately influence electron transport in LSVs [1,2]. In this study, to clarify the mechanism of electron transport in LSVs, we have systematically measured contact resistance and non-local voltages for permalloy (Py)-based LSVs.

Py(20)/SiO_2(2) and Ta(3)/Cu(10)/Py(20)/SiO_2(2) (unit: nm) were prepared on thermally oxidized Si substrates by using magnetron sputtering. For fabricating a LSV structure, these multilayers were micro-patterned by using electron-beam lithography and Ar-ion milling techniques, and the center-to-center distance between two ferromagnetic electrodes are varied from 300 nm to 1050 nm to determine the spin diffusion length of a non-magnetic Cu wire with the thickness of 100 nm. Transport measurements were conducted for the LSV samples by using a conventional dc technique under magnetic fields at room temperature.

Fig.1 shows non-local spin signals for the Py-based LSVs at the distance of 300 nm. While the spin signal, $\Delta V/I$, was decreased by inserting the Ta/Cu buffer layer, a large reduction of the offset voltage was found. This suggests that the thermal effects, especially Joule heating, in the Py injector, are related to the magnitude of the offset. Fig. 2 shows a contact voltage (red curve) and a non-local voltage (blue curve), measured as shown in the inset, as a function of bias current I for the Py-based LSV without buffer layer (distance between Py electrodes: 750 nm) in the parallel configuration of magnetization. The negative slope of the contact voltage at I=0 indicates that the contact resistance is so small that it cannot be evaluated due to the geometrical effect [3]. The parabolic curvatures, being convex upward, of both the voltages show that Seebeck effect occurs at the Py injector and detector in a similar manner. These results will be discussed in details in the presentation.

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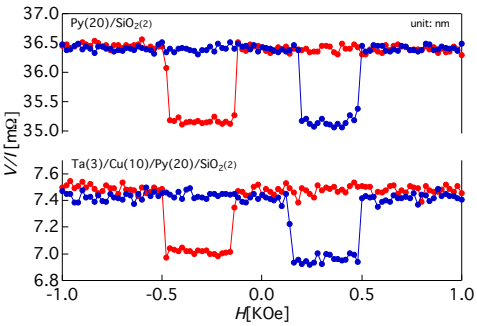

Fig.1. Spin signals in Py-based LSVs.

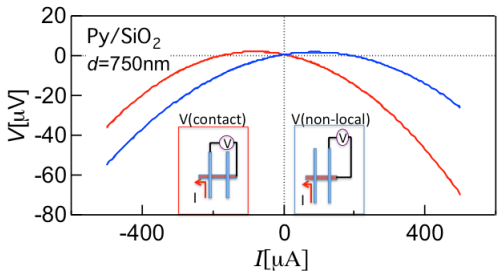

Fig. 2. Contact and non-local voltages for a Py-based LSV without buffer layer (Py electrode distance: 750 nm).

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