弱反局在効果による酸化銅のスピン軌道相互作用の定量

Quantification of spin-orbit coupling in copper oxide using weak anti-localization

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The conversion between an electric current and a spin current through spin-orbit coupling is fundamental to realize spintronic devices. The quantification of the strength of the spin-orbit coupling is crucial to develop efficient spintronic devices. Conventionally, the efficient conversion from an electric current to a spin current has been achieved using heavy metals with strong spin-orbit coupling, such as Pt. However, recently it was discovered that the conversion efficiency of Cu with weak spin-orbit coupling is found to be significantly enhanced through natural oxidation [1]. The conversion efficiency from an electric current into a spin current of naturally-oxidized Cu is comparable to that of Pt. Although the efficient conversion using Cu promises a way to realize efficient spin-orbit devices without using heavy metals, the mechanism of the enhancement of the conversion efficiency through the oxidation remains elusive. Thus, it is important to quantify the oxidation effect on the spin-orbit coupling of Cu.

In this study, we characterize the spin-orbit coupling strength of CuO_x by measuring the weak anti-localization (WAL) effect. To study the oxidation effect on the spin transport properties of Cu, we fabricated the CuO_x films with different oxidation levels using reactive sputtering. Figure 1 (a) shows the magnetoconductivity for the CuO_x films with different oxidation levels. From this result, we have extracted the oxidation level dependence of the spin diffusion length (L_S) and strength of the spin-orbit coupling (λ_{SO}) as shown in Figs. 1(b) and 1(c), where λ_{SO} was calculated from the spin relaxation time and momentum scattering time. Figures 1(b) and 1(c) demonstrate that the spin diffusion length decreases monotonically, whereas λ_{SO} decreases at the low oxidation level and increases at the high oxidation level.

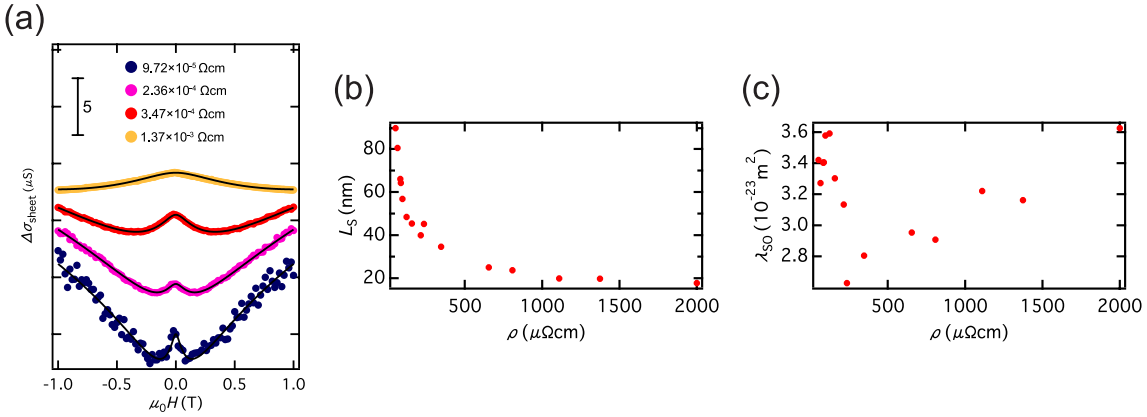

Fig. 1 Weak anti-localization. (a) WAL curves for the CuO_x films. (b) Resistivity (ρ) dependence of the spin diffusion length (L_S). (c) ρ dependence of the spin-orbit strength (λ_{SO}).

[1] H. An, Y. Kageyama, Y. Kanno, N. Enishi, and K. Ando, Nat. Commun. **7,** 13069 (2016).