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Weak anti-localization in CuPt thin films with different Pt concentrations

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1. Introduction

It is expected that spintronics technology enables us for lower energy consumption by using pure spin current where the spin angular momentum flows without charge current. In order to generate spin current, the spin-orbit interaction (SOI), which is an interaction of electron orbital motion and angular momentum, plays an important role [1]. In general, the stronger SOI effect is expected in materials with the larger an atomic number. However, it was demonstrated that Cu thin film with small amount of Mn impurity shows larger anomalous Hall effect (AHE) than that of CuMn alloy [2]. Similarly, large spin Hall effect (SHE) in a Cu thin film with a small amount of Bi impurity was discovered by Niimi *et al*. [3]. Here, we evaluate SOI effect in CuPt thin films by varying Pt concentration.

2. Sample fabrication and measurement

We prepared five different Cu thin films with different Pt concentrations (Pt: 3.7%, 9.7%, 12.4%, 14.9%, and 19.1%). The 10 nm-thick CuPt was deposited on GaAs substrate by RF co-sputtering technique. The Pt concentration was controlled by the relative RF power between Cu and Pt target. A Hall bar structure was fabricated by using photo lithography, dry etching and lift-off processes.

In order to evaluate SOI effect, we measured magneto-resistance for the above fabricated Hall bar structures of CuPt thin films using ^{4}He cryostat at T = 1.55 K and the magneto-resistance data were analyzed by weak antilocalization (WAL) theory.

3. Result and discussion

Figure 1 shows the magneto-resistance profiles of CuPt thin films with different Pt concentrations. Positive magneto-resistance region is enlarged with increasing the Pt concentration, which indicates that the WAL is enhanced with Pt. The results are analyzed by the WAL theory proposed by Hikami - Larkin – Nagaoka (HLN) [5]. To evaluate the SOI strength with different Pt concentrations, we plot the spin relaxation time (τ_s) as a function of Pt concentration as shown in Fig 2. In this analysis, we use the following relation $\tau_s = L_{so}^2/D$, where D is diffusion constant deduced by the Einstein relation $D=1/(e^2\rho N)$ (N is the density of state at the Fermi levels). Spin relaxation time is decreased from 560 fs to 40 fs with increasing Pt concentration. The spin relaxation time of CuPt film with Pt = 19.1% is already comparable to that of pure Pt film (30 fs). This result suggests that the enhancement of SOI is expected in CuPt thin films even with relatively small amount of Pt concentration.

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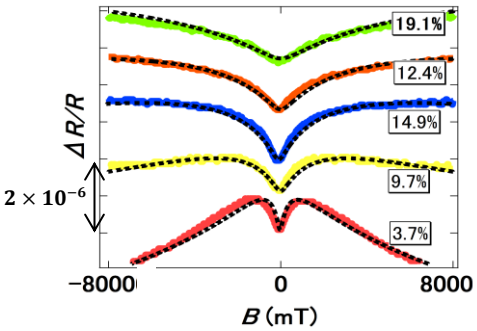

Fig. 1. Pt concentration dependence of WAL profiles measured at 1.55 K. The broken lines are the best fits based on the HLN theory.

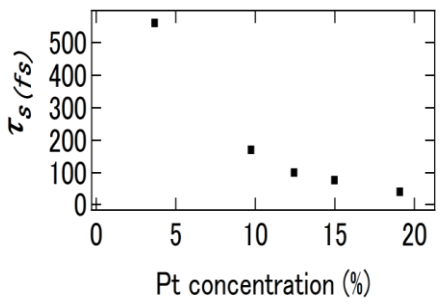

Fig. 2. Spin relaxation time of CuPt thin films depending on different Pt concentration.