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Thickness dependence of spin relaxation in polycrystalline AlO / Pt / GaAs

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1. Introduction

Understanding the spin relaxation mechanism in thin metal films, closely related to spin-orbit interaction (SOI), is important for the design of future spintronic devices. Two dominant mechanisms of spin relaxation are considered in thin metal films: the D'yakonov-Perel' (DP) mechanism originated from the Rashba SOI and the Elliott-Yafet (EY) mechanism associated with the momentum scattering by impurities [1, 2]. For the Rashba SOI, spin relaxation can be manipulated by an external electric field. This electrical manipulation has great advantages for future spintronic applications. Recently, M. Miron *et al.*, suggested magnetization switching induced by the Rashba SOI in AlO / Co / Pt layers [3]. Applying this result, the Rashba SOI is expected in asymmetric interface structure of paramagnetic metal. Here, we investigate the Pt thickness dependence of spin diffusion length and discuss its spin relaxation mechanisms in AlO / Pt / GaAs films.

2. Experimental procedure

Each Pt layer was deposited on *i*- GaAs substrates by Radio-Frequency sputtering with a different thickness: d = 2 nm, 4 nm, 6 nm, 8 nm, 10 nm, 15 nm, and 20 nm. All samples were covered with an AlO layer (0.6 nm) in order to induce the Rashba SOI originated by the structure inversion asymmetry at the interface.

To evaluate the SOI in thin Pt films, we focus on quantum correction of the conductance, *i.e.* weak antilocalization (WAL). If strong SOI exists, negative magneto-conductance is observed around zero magnetic fields. After fitting data with the WAL theory by Hikami - Larkin – Nagaoka (HLN) [4], we can evaluate the strength of SOI from spin diffusion length $L_{so} = \sqrt{D\tau_{so}}$ (the shorter L_{so}, the stronger SOI).

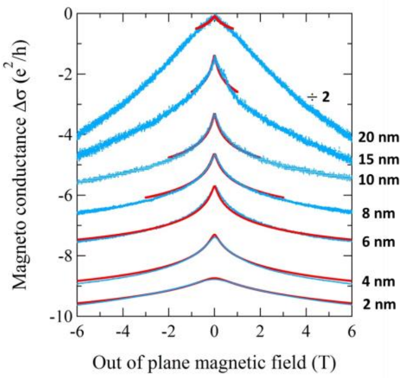

Fig. 1 Pt thickness dependence of WAL curves measured at T = 1.6K. Red lines are the best fitted results based on the HLN theory. [4]

3. Results

Figure 1 shows the Pt thickness dependence of WAL in AlO / Pt / GaAs layers. Since Pt has strong SOI, all samples show WAL. However, the strength of SOI is not simple and depends on the Pt thickness. In the EY mechanism, L_{so} has a proportional relation to the diffusion constant [5]. Relatively thick Pt films over 6 nm followed this relationship, however the deviation from the linear relation becomes clear with decreasing the thickness as shown in Fig. 2. The deviation from the linear relation suggests the DP mechanism. Since τ_{so} in the DP mechanism is inversely proportional to τ [6], L_{so} becomes independent of the diffusion constant. When the Pt film is relatively thick, dominant spin relaxation is caused by the EY mechanism. By decreasing the thickness, the spin relaxation seems to be governed by the Rashba SOI originated from the interface. For further study to clarify the mechanism, epitaxial Pt thin films on MgO are being prepared.

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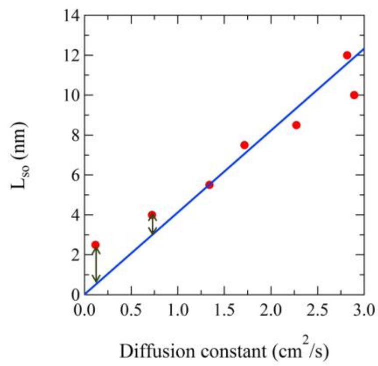

Fig. 2 Relationship between diffusion constant and spin diffusion length. Blue line shows the EY mechanism in thick Pt films.