Spin-relaxation mechanism in Cu/Bi systems investigated by weak anti-localization

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The Rashba-Edelstein effect (REE) is known as the alternative way to generate spin current in addition to the bulk spin Hall effect (SHE). A Cu/Bi interface is expected to generate spin current due to the strong REE. It is often difficult to separate the REE and the SHE by using heavy metal/ferromagnet bi-layer systems [1]. In this study, we have investigated the spin-relaxation mechanism of Cu/Bi system by utilizing weak antilocalization (WAL) analysis which does not require any ferromagnet layer. Cu (0.6-8 nm)/Bi (2, 3, 5 nm)/AlO_x (2 nm) thin films were sputtered on sapphire (0001) substrates. It was found that the Cu layers are epitaxially grown although the Bi layers are polycrystalline. Magneto-conductance and Hall resistance measurements were perfomed in a ^{4}He cryostat at 2 K.

The results of the magneto-conductance measurement are shown in Figs. 1(a), (b) and (c) with different Cu and Bi thicknesses. All data show WAL. Spin relaxation time τ_{so} was evaluated by fitting the Hikami-Larkin-Nagaoka formula [2], and momentum scattering time τ_p was calculated by using the carrier density estimated by the Hall resistance measurement. Figure 1(d) shows that the τ_{so} is inversely proportional to the τ_p, meaning that the D'yakonov-Perel mechanism [3] is dominant over the Elliot-Yafet mechanism [4]. This result indicates that the REE is important at the Cu/Bi interface.

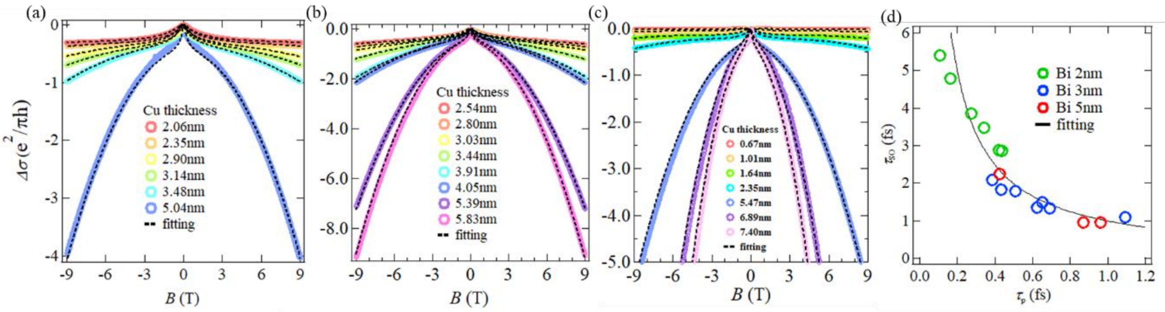

Fig 1. (a), (b) and (c) Magneto-conductance of Cu/Bi with different Cu thickness at 2 K when Bi thickness is (a) 2 nm, (b) 3 nm and (c) 5 nm, respectively. (d) The relationship between spin relaxation time τ_{so} and momentum scattering time τ_p .

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