Enhancement of spin orbit interaction in Cu by doping nitrogen impurities

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1, Introduction

It is well known that Cu is material with very weak spin orbit interaction (SOI). However, it has been recently reported that SOI in Cu is enhanced by oxidation or impurity doping [1, 2]. In this research, we doped nitrogen impurities to Cu thin films and demonstrated the enhancement of SOI in N doped Cu by comparison to the non-doped Cu. This approach can provide further comprehension of enhancement of SOI by impurities doping in weak SOI materials. In addition, this is industrially more profitable method as enhancement of SOI due to the cheapness of Cu and N.

2, Experimental procedure

Both pure Cu (9 nm) and CuN (9.5 nm) thin films were deposited on SiO_2 substrate by RF sputtering machine. Substrate temperature during sputtering in Cu and CuN was RT and 100℃[3] respectively. CuN films were sputtered by varying N_2 gas pressure between 0.03 and 0.1 Pa during the sputtering.

To evaluate spin relaxation length L_{so}, we focused on quantum correction of the magneto conductance (MC). The results of MCs were fitted by Hikami-Larkin-Nagaoka formula [4].

3, Result

Experimental MC results for pure Cu and CuN are shown in Fig. 1 (a) and (b), respectively. In Fig. 1(a), positive MC observed for pure Cu 9 nm film represents weak SOI. On the other hand, negative MC signals (*i.e.* weak-anti localization (WAL)) are observed in all CuN thin films. The magnetic field region showing WAL is enlarged by increasing the N_2 partial pressure. This transition from positive to negative MCs shown in Fig. 1 directly indicates the enhancement of SOI by doping N impurities to Cu thin films.

In order to realize the more quantitative analysis, the relationship between L_{so} and N_2 pressure during sputtering is shown in Fig. 2. From this figure, L_{so} becomes 20 times shorter than minimum value of that in pure Cu films. Thus, we have demonstrated that the strength of SOI in CuN can be tuned by controlling partial N_2 pressure during sputtering.

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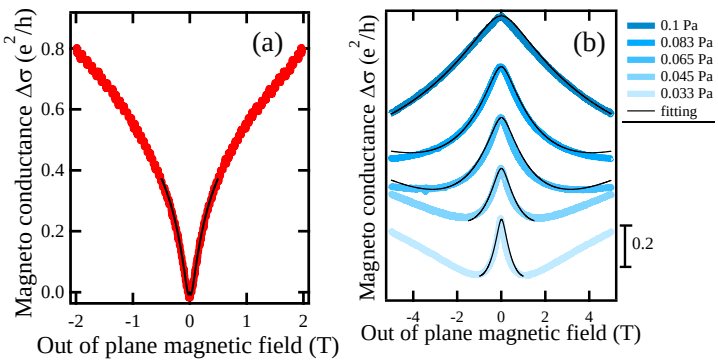

Fig. 1. MC of (a) pure Cu (9 nm) and (b) CuN (9.5 nm) respectively at 2 K.

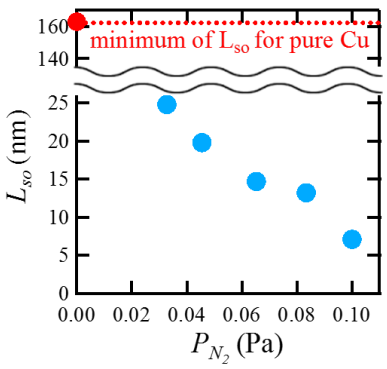

Fig. 2. The relationship between spin relaxation length and N_2 partial pressure during sputtering.