Spin Pumping in High Tc Superconductor $La_{1.85}Sr_{0.15}CuO_4$ thin films

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Introduction

Spin Current

Charge current

$J_G = J_↓ + J_↑$

A flow of charge current with random spin

Spin current

$J_S = J_↓ - J_↑$

A flow of spin angular momentum no net charge current (free from Joule heating)

Inverse Spin Hall Effect

Electric current converted from spin current

$E_{SHE} \propto j_s \times \sigma$


Inverse Spin Hall Effect

Spin current source by processing moment

$j_s = \frac{\omega}{2e\sigma} \int_0^t \frac{h}{4\pi^2} \frac{1}{M(t)} \frac{dM(t)}{dt}$


Sample fabrication

La$_{1.85}$Sr$_{0.15}$CuO$_4$ sample has been deposited by Pulse Laser Deposition (PLD) process on SrLaAlO$_4$ substrate.

PLD deposition condition for La$_{1.85}$Sr$_{0.15}$CuO$_4$ sample at (001) direction:
Deposition Temperature : 775°C
Deposition Pressure : 1.2 $\times$ 10$^{-1}$ Torr
Deposition frequency : 4Hz
Post deposition annealing : 60min @ 400°C, 400 Torr

Fabrication for spin pumping:

10nm thick Permalloy (Ni$_{81}$Fe$_{19}$) layer has been deposited on LSCO (La$_{1.85}$Sr$_{0.15}$CuO$_4$) by evaporation process.

Result and discussion

Spin pumping

FMR signal of Py/LSCO bi-layer

Damping constant vs. thickness

Calculation

$a_{eff} = a_0 + \Delta a$

$\Delta a = \frac{3}{4}\tau (W_F/N - W_H)$

LSCO’s damping constant is lower than Pt’s

Measurement

1. The Gilbert damping Constant $a_{eff}$ for LSCO is ~0.018 which is lower than that of Platinum.
2. From calculation, mixing conductance $g^{↑↓}$ and spin diffusion length $\lambda$ is predicted as $\sim 5 \times 10^{12}$ (m$^2$) and $\sim$35nm.
3. Experiment on LSCO at lower thickness is necessary to verify the prediction.

Conclusion