CC06

Spin Accumulation and Magnetoreistance of a CPP-GMR System with a Current Confined Path

Hiroshi Imamura
Nanotechnology Research Institute, AIST, Tsukuba 305-8568, Japan
*Corresponding author: h-imamura@aist.go.jp, Phone: +81 29 862 6713, Fax: +81 29 862 6574

Current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) has attracted much attention for its potential application as a read sensor for high-density magnetic recording. In order to realize the high-density magnetic recording, we need MR devices with high MR ratio and low resistance area product (RA). Although the RA value of a CPP-GMR system is much smaller than that of a tunnelling magnetoresistance (TMR) system, the MR ratio of a conventional CPP-GMR system still remains a small value of less than 10 %. Much effort has been devoted to increasing the MR ratio of the CPP-GMR system.

Recently, Fukuzawa et al.reported that they achieved the MR ratio of 10.2 % by CPP-GMR spin-valve with a current-confined-path (CCP) structure [1]. They showed that the MR ratio increases with increasing the RA value, which means that the MR ratio is enhanced for the narrow CCP. The similar enhancement of the MR ratio of a CCP structure with a domain wall was also reported by Fukue et al. [2]. They discussed the enhancement of the MR value due to the CCP by introducing the effective circuit model. However, the physics behind the enhancement of the MR ratio is still unclear.

The origin of CPP-GMR is the boundary resistance due to the spin accumulation as shown by Valet and Fert [3]. We theoretically study the spin accumulation and magnetoresistance of the CCP-CPP-GMR system by starting with the Boltzmann equation. We numerically solve the continuity equations for charge and spin currents by using the finite element method and show that the MR ratio is enhanced for the system with a narrow CCP as shown in Fig. 1. We also analyze how the spin accumulation and therefore the MR ratio are affected by the geometry of the CPP structure.

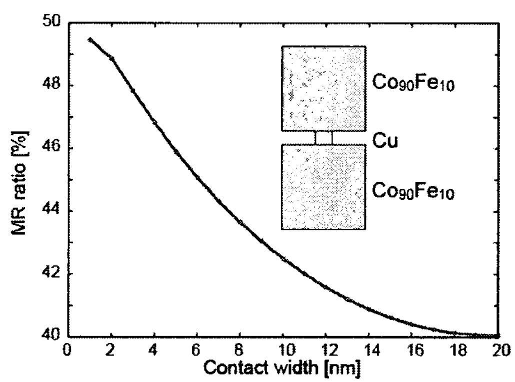

Fig. 1. MR ratio of a CCP-CPP-GMR system is plotted aginast the width of the CCP. The simulation is done in 2D. The top and bottom electrodes are asssumed to be made of Co90Fe10 with dimensions of 20nm×20nm. The CCP structure is assumed to be made of Cu and its length is taken to be 2nm.

REFERENCES
[1] H. Fukuzawa et al., Appl. Phys. Lett. 87, 082507 (2005)
[2] Fukue et al., to be published in IEEE Trans. Magn. (2007)
[3] T. Valet and A. Fert, Phys. Rev. B 48, 7099 (1993)

CC07

Spin Accumulation From the Spin Hall Effect and the Anisotropic Effect Studied Using the Effective Mean-Free-Path Model

Sui-Pin Chen*[1] and Ching-Ray Chang[2]
[1]Department of Applied Physics, National Chia Yi University, 60004, Chia Yi, Taiwan
[2]Center for Nanostorage Research and Department of Physics, National Taiwan University, 10617 Taipei, Taiwan
* Corresponding author: d89222002@ntu.edu.tw, Phone: +886 5 271 7459, Fax: +886 5 271 7909

The spin accumulation from the spin Hall effect can be studied by the effective mean-free-path model [1]. The effective mean-free-path model is equivalent to the Boltzmann transport equation model, which is useful to study the electron transport in a finite system [2]. Given boundary conditions, the solution of the electron distribution to specify the electron transport can be easily obtained from this model, andis always explicitly expressed in an analytic form. The electron distribution is governed by the chemical potential in an investigated system; therefore, the electron distribution response to various scatterings can be related to the change of the chemical potential. When the scattering is spin-dependent, this change becomes spin-dependent; thus, the spin accumulation occurs. In presence of the spin Hall effect, or the anomalous scattering [3,4], there exists the spin-dependent scattering, and also the spin accumulation. The resulting spin accumulation is specified by the difference between the spin-up and the spin-down chemical potentials, which can be easily obtained by using the effective mean-free-path model [1]. In this paper, a system with the spin Hall effect and the anisotropic effect is investigated. Due to the spin Hall effect, it has two different conductivities: the longitudinal Drude conductivity and the transverse anomalous Hall conductivity [3,4]. Due to the anisotropic effect, its mean free path depends on the angle between the electron velocity and the magnetization [5]. The difference between the Drude conductivity and the anomalous Hall conductivity varies with the angle and induces a spin-dependent, directional diffusive scattering, and thus causes the spin accumulation in terms of the effective mean-free-path model.

REFERENCES
[1] S.-P. Chen, C.-R. Chang, T.-M. Hong, and C.-H. Lai,IEEE Trans. Magn. 42(10), 2667 (2006).
[2] S.-P. Chen and C.-R. Chang, Phys. Rev. B 72, 064445 (2005).
[3] J. E. Hirsch, Phys. Rev. Lett. 83, 1834 (1999).
[4] S. Zhang, Phys. Rev. Lett. 85,393 (2000).
[5] Th. G. S. M. Rijks, R. Coehoorn, M. J. M. de Jong, and W. J. M. de Jonge, Phys. Rev. B 51, 283 (1995).