FB06

Observation of Room Temperature Magnetoresistance in a Lateral Ferromagnet-semiconductor structure

Hyun Cheol Koo*[1], Jae Hyun Kwon[1], Jonghwa Eom[1, 2], Joonyeon Chang[1], and Suk-Hee Han[1]
[1] Center for Spintronics Research, Korea Institute of Science and Technology, Seoul 136-791, Korea
[2] Department of Physics, Sejong University, Seoul 143-747, Korea
*Corresponding author: hckoo@kist.re.kr, Phone: +82 2 958 5423, Fax: +82 2 958 6851

In order to realize Datta-Das spin field effect transistor (spin-FET) [1], noticeable magnetoresistance at room temperature is an essential requirement. InAs-based two-dimensional electron gas (2DEG) layer is a favourable candidate for a spin-FET, because of high mobility and large spin-orbit coupling. In this research, we utilizedinverted heterostructure with InAs active layer as a transport channel and NiFe electrodes as a spin injector and a detector. For an efficient spin transport we controlled FM-2DEG interface resistance and selected 4~50 Ω-μm^2. The non-local geometry signal rules out possible spurious effects,so spin relative parameters were extracted by this method [2]. However, the local spin valve signal should be detected for the real device operation. Figure 1(a) shows resistance change of the local spin valve measurement at room temperature. In this measurement,the current flows between two ferromagnets (FMs) and the voltage probe detects potential difference of the same terminals. The magnetic field is applied to the easy axis of FMs. The high-resistance state corresponds to the antiparallel alignment of two FMs. The dips in non-local signal, which contains only pure spin signal, exactly match the peaks in local spin valve signal, *so that the detected signal in Fig 1(a) is believed to be originated from the spin polarized electrons. Figure* 1(b) shows temperature dependence of magnetoresistance ($\Delta R/R$) for the local spin valve measurement. The magnetoresistance slowly reduces with increasing temperature, but $\Delta R/R$ remains near 1% at room temperature. The obvious spin valve signal at room temperature in a FM-semiconductor system with a large spin-orbit coupling channel is a great progress for an operational spin-FET.

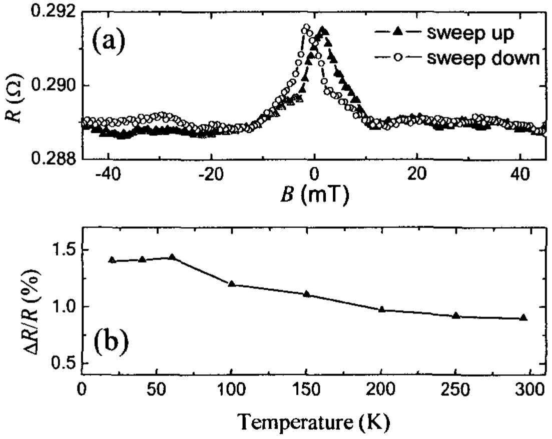

Fig. 1. Local spin valve signal. (a) Spin signal at room temperature. (b) Temperature dependence of magnetoresistance.

REFERENCES

[1] S. Datta and B. Das, Appl. Phys. Lett. 56, 665 (1990).
[2] H. C. Koo, H. Yi, D. Jung, J.-B. Ko, S.-G. Huh, J. Eom, J. Chang, and S.-H. Han, Appl. Phys. Lett. 90, 022101 (2007).

FB07

Magnetotransport Properties of Magnetic Tunnel Junctions with Half-metallic Co_2MnZ (Z = Al, Si) Electrode

Y. Sakuraba*[1], M. Hattori[1], M. Oogane[1], H. Kubota[2], Y. Ando[1], A. Sakuma[1] and T. Miyazaki[1]
1 Department of Applied Physics, Graduate School of Engineering, Tohoku University, Aoba-yama 6-6-05,
Aramaki, Aoba-ku, Sendai 980-8579, Japan
[2] NanoElectronics Research Institute, National Institute of Advanced Industrial Science and technology (AIST),
1-1-1, Umezono, Tsukuba 305-8568, Japan
*Corresponding author: sakuraba@mlab.apph.tohoku.ac.jp, Phone: +81 22 795 7949, Fax: +81 22 795 7947

Some of full-Heusler alloys (Co_2MnSi, Co_2MnGe, Co_2MnAl *etc.*) have been predicted as half-metallic compounds, which haveperfect spin-polarized conduction electronsdue to energy band gap of one-spin channel at Fermi level. Our recent works have fabricated magnetic tunnel junctions (MTJs) with Co_2MnSi/Al-O/Co2MnSi structure and demonstrated giant TMR ratio of 570% at 2 K, indicating the half-metallic property of Co_2MnSi.[1] However, this TMR ratio drastically decreased with increasing temperature and finally became only 70% at RT. We suggested from tunnelling conductance spectroscopy measurements that this large temperature dependence of TMR ratio may be attributed to a tiny energy separation less than 10 meV between Fermi level (E_F) and conduction band (CB) edge of half-metallic energy gap.[2] Therefore, the easiest method to improve extremely large temperature dependence of TMR ratio is to adopt other half-metallic full-Heusler alloys such as Co_2MnAl or Co_2MnGe as electrode of MTJs and change the location of E_F in half-metallic energy gap.

The purpose of this study is to fabricate MTJs with Co_2MnAl and Co_2MnSi electrode and compare the tunnelling properties between these MTJs. All the samples were fabricated by UHV magnetron sputtering system. The stacking structure of the MTJs is MgO-subs./Cr /Co_2MnZ (Z = Al, Si)/Mg/Al-O/ CoFe/IrMn/Ta. Inserted Mg layer between Al-O and Co_2MnZ can suppress the creation of magnetic impurities at interface. Fig. 1 shows temperature dependence of TMR ratio for the MTJs with Co_2MnSi and Co_2MnAl electrode. Co_2MnAl/Mg/Al-O/CoFe-MTJ shows large TMR ratio of 171% at 2 K, suggesting half-metallic nature of Co_2MnAl. However TMR ratio drastically decreased to 72% at 300 K as well as Co2MnSi-based MTJs.

The results of tunnelling conductance spectroscopy in these MTJs and possible origin of large temperature dependence will be discussed.

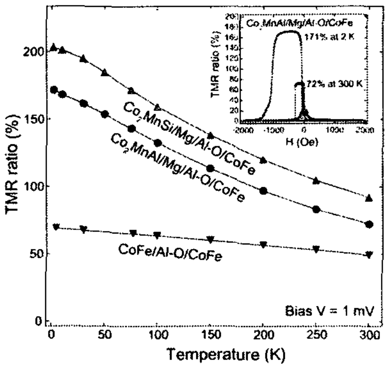

Fig. 1. Temperature dependence of TMR ratio for the MTJs with Co_2MnSi, Co_2MnAl and CoFe bottom electrodes.

REFERENCES

[1] Y. Sakuraba, M. Hattori, M. Oogane, H. Kubota, Y. Ando, H. Kato, A. Sakuma, and T. Miyazaki, Appl. Phys. Lett., 88, 192508 (2006).
[2] Y. Sakuraba, T. Miyakoshi, M. Oogane, H. Kubota, Y. Ando, H. Kato, A. Sakuma, and T. Miyazaki, Appl. Phys. Lett., 89, 052508 (2006).