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FM/Si/FM device on silicon on insulator (SOI) wafer

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1. Introduction

Demonstration of spin injection and transport through Si channel gives a big impact on spintronics technology because of its potential compatibility of conventional complementary metal oxide semiconductor (CMOS) technology. Since spin valve effect in Ni/Si/Ni junction was first reported by S. Chou, [1] little progress has been made on spin injection and transport through Si. Some works studying spin injection into Si also suffered from large contact resistance, high possibility of magnetostatic interaction between two ferromagnetic electrodes and high leakage current which make it difficult to discriminate spin signal. [2,3]

In the present work, we report on the spin valve effect in a Permalloy/Si/Permalloy hybrid device. In order to reduce the leakage current and to confine carriers in the pseudo two dimensional structure, we use silicon on insulator (SOI) wafer where 50nm thick silicon channel is formed on SiO_2 insulating layer. Narrow Si nano channels enhance the spin injection and transport signal as well as signal to noise ratio by decreasing side effects such as local Hall or fringe field effects.

2. Experiment

The device consists of n-type Si (ρ = 1~10 Ωcm) on insulator and two ferromagnetic contacts (Py) as shown in Fig. 1. The numbers of narrow spin transport channel of which size is 1200 nm long and 400 nm separated by TaO were patterned on SOI wafer. $Ni_{0.8}Fe_{0.2}$ ferromagnetic electrodes, with different aspect ratio are used as spin injector and detector. The different width of the Pys is expected to give rise to two distinct switching fields. Py electrodes are deposited in a magnetron sputtering chamber with a base pressure of 10^{-8} Torr. Electrical measurements were performed using PPMS (Quantum design) at various temperatures and external magnetic fields.

3. Results and discussion

In Fig. 2, shown is the spin valve effect measured at 10K as a function of magnetic field applied along the long axis of the Py electrodes. Two peaks with plateau are found to appear in the range of magnetic field of 100~200Oe over which the magnetization in one Py electrode is aligned antiparallel to that in the other. The MR ratio is observed to

0.19%. The spin-valve effect presents that the spin-polarized electrons are injected from one Py and after transporting through thin and narrow Si channels are detected by the other Py. The antiparallel configuration of the magnetizations in the two Py electrodes yields maximum resistance in the device, which is corresponding to the Ni/Si/Ni junction.[1]

4. Summary

We have investigated the magnetoresistance of the Py/Si/Py device. Clear spin valve signals were found in the field range of 100~200Oe over which magnetization of two Pys is aligned antiparallel showing maximum resistance. The results indicate that the spin polarized electrons are injected and are detected after transporting through Si channel.

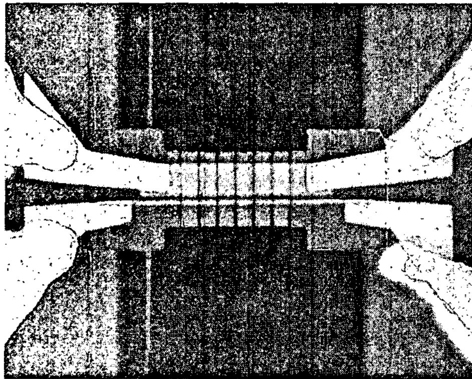

Fig.1. Top view of the device on SOI

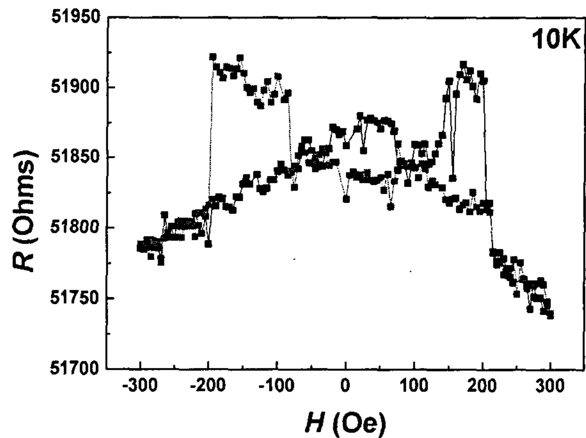

Fig. 2. Spin valve effect found in the device

References

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