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Spin Accumulation and Magnetotransport in NiFe/Al/NiFe Single-electron Transistors

J. H. Shyu[1,2]*, T. F. Tang[2], Y. D. Yao[2] and J. W. Chen[1]
[1]Department of Physics, National Taiwan University, Taipei, Taiwan 10617, R.O.C.
[2]Instituteof Physics, Academia Sinica, Nankang, Taipei, Taiwan 11529, R.O.C.
*Corresponding author: jhshyu@gmail.com, Phone: +886 2 27880058#1130, Fax: +886 2 27834187

We present suppression of superconductivity and oscillation of magnetoresistance resulting in spin dependent transport in NiFe/Al/NiFe single-electron transistors. For the different magnetic states of leads, spin accumulation is induced in *superconducting island and suppresses superconducting gap [1]. Charging energy in the single-electron transistor influences* spin accumulation to oscillate magnetoresistance in Coulomb staircase structure [2].The e-beam lithograph was used to write the patterns, and the patterned NiFe and Al were fabricated by conventional lift off processes. The Current-Voltage (I-V) characteristics were taken using a dilution refrigerator and the magnetic field was applied in the parallel of the current direction up to 2.5 T. Magnetic force microscopy (MFM) was used to clarify magnetization states of two NiFe leads and scanning electron microscopy (SEM) was used to observe morphology of samples. Although the dimensions of twomagnetic leads are almost the same, the MFM images show two magnetization states, parallel and antiparallel states, for reversibly switching magnetic fields. In this study we find out spin accumulation that is influenced by charging energy suppresses superconducting gap of the central island and oscillates magnetoresistance with bias voltage from positive to negative value.

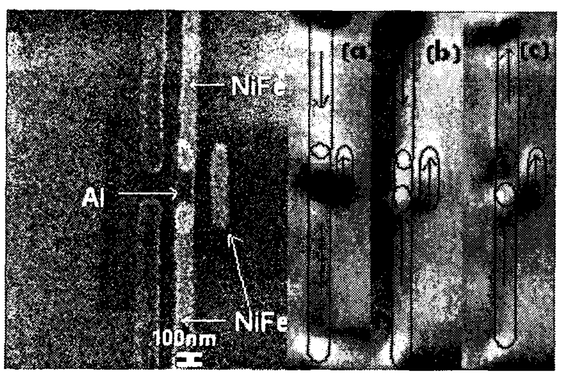

Fig. 1. The SEM image (left) of NiFe-Al-NiFe a single-electron transistor and corresponding MFM images (right) with switching fields.

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SC04

Drift Effect on Spin Transport in a Ferromagnet-Semiconductor Hybrid Device

Jae Hyun Kwon[1], Jung Seung Kim[1], Hyun Cheol Koo[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

Spin transport in a ferromanget-semiconductor hybrid system has a great concern to develop spin transistor. Non-local measurement [1, 2] is a robust method to measure the spin injection and detection without spurious effect. In diffusive regime, the accumulated spins evenly diffuse out every direction and the spin signal (ΔR) decays exponentially with the distance between the injector and detector, L. If we only consider the diffusion mechanism, we should obtain the same amount of ΔR in Fig. 1(a) and (b). However, if we take into account spin drift induced by electrical current, the spin diffusion model should be modified. To clarify the spin drift effect, the lateral spin valve device is fabricated on the micron sized InAs quantum well channel. As shown in Fig. 1 (a) the current flows from injector (FM2) to channel end which is opposite direction to the detector (FM1), so the spin distribution shifts far away from FM1. Note that the magnetic field is applied to the easy axis of ferromagnets. However in the case of Fig. 1(b) the spin drift occurs towards FM1. Therefore, as shown in the manetoresistance curves of Fig. 1 the spin drift as well as spin diffusion contributes to the spin signal. We found this phenomenon ranging from T = 20 K to room temperature but ΔR difference of two geometries decreases with increasing temperature. In the modified diffusion model including spin drift, the distance, L, should be modified to $L \pm \Delta L$, where ΔL is decided by channel properties and the sign (+ or -) is determined by the injection current direction in the channel.

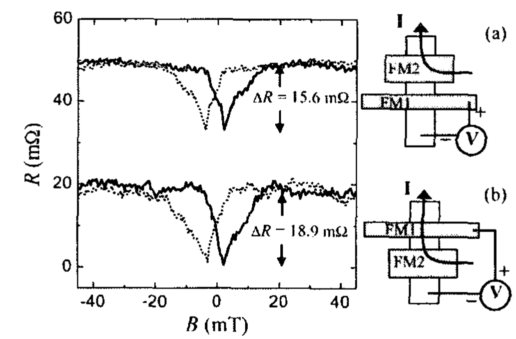

Fig. 1. Magnetoresistances of two different non-local geometries at T = 60 K. Solid and dotted line indicates field sweep up and down, respectively.

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