課題番号	:F-15- IT-0026
利用形態	:機器利用
利用課題名（日本語）	:ナノスケールスピントランジスタにおけるスピン依存伝特性
Program Title (English)	:Spin-dependent transport phenomena in nano-scale spin transistors
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1. 概要（Summary）

In this research, we fabricate **the Si-based nano-scale spin-transistors**. In our device concept, the spin information of electrons will be preserved by ballistic transport in a nanoscale silicon channel to avoid the conductivity mismatch between FM and NF as well as avoid the scattering in long channel. The output voltage can be controlled by the internal magnetization of the ferromagnetic electrodes in addition to the gate voltage.

2. 実験（Experimental）

【利用した主な装置】

High-resolution scanning electron microscope and surface profiler.

【実験方法】

- **Fabricate the nanoscale Si channel fabrication**

The 1st step is thinning the Si-on-Insulator (SOI) layer by oxidation and wet etching. The 2nd step is fabricating the nanoscale Si channel for spin ballistic transport. Our goal is to achieve the ~ 10 nm channel length. Confirmation of the channel length and the thickness of the ferromagnetic electrodes were done by using the high-resolution scanning electron microscope and surface profiler of the nano-tech platform.

- **Develop the high quality tunnel barrier layer**

The tunnel barrier layer is a crucial factor in improving the spin injection efficiency. The high quality MgO tunnel barrier will be grown by molecular beam epitaxy (MBE) technique.

3. 結果と考察（Results and Discussion）

We have successfully fabricated spin valve devices with 20 nm-long silicon channel. We fabricated two spin valve devices; device 1 with Fe electrodes deposited directly on a 20 nm-long n-type Si channel, and device 2 with a 1 nm-thick MgO tunnel barrier. Because the Hanle effect cannot be measured in nano-scale Si channels, we employed the two-terminal spin-valve effect to detect spin transport. For devices without the tunnel barrier, we achieved the local spin signal around 1.3 Ω at 4.3 K. For devices with the tunnel barrier, the local spin signal increased by an order of magnitude, and reached 12 Ω at 4.3 K. We found that these signals strongly depended on the bias voltage and temperature. These indicate that the anisotropy magnetoresistance (AMR) of Fe electrodes was not the origin of the observed MR. Furthermore, the same spin valve effect was observed when the magnetic field was applied perpendicular to the Si channel, indicating that tunneling anisotropy magnetoresistance (TAMR) is also not the origin. These results indicate that the observed spin valve effect is governed by spin transport through the nano-scale Si channel. The spin-dependent output voltage $(\Delta R/R)^{*}V$ is about 8 mV at the bias voltage of 1 V, which is among the highest values reported so far.

4. その他・特記事項（Others）

None

5. 論文・学会発表（Publication/Presentation）

None

6. 関連特許（Patent）

None