

Electrical Spin Injection and Detection in Spin FET Device structures by using InAs Channel

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The spin FET (Field Effect Transistor)^[1] forms the basic structure that consists of FM1/NM(Semi-conductor)/FM2. In this device, the electron injected from ferromagnetic material FM1 transports through NM(Semi-conductor) channel under the influence of the effective magnetic field (Rashba effect)^[2] which originates from the gate voltage. Therefore, spin directions of electrons vary in channel. These characteristics make MR (Magneto resistance) difference depending on the magnetization direction of FM2 and spin direction of electrons coming from FM1 to NM channel.

We have investigated spin injection and detection^[3] by measuring a chemical potential which originates from spin accumulation in two-dimensional electron gas (2DEG) based on InAs heterostructure (Fig. 1).

InAs (2 nm)
In _{0.52} Al _{0.48} As (20 nm)
In _{0.53} Ga _{0.47} As (13.5 nm)
quantum well (2 nm)
In _{0.53} Ga _{0.47} As (2.5 nm)
In _{0.52} Al _{0.48} As (6 nm)
n ⁺ In _{0.52} Ga _{0.48} As (7 nm)
In _{0.52} Al _{0.48} As (buffer layer)
Semi-insulating InP(100)

Fig. 1. InAs multilayer structure.

The device consists of two ferromagnetic electrodes and a transport channel made of the InAs heterostructure. In the first fabrication process, a 15- μm -wide InAs channel of 2DEG was defined by photolithography and Ar-milling. In the subsequent step, ferromagnetic film (NiFe) was deposited to make spin injector and detector after cleaning the surface of the InAs channel by oxygen plasma and Ar-milling. The sizes of injector and detector are 0.2 x 15 μm^2 and 0.4 x 15 μm^2 .

Fabricated devices have various channel width that has been defined by using Ar-milling after E-beam lithography, but the channel length between NiFe electrodes remains same for all the devices (Fig. 2, 3). The effect of channel width on the spin transport has been studied at low temperature.

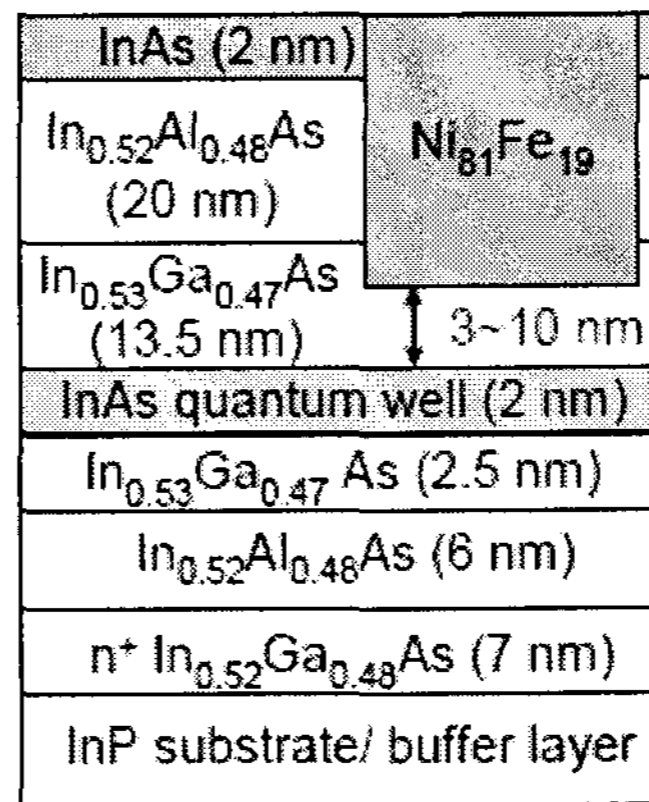


Fig. 2. InAs multilayer structure after NiFe deposition.

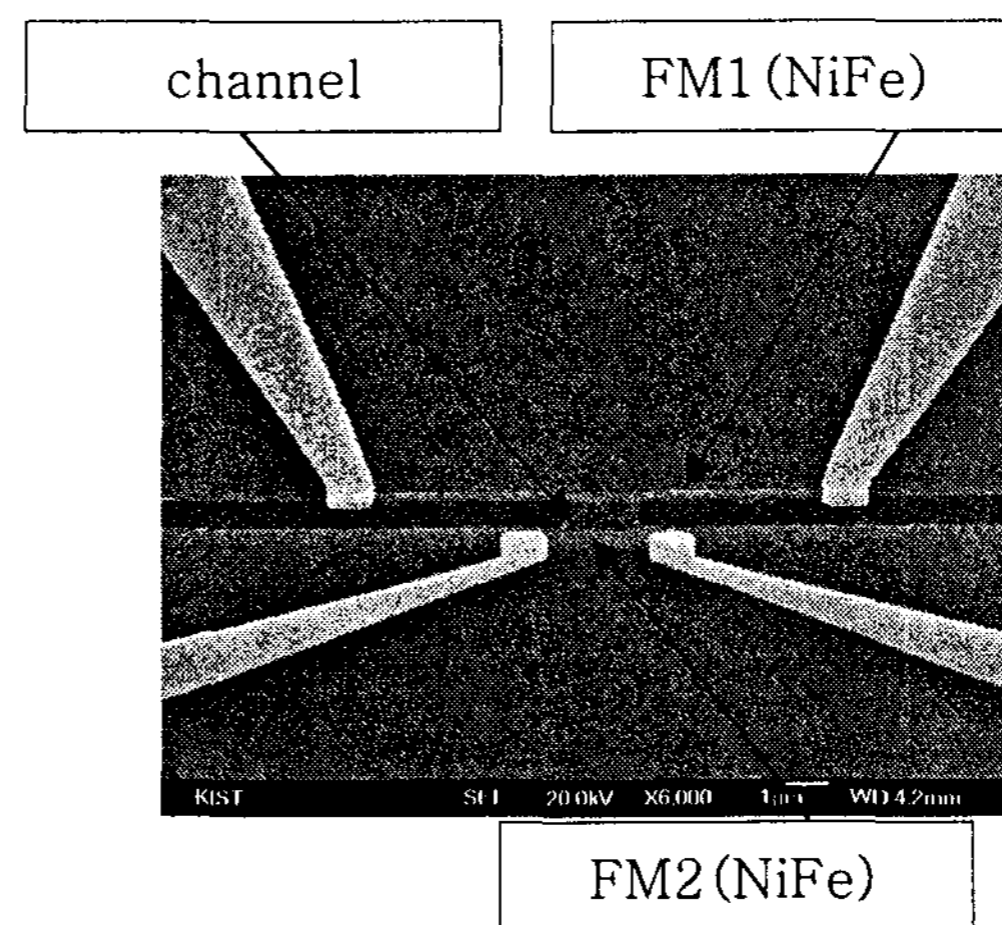


Fig. 3. Spin FET injection Device.

References

- [1] Suproyo Datta and Biswajit Das , Appl. Phys. Lett. 56, 665 (1989).
- [2] S. Dehd and B. Kramer Phys. Rev B, 71, 115322 (2005).
- [3] S. Takahashi and S. Maekawa. Phys. Rev. B 67, 052409 (2003).