Spin FET

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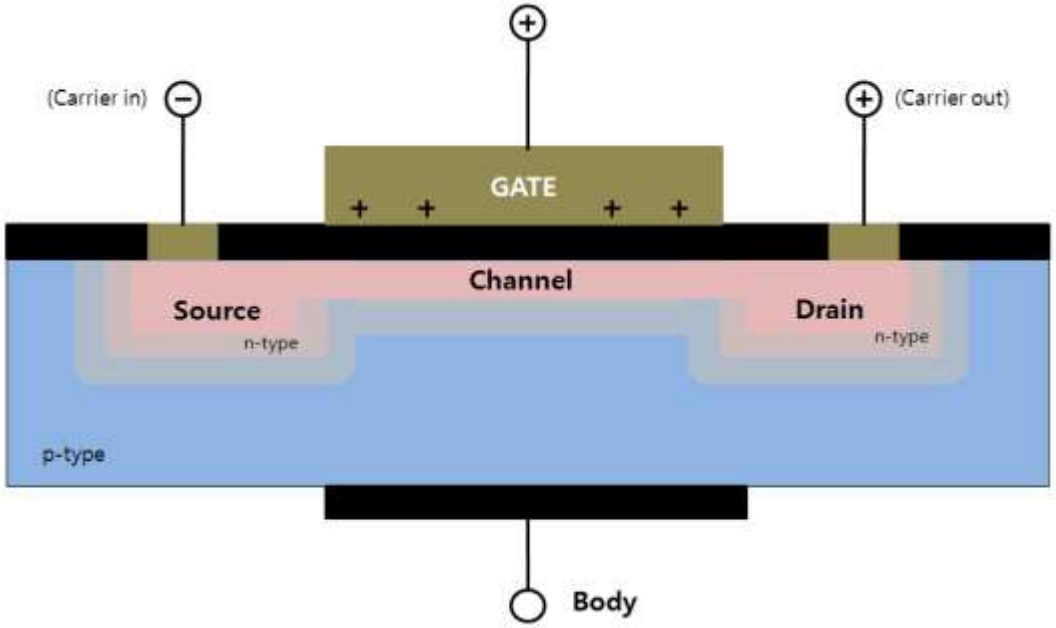
Contents

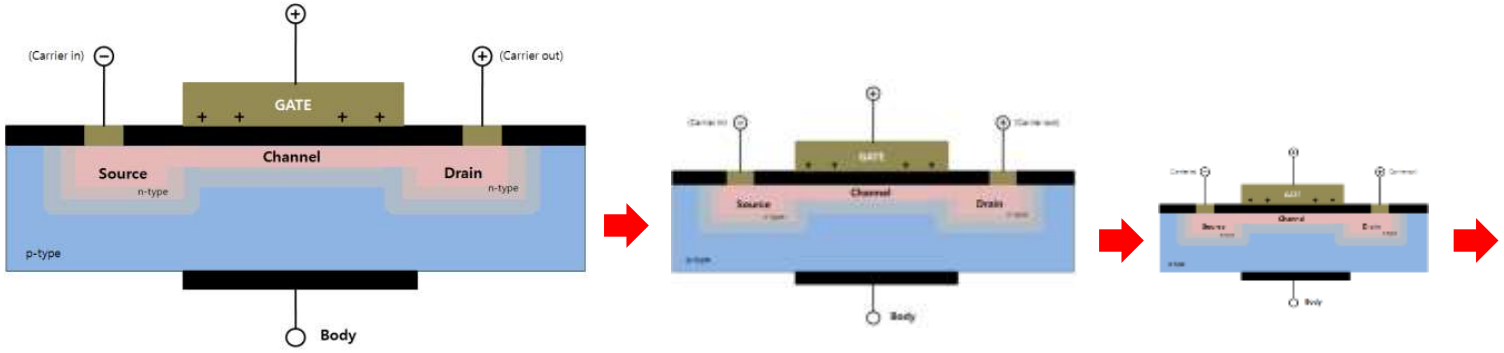
- What is history of the Spin FET?
- How does the Spin FET work?
- What is current situation of the Spin FET?
- What is challenge of the Spin FET?

What is history of the Spin FET?

MOSFET



Scaling down

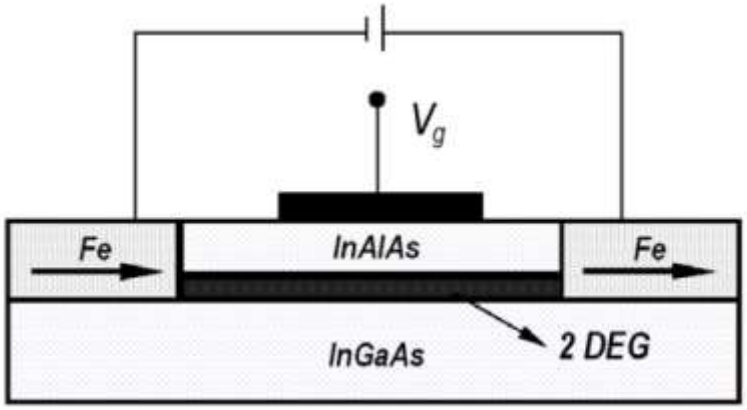


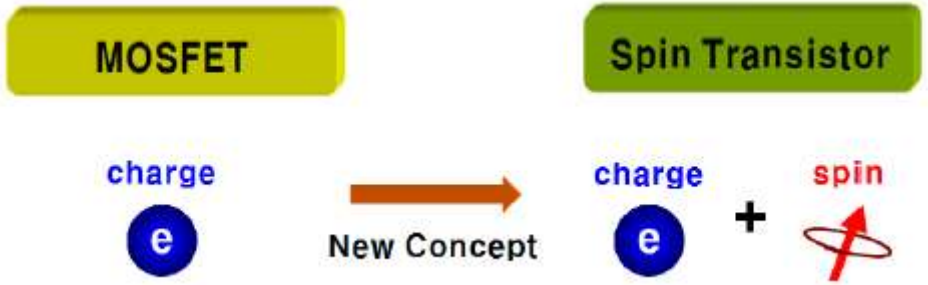
Lattice constant of Silicon

- Physical limitation of current Si-based electronics.

What is history of the Spin FET?

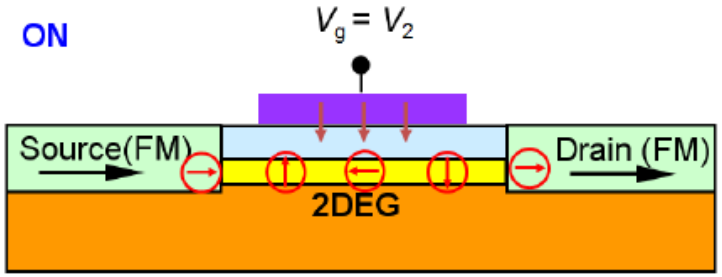
Spin FET

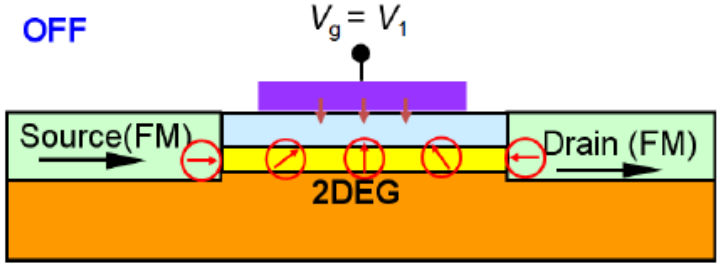


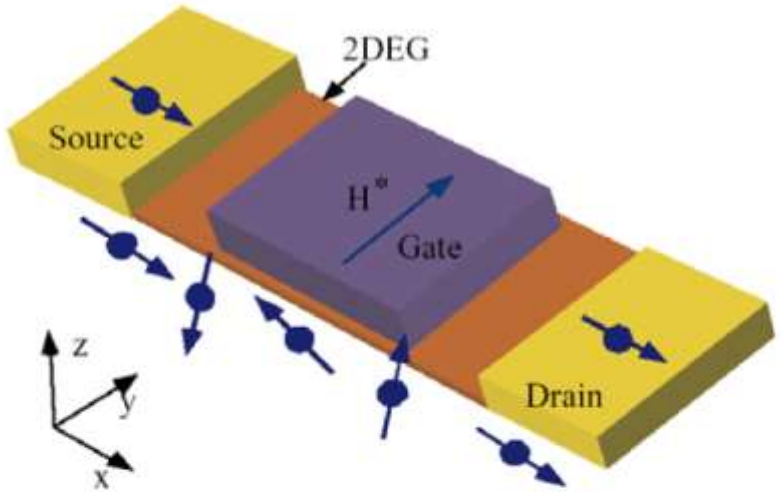


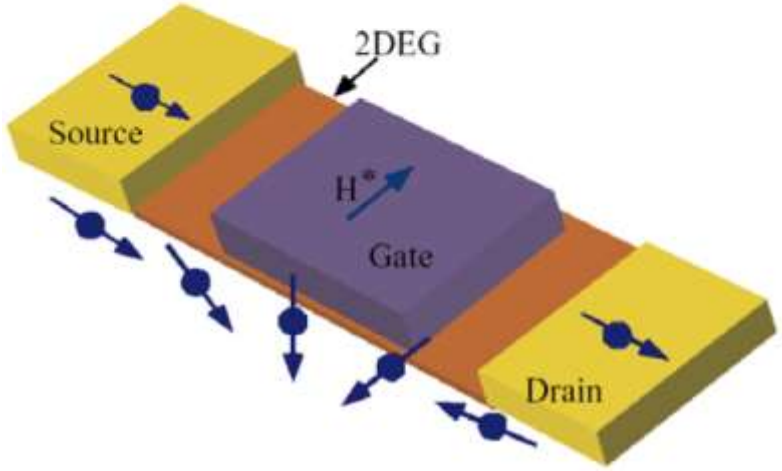
- In 1990, Datta & Das proposed theoretical idea of Spin FET.
- Hybrid-structure of semiconductor and ferromagnet.
- It can be used for memory device by using non-volatile property.

How does the Spin FET work?





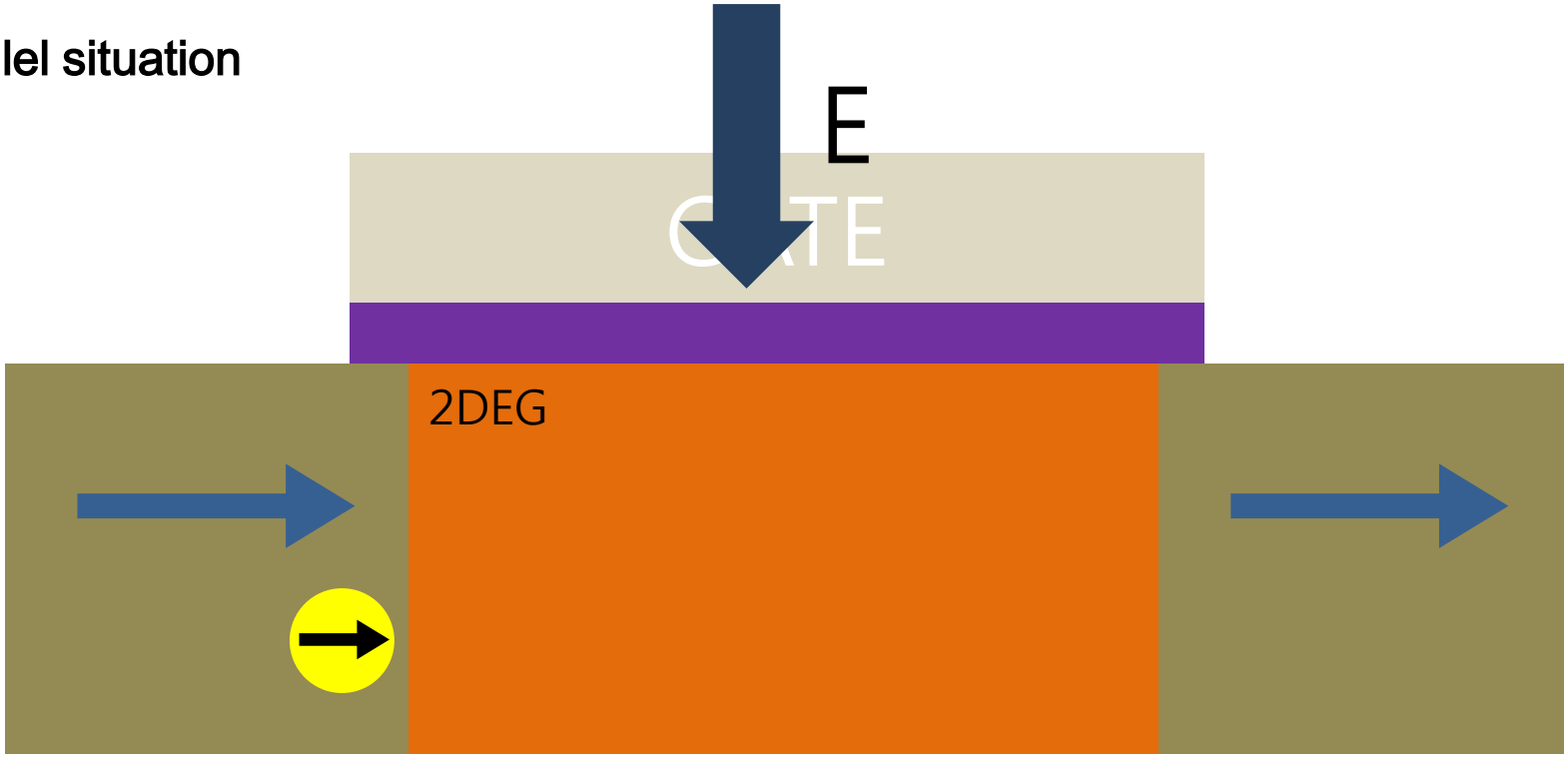




① Spin in the source & drain is aligned.
② Spin-polarized electron is injected to semiconductor.
③ By controlling gate voltage, induce spin precession.
(Rashba effect)
④ Resistance depends on direction of spin that reaches drain.

How does the Spin FET work?

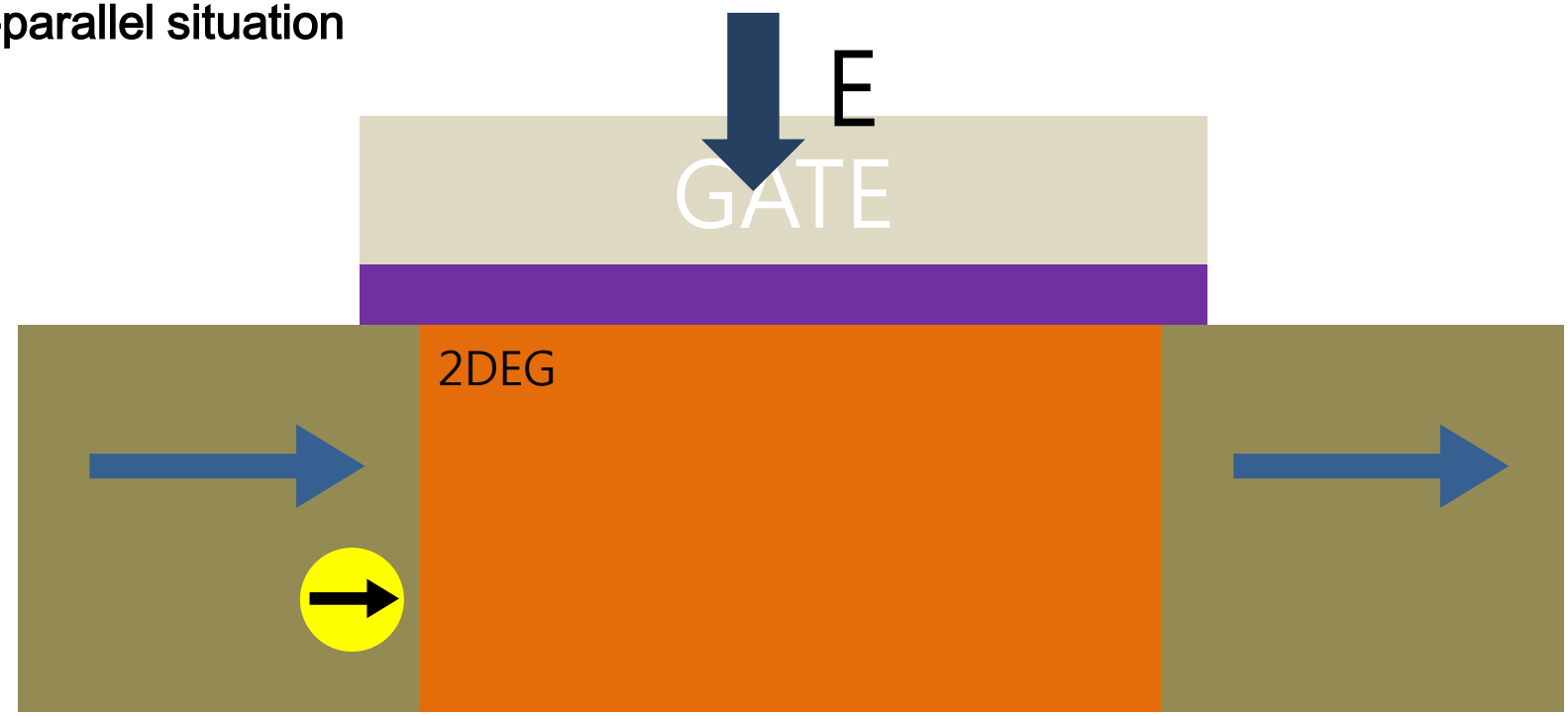
Parallel situation



Low Resistance

How does the Spin FET work?

Anti-parallel situation



High Resistance

What is current situation of Spin FET?

World-first spin transistor development

Control of Spin Precession in a Spin-Injected Field Effect Transistor

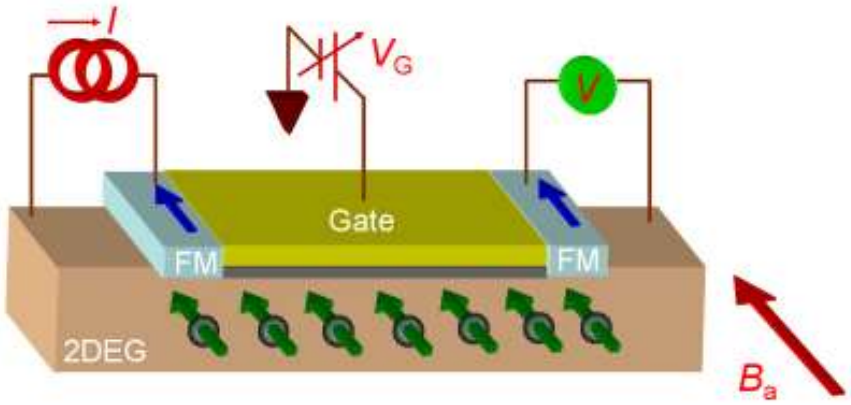
Hyun Cheol Koo,[1] Jae Hyun Kwon,[1] Jonghwa Eom,[1,2] Joonyeon Chang,[1]*
Suk Hee Han,[1] Mark Johnson[3]

Spintronics increases the functionality of information processing while seeking to overcome some of the limitations of conventional electronics. The spin-injected field effect transistor, a lateral semiconducting channel with two ferromagnetic electrodes, lies at the foundation of spintronics research. We demonstrated a spin-injected field effect transistor in a high-mobility InAs heterostructure with empirically calibrated electrical injection and detection of ballistic spin-polarized electrons. We observed and fit to theory an oscillatory channel conductance as a function of monotonically increasing gate voltage.

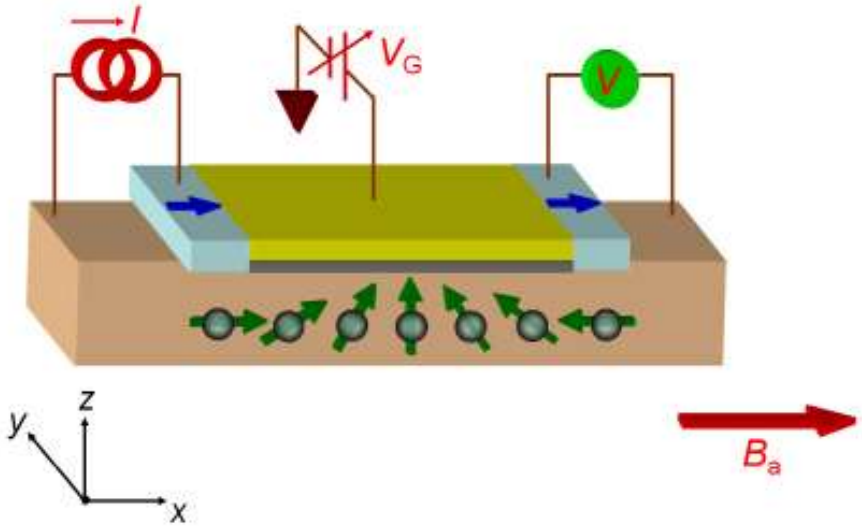
- The theory of Datta and Das was realized

What is current situation of Spin FET?

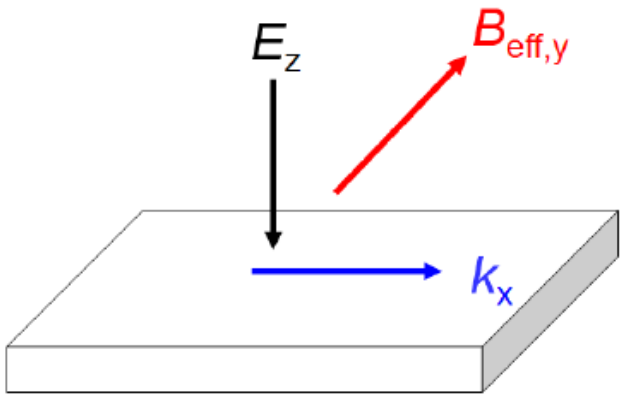
1



2



Hyun Cheol Koo et al., *Science* **325**, 1515(2009)

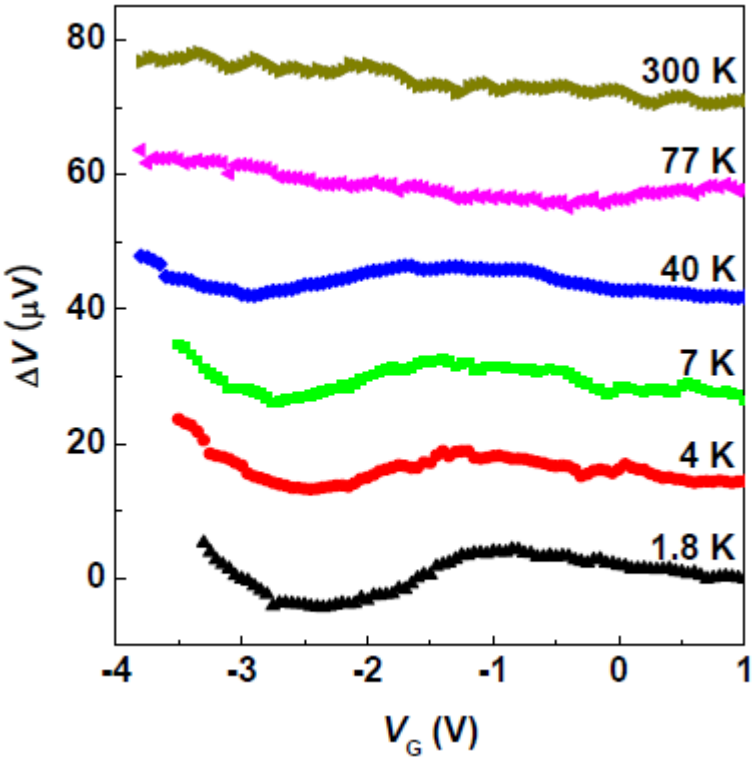


Rashba effect
(moving electron with electric field produce magnetic field)

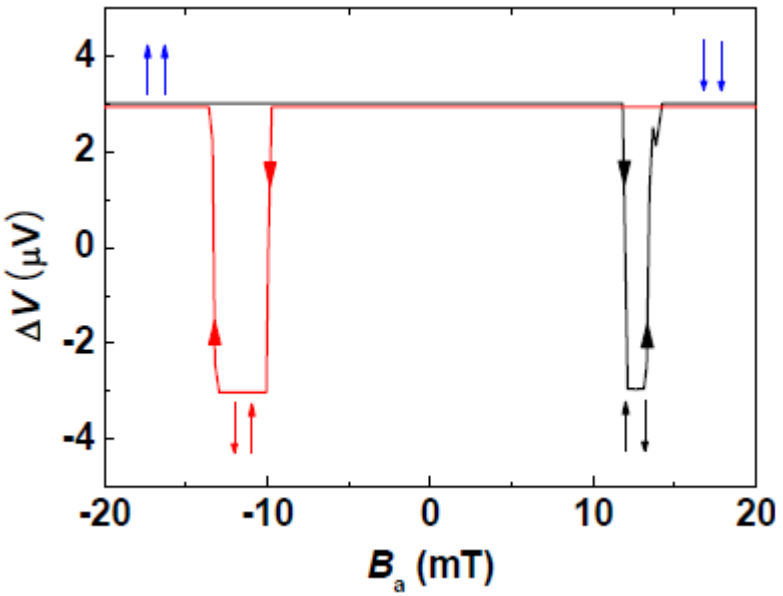
1 : There is no spin precession

2 : There is spin precession in x-z plane

What is current situation of Spin FET?



Spin precession signal as a function of temperature.



Non-local measurement

Hyun Cheol Koo et al., *Science* **325**, 1515(2009)

What is challenge of Spin FET?

1) High spin polarization of source & drain materials.

2) High efficiency of spin injection to semiconductor.

3) Spin loss at the interface between ferromagnet and semiconductor.

4) Working at room temperature

Thank you