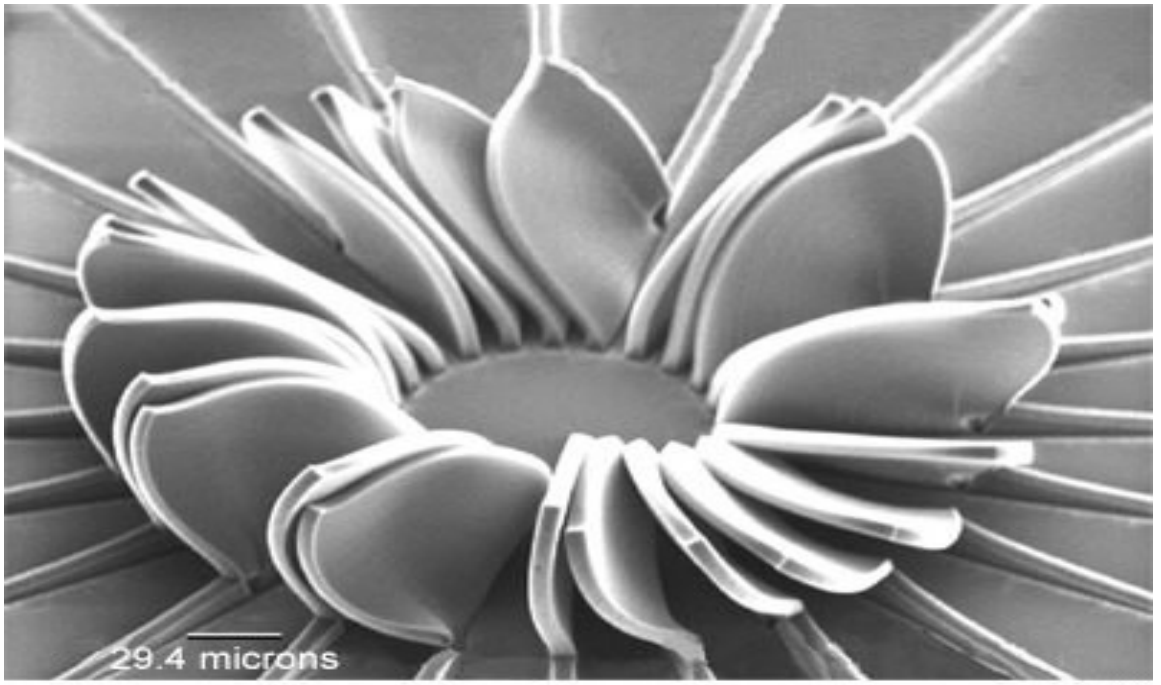
Gated Spin Transport through an Individual Single Wall Carbon Nanotube



Source: AIST

Gated Spin Transport through an Individual Single Wall Carbon Nanotube

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ABSTRACT Hysteretic switching in the magnetoresistance of short-channel, ferromagnetically contacted individual single wall carbon nanotubes is observed, providing strong evidence for nanotube spin transport. By varying the voltage on a capacitively coupled gate, the magnetoresistance can be reproducibly modified between +10% and -15%. The results are explained in terms of wave vector matching of the spin polarized electron states at the ferromagnetic / nanotube interfaces.

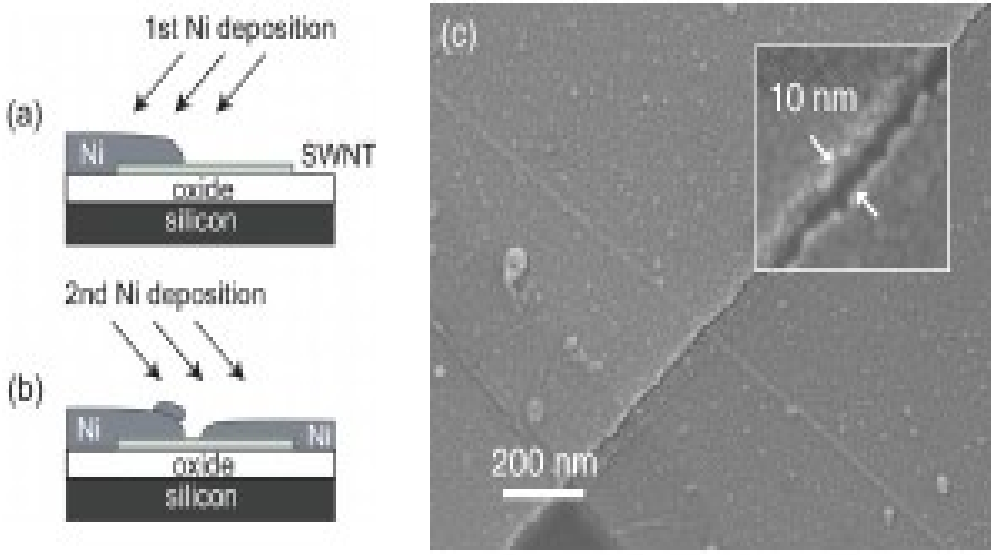
Why Short Channel SWNT Devices

- SWNTs have an almost perfect crystalline structure
- Long el. scattering length, weak spin orbit coupling
- SWNTs have lower intrinsic magnetoresistance

- Many attempts to get clear evidence of spin transport in SWNTs

If there are spin flip processes involved, decreasing the channel length improve the spin signal.

Sample preparation



NICHEL CONTACTS

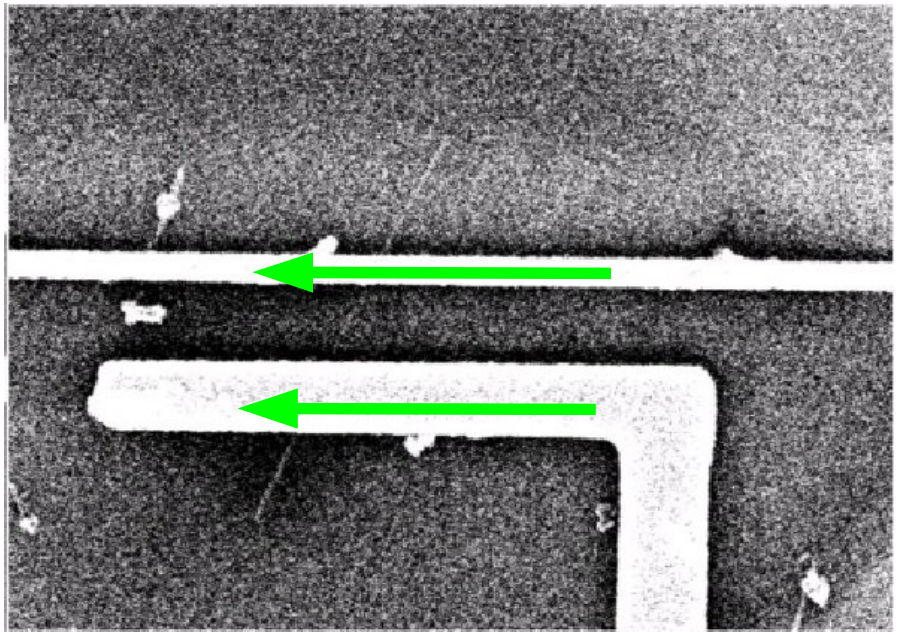
Doped silicon was used as backgate.

Conductance measured as a function of the applied magnetic field parallel to the contact at 4.2k

TO EBL

Ferromagnetic contacts

Applied magnetic field

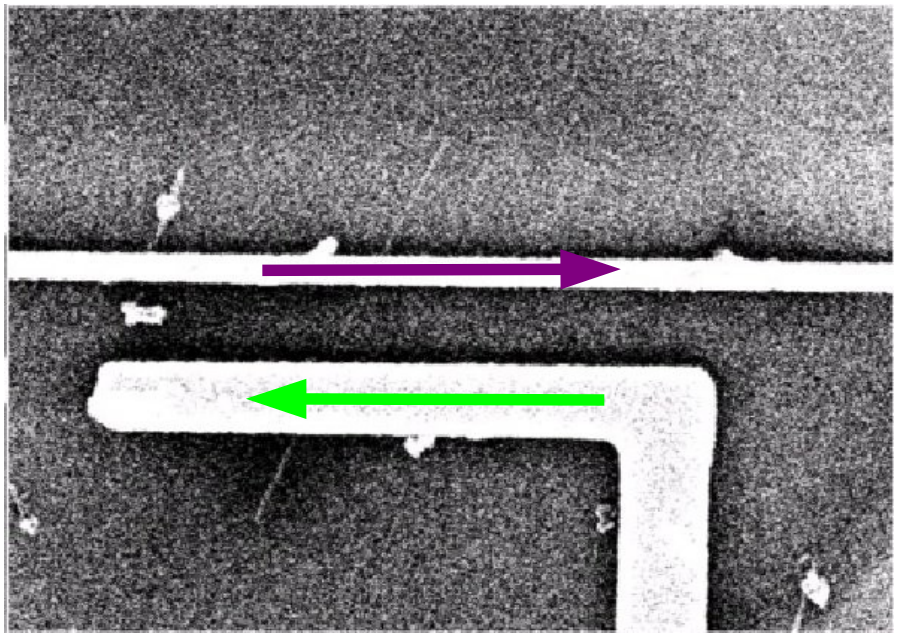


Parallel configuration

Please note that this is not the sample measured in the paper !!
It's just to explain the idea behind the measurements

Ferromagnetic contacts

Applied magnetic field

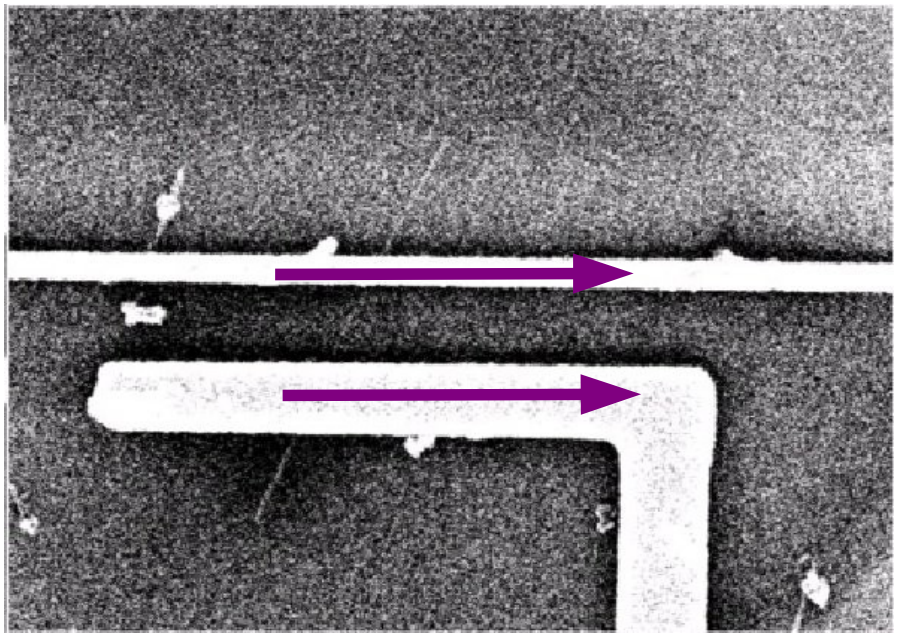


AntiParallel configuration

Please note that this is not the sample measured in the paper !!
It's just to explain the idea behind the measurements

Ferromagnetic contacts

Applied magnetic field

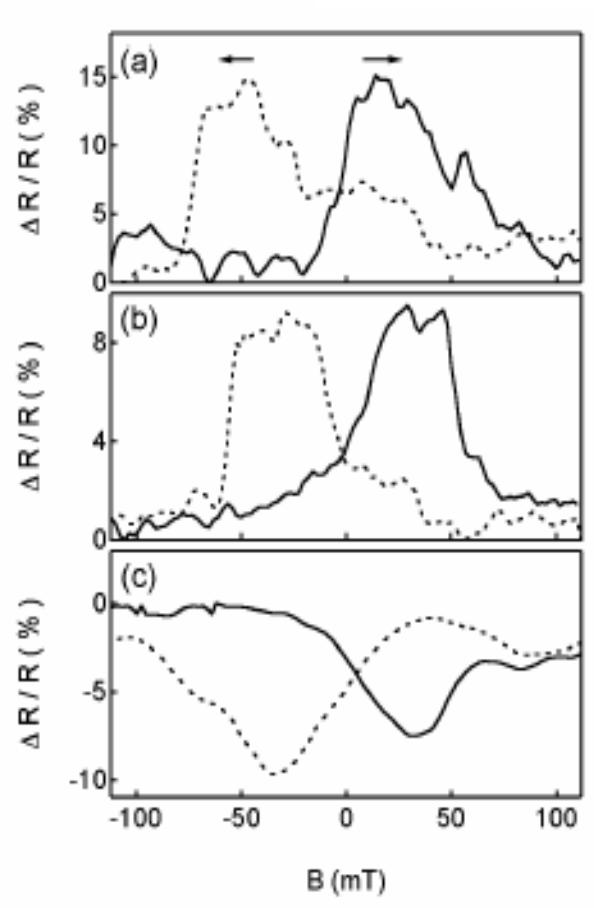


Parallel configuration

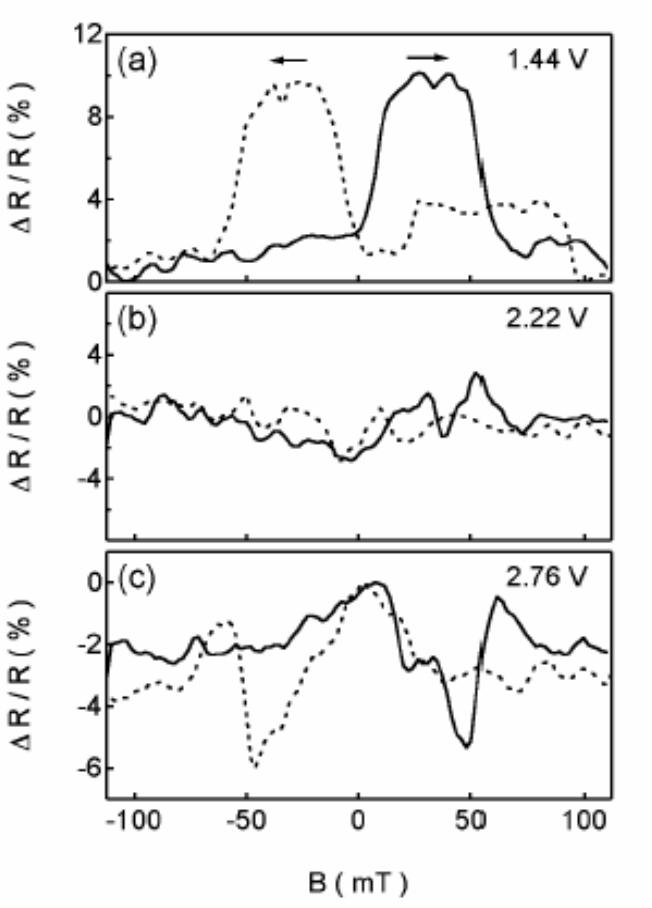
Please note that this is not the sample measured in the paper !!
It's just to explain the idea behind the measurements

Magnetoresistance measurements

$$\Delta R/R = 2\left(R_a - R_p\right)/\left(R_a + R_p\right)$$

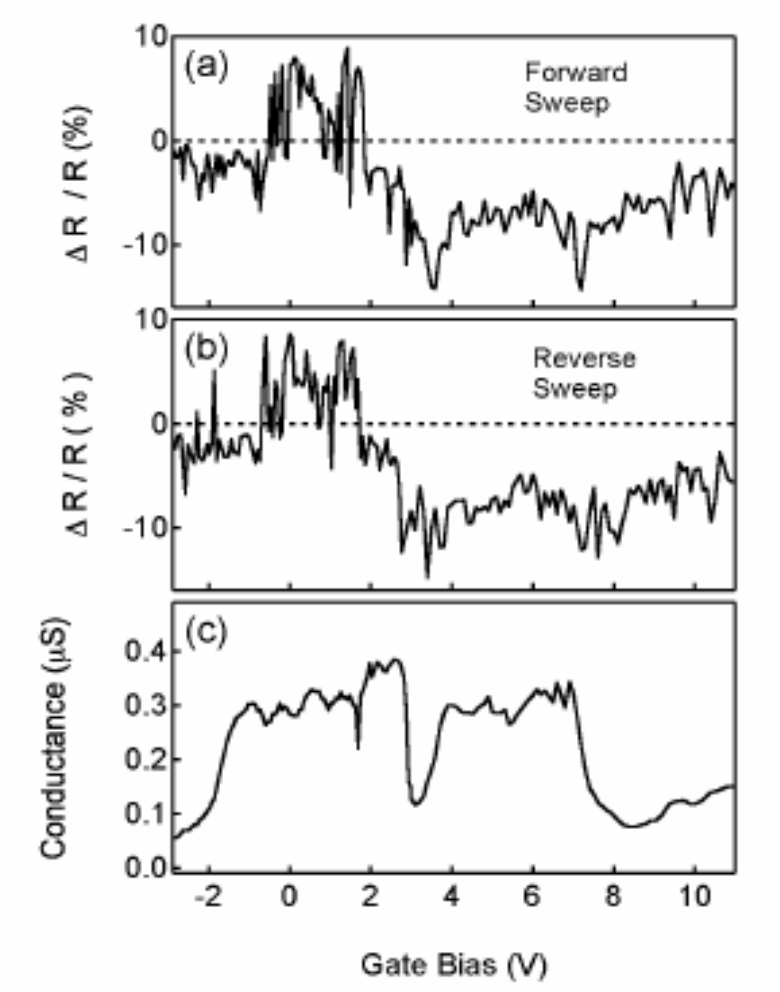


Three different samples
at zero gate voltage



Sample C

Magnetoconductance vs. Gate voltage

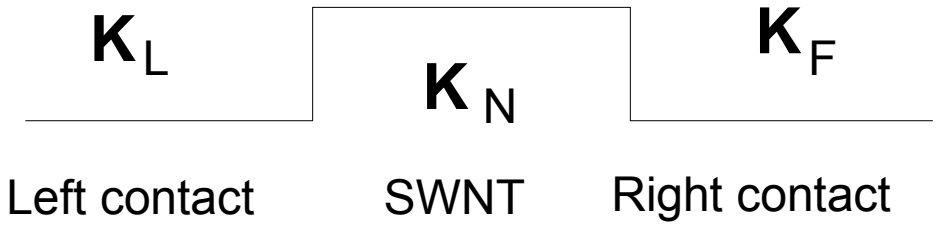


$$\Delta R/R = 2\left(R_a - R_p\right)\left(R_a + R_p\right)$$

Sample C

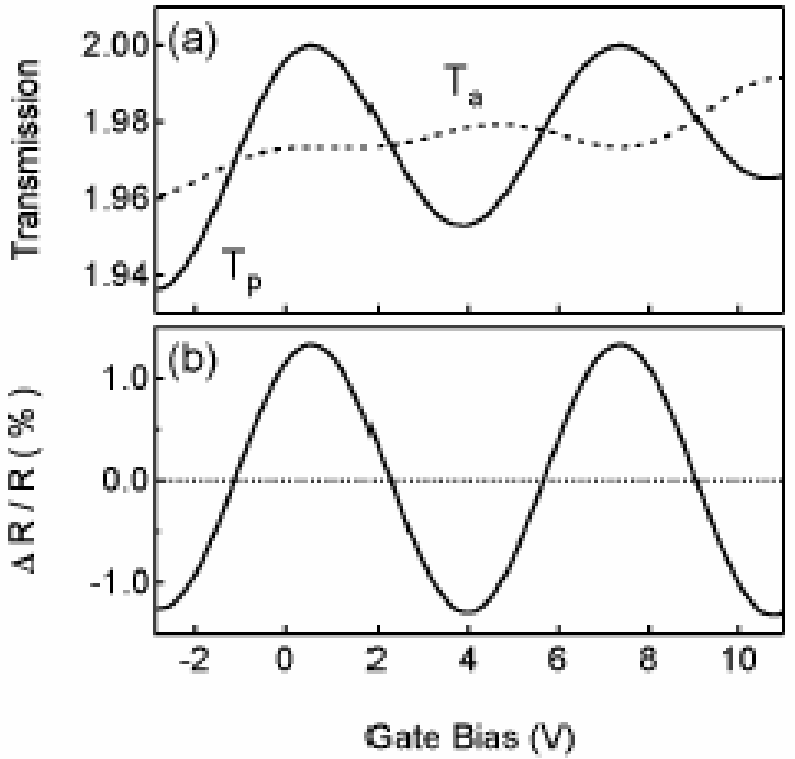
- Intrinsic magnetoconductance
- Leakage current

Simple model – one dimensional Schroed. problem



$K_{L,R}\uparrow$ and $K_{L,R}\downarrow$ **ARE DIFFERENT**

V_{gate} **MODULATES** K_N



Imposing the continuity of the wave function it is possible to calculate the transmission probability for the Parallel and the Antiparallel case. The magneto resistance is then:

$$\Delta R_s/R = 2(T_p - T_a)/(T_a + T_p)$$

Conclusions

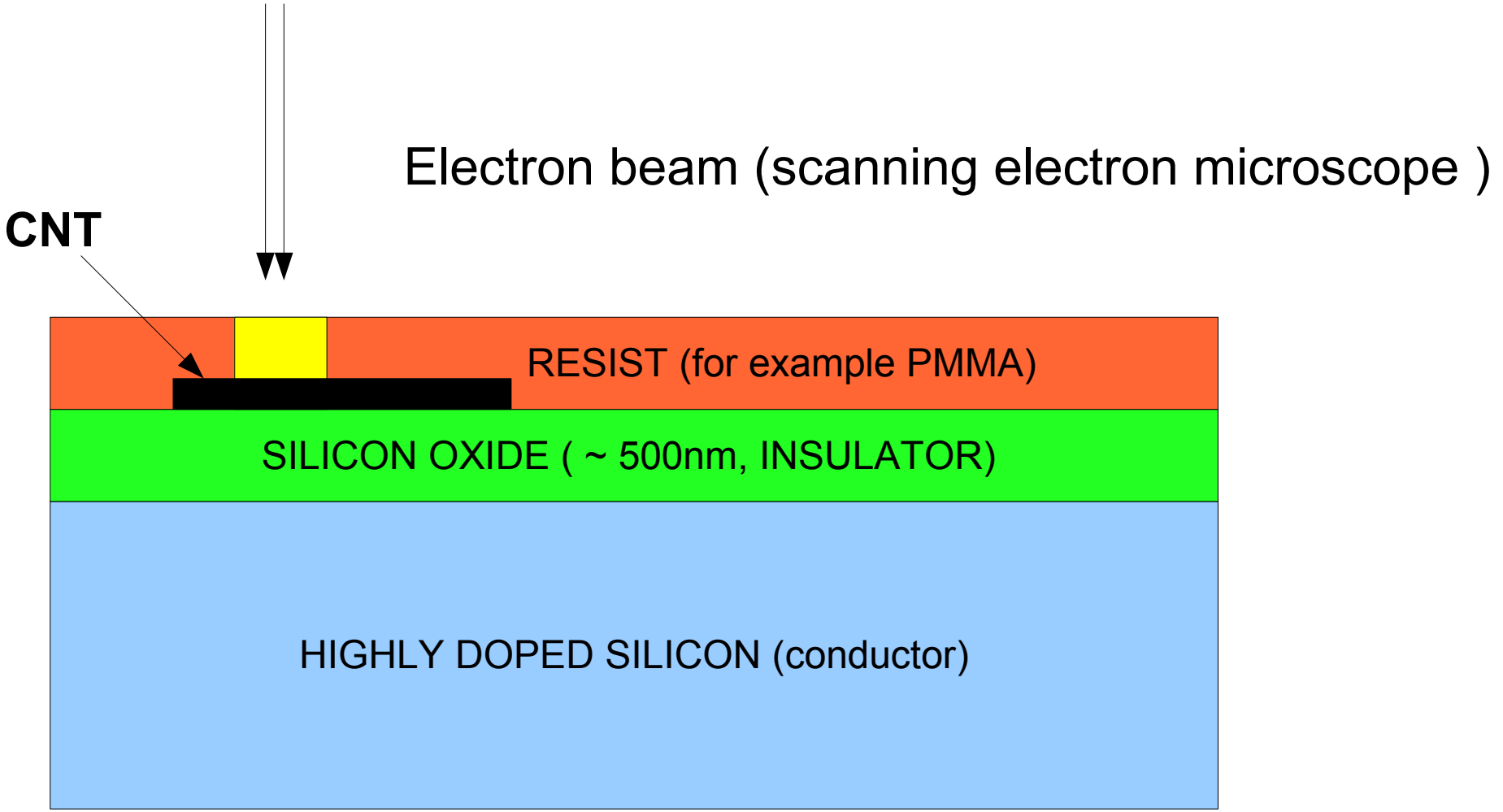
- *MEASUREMENTS IN SMALL CHANNEL SWNT DEVICES*
- *MAGNETORESISTANCE MODIFIED BY APPLYING A GATE VOLTAGE BETWEEN -15% and + 10%*
- *SIMPLE MODEL EXPLAIN THE OSCILLATORY BEHAVIOUR OF THE MAGNETORESISTANCE*

Questions

Why the magnetoresistance depends so much on the channel length?

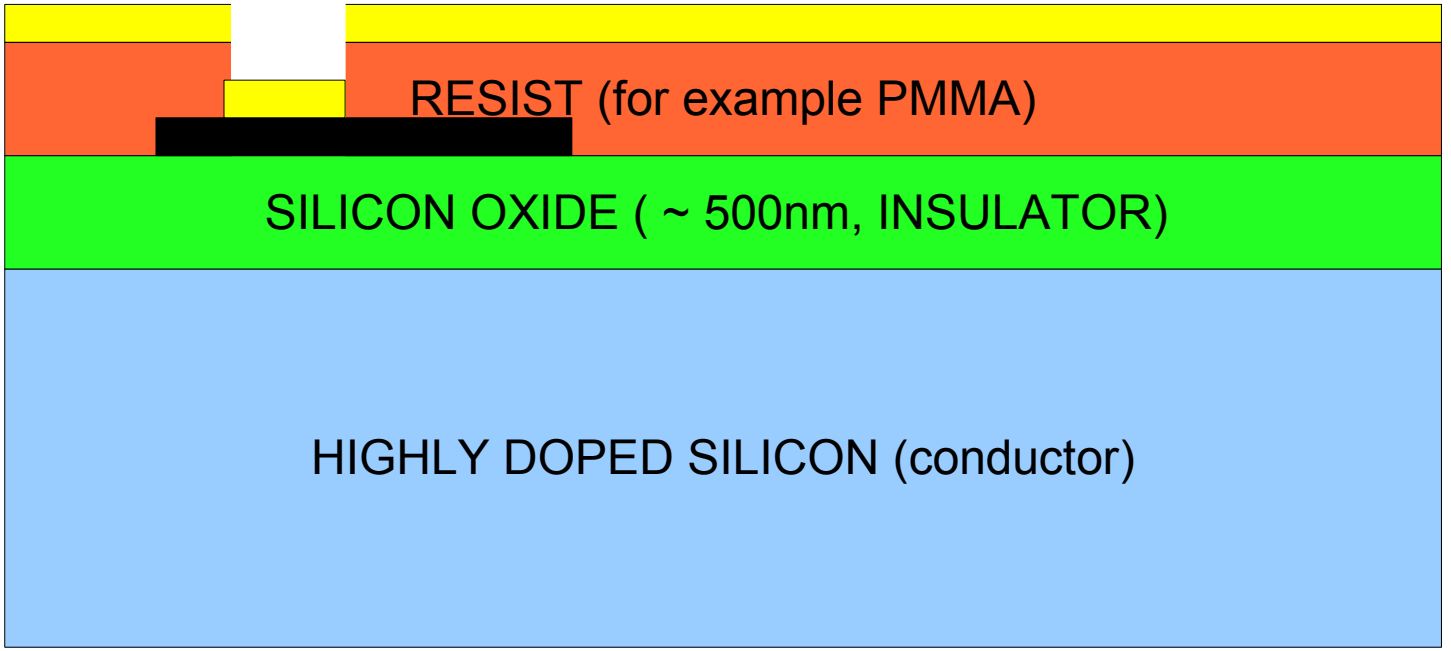
Magnetic impurities or electron-electron interaction cause spin flip?

Sample preparation: Electron Beam Lithography



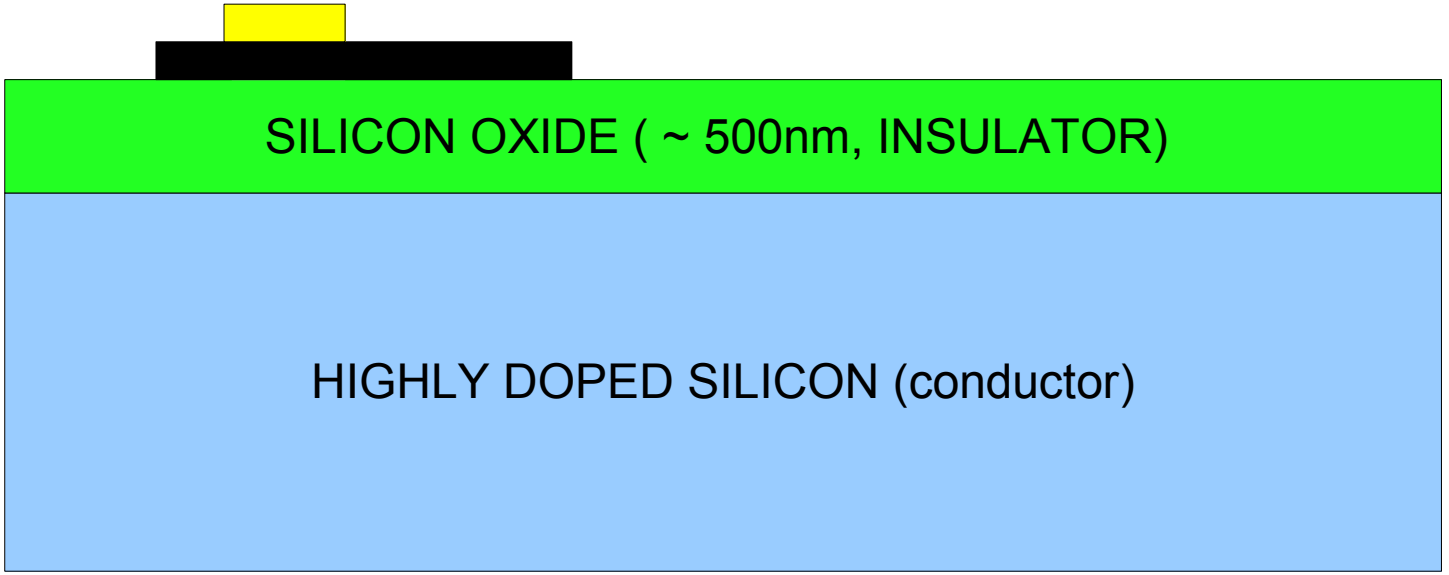
Sample preparation: Electron Beam Lithography

We can get rid of the exposed PMMA using an appropriate chemical.



Sample preparation: Electron Beam Lithography

After the removal of al the PMMA (with Aceton f.e) we have made our contact to the tube.



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