Magnetic Force Imaging

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Magnetic Force Imaging

PLAN

Magnetic Force Imaging

INTRODUCTION

**Aim :*

Non destructive FA is more and more required.

Different kind of magnetic sensors exist on the market, which present different characteristic.

Current mapping using very low field magnetic sensors is explored.

**Expected sensibility :*

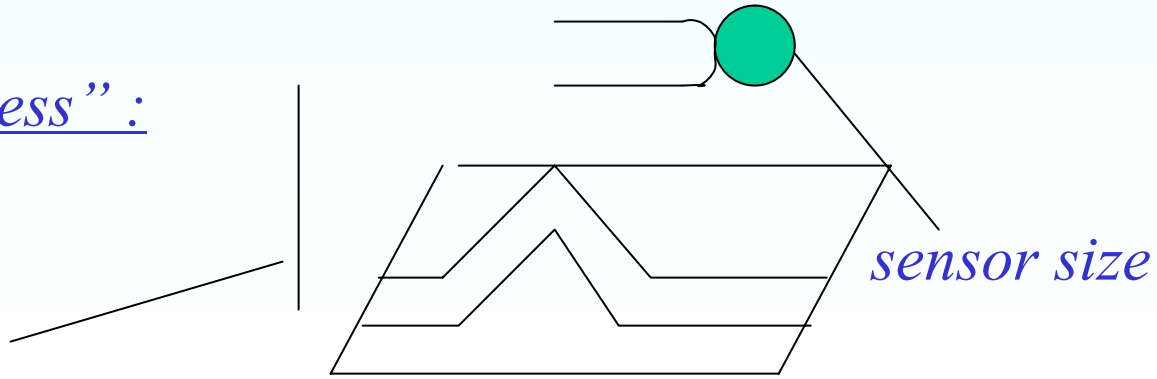
better than 1 µT for PCB imaging (2.5 mA and 500µm).

better than 10 nT for IC imaging (5µA and 100µm).

**"factor of goodness" :*

sensibility

working distance



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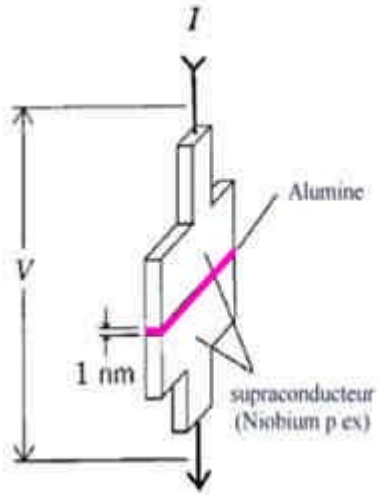
State of the art of magnetic sensors (1)

SQUID



*More sensible sensor.(noise :<1pT /$Hz^{1/2}$)[1]

*Based on superconductor Josephson junctions.

*Principle : detection of magnetic flux variation.

*Drawbacks :

need cryogenics (liquid He or N_2)

⇨ important working distance

⇨ low spatial resolution.

- Low Tc Squid 4.2K liquid helium
- High Tc Squid 77K liquid nitrogen

Factor of goodness :
- sensibility : OK
- spatial resolution : bad.

[1] www.neocera.com

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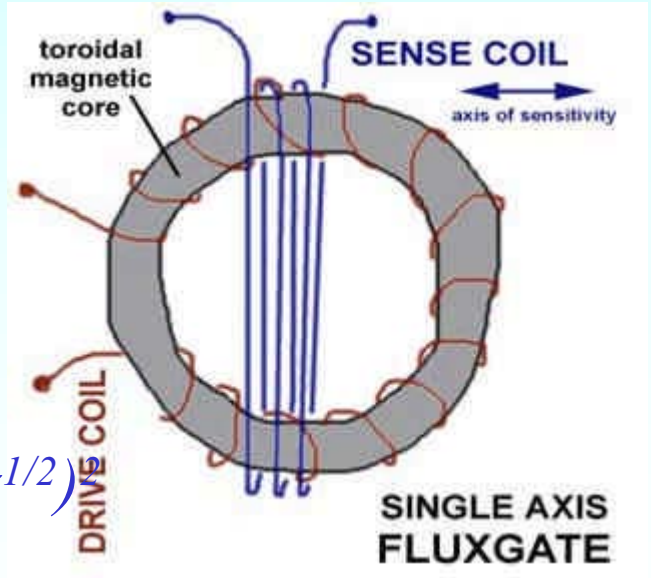
State of the art of magnetic sensors (2)

Fluxgate sensor



*Based on ferromagnetic core surrounded by excitation coil.

*Principle : detection of flux variation.

*Optimal performance : few nT (noise :2pT/$Hz^{1/2}$)

*Drawbacks : size of the core.

*Factor of goodness : sensibility : OK
spatial resolution : bad.

[2] www.stefan-mayer.com

State of the art of magnetic sensors (3)

Giant Magnetoimpedance sensors

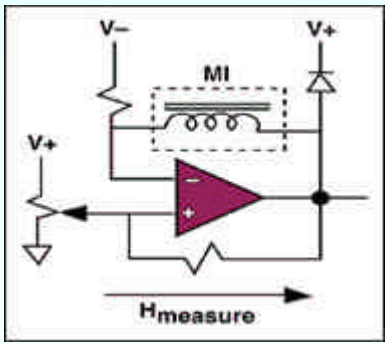
*Based on variation of the magnetic permeability of the element

➡ *variation of skin depth* $\delta=(2\rho/\mu(B)\omega)^{1/2}$

*Principle : variation of the very high Q oscillator.

*Noise : 20pT/Hz$^{1/2}$

*Drawback : size of the GMI core for acceptable response.



*Factor of goodness : sensibility : OK

spatial resolution : bad.

➡ *Spatial resolution is a common drawback of the precedent sensors.*

➡ *They can provide local magnetic information (packaged circuits).*

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State of the art of magnetic sensors (4)

Magneto resistive elements AMR and GMR

Anisotropic Magnetoresistance / Giant Magnetoresistance

*Based on variation of resistance due to spin scattering.

*constituted with NiFe layer on Si substrate for AMR sensors and multilayer materials (Cu and NiFe) for GMR sensors.

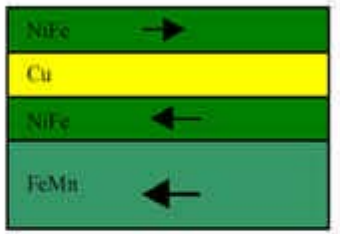
*resistance variation is about few percents for AMRsensors and more than 100% for GMR.

*Noise : 10pT/$Hz^{1/2}$ for AMR and 6pT/$Hz^{1/2}$ for GMR.

*GMR :constituted by a pinned layer and free layer(NiFe).

Resistance ↘ with spin alignment.

*Compromise between size and sensibility : good factor of goodness.



GMR spin valves

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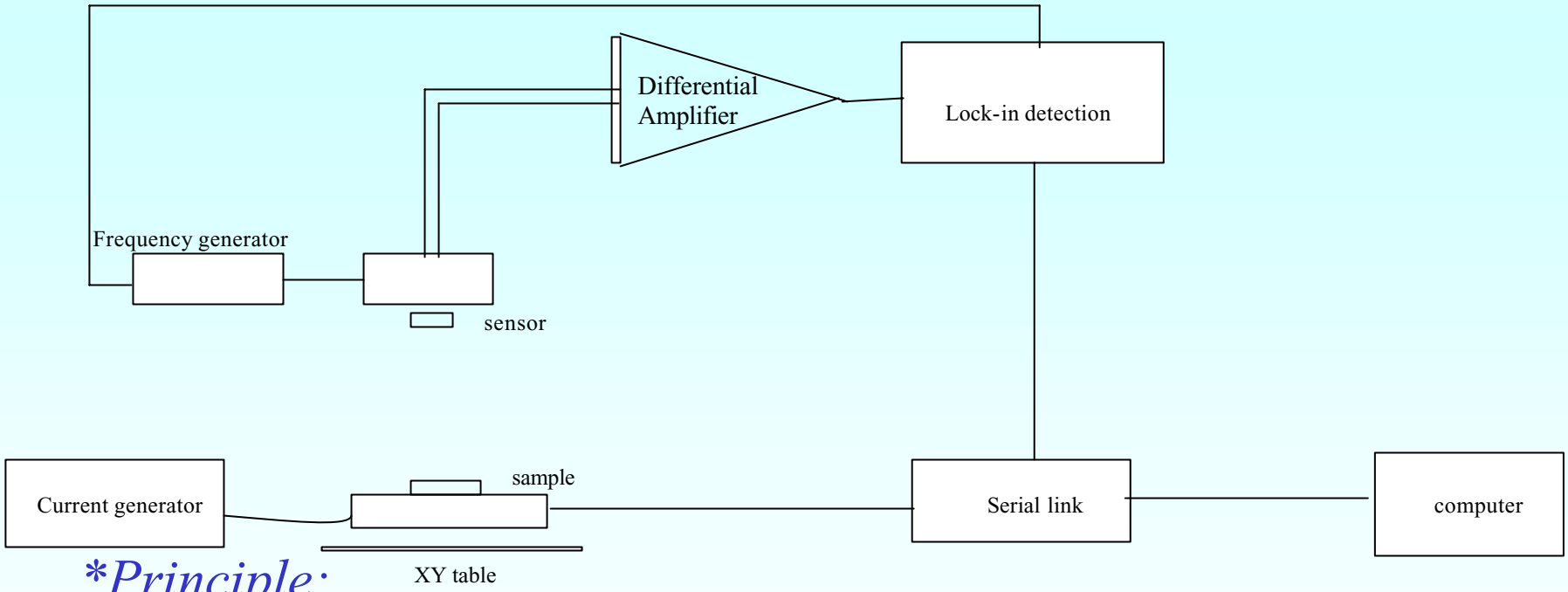
Current mapping system



*Principle:

analysed circuit is fixed on XY table.

Sensor is fixed on Z axis.

Lock-in detection processes the sensor output signal to measure signal with good S/N ratio.

Software has been developed to automate measurements.

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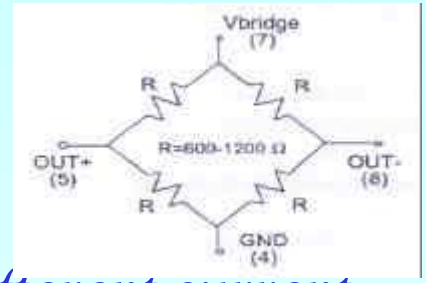
Results with AMR sensor

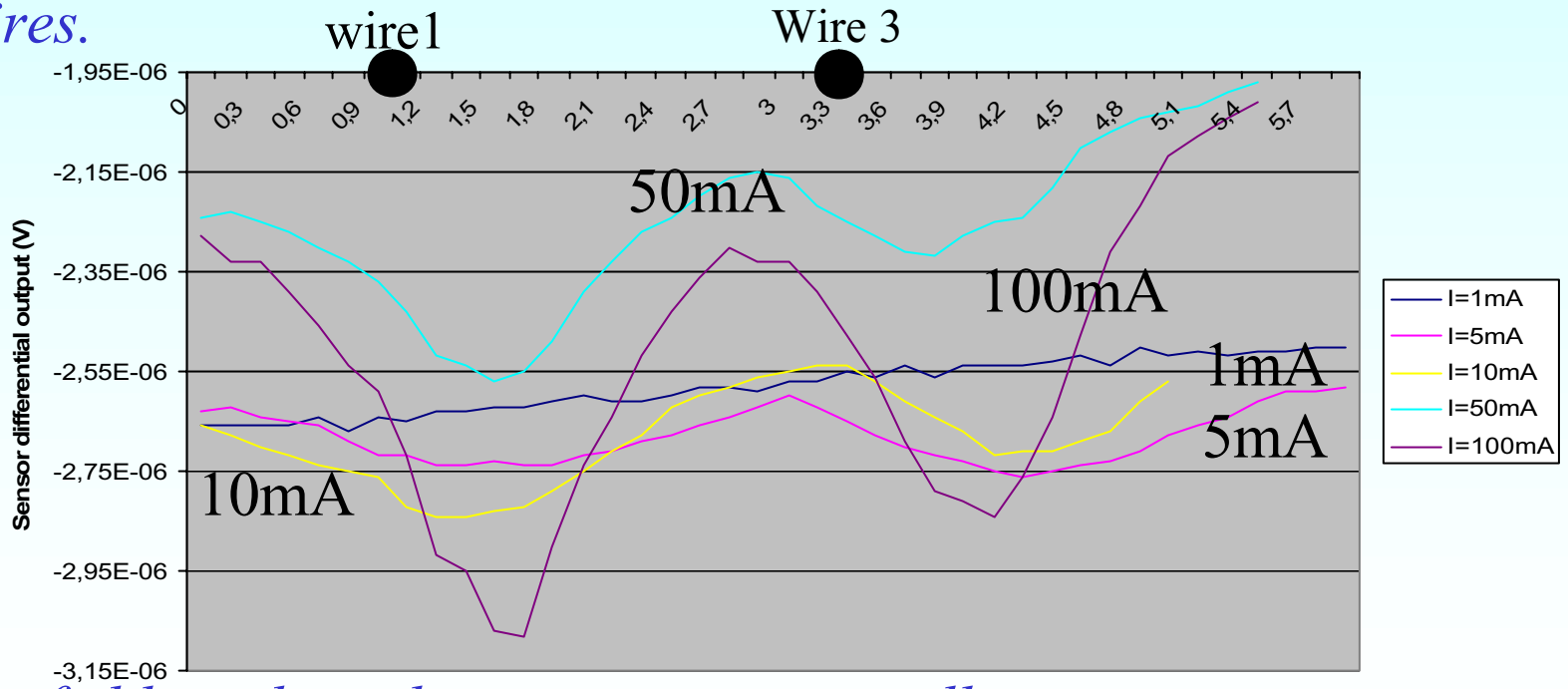


*Used AMR sensor :Honeywell HMC 1001

*Equivalent scheme : Wheastone resistive bridge.

*Constitution :4 AMR elements including 2 shielded.

*Principle : moving and measure of sensor output for different current value in 2 wires.



*Remark :field gradient due to a parasite metallic piece.

Limit detected value :5mA for a 500µm working distance.

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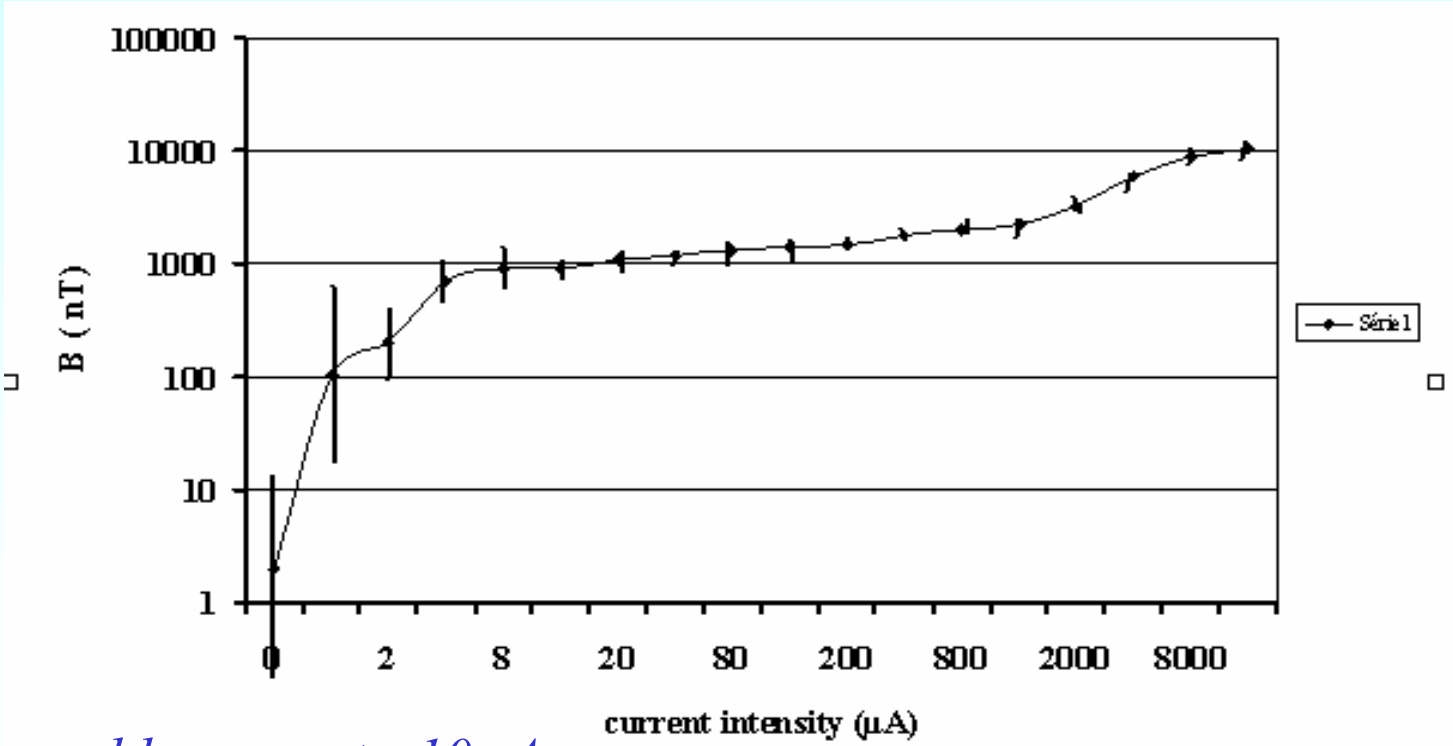
Results with GMR sensor

*Used GMR sensor :NVE AA002.

*Constitution :4 GMR elements including 2 shielded.

*Principle : measure of sensor output for different current value.



*Limit observable current : 10µA.

*Bad spatial (500µm)resolution because of important working distance(500µm).

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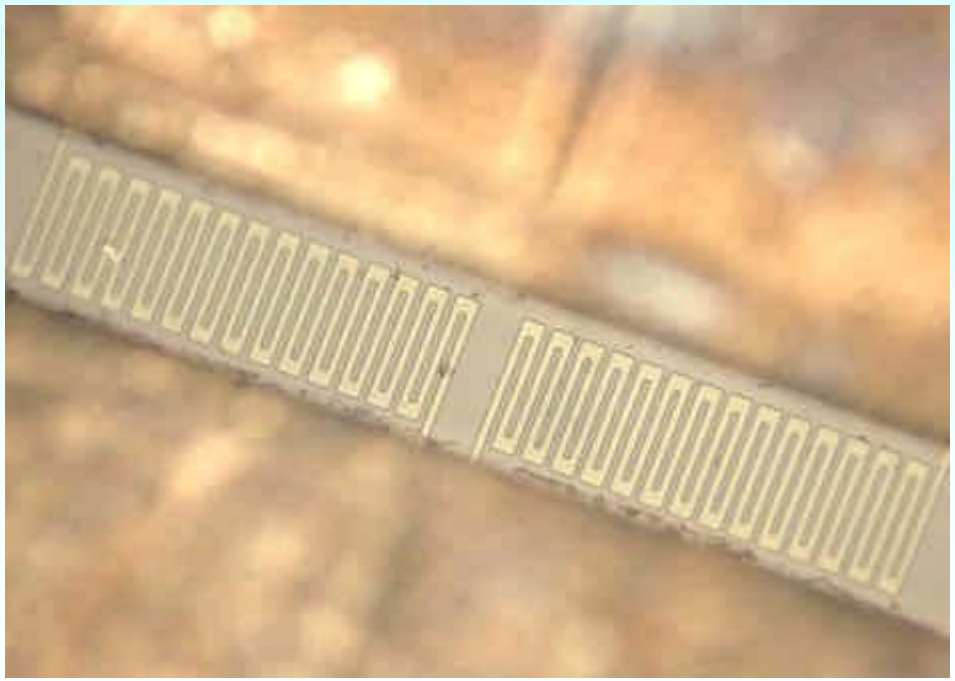
FIB improvement (1)

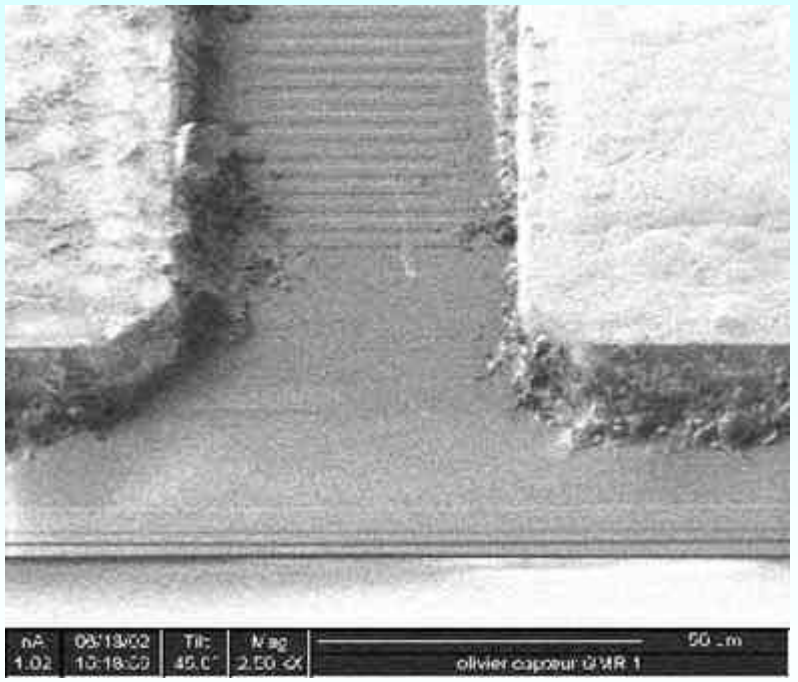
Sensor size important.=>reduction of active GMR layer size to improve spatial resolution.



Photography of the GMR active layer

400µm

25µm



12µm

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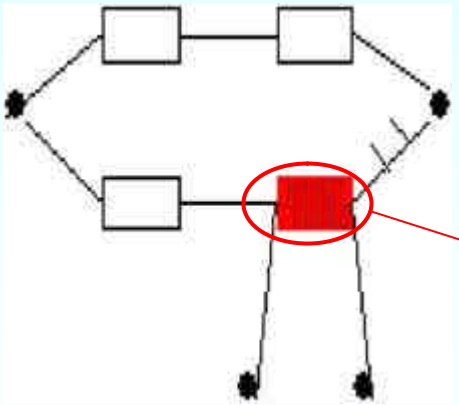
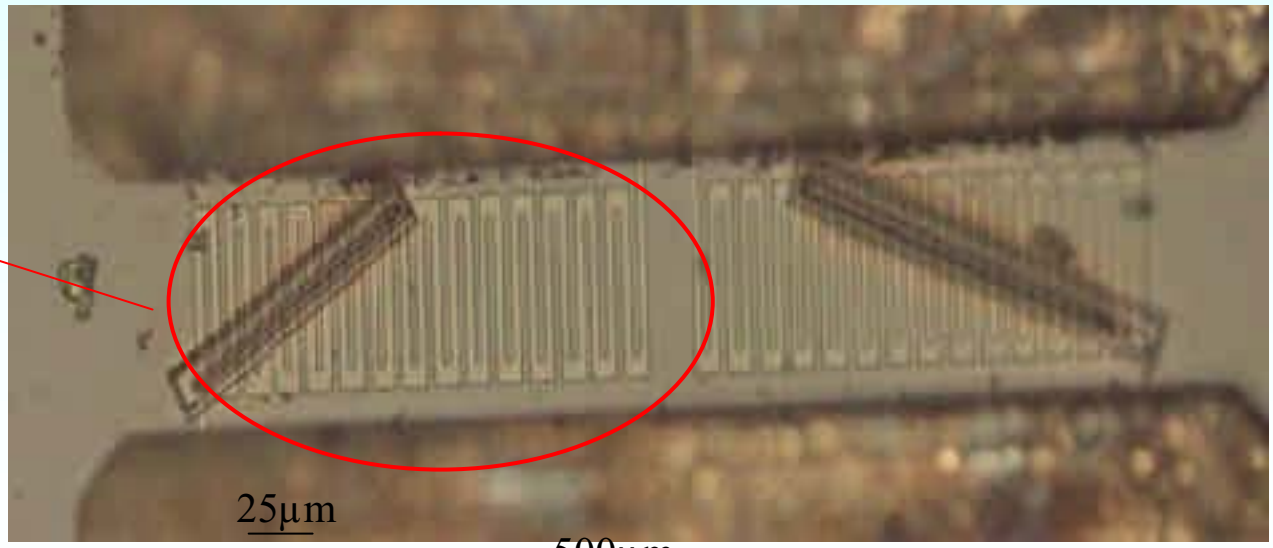
FIB improvement (2)

Objective : FIB modification on the GMR layer by depositing Platinum to improve the spatial resolution.





Conclusion

*Good sensibility obtained with GMR sensors.

*New objectives :design new sensors with especially patterned GMR films.

*Aim :

Working distance 10µm.
Sensor size 10µm.
Sensibility 1 nT.