A Magnetizing Technology:

Nanowire Biosensors

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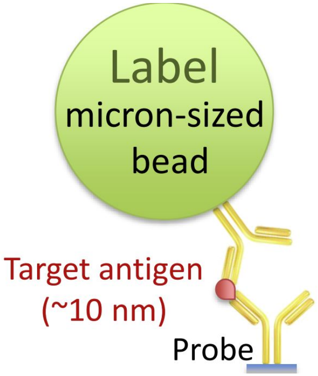
Electrical Engineering

Group 2

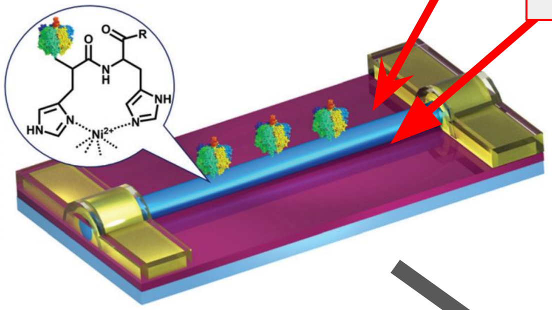
Nanowire Biosensors So Far…



Labeled:

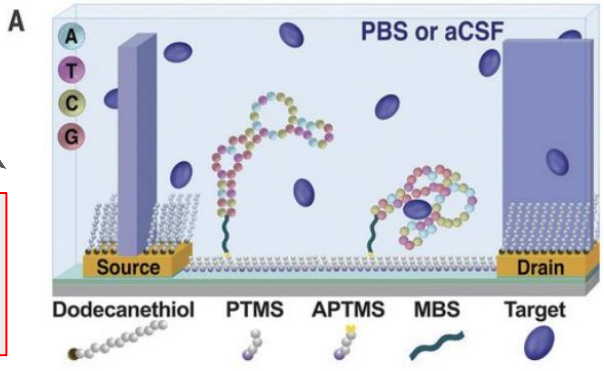
- Pre-Amplifying signal
- Indirect measurement

Label Free



- **Noise** from solution
- **Debye** length / charge screening
- **Fabrication** random

Aptamer Approach



Aptamers require a special touch to develop

But Wait… Why Should We Care?

Diagnostic Capabilities

1

Compatibility

2

Microfluidic Integration

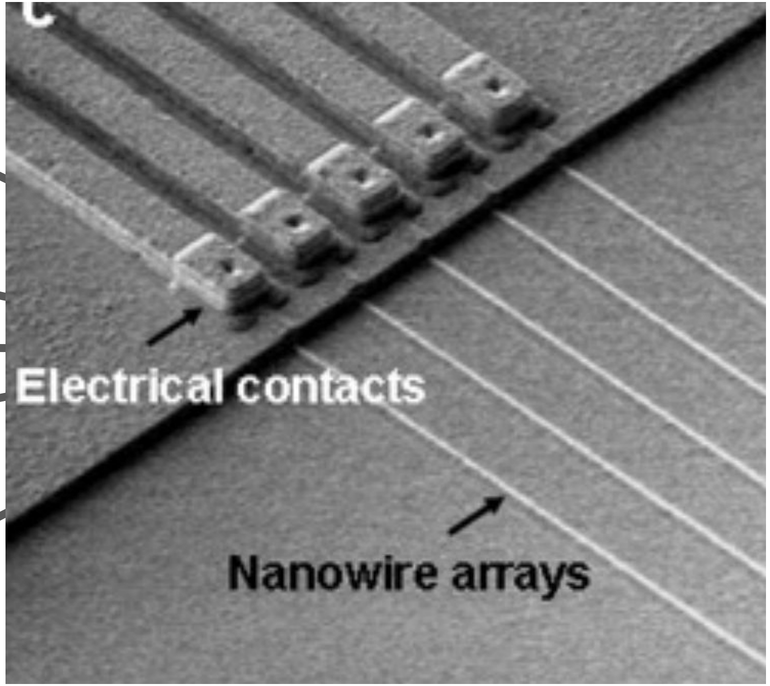
3

Low Concentration

4

Minimally Invasive (sample size)

5



An Alternative? → Magnetic Nanowire Biosensors

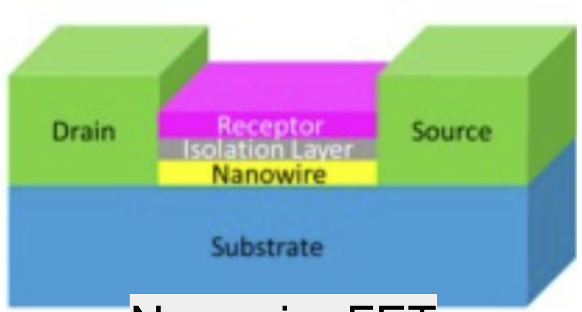
Fundamentally:

1. Target exists in media
2. Target changes resistance
3. Measure resistance change

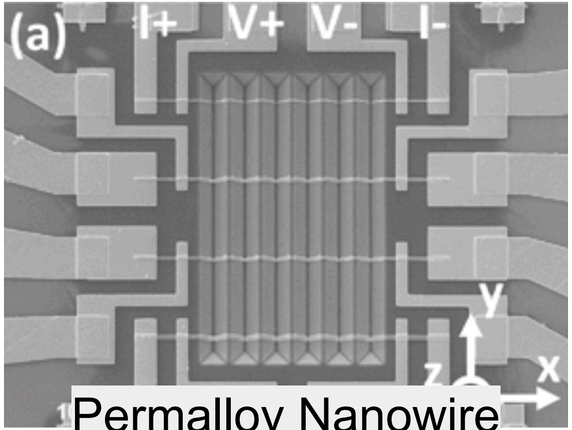
How does target change resistance?

Nanowire FET → Electrically

Permalloy nanowire → Magnetically



Nanowire FET

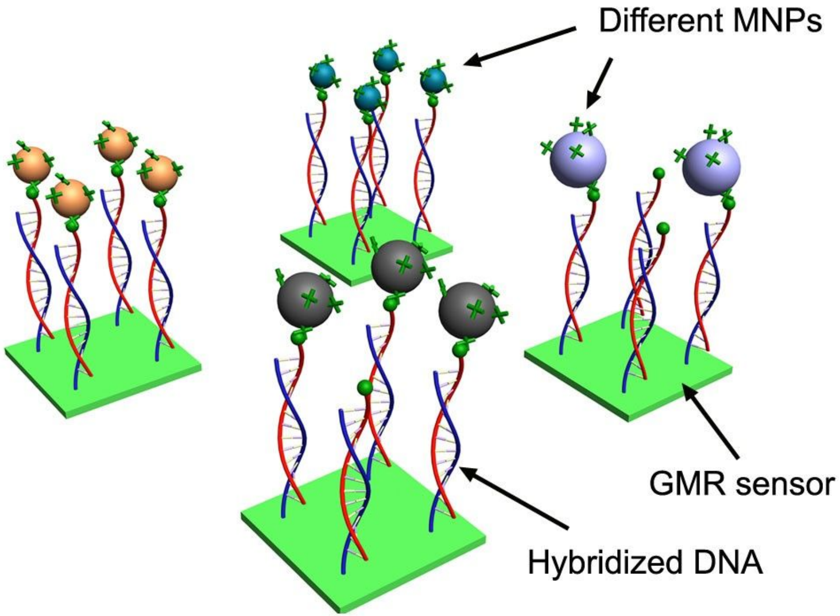


Permalloy Nanowire

Why Magnetic Systems?

At its core: **INTERFERENCE**

- low background **noise**
- competitive **sensitivity**
- large dynamic **range**
- low **cost**
- capability of **multiplexed** detection

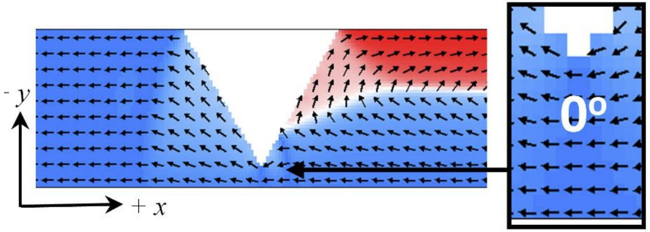


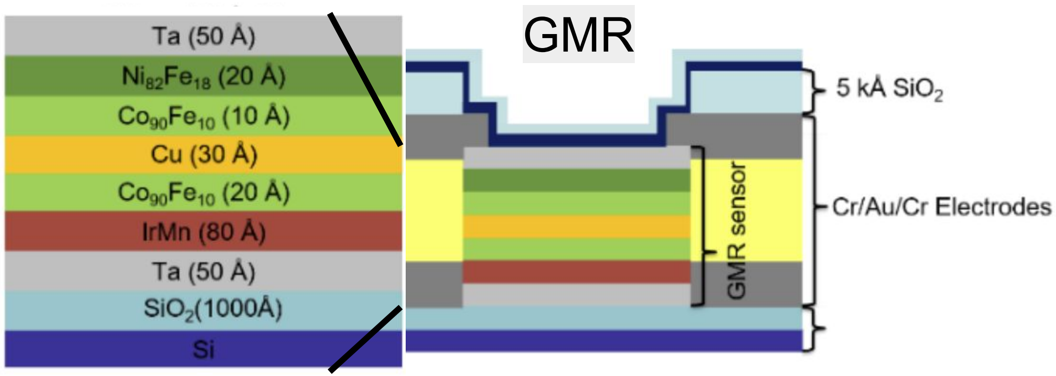
Magnetic Nanowire Biosensors – an overview

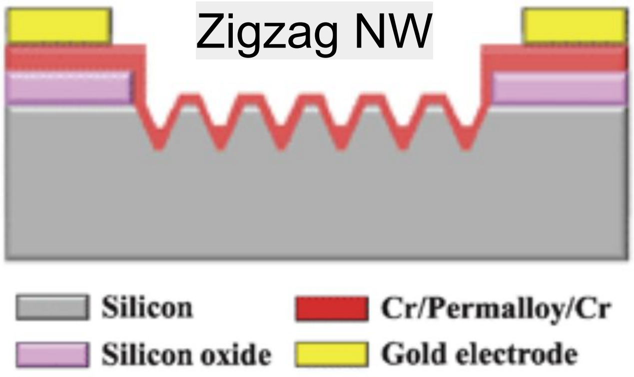
Vary **σ** with magnetic field effects:

- Giant Magnetoresistance (electron spin)
- Domain Wall Shift (notched nanowire)
- Magnetophoresis (zigzag nanowire)

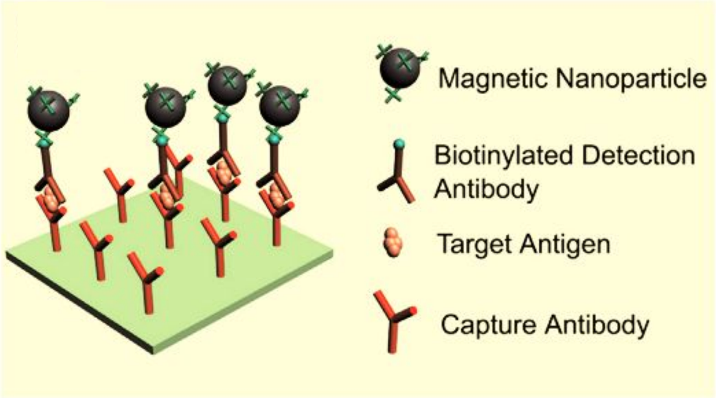
Domain Wall Shift

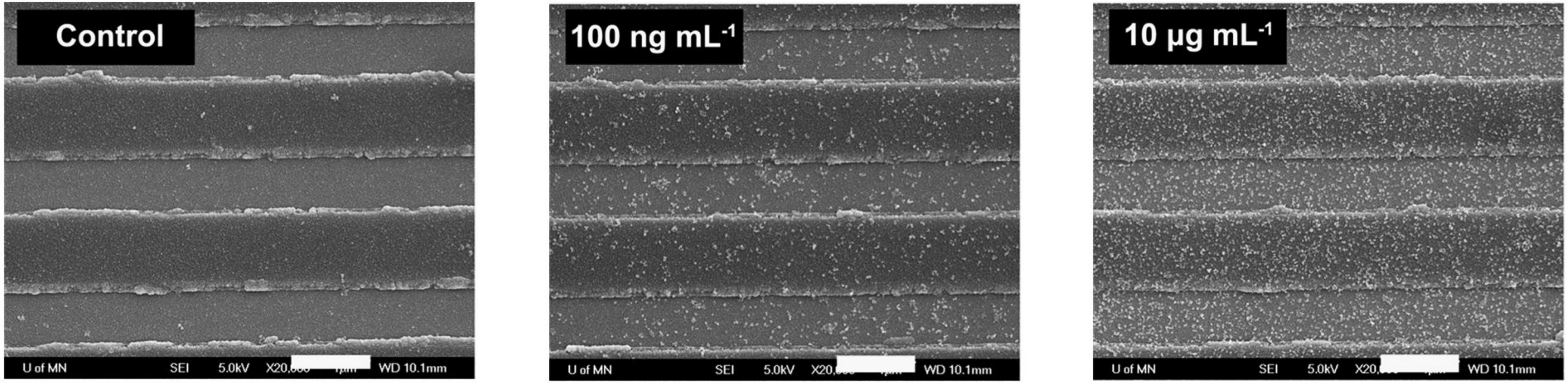




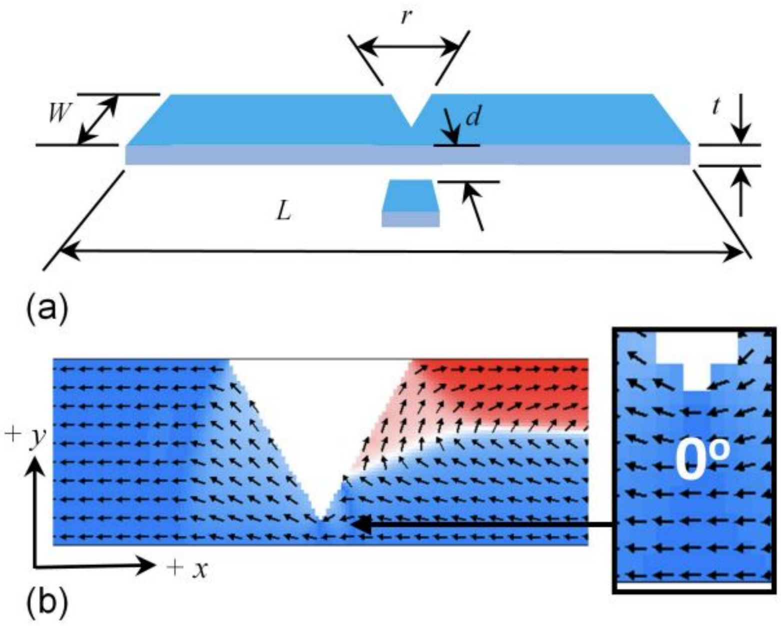


MBS – Nanobeads as Labels





Giant magnetoresistive-based biosensing probe station system for multiplex protein assays
Yi Wang 1 , Wei Wang 1 , Lina Yu, Liang Tu, Yinglong Feng, Todd Klein, Jian-Ping Wang



r = 500nm L = 5μm
W = 500nm t = 20nm

Labels are about 200nm wide

Magnetic Particle Labeling

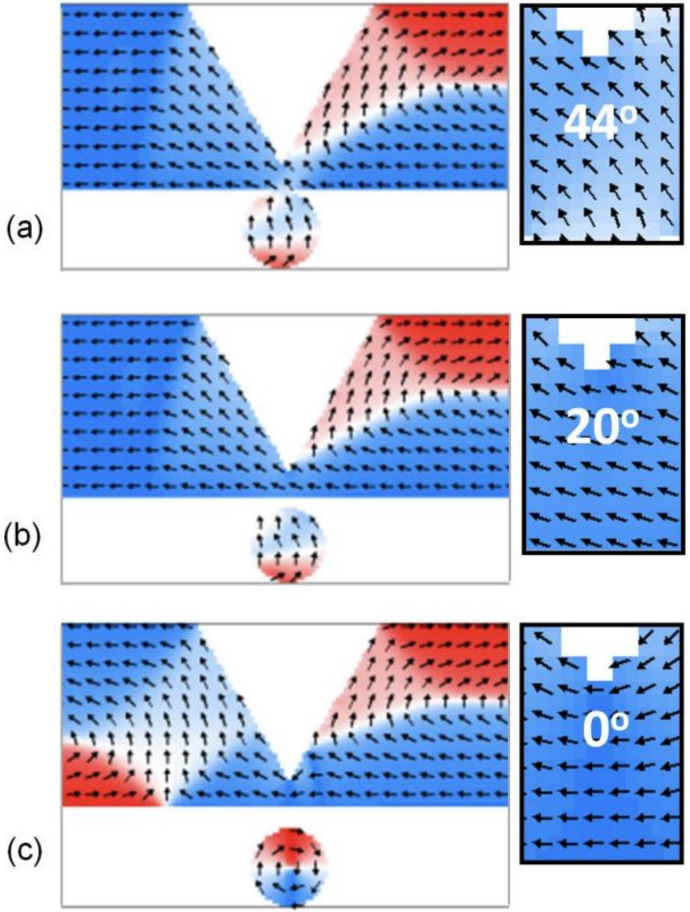
Permalloy (Ni80Fe20) nanowire

Search currents measure resistance changes in nanowires

0.3 T magnetic field +y
ensure that all the biosensor configurations are fully saturated

Allows for single label detection

Shape and Proximity Effect of Magnetic Nanoelements Used as Biomolecular Labels for Magnetic Notched Nanowire Biosensors
Iain Will, An Ding, and Yongbing Xu



$$R(\theta) = R_{\text{perp}} + \delta R \cos^2(\theta)$$

R_{perp} = resistance of notch when the magnetization is perpendicular to the current ($\theta = 90°$)

δR = change in resistance between 0° and 90°

Domain wall structure in larger cross sections influence resistance to a lesser extent

Closed domain structure reduces probability of label-label interactions

Shape and Proximity Effect of Magnetic Nanoelements Used as Biomolecular Labels for Magnetic Notched Nanowire Biosensors
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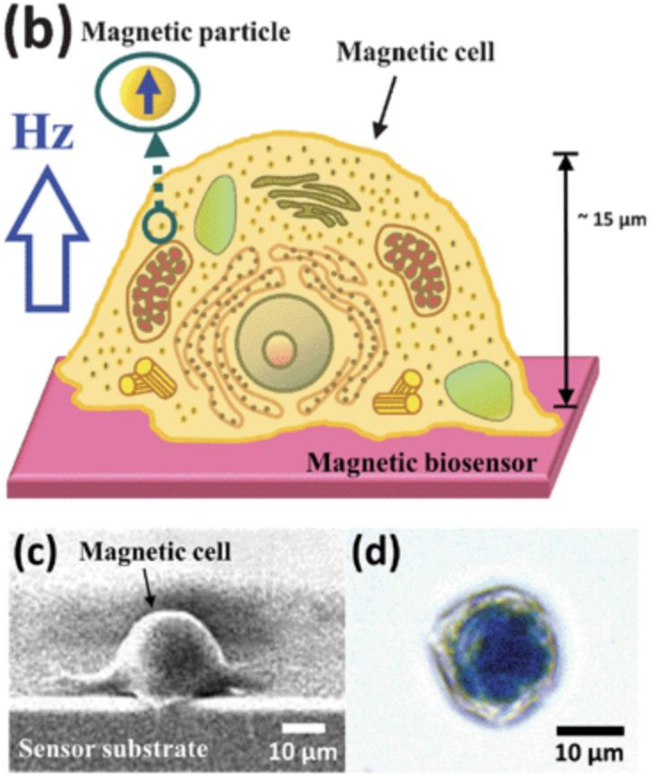
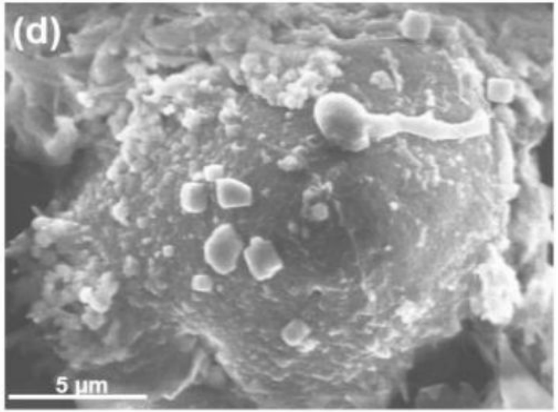
Zigzag Magnetic Label for Detection of Cancer Cells

Sensor size	Magnetic label particle(s)
150–800 nm nanowire	Fe_3O_4

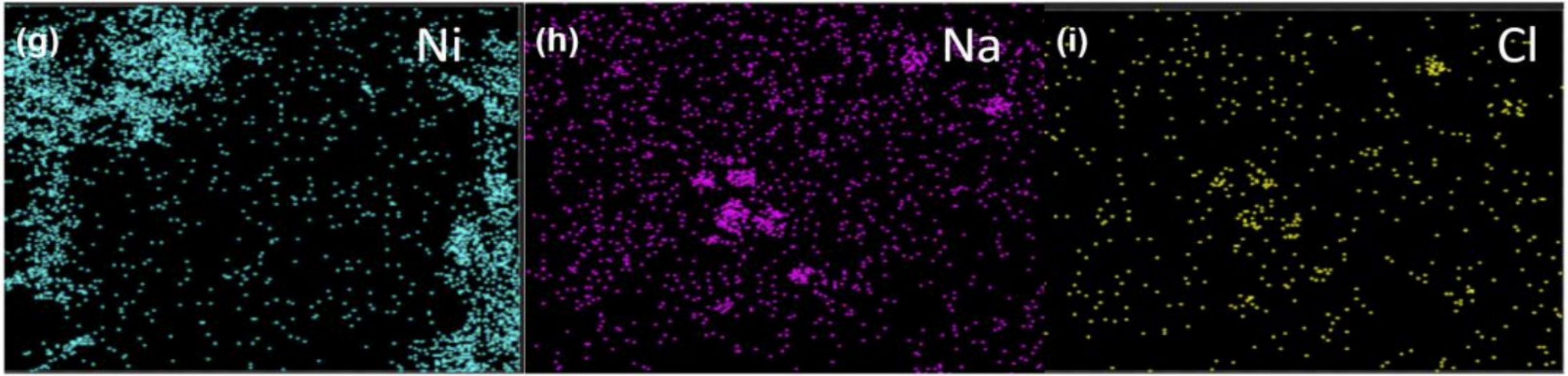
Label size (diameter)	Normalized signal magnitude [a]
10 nm	1.74×10^{13}



Single cell detection using a magnetic zigzag nanowire biosensor
Hao-Ting Huang Tzong-Rong Ger Ya-Hui Lin*a* and Zung-Hang Wei



Magnetic Nanowire Labels



https://conservancy.umn.edu/bitstream/handle/11299/226637/Su_umn_0130E_22057.pdf?sequence=1&isAllowed=y

Future - Magnetic Systems for Streamlined Surface

1. Diagnostics
   a. Magnetic labeling for magnetic nanowire sensors
2. Treatment - Hyperthermia
   a. Vibrate nanowires within cancer cells to “cook” them
3. Checkups

Thank You!

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