



Institute for Bioengineering of Catalonia

# Sensores electroquímicos para diagnóstico en centros de atención primaria

Dr. Mònica Mir

27/09/17

NanoMercosur

Engineering  
solutions for health

# Institute for Bioengineering of Catalonia (IBEC)



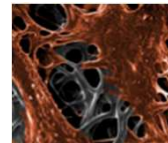
# Institute for Bioengineering of Catalonia (IBEC)



IBEC's research interest; **Nanomedicine, Cell Engineering, and ICT for Health** for applications in:



**Bioengineering**  
for Future Medicine



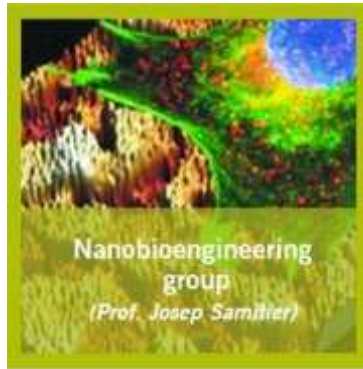
**Bioengineering**  
for Regenerative Therapies



**Bioengineering**  
for Healthy Ageing







# Nanobioengineering Group



**Biosensors & lab-on-a-chip devices**

**Microfluidics**

- Microcounters
- Blood filters

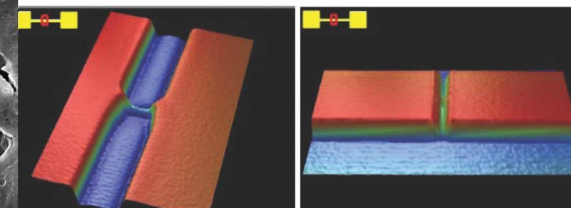
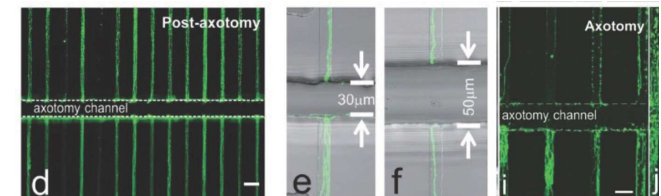
**Micro&nano systems for biomedical applications**

**Organ on a chip**

- Spleen-on-a-chip
- Kidney-on-a-chip

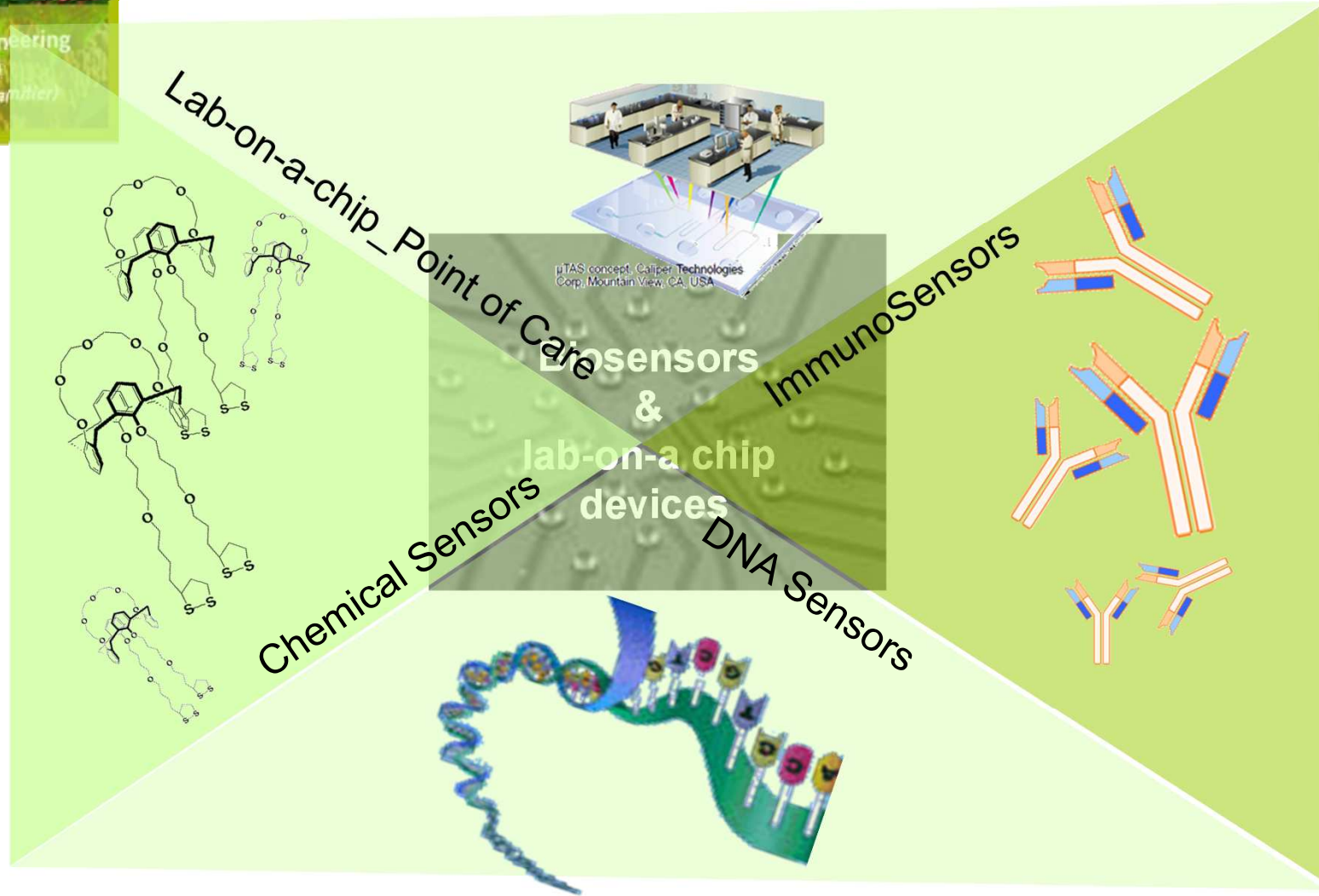
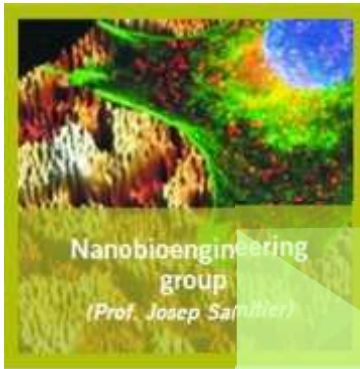
**Cell nano-bio interactions**

- Regenerative medicine
- Cell characterisation

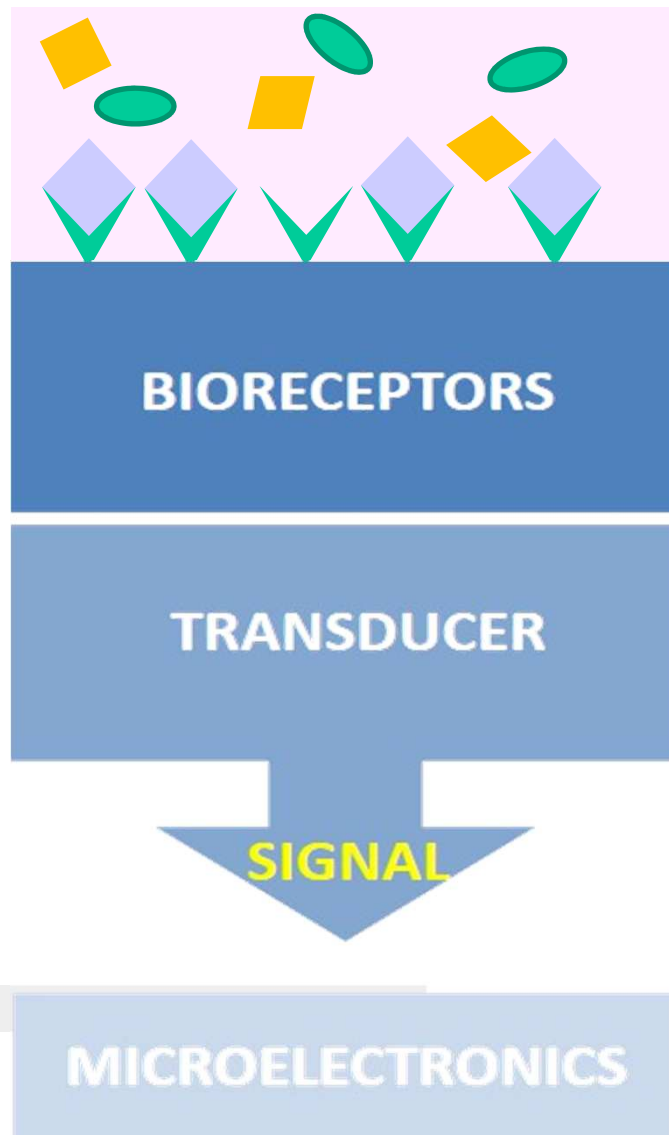




# Nanobioengineering



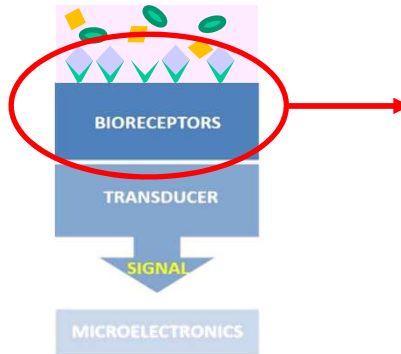
# Biosensor's Structure



## Chemical Sensor by IUPAC;

*“is a device that transform chemical information, ranging from the concentration of a specific sample component to total composition analysis, into an analytical useful signal”*

# Bioreceptors & applications



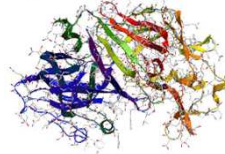
- DNA Sensors**
- Diagnosis of diseases-related genes
  - Personalized medicine
  - Gene expression profile
  - Genetic predisposition
  - Gene analysis for drug action



- Immunosensors**
- Pathogens
  - Toxins
  - Biomarkers

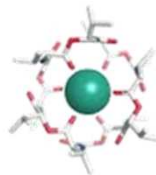


- Enzymatic Sensors**
- Aspartate, Alanine AT
  - Lactate D, Alkaline P
  - Phosphatase, amylase
  - Glucose, Urease



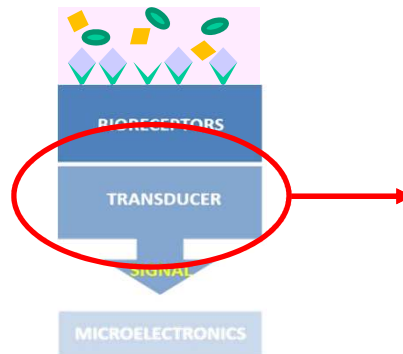
## Ions Selective Sensors

- pH, O<sub>2</sub>, CO<sub>2</sub>
- Na, K, Ca, Cl, NH<sub>3</sub>
- NO<sub>3</sub>, PO<sub>3</sub>, CN, Cd, Co, Hg





# Main Transducers



## Optical



## Electrochemical

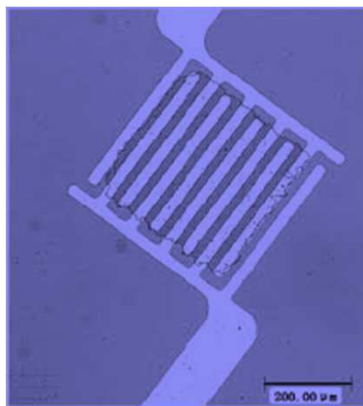
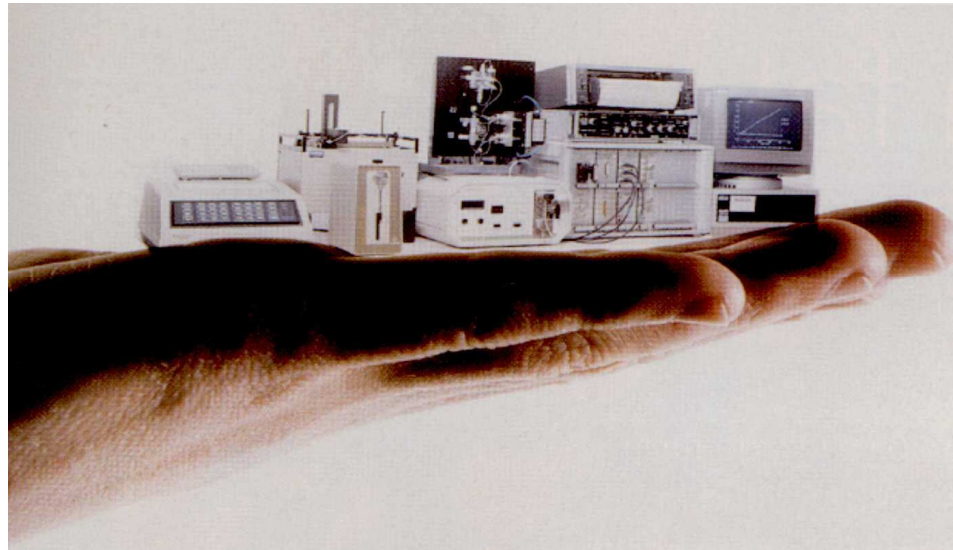
- ✓ Higher sensitivity
- ✓ Faster response
- ✓ Lower cost (digital signal)
- ✓ Wide range of analytes
- ✓ Easier to miniaturize



# Miniaturized Biosensors



## Miniaturization; Lab-on-a-chip



- ✓ Required for many applications
- ✓ Wearable, implantable
- ✓ High parallelization; Array concept
- ✓ Faster response time, easy to use
- ✓ Lower sample volumes
- ✓ Real time monitoring
- ✓ Lower signal to noise ratio

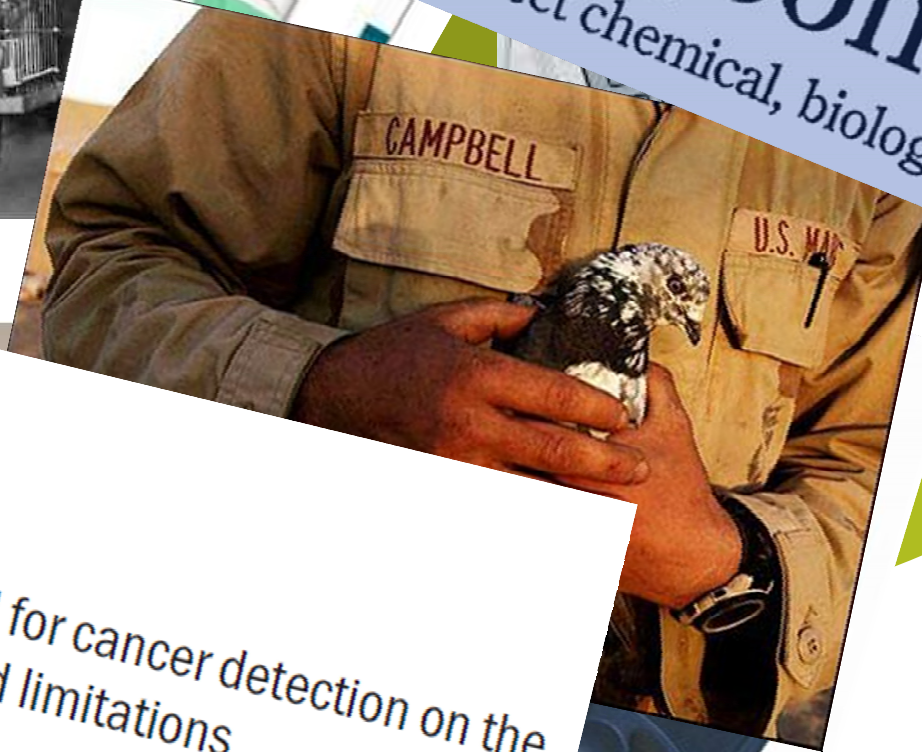


## Examples of biosensor

STARTING



**Tool pigeons**  
Marines use birds to detect chemical, biological attack



**Journal of Breath Research**

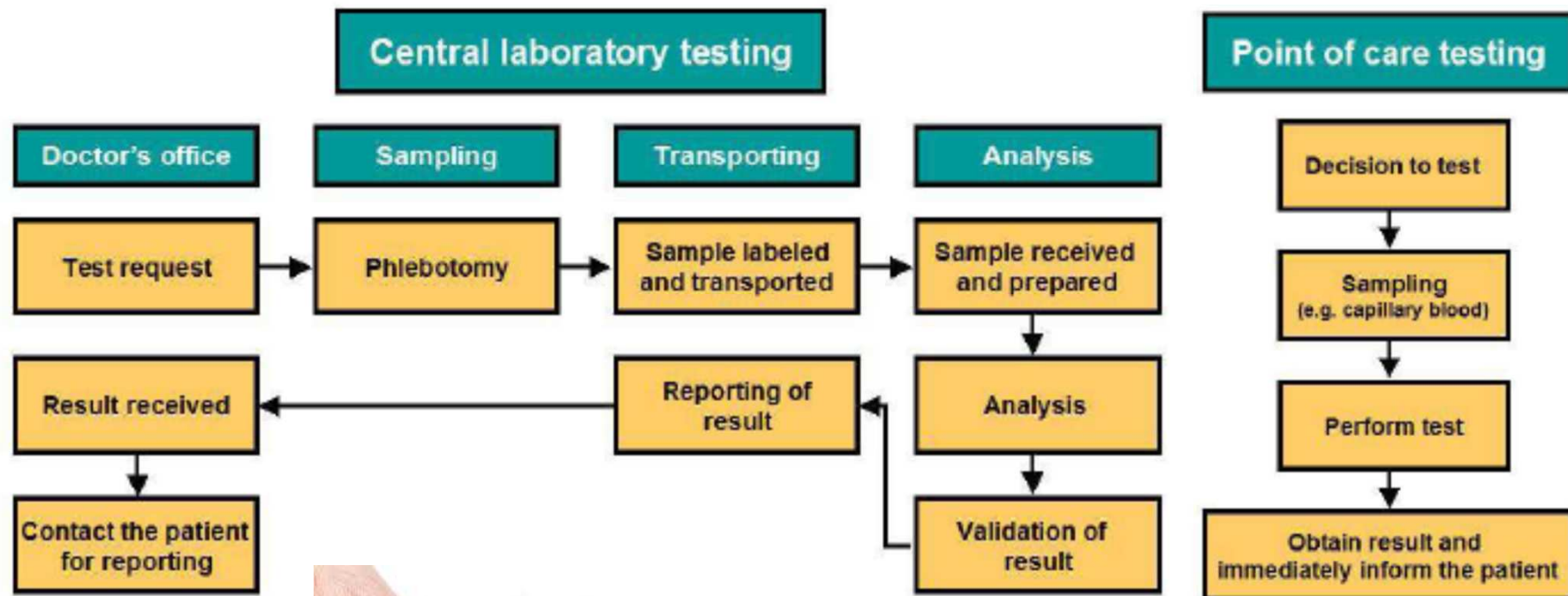
TOPICAL REVIEW

Study of the art: canine olfaction used for cancer detection on the basis of breath odour. Perspectives and limitations

Tadeusz Jezierski<sup>1</sup>, Marta Walczak<sup>1</sup>, Tomasz Ligor<sup>2</sup>, Joanna Rudnicka<sup>2</sup> and Bogusław Buszewski<sup>2</sup>  
Department of Animal Behaviour, Institute of Genetics and Animal Breeding of Polish Academy of Sciences, Jastrzębiec, O5-552  
Magdalena, Poland



# Biosensor's Advantages\_Medical Diagnosis

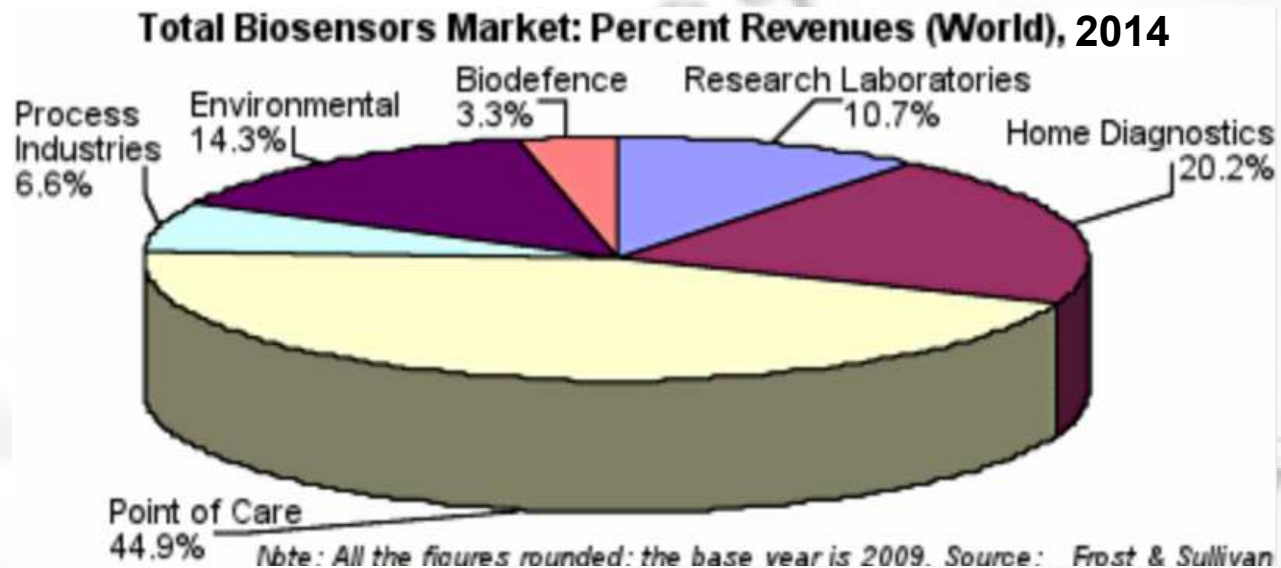


## Biosensor's Advantages

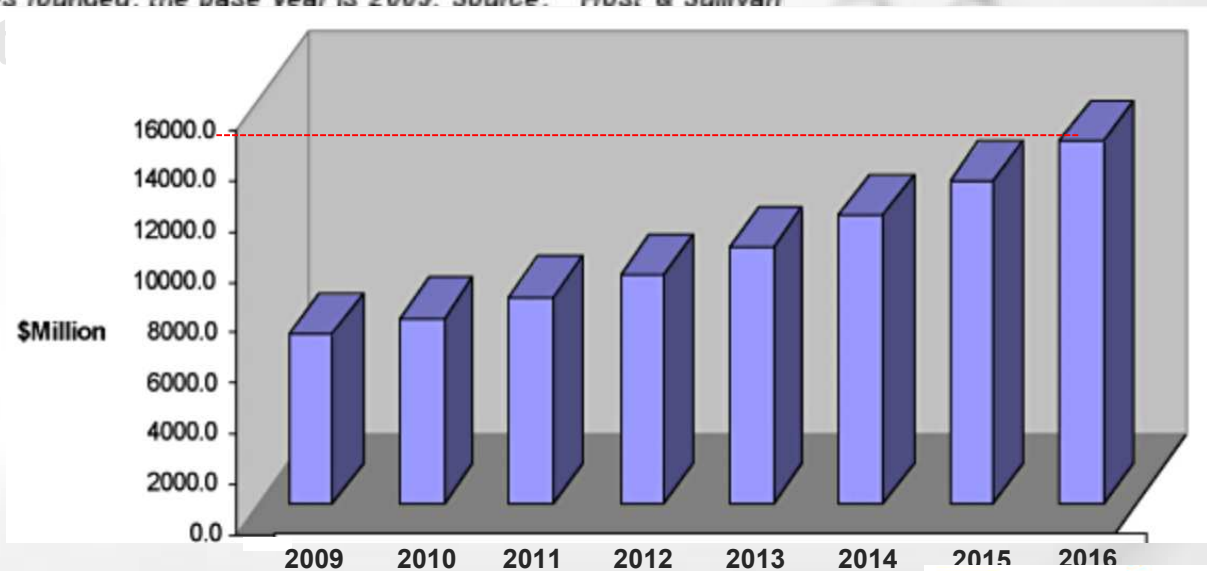
- ✓ Portable
- ✓ Short time analysis
- ✓ Easy to use
- ✓ High sensitivity & selectivity
- ✓ High throughput analysis
- ✓ Low sample volume
- ✓ Lower cost of analysis



## Biosensor's Market & fields



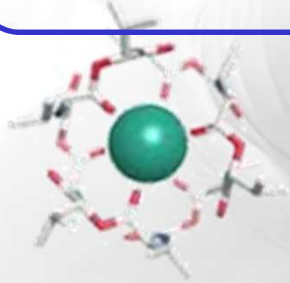
- Detect



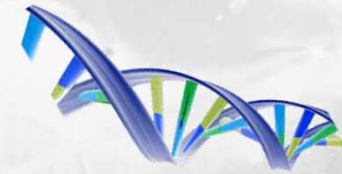


## Our Technology

Our platforms are focused in the improvement of point of care diagnosis for biomedical application



➤ Endoscopic  
ischemia sensor



➤ DNA array integrated  
in a lab-on-a-chip

➤ DNA nano-gap

## Endoscopic Ischemia Sensor



To transfer the traditional laparoscopic technologies to a scar-less minimal invasive robotic laparoscopy device for gastric bypass in morbid obesity

**SENSOR** miniaturized & endoscope integrated permits a continuous monitoring of the state of the patient by measuring ischemia inside the stomach in a fast and low cost way



# Endoscopic Ischemia Sensor \_ Competitors



## ➤ Flap Microdialysis



- ☒ Complex use
- ☒ Not continuous monitor (30 min)
- ☒ Equip. 52.000 + Disp. 570€

## ➤ Cook-Swartz Doppler

- ☒ High false positive
- ☒ Risk; artery manipulation
- ☒ Equip. 2.100 + Disp. 400€



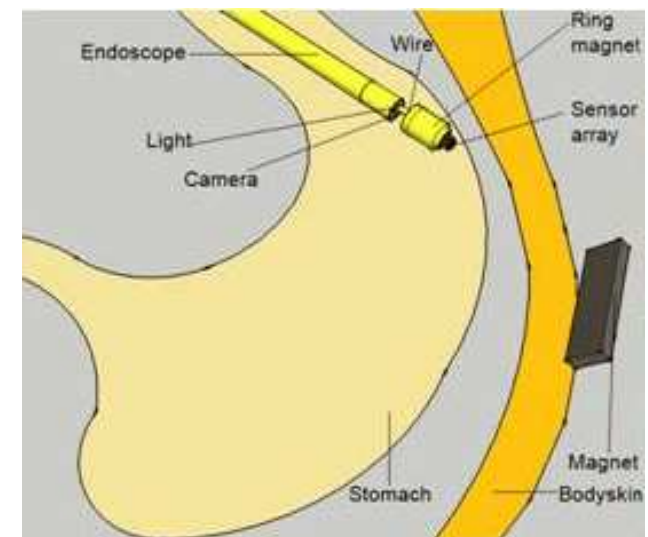
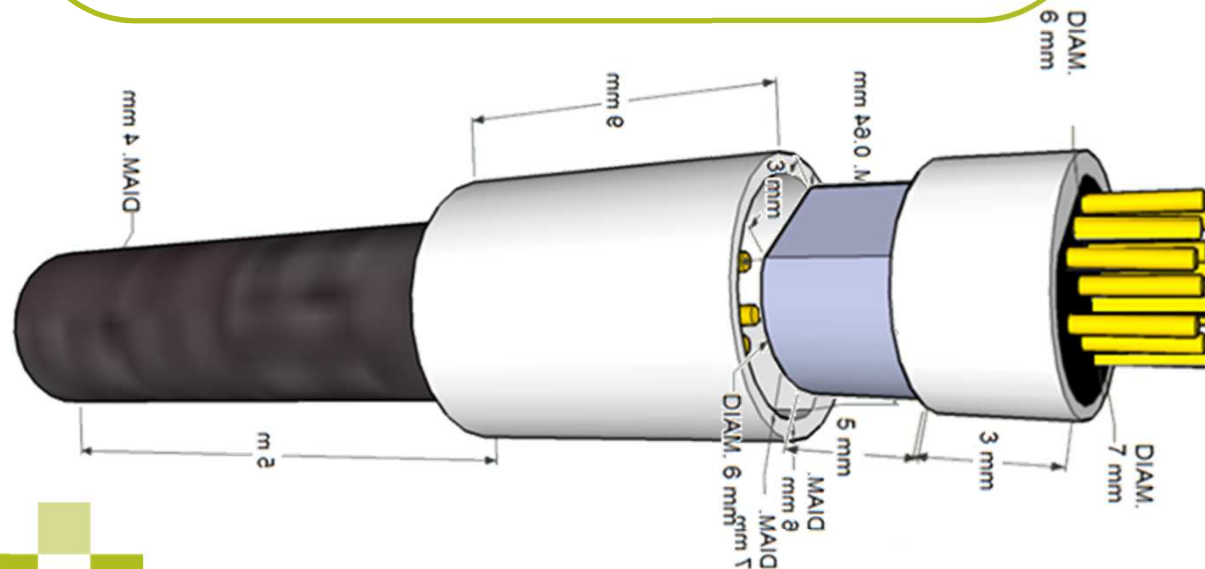
- ☒ None device enough miniaturized for it integration in an endoscope





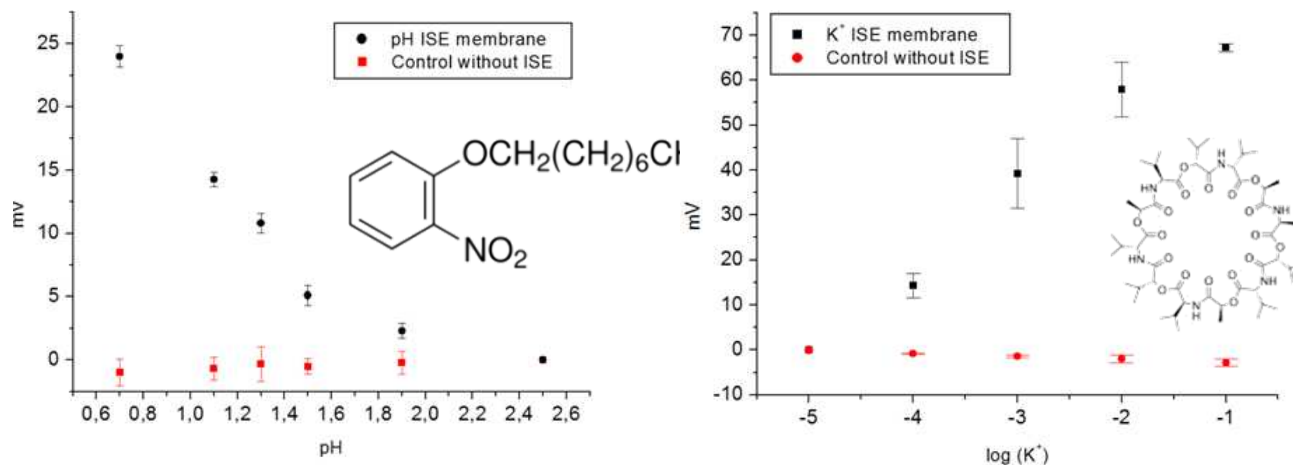
# Endoscopic Ischemia Sensor \_ Our technology

- ✓ Low cost fabrication
- ✓ Portable and endoscopic plug in device
- ✓ Partially disposable and interchangeable
- ✓ Integration of pH,  $K^+$  and impedance detection
- ✓ Stable and robust under low pHs
- ✓ Full contact and no crosstalk of the electrodes
- ✓ Biocompatible

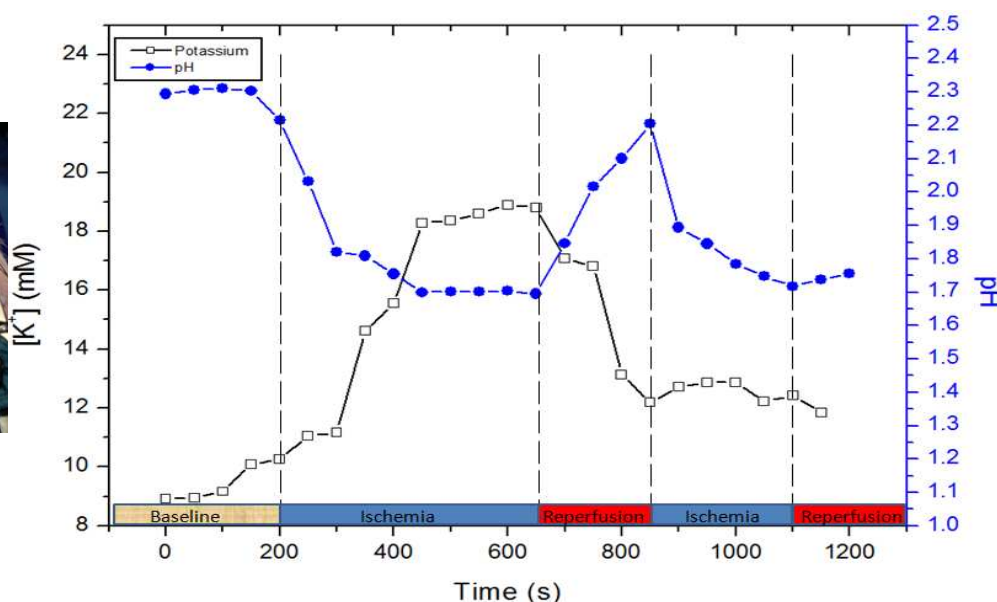


# Endoscopic Ischemia Sensor \_ Our technology

## ➤ *In vitro* optimization of pH and pK sensors

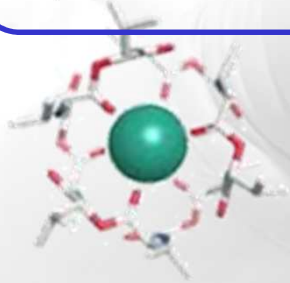


## ➤ *In vivo* test, tested in 3 pigs by endoscopic surgery

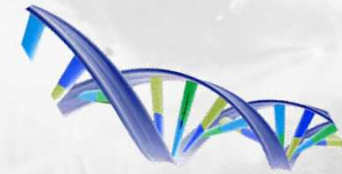


## Our Technology

Our platforms are focused in the improvement of point of care diagnosis for biomedical application



- Endoscopic ischemia sensor



- DNA array integrated in a lab-on-a-chip
- DNA nano-gap

# DNA array integrated in Lab-on-a-chip for POC

Sampling

Transporting

Analysis

- ✗ Time consuming  
Analysis 10h, process 1week
- ✗ Bulky and expensive equipment
- ✗ Required trained personnel

PCR + ELONA



- ✓ Short response (1 h)
- ✓ Easy to use
- ✓ Not required personnel
- ✓ Portable





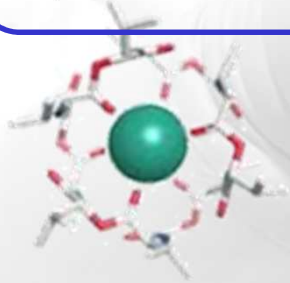
# DNA array integrated in Lab-on-a-chip for POC

NEDXA Comercial lab-on-a-chip; IBEC & Genomica Joint Unit

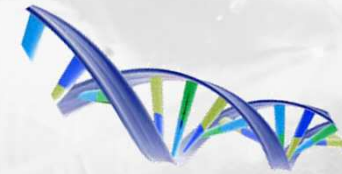


## Our Technology

Our platforms are focused in the improvement of point of care diagnosis for biomedical application



➤ Endoscopic ischemia sensor

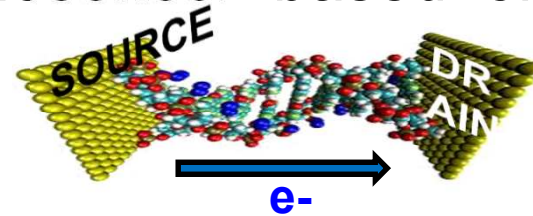
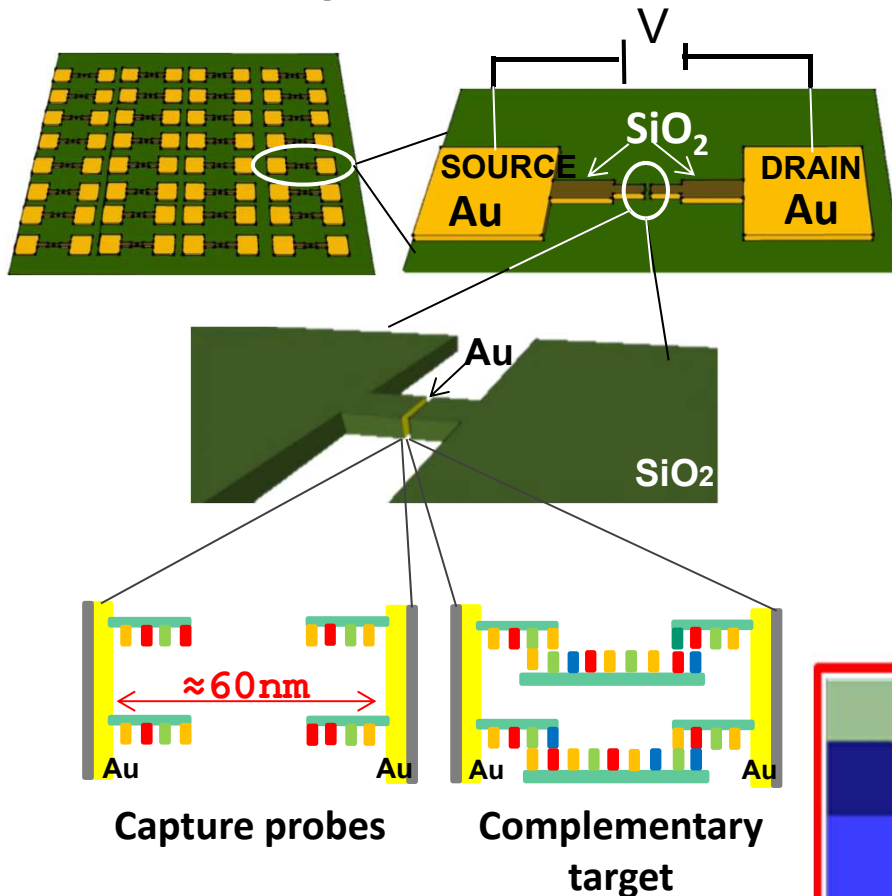


➤ DNA array integrated in a lab-on-a-chip

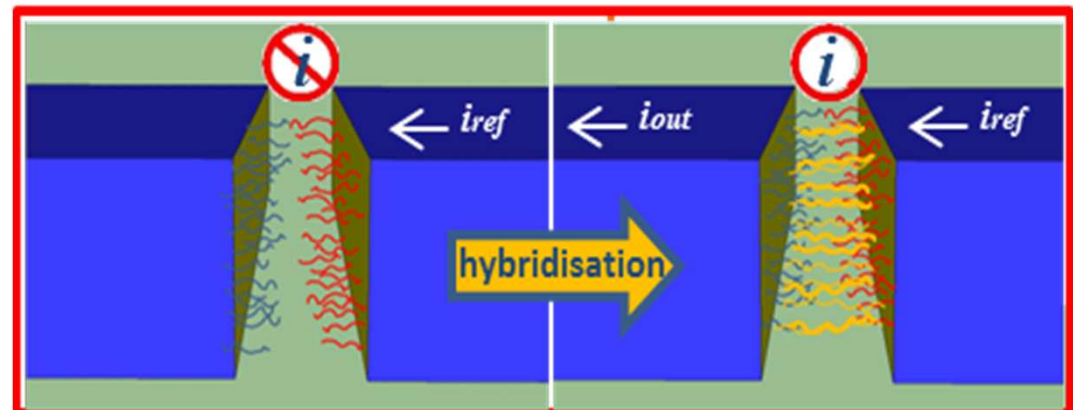
➤ DNA nano-gap

## PCR free DNA nanoarray

- Switchable DNA nano-gap biosensor based on long range electron transport

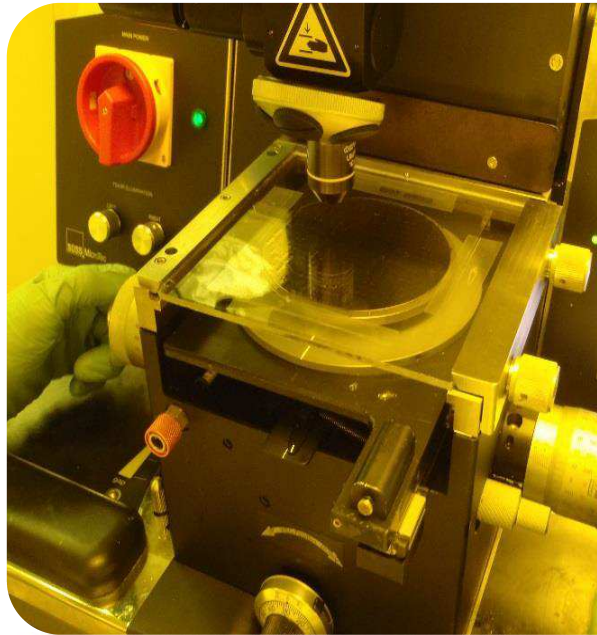


- ✓ **Direct transduction** of biomolecules-probes interaction in an electrical signal.
- ✓ Detection of **very small** quantities by shrinking down the probe size.
- ✓ **Multiplexed** assays and compatible with CMOS technology.





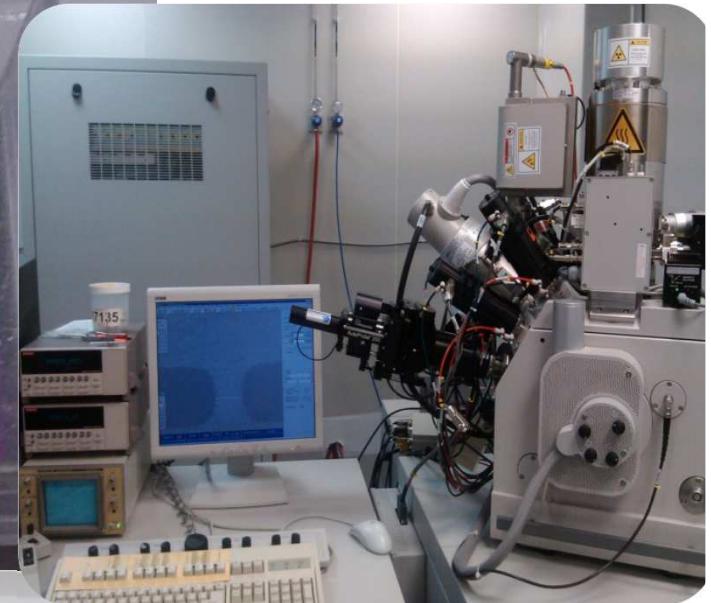
# PCR free DNA nanoarray \_ Nanofabrication



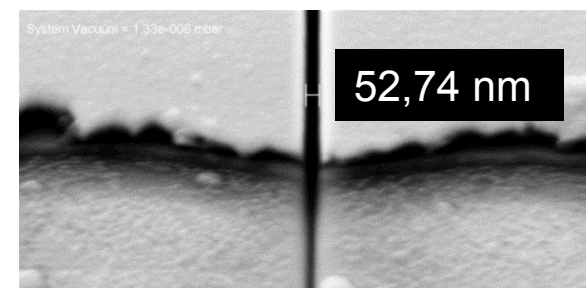
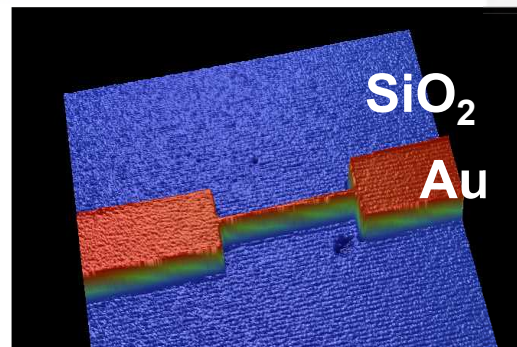
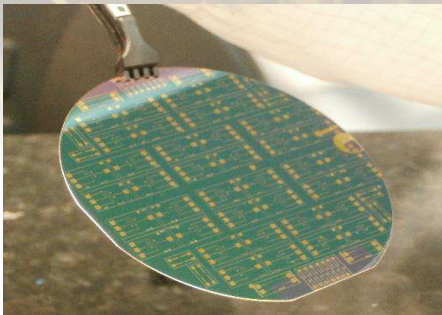
Electrodes pattern  
Lift-off photolithography



Electrodes passivation  
 $\text{SiO}_2$  Sputtering



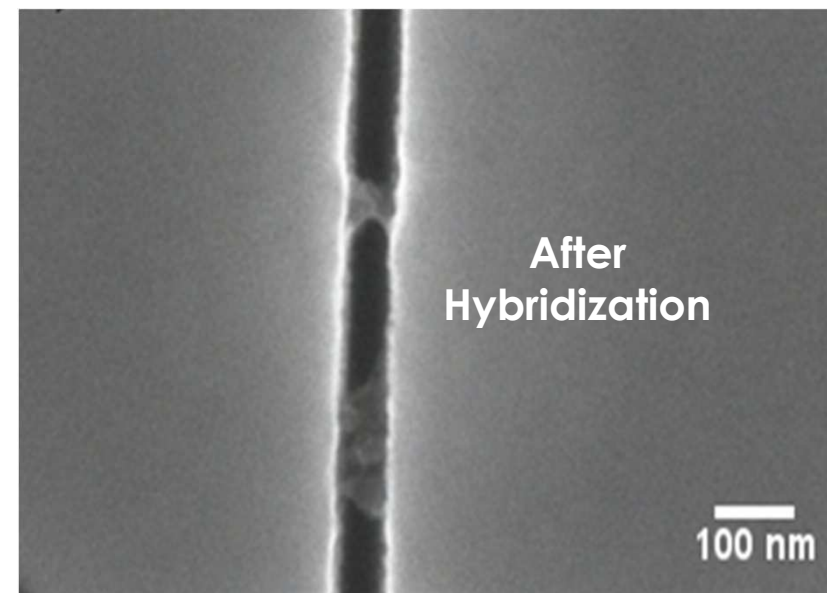
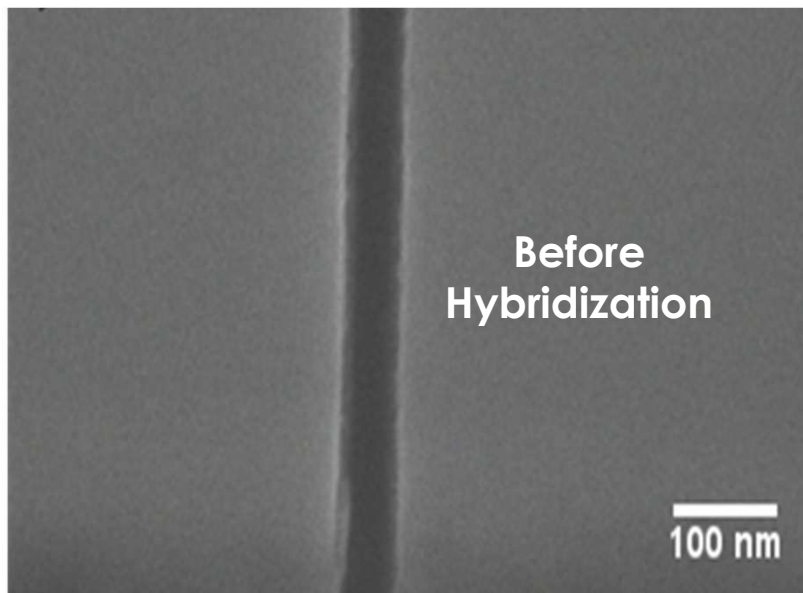
Nano-gap milling  
Focused Ion Beam



# PCR free DNA nanoarray \_ electronic detection



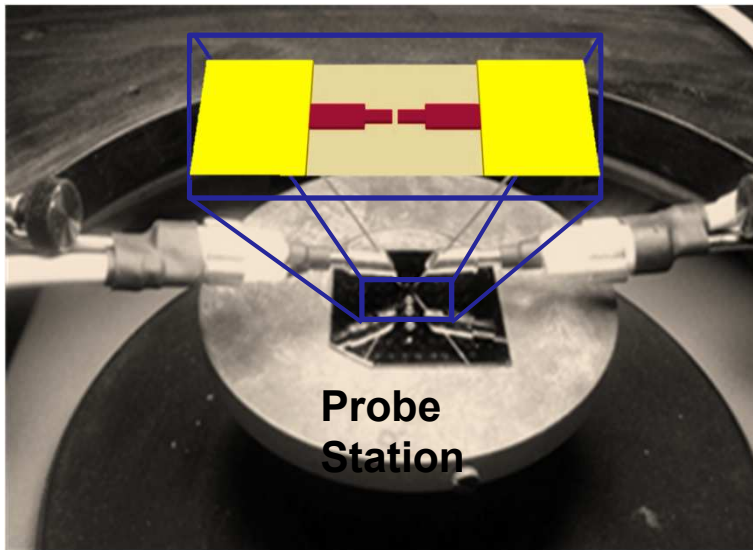
- Optical microscope characterisation





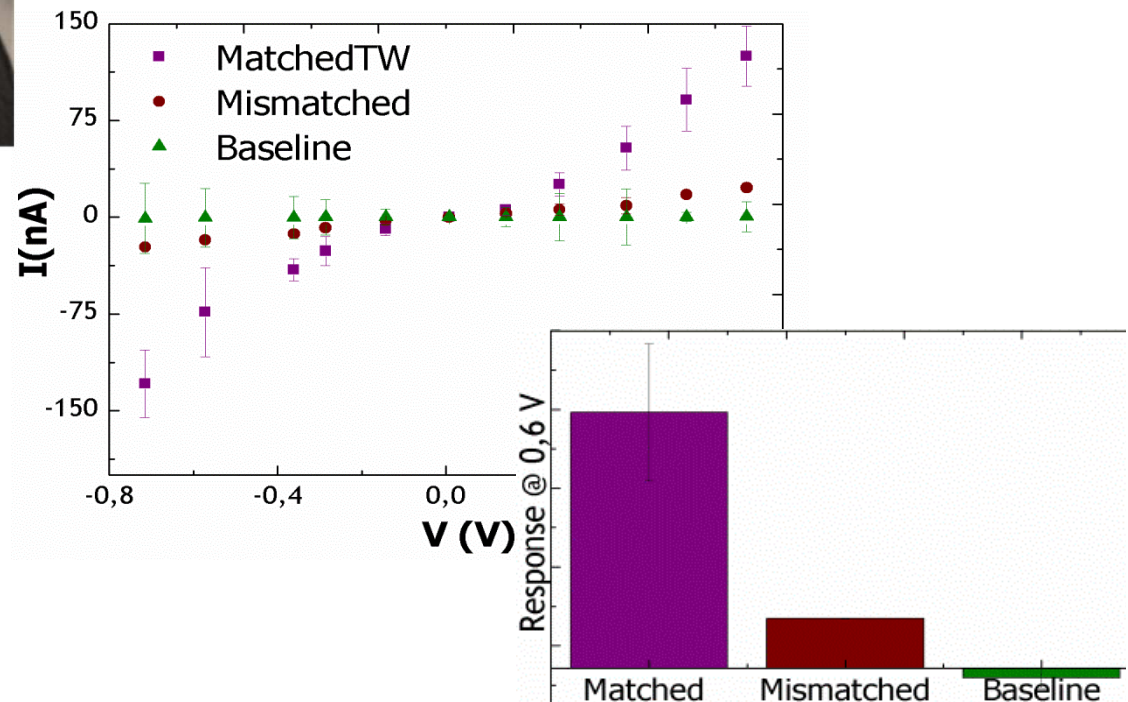
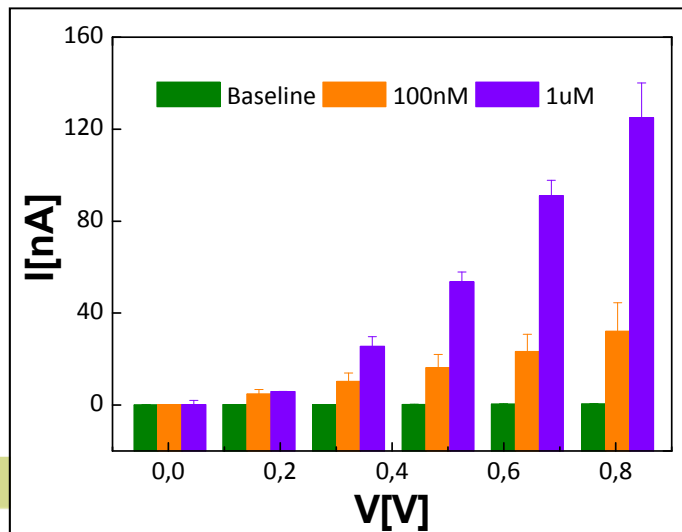
# PCR free DNA nanoarray \_ electronic detection

## ➤ Electronic characterisation

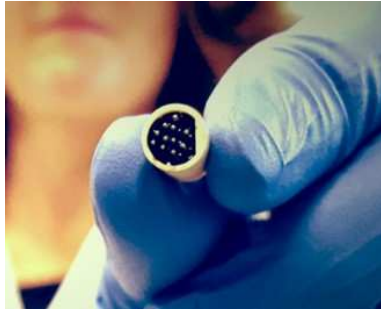


✓ Successful detection of DNA hybridization & single point mismatches

✓ Quantitative detection



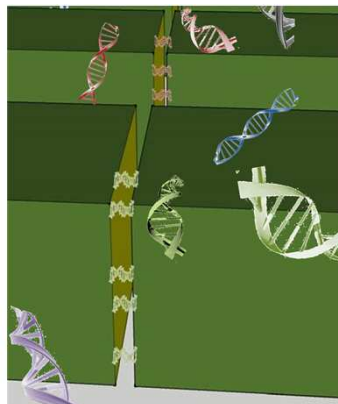
## Conclusions



- Endoscopic array for ischemia detection tested in vivo



- Integration in a lab-on-a-chip a PCR and Array for point of care diagnosis



- Quantitative DNA nano-gap for SNP detection



# Institute for Bioengineering of Catalonia (IBEC)

*ciber-66n*

Biomedical Research Networking Center  
Bioengineering, Biomaterials, Nanomedicine



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