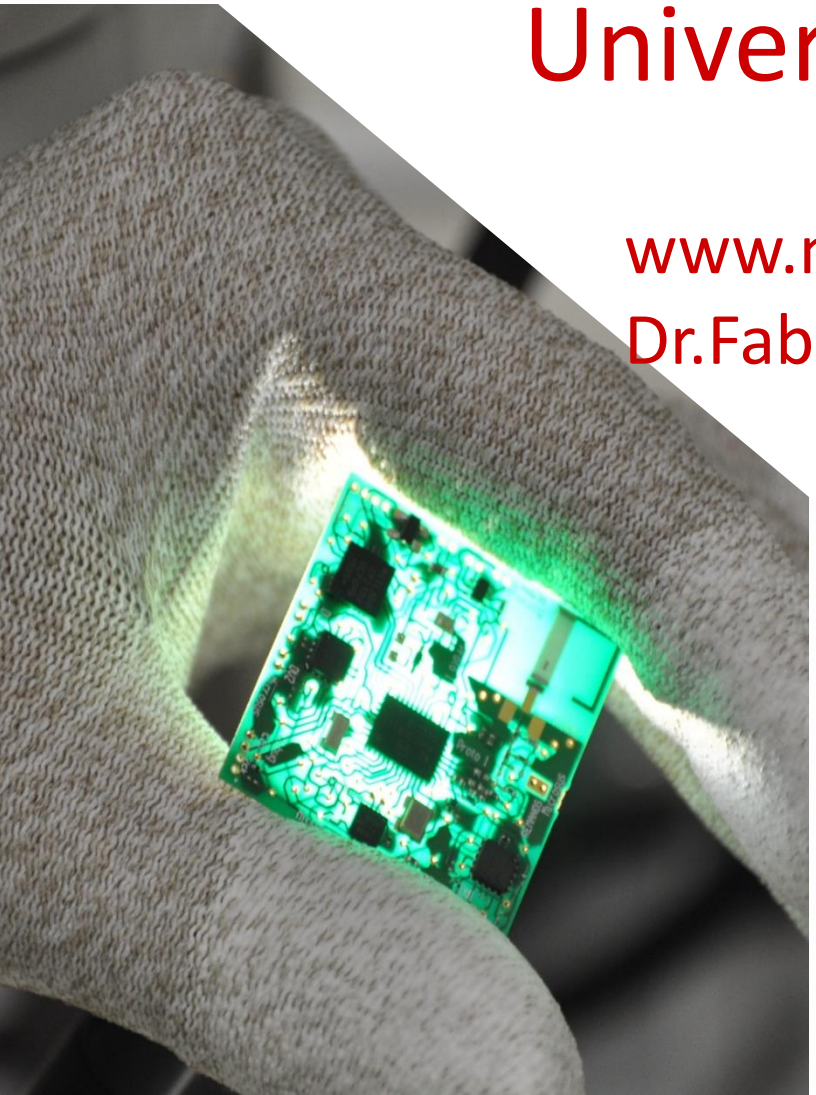
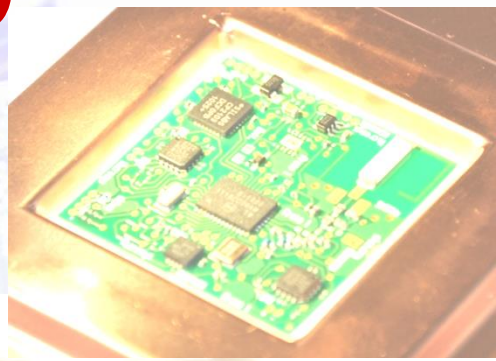
MICROSYS lab

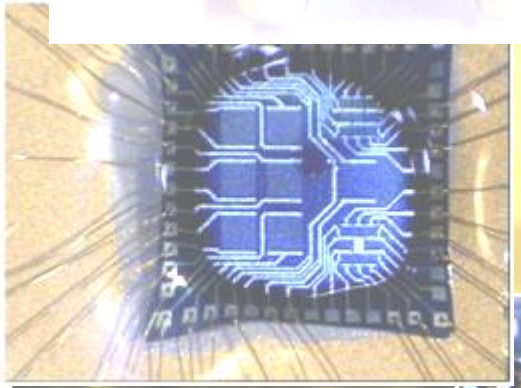
University of Liege

www.microsys.ulg.ac.be

Dr.Fabrice Axisa, Microsys lab responsible







Introduction

- Microsys Description
- Microsys Expertise
- Technology Portfolio
- Facility and equipment
- Microsys Research projects overview
- Bio-sensor for bio-molecules detection (DNASip project)

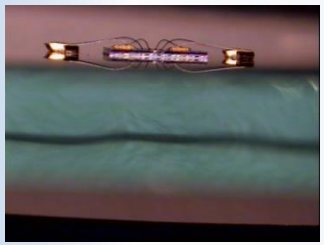
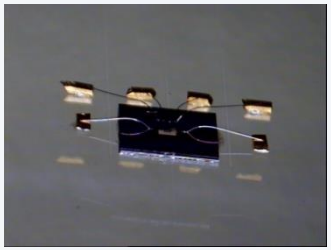
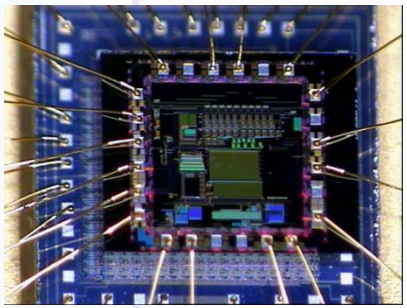
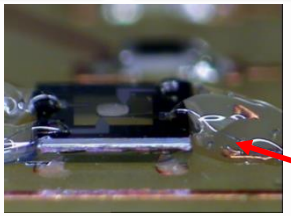
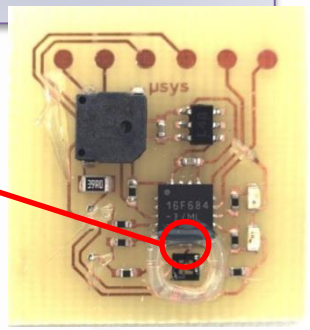
Microsys Description

- MICROSYS is a laboratory of the University of Liege (part of EMMI) created in 2006
- Main research fields :
  - Energy harvesting and scavenger system
  - Microsystem in harsh environment and Bio/Organic chip encapsulation
  - Autonomous micro system
- 9 projects : 5 ERDF (European Regional Development Fund) funding, 4 industrial (Walloon Region funding) → total budget of 4 millions €
- Team : 1 Professor, 3 senior researcher, 4 research engineers, 1 technicians, 1 PhD student
- 1 spin-off company : TAIPRO Engineering (created in 2009), the commercial answer of Microsys for packaging and microsystem engineering service for industrial needs

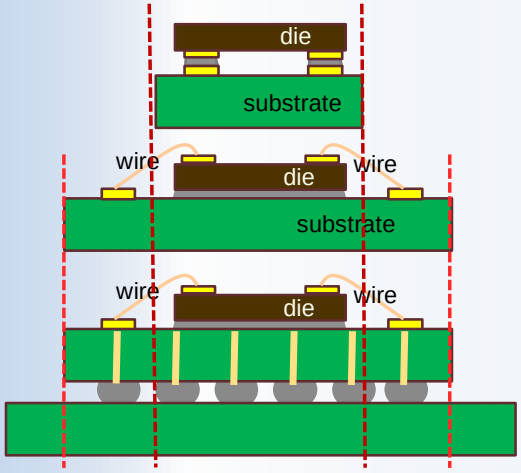
Microsys Expertise

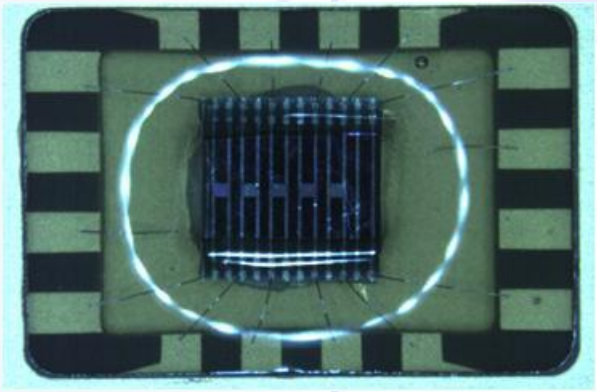
4 core competences of Microsys lab

- Design and development state-of-art microsystems
- Multiphysics modeling & simulation (incl. thermal mechanical)
- Edge-cut micro-assembly, interconnect and packaging technology
- Test and characterization

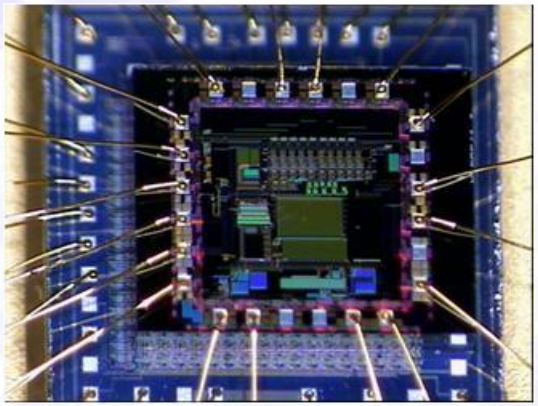






Packaging and integration

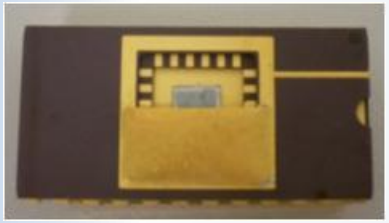




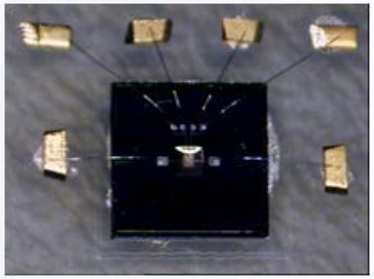
Biochip encapsulation



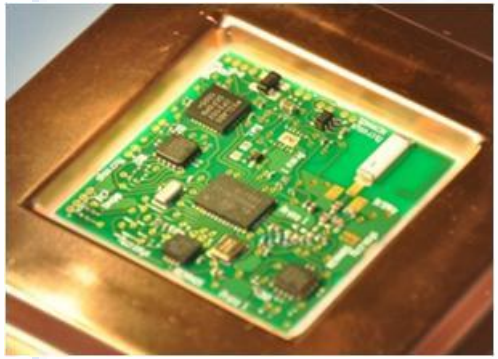
Stacking



Système in Package

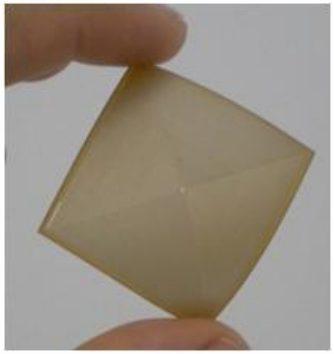


Application on glass



Microsystem packaged

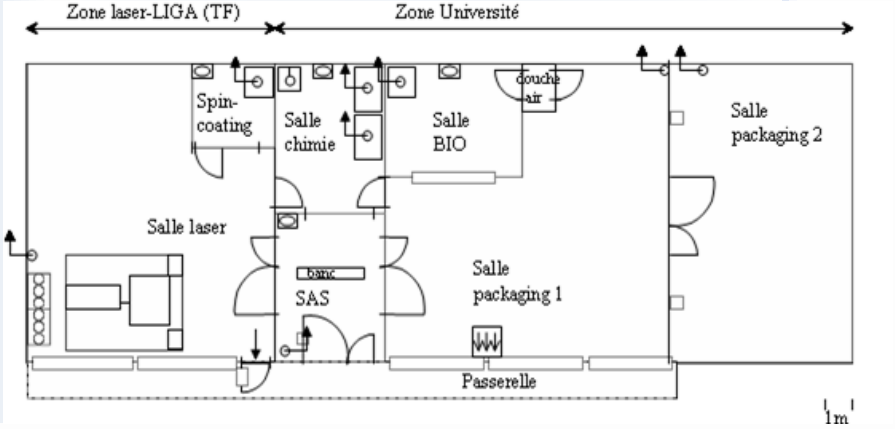
For high temperature



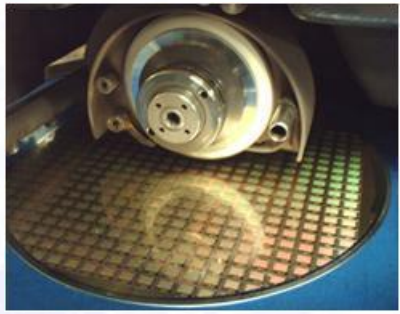
Flexible electronic

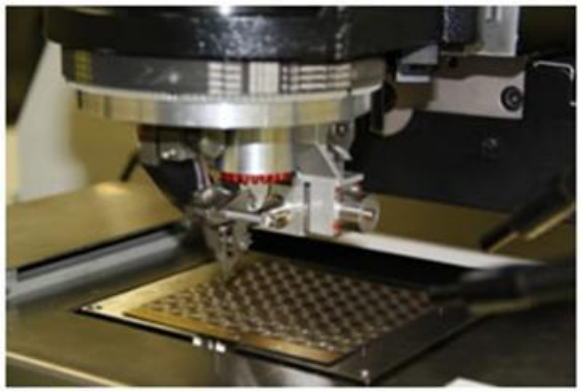
Facilities

- 200 m² certified clean room class 10.000 (ISO7)
- 4 separate rooms (2 for packaging, 1 bio, 1 chemical)
- Fully ESD equipped infrastructure (rooms, furniture, clothes etc)



Equipement





Industrial Projects

- **Techspace Aero (HM+)** : Microsystem for health monitoring of aircraft engine lubrication system.
- **Sonaca (HM+)** : Microsystem for health monitoring of moving wing parts
- **CMI (MINT)** : Microsystem for identification and control of bearings lubrication on heavy industrial line.
- **Tecnolub (Micro Lub)** : Microsystem for the monitoring of a microlubrication system on CNC equipments
- **GreenCom Development (Green+)** : development of a double flux heat scavenging system for existing buildings.
- **CorisBio (DNASip)** : Integration of protein grafted chip in microfluidic envronement

Research Projects (ERDF)

- **Medipump** : Microsystem for controlling a medical perfusion pump
- **Monsotex** : Integration of sensors in a textile (smart clothes) for medical applications
- **Remanos** : Autonomous microsystems for industrial applications (energy harvesting and power management)
- **Minatis** : Packaging of dies made by UCL
- **Tracemedia :** Packaging of microsystem for track and trace.

TOUJOURS PLUS HAUT

Projets Piμi et Piμi-2

www.plushaut.be

FEDER

UNION EUROPEENNE

Wallonie

LE FONDS EUROPEEN DE DEVELOPPEMENT REGIONAL ET LA WALLONIE INVESTISSENT DANS VOTRE AVENIR.

Piμi platform

- Piμi: Platform for the integration of industrialisable microsystem

- Partners within the Piμi platform :

www.microsys.ulg.ac.be

www.cewac.be

www.centexbel.be

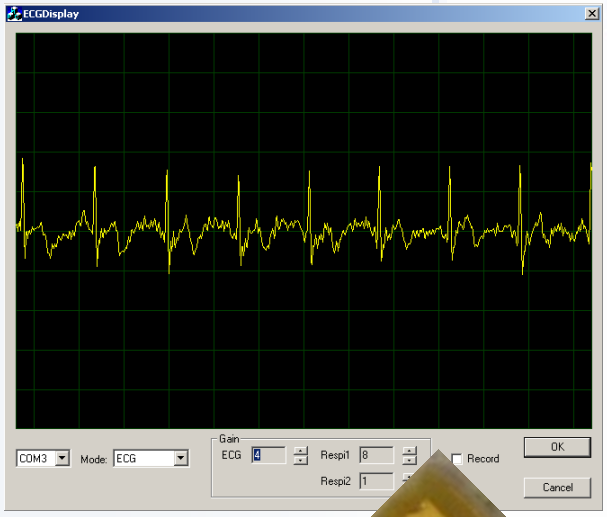
*www.**umons**.ac.be*

www.sirris.be

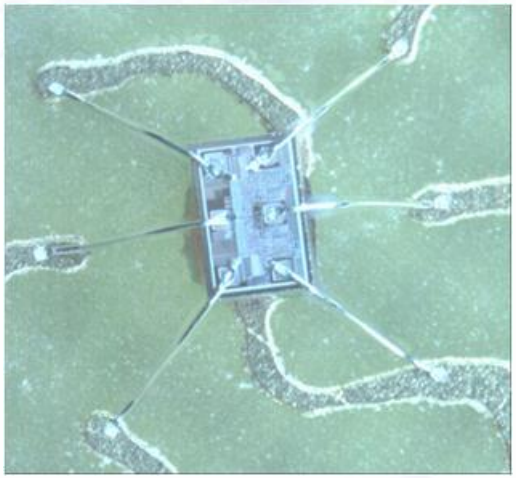
*www.**materianova**.be*

MONSOTEX

- **Conception and realization of smart textile for sleep monitoring**



ECG with fully textile ECG electrodes and distributed electronic using flexible electronic

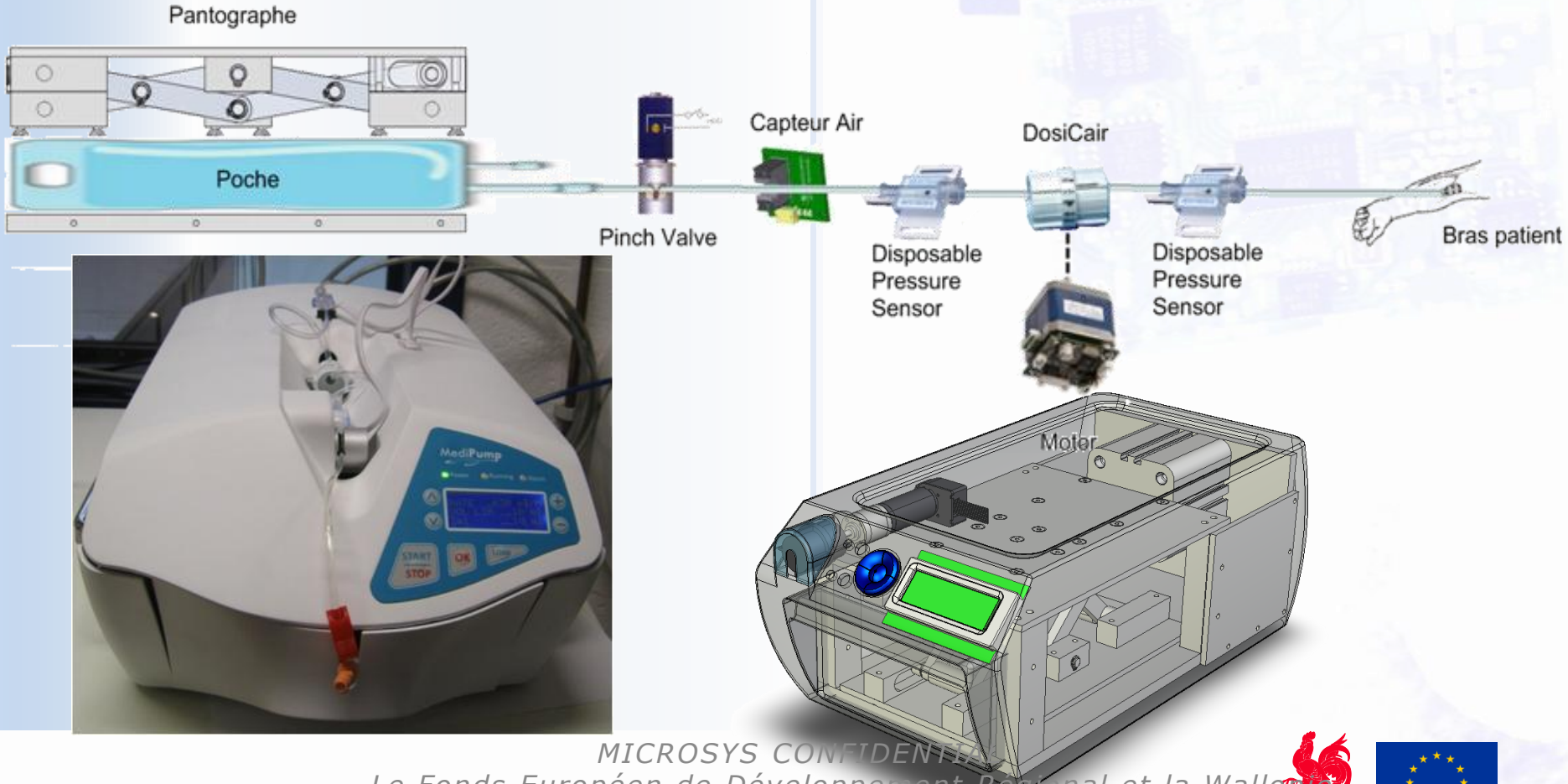


Prototype of fully integrated textile shirt for apnea monitoring

Le Fonds Européen de Développement Régional et la Wallonie investissent dans votre avenir

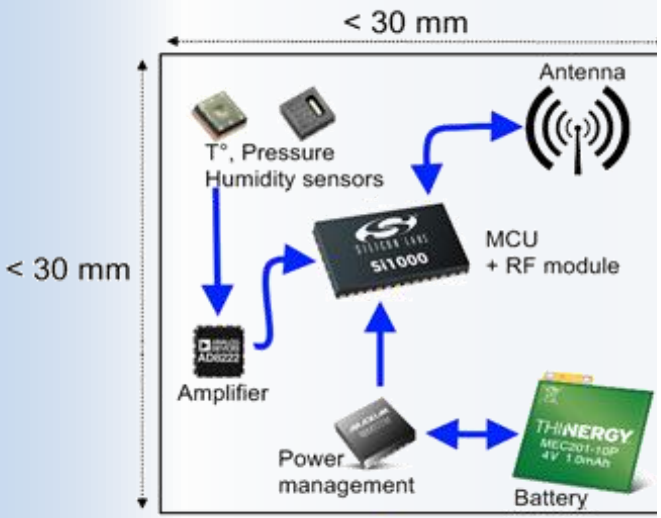
MEDIPUMP

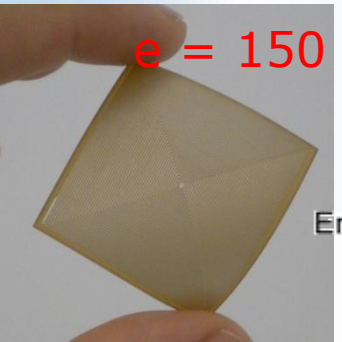
- **A new kind of medical perfusion pump, fully controlled with disposable sensors, for very small flow. Pressure sensors, flow sensors, bubble sensors.**

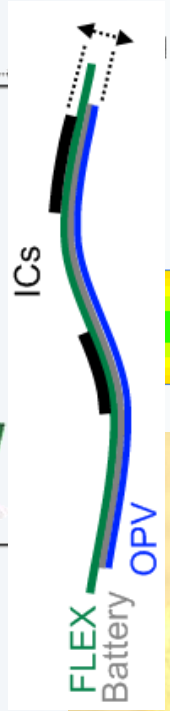


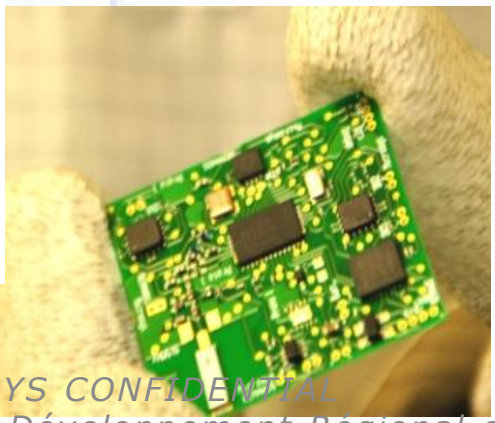
REMANOS

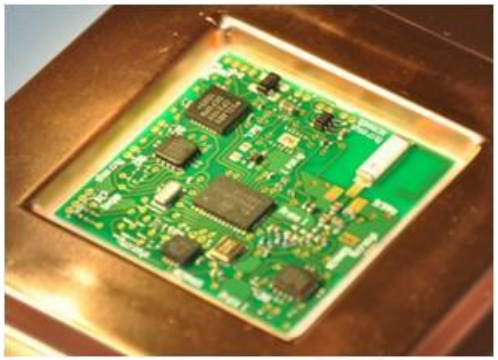
- Development of an integration platform for autonomous microsystems
- Integration of unconventional substrates, non-planar, autonomous microsystems (for energy recovery and storage management, communication) and specific cases
- Identifying industrial needs and building capacity of support for applied research



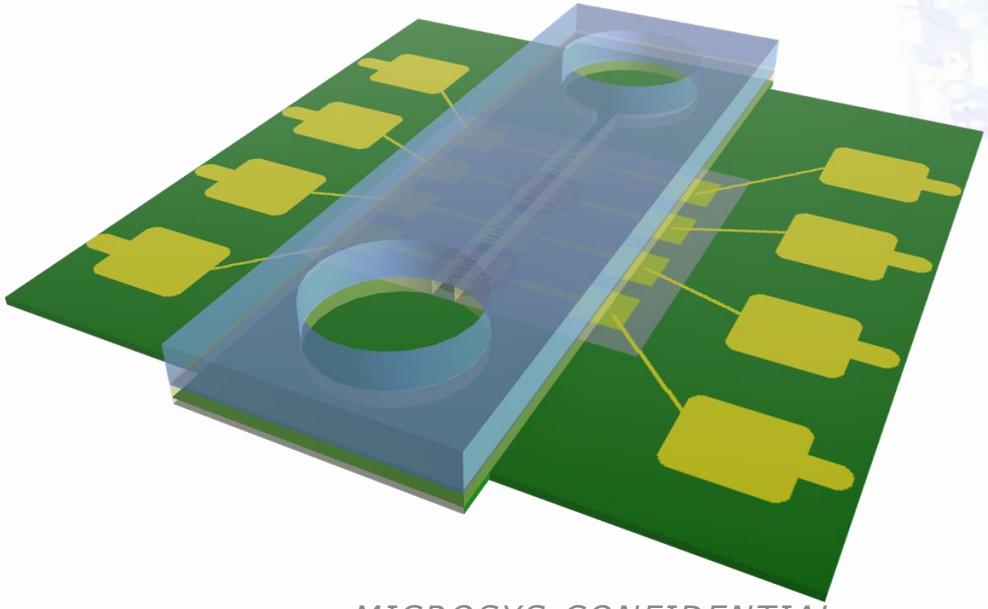




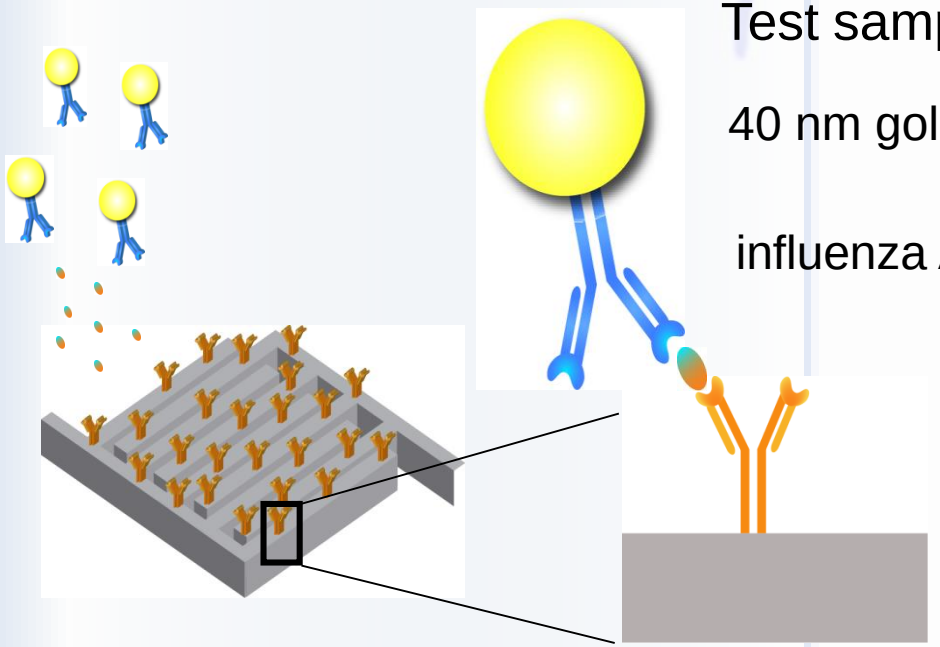




Bio-sensor for protein detection (DNASip project): Bio chip and Microfluidic device integrated in one fully functional device



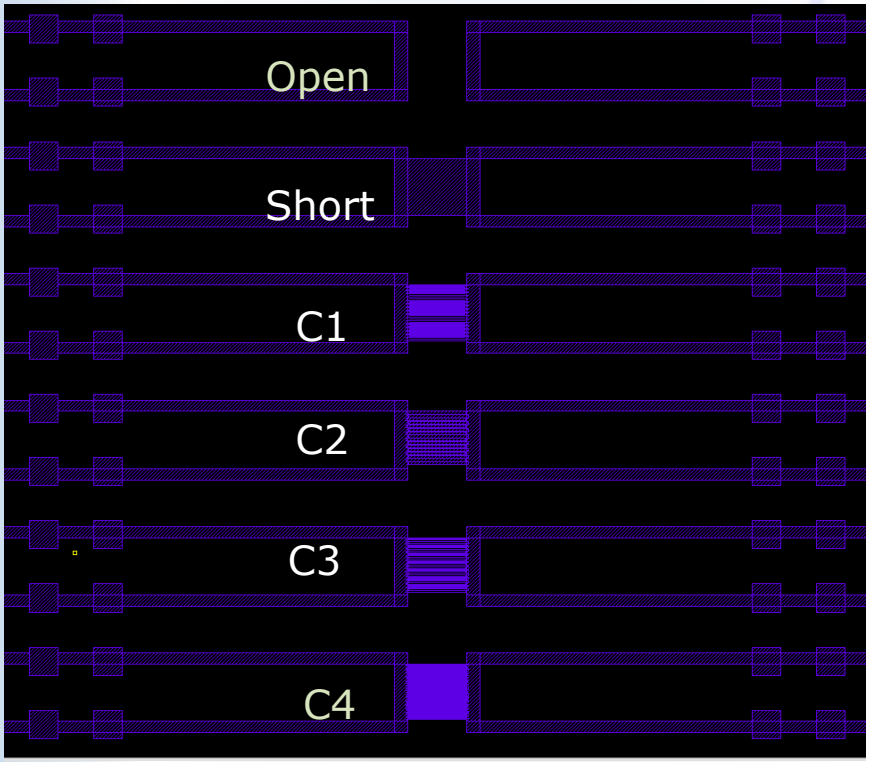
Principe of detection



The inter-digitated array microelectrodes (IDAM) is covered with a bio-functional layer (specific antibody recognizing the nucleoprotein of the Influenza A virus). The registered response is variation of the capacitance and conductivity between the IDAM. To increase the signal a 40 nm gold nano-bead are conjugated with influenza A virus.

Sensor die

Sensor die layout (top view)

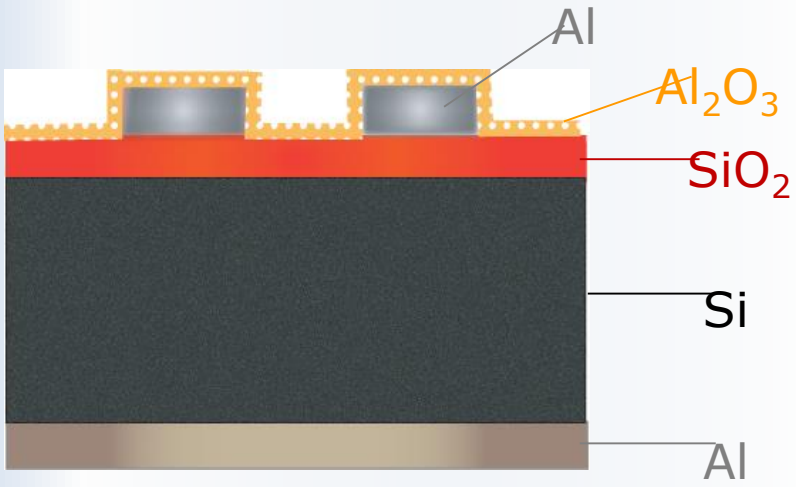


Sensing areas (C1…C4) configuration

Sensor	Finger width (µm)	Interspace (µm)
C1	2	4
C2	10	2
C3	5	2
C4	2	2

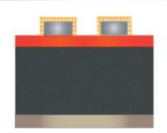
Si sensor die of 3.2mmx3.2mm with 4 of 200µmx200µm sensing areas (C1…C4) of different configuration IDAM (inter-digitated array microelectrodes)

Sensor die cross sectional view



Al=800nm
SiO2=50nm
Si wafer=600µm
Al=400nm

Bio-functionalization



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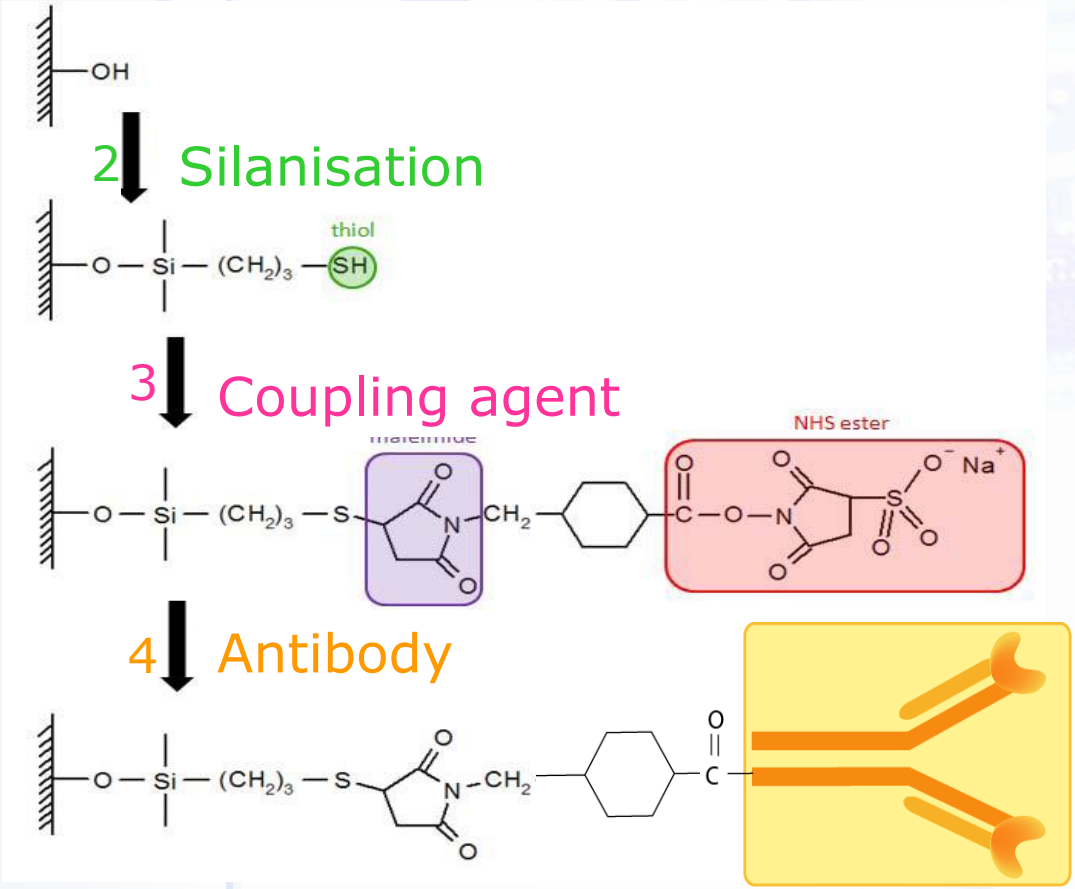
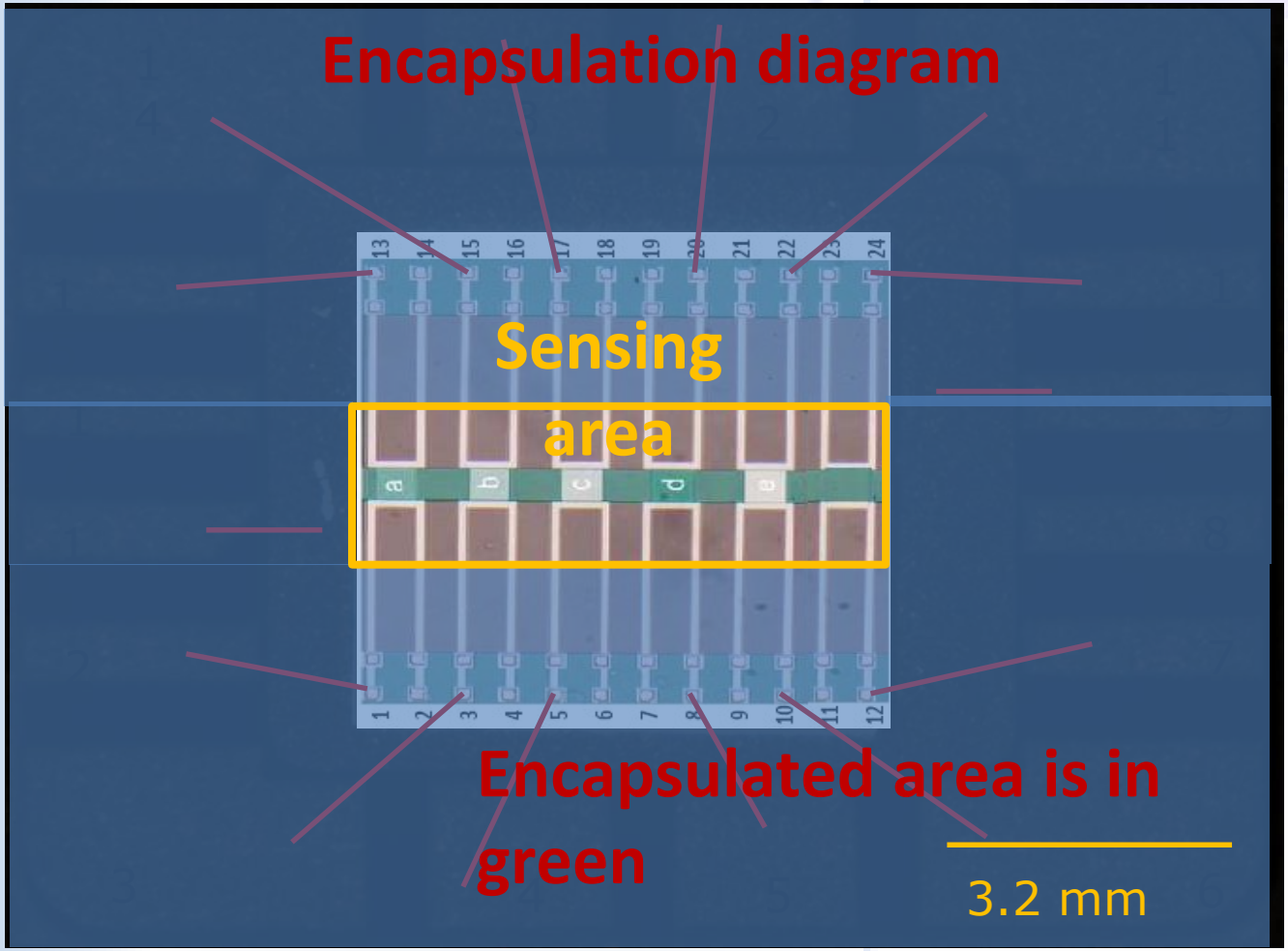
Plasma/O_2 treatment



Assembly schematic view



Sensing channel (configuration of 1mm width x 3 mm length and 0.5 mm high) is to doze 1-1.5 ml volume of the test sample.

Assembly process flow

- Die attach (mounting the sensor die in the package)
- Wire bonding (electrical connection between the sensor die and the package)
- Encapsulation:
  - Protect the bond pad on the sensor die
  - Protect the wire
  - Protect the lead (bond pad) on the package
  - Define the sensing area

Assembly process challenges

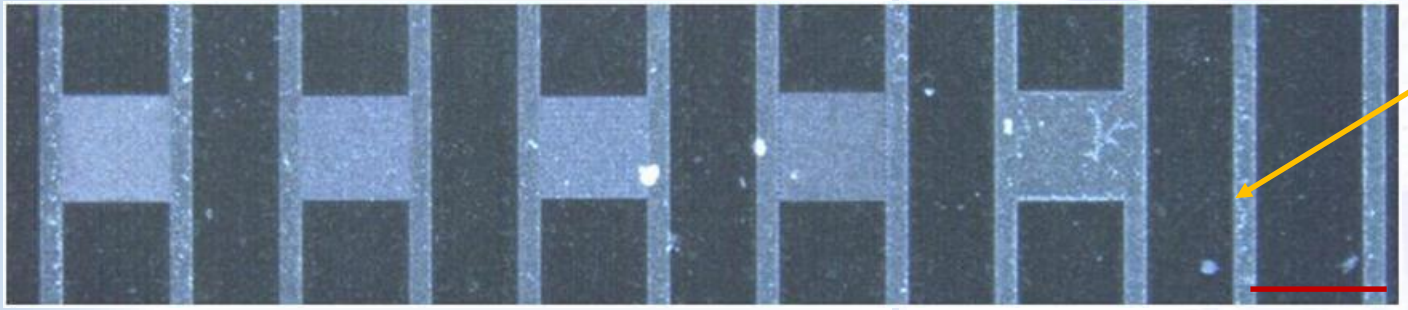
- Die attach:
  - Die pick and place normally required a direct top contact on the die
  - Permanent die fixation usually performed at elevated temperature (>40°C, typically 150°C)
- Wire bonding: standard technology requires elevated temperature (>40°C, typically 150°C)
- Encapsulation: standard technology requires elevated temperature (>40°C, typically 150°C)

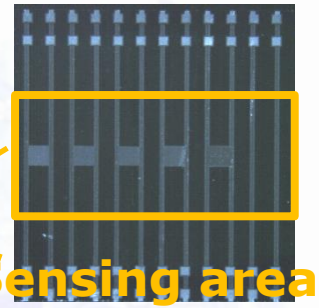
Die mounting

- Pick and place without direct contact with sensing area (no damage to the bio-functionalized layer, no damage to vulnerable IDAM)
- Permanent fixation is achieved at room temperature

Sensing area observation

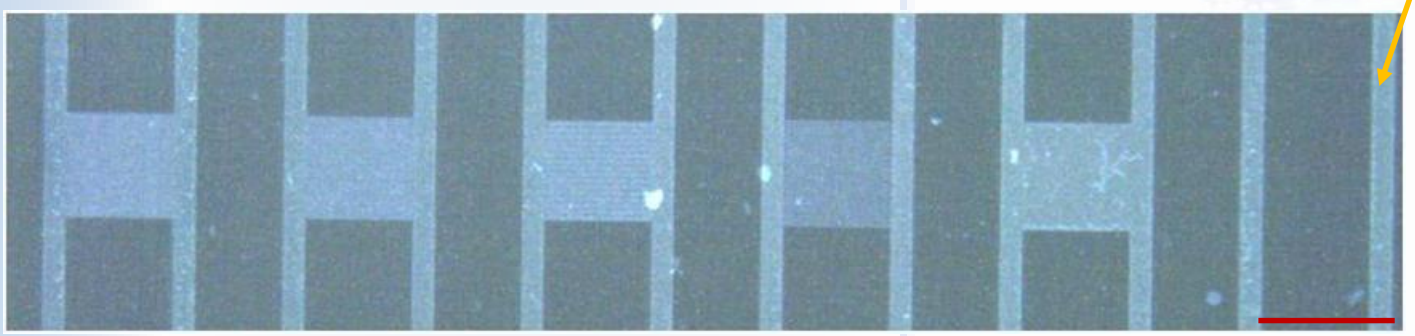
As received





200 µm

After encapsulation



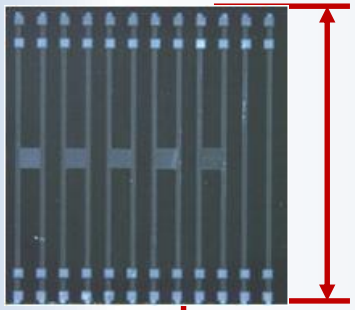
200 µm

No visual damage induced during the assembly flow

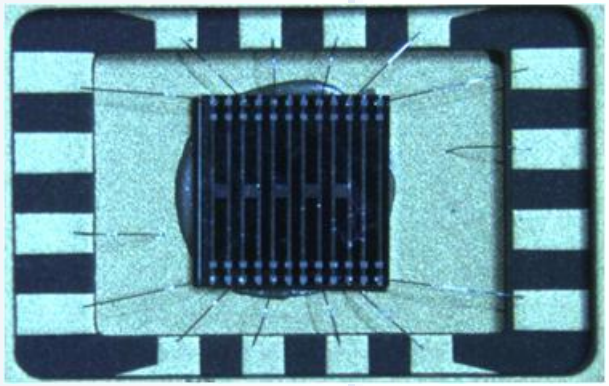
Wire bonding

- Industrial standard is Au wire bonding. Cu wire bonding emerges. It total they counts for 90%. They requires elevated temperature (typically 150-220°C)
- We interconnect the sensor die using Al wire bonding (room temperature process)
- Al wire bonding is currently used for special application (military, space etc)

Process flow

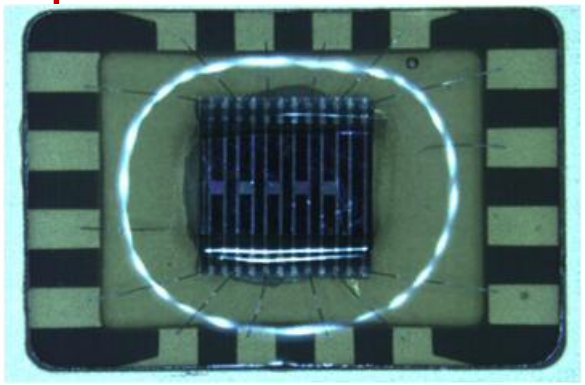


"As received sensor die (after bio-functionalizati on)



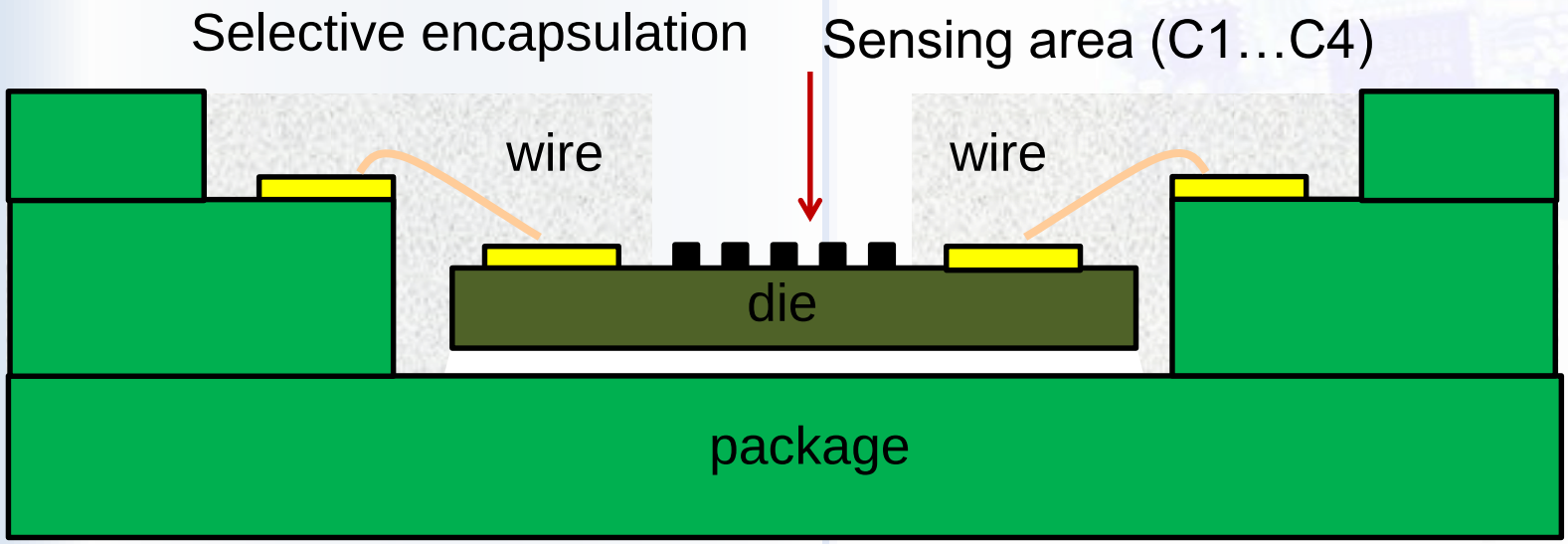
Sensor die mounted into package and wire bonded

Encapsulated sensor die (transparent encapsulant)



Assembled sensor

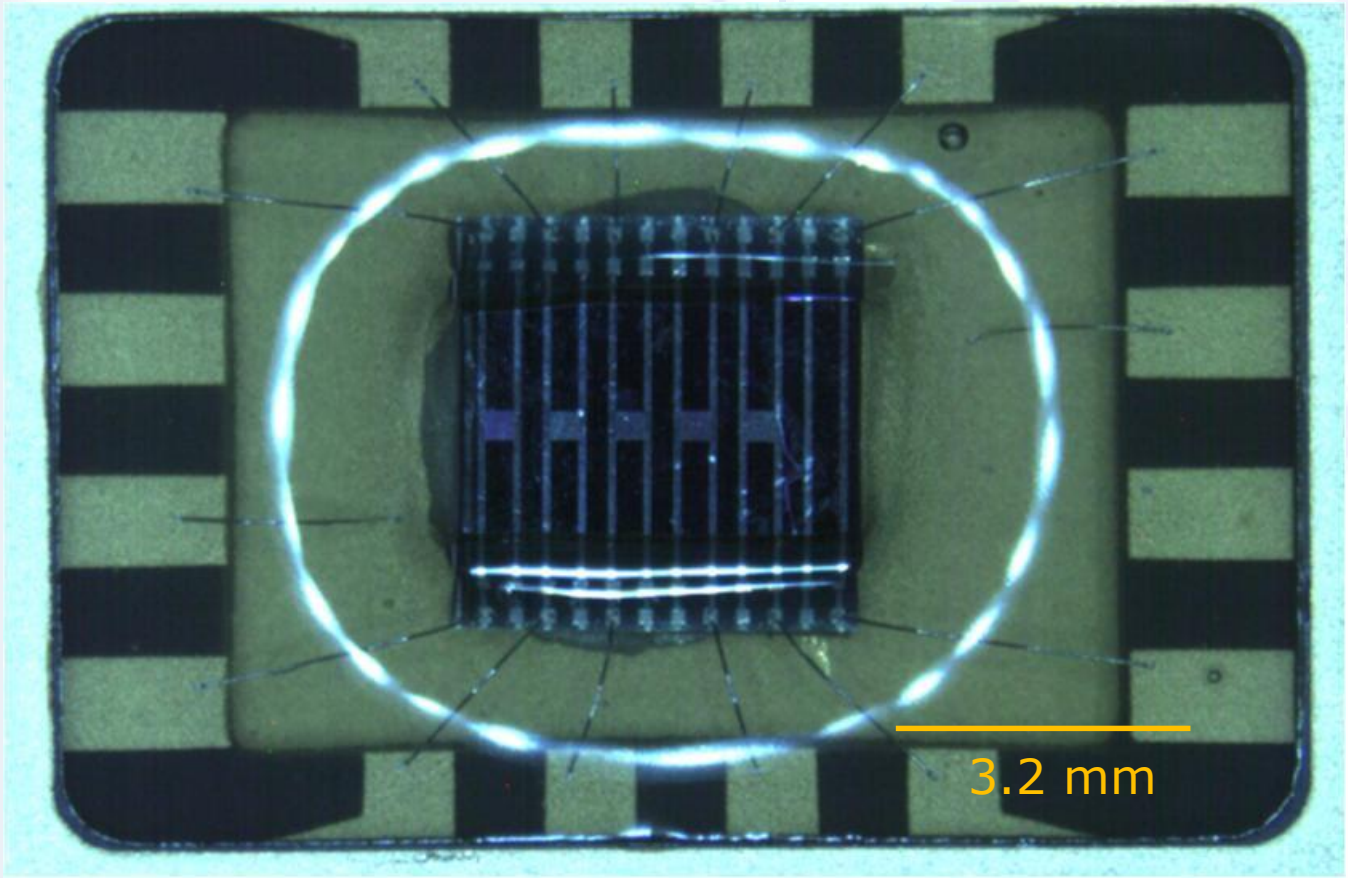
Cross sectional view



Encapsulation challenges

- Partial encapsulation to define accurately the sensing area (1mm x 3 mm and 0.5 mm high):
  - dam (high viscosity) and encapsulant (lower viscosity)
  - Industrial process: partial molding
- UV curable encapsulant (UV spot intensity: 18.5W/cm2 irradiance maximum output, wave length of 320-500nm), maximum 20 sec
- Such UV exposure causing no direct damage to bio-functionalized layer of the sensor (tested experimentally)

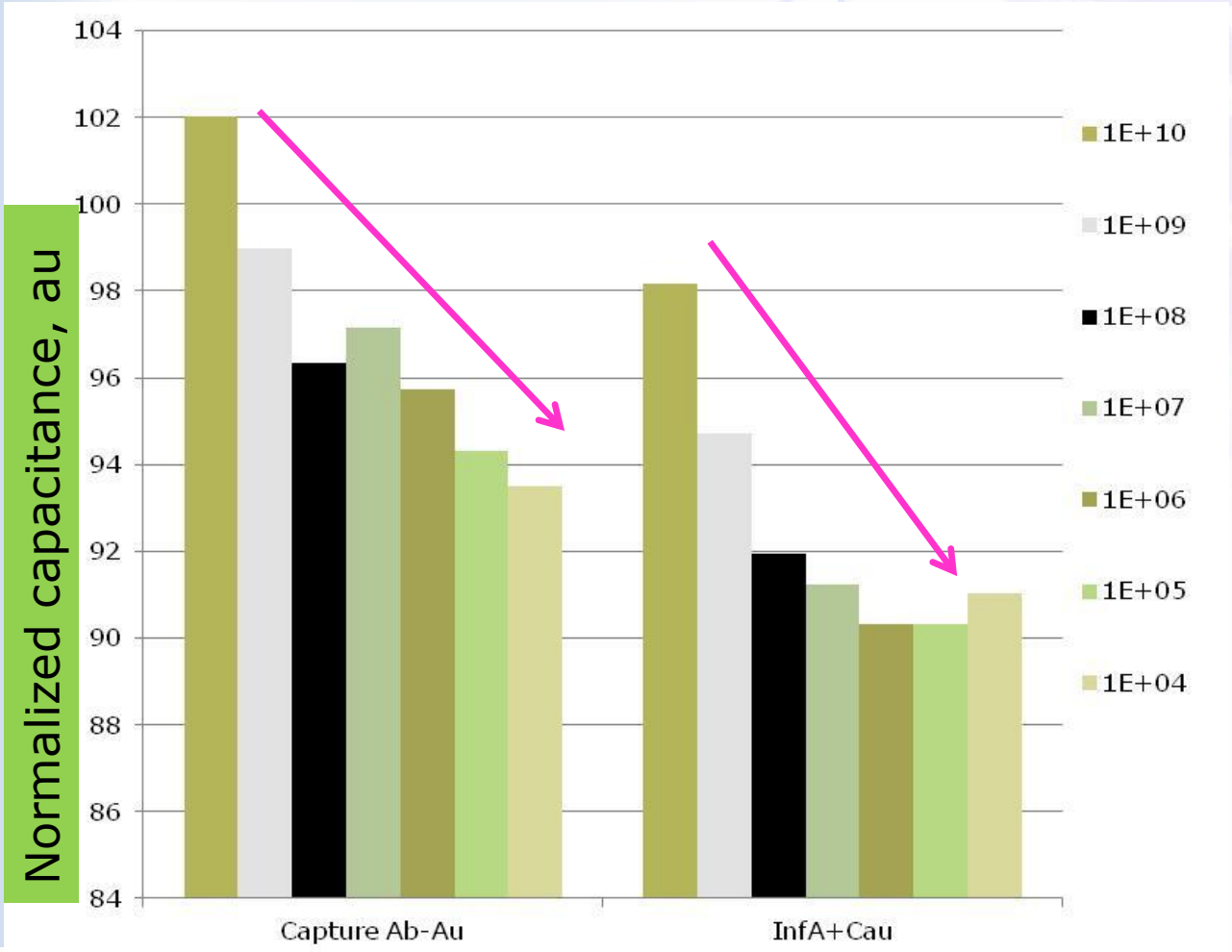
Assembled sensor (top view)



Electrical characterization

- Capacitance and conductivity measurements (PO_4 buffer; 20 mM, pH 8)(freq=100 kHz): the measurements were performed with a LCR meter with different bias voltages. Different dilutions of (left) antibody conjugated with gold bead, in contact with antibodies (initial concentration= 10^{13} beads/mL) or (right) different dilutions of the Influenza A virus were tested.
- For the measurements of the Influenza A virus, the signal was enhanced with an anti-Influenza antibody conjugated with a gold nano-bead. The same trend was observed for both targets.

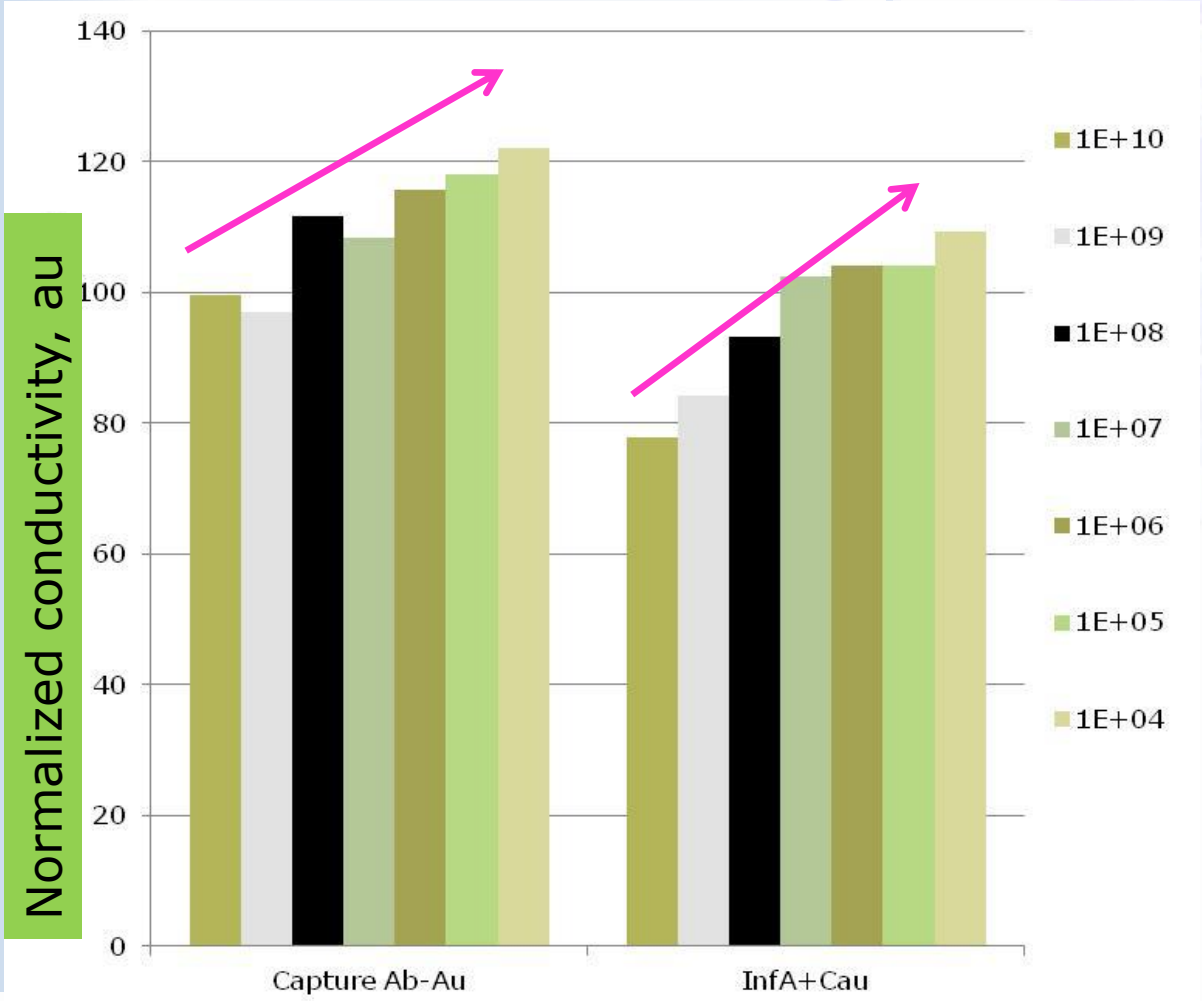
Capacitance



Ab-Au:
antibody conjugated with gold nano-bead

InfA+Cau:
Influenza A virus enhanced with an anti-Influenza antibody conjugated with a gold nano-bead

Conductivity



Ab-Au:
antibody conjugated with gold nano-bead
InfA+Cau:
Influenza A virus enhanced with an anti-Influenza antibody conjugated with a gold nano-bead

Conclusion

- We developed a convenient method for the assembly of the bio-functionalized sensor
- The process temperature is below 37°C; there is no direct contact between the die handling tool and the bio-functionalized area of the bio-sensor
- Additionally, the UV exposure, specifically intensity and time are limited to a sustainable level for inducing no damage to the bio-sensor
- The realized sensor performs detection and semi-quantification of influenza A viruses.

Partner and contact

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