

# L2: Laboratory for Microsystems in biomedical and environmental applications

- Mission
- Main expertise
- International Networks
- National Networks
- Research Team

The **Mission** of the laboratory for microsystems in biomedical and environmental applications is research, focused on the

development of microsensors (chemo resistive and resonant gas sensors), electrodes for biological sensors, microprobes for recording of electrical activity of cells and tissues, microfluidics and integrated technologies (silicon, polymers, biomaterials), education in the field of micro chemo and biosensors (in cooperation with University "Politehnica" of Bucharest), and services in design, simulation and technology for bio- and chemo-applications.

**Main expertise:** development of a large area of microsensors (chemoresistive, resonant gas sensors, accelerometers, microarrays, ISFET (Ion Sensitive Field Effect Transistors) sensors, electrodes for biological sensors, microprobes for recording of electrical activity of cells and tissues), in terms of software simulations / modelling, using MEMS-specific CAD software (CoventorWare, CADENCE), technological development and electrical characterisation. Microfluidic platforms simulation and realization including tubes, microfluidic connectors and reservoirs, pumping system and microsensors integration are part of the laboratory expertise.

The team was working in 20 national projects during the last 5 years, and is currently involved in seven FP6 projects, both research projects and support actions.

The laboratory is involved in several **national and FP6 projects and networks**.

#### **National projects:**

- **NEUROSENSE** ("Integrated system for concurrent electrophysiological and chemical recording at neuronal level");
- **IMUNOSENSE** ("Miniaturized immunosensor arrays technology, for herbicide detection");
- **HINAMASENS** - ("Nanostructured hybrid materials for sensors, for therapy and diagnostic usage") - all are national complex projects,.

The most important **International projects:**

- **INTEGRAMplus** ("Integrated MNT platforms and services - Service Action") - FP6 IP, IST, 2006 - 2008,
- **TOXICHIP** ("Development of a toxin screening multi-parameter on-line biochip system") - FP6 STREP, IST, 2006 - 2009; Network of Excellence: **4M** ("Multi-Material Micro Manufacture: Technologies and Applications") - FP6 NMP NoE, 2004 - 2009;

#### **Research team:**

The Laboratory team includes 12 people, seniors and young researchers with multidisciplinary expertise (microelectronics, physics, chemistry, biology).



**Team from left to right:** Claudia Roman; Carmen Moldovan; Bogdan Firtat; Rodica Iosub; Cristina Pachi; Marian Ion;

## Laboratory Head - Dr. Carmen Moldovan ([carmen.moldovan@imt.ro](mailto:carmen.moldovan@imt.ro))



**Dr. Carmen MOLDOVAN** is the head of the laboratory, and Associated Professor at the Faculty of Electronics and Telecommunications, University "Politehnica" of Bucharest.

She graduated on Electronics and Telecommunications and she owns a PhD in Microsensors.

She is contact person for IMT in **INTEGRAMplus** IP (IST), dealing with technology convergence and integration and virtual design and manufacturing. She is responsible from IMT side in the TOXICHIP project, STREP (IST), for the development of temperature, pH sensors and O2 sensor integrated into a microfluidic platform for toxicity detection. She is involved in the **4M** NoE (NMP), working on demonstrators, in Ceramic cluster, having the goal to integrate a non-standard micromachining process into a ceramic substrate and in the Sensors and Actuators cluster. She is a member of: **IEEE and Science and Technology Commission of the Romanian Academy** and **NEXUS Steering Committee Member**. The scientific activity is published in more than 55 papers in journals, books and communications in Proceedings.

L2: The most Important running projects

**“Integrated MNT platforms and services – Service Action” – INTEGAMplus**

(Contract no. 027540).

Project coordinator: Dr. Christopher Pickering, QinetiQ, Malvern, UK.

**MICROFLUIDIC PESTICIDE BIOSENSOR**

**Characteristics:**

- The biosensor is based on silicon chip and acetylcholinesterase biomaterial
- The sensitivity of the sensors is in the range of  $10^{-9}$  M-  $10^{-6}$  M
- The sensor is reacting at organophosphorus compounds that can be found in food, water, drugs, soil, vegetables, fruits.
- The answer of the sensor is fast and the overall preparation and measuring operation can be done in less of ½ hour.

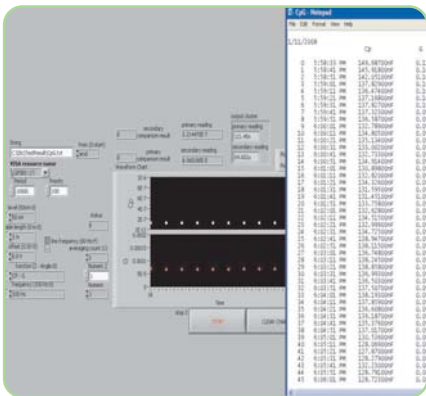
**Overview:** The biosensor is placed into the microfluidic module which allows the preparation of the sensor by injection of the electrolyte, the introduction of the sample and the electrical signal recording by using 4 spring probes connecting the biosensor pads with the measuring instruments.

IMT has developed the silicon chip, the electrolytes and the specifications for sensor preparation and measuring. The sensor is a consumable one and needs to be removed after every detection step. According to end-users requests, the pH and temperature can be monitored inside the microchannels. A pH and a temperature sensor will be placed close to biosensor side.

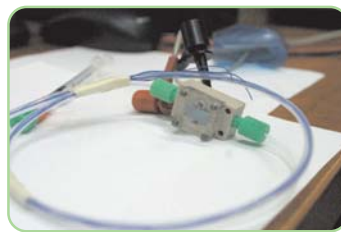
The microfluidic module hosting the silicon biochip was developed in partnership with Epigem Ltd., UK.

The sensor’s measurements were performed using a LabView environment.

The system can be a useful tool for Food Inspection Laboratories (milk, water, juice, etc), Food industry, Pharmaceutical industry, Environment and Agriculture organizations, allowing fast detection, fast replacement of samples, data acquisition and data storage. The system will be low cost, user friendly, precise and efficient.



Print screen of the Labview interface



Microfluidic pesticide biosensor

**PESTICIDE BIOSENSOR**

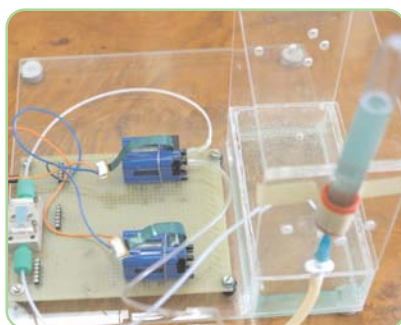
The interdigitated electrodes surface is functionalised for biomaterial deposition in oxygen plasma, Plasma Etcher Etchlab 200, than Poly(ethylene glycol)300 (PEG): Ethanol (EtOH) 1:1 solution is deposited by adjustable air-displacement pipette (Gilson) 0,2 µL, as matrix for immobilized enzyme (AChE). The sensor was placed into a fluidic module which contains the electrical connections, injection and/or fluid transport and the reaction chamber with 2,5 µL volume, to ensure the measurements.

The silicon chip is based on interdigitated electrodes, 6mm x12 mm which are deposited with acetylcholinesterase enzyme.

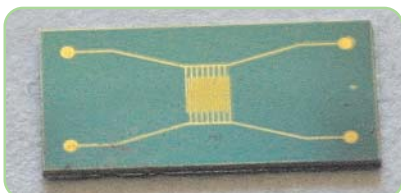
**Measurements**

The impedimetric acetylcholinesterase (AChE) biosensor allows the detection of the pesticides by the enzyme blocking in the presence of pesticide in the sample near  $10^{-6}$  M.

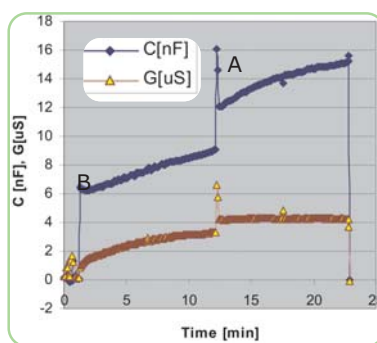
**Example: Detection of Dichlorvos.** Acetylcholine iodide as substrate was injected and a clear and fast increase of the capacity and conductivity has been observed (Figure 3, point A). The evolution of the values was monitored for 10 minutes. Then, it was injected an inhibitor solution, Dichlorvos  $10^{-6}$  M in the same electrolyte



Silicon biochip into the microfluidic module, pumps and reservoirs



The interdigitated silicon chip



Conductance and capacity versus time: A- substrate injection, B – inhibitor injection

solution (point B), which remained in contact with the immobilized enzyme for the next 10 minutes. After the injection of the inhibitor (insecticide Dichlorvos), measured values of the conductivity remained constant while the values of the capacity tend to be stabilized at the end of the measuring period. This demonstrates that the enzyme reaction was blocked by the presence of the studied insecticide.

\* Results obtained within the FP6 project **INTEGAMplus**

**Project coordinator: Dr. Christopher Pickering, QinetiQ, Malvern, UK.**

**Consortium members:** Coventor, France; CSEM, Switzerland; Epigem, UK; IMM, Germany; IMT, Romania; ITE, Poland; Silix, Sweden; ULAN, UK; Yole, France.

### EUKARYOTE TOXICHIP PLATFORM

**ToxiChip, STREP**, Priority 2 -IST, Contract Number: 027900, 2006-2009,  
**Coordinator: PhD. Eric Moore**, e-mail:eric.moore@tyndall.ie; Univ College Cork - National University of Ireland.  
<http://www.toxichip.org>

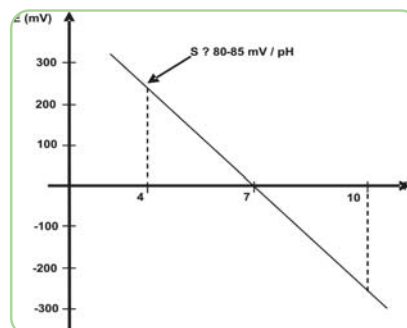
IMT provided within the project integrated pH and Oxygen sensors for monitoring of living cells exposed to toxicants. The sensors have been designed, fabricated and measured within IMT. The sensor platform (containing temperature, oxygen and pH sensors) was implemented and characterized.

Also, IMT worked on the microfluidic system to integrate the sensors platform. The microfluidic design was aimed at providing independent exhaust in order to avoid cross contamination issues.

#### Measurements:

##### pH Measurement

It is a voltage measurement at zero current. The instrument must have the input resistance higher as 100MΩ.



pH Measurement

##### Measurement of the diluted O<sub>2</sub>

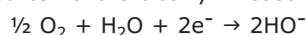
It is a current (I) measurement in the range of μA at a preset voltage of (between -700 and -900mV) applied on the working electrode.

In order to reduce the problem of O<sub>2</sub> consumption during the measurement step, it is very important to define the appropriate duration for measuring (in LabView).

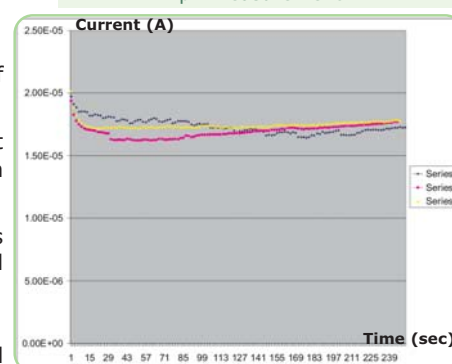
In our experiment we used 6-10 seconds, no more than 10-15sec is recommended. After measurement, the voltage source must be electrical decoupled to avoid any O<sub>2</sub> consumption.

The measurement cell answer at O<sub>2</sub> is linear, with the values 0.00μA for CO<sub>2</sub> = 0. From that reason the current initially measured will be considered the current corresponding to saturation of the solution with O<sub>2</sub> (100% at the ambient pressure and temperature, which is corresponding at ~ 8mg O<sub>2</sub> / liter in water).

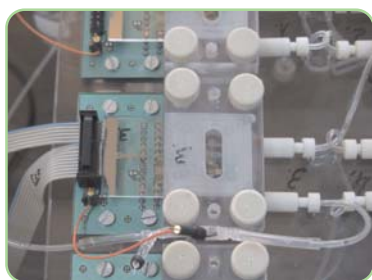
We are applying -900mV on the working electrode versus the reference electrode. We started with low values of Voltage and we are increasing the voltage value up to the point (-900mV) where the measured current is clearly "measurable" as an indication that the reaction is taking place.



It is very important to measure O<sub>2</sub> in short duration steps (up to max 10 sec/ measurement).



Measurement curves of O<sub>2</sub> - Very High concentration oxygen media (micro Amps range)



Picture of the microfluidic module and sensors



\* **Results** obtained within the FP6 project "Development of a toxin screening multi-parameter on-line biochip system" – **TOXICHIP**

**Project coordinator: Dr. Eric Moore, Tyndall National Institute, Cork, Ireland. Consortium members:** HUJ, Israel; IMT, Romania; JRC, Italy; TAU, Israel; Scienion, France; Vigicell, France; ISMB, Italy.