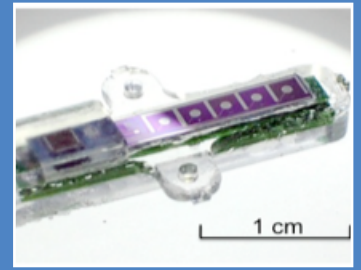




i-IronIC

IMPLANTABLE/WEARABLE SYSTEM FOR ON-LINE MONITORING OF HUMAN METABOLIC CONDITIONS



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What it's about...

Building a prototype of a human implant to detect various markers of diseases and supporting remote monitoring.

Context and project goals

The project goals were to develop a fully implantable sensors system, involving multi-panel sensors capable to sense several metabolites, all in parallel, in real-time and CMOS design for the fully-implanted, complex, and low-consumption electronics for sensing and remote powering.

How the project differentiates from similar competition in the field

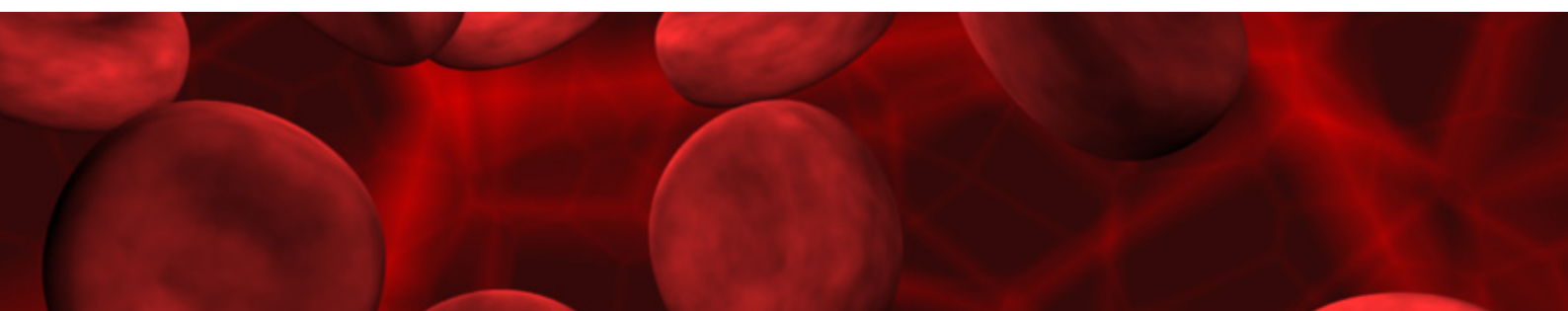
- The smallest multi-panel fully implantable biochip ever built
- A deep integration of bio and nano-materials onto micro-fabricated platform for multi-target sensing
- The development of an intelligent patch to be located on top of the skin for remote powering of the implant and data transition to a smart-phone.

Quick summary of the project status and key results

- The smallest multi-panel fully implantable biochip
- Biocompatible packaging for the implantable biochip
- The intelligent patch for remote powering
- Detection of some non-commonly detected metabolites (e.g., the ATP)
- Design of a very tiny ($1.5 \times 1.5 \text{ mm}^2$) integrated circuit CMOS frontend for the nano-bio-sensor

Patent

Irene Taurino, Magrez Arnaud, Forro Laszlo, Giovanni De Micheli, Sandro Carrara: Close and Selective Integration of Carbon Nanomaterials by CVD onto working microelectrodes of multi sensing electrochemical biosensors, filed at the European Patent Office on September 13th 2013, registration # EP 13184291.6.



Success stories

One of the industrial partners (Menarini Diagnostics) asked the team to push the technology set during this project for applications on intensive care units. A new proposal has been written following this request and the project has been funded. The new project phase under this new grant started in late 2013. Another successful story is the deep and intimate integration of Carbon nanotubes in a selective manner on multi-panel platforms that succeeded in getting a new patent and a top-publication in the Royal Society Journal *Nanoscale* (Impact Factor > 6).

Presence in the media:

Strong coverage in dozens of media outlets worldwide, including:

- BBC News - 'Under the skin' blood-testing device developed
- le figaro.fr: Un mini-laboratoire sous la peau
- bild.de: Dieser Chip kontrolliert ihr Blut
- El Mundo - Un diminuto laboratorio portátil bajo la piel
- corriere.it: Sotto pelle laboratorio analisi sangue
- dailymail: The medical lab implanted under the skin that can automatically phone a doctor BEFORE you fall ill
- The Times of India: Now, a device to predict heart attacks
- Hong Kong Herald - Mini 'Blood Labs' Can Predict A Heart Attack
- NZZ: Blutanalyse unter der Haut
- die Welt: Mini-Labor unter der Haut kontrolliert Blutwerte
- Tages Anzeiger: Ein Blutlabor, das unter die Haut geht

Main publications

Jacopo Olivo, Sandro Carrara, Giovanni De Micheli, Energy Harvesting and Remote Powering for Implantable Biosensors, *IEEE Sensors Journal*, 11(2011), 1573-1586 (Journal-Issue Cover-Page)

Irene Taurino, Sandro Carrara, Mauro Giorcelli, Alberto Tagliaferro, Giovanni De Micheli, Electrochemical comparison of two different oriented multi-walled carbon nanotubes directly grown on Si-wafers toward potassium ferricyanide detection, *Surface Science*, 606 (2012) 156-160

Irene Taurino, Sandro Carrara, Mauro Giorcelli, Alberto Tagliaferro, Giovanni De Micheli, Comparing sensitivities of multiple oriented multi-walled carbon nanotubes on silicon wafer for electrochemical biochips, *Sensors and Actuators B: Chemicals* 160 (2011) 327-333

Jacopo Olivo, Sandro Carrara, Giovanni De Micheli, Biofuel Cells and Inductive Powering as Harvesting Techniques for Implantable Sensors, *Science of Advanced Materials*, 3(2011), 420-425

Cristina Boero, Jacopo Olivo, Sandro Carrara, and Giovanni De Micheli, A self-contained system with CNTs-based biosensors for cell culture monitoring, *IEEE Journal on Emerging and Selected Topics in Circuits and Systems (JETCAS)* 2(4), pp.658-671 (2012).

Irene Taurino, Sandro Carrara, Mauro Giorcelli, Alberto Tagliaferro, Giovanni De Micheli, Carbon Nanotubes With Different Orientations for Electrochemical Biodevices, *IEEE Sensors*, 12, 3356-3362 (2012)

Sandro Carrara, Sara Seyedeh Ghoreishizadeh, Jacopo Olivo, Irene Taurino, Camilla Baj-Rossi, Andrea Cavallini, Maaikje Op de Beeck, Catherine Dehollain, Wayne Burleson, Francis Gabriel Moussy, Anthony Guiseppi-Elie, Giovanni De Micheli, Fully Integrated Biochip Platforms for Advanced Healthcare, *Sensors* 12, 11013-11060 (2012)

Irene Taurino, Arnaud Magrez, Federico Matteini, László Forró, Giovanni De Micheli, Sandro Carrara, Direct growth of nanotubes and graphene nanoflowers on electrochemical platinum electrodes, accepted in *Nanoscale*, 2013

Irene Taurino, Viviane Van Hoof, Giovanni De Micheli, Sandro Carrara,, Superior sensing performance of MWCNT-based electrodes to detect unconjugated bilirubin, *Thin Solid Films* 548, 546-550 (2013)

Jacopo Olivo, Sandro Carrara, and Giovanni De Micheli,, A study of Multi-Layer Spiral Inductors for Remote Powering of Implantable Sensors, , *IEEE Transaction of Biomedical Circuits and Systems* 7(2013) 536-547

Jacopo Olivo, Sandro Carrara, and Giovanni De Micheli,, Micro-fabrication of high-thickness spiral inductors for the remote powering of implantable biosensors, , *Journal of Micromechanics and Microengineering*, 113 (2014) 130-135

Fabrizio Mastrantonio, Francesco Valgimigli, Lucia Grassi, Paolo Cappa, Giovanni De Micheli, Sandro Carrara,, Comparative Performance of Different Nanostructured Electrochemical Sensors on Insulin Detection, , *BioNanoScience* 2(2013) 1-4

Irene Taurino & Reiss Renate, Michael Fairhead, Michael Richter, Linda Thšny-Meyer, Giovanni De Micheli, Sandro Carrara,, Comparative study of three lactate oxidases from *Aerococcus viridans* for biosensing applications, *Electrochimica Acta*, 93 (2013) 72-79

