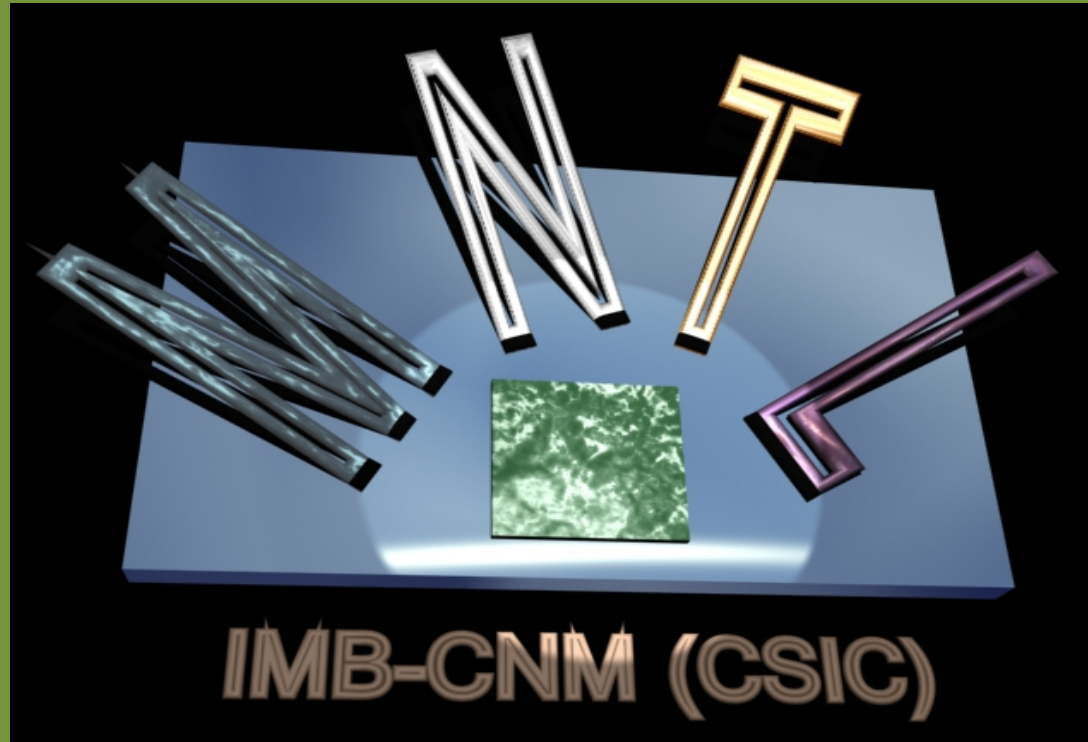


# Silicon chips inserted into living cells



**José A. Plaza**

Micro- and NanoTools Group IMB-CNM (CSIC)

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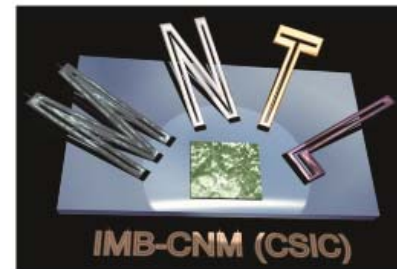
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## Micro and Nano Tools Group

### Introduction



**Welcome to our research group!**



Micro and Nano Tools group was created in 2001 within the frame of Micro and Nano Systems Department at the **National Microelectronic Institute of Barcelona IMB-CNM (CSIC)**, Cerdanyola del Valles, (Barcelona - Spain). With strong background in MEMS/NEMS, our main goals are the development of micro and nano tools based on semiconductor technology, to provide unprecedented knowledge related to fundamental problems in science.

We are a small but highly multidisciplinary group composed of physicists, engineers and chemists, that allows us to work in different areas of knowledge ranging between design, FEM simulations, fabrication and characterization of microsystems and nanosystems.

## NewsRoom

2013 Nanowerk's TOP TEN Spotlight:

[Silicon chips inserted into living cells can feel the pressure](#)

Link: <http://www.nanowerk.com/spotlight/spotid=31406.php>



2010 Nanowerk's TOP TEN Spotlight:

[Future bio-nanotechnology will use computer chips inside living cells](#)

Link: <http://www.nanowerk.com/spotlight/spotid=15292.php>



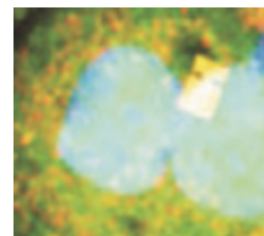
[Silicon chips detect intracellular pressure changes in living cells](#); R. Gómez-Martínez et al.; *Nature Nanotechnology* 8 (2013) 517-521.

- 18 July 2013

[Silicon chips inserted into living cells](#)

- 24 August 2013

[The Inside of Scoop](#)



Fundación Repsol selecciona a la Spin-off del grupo "Smalle Technologies" como uno de los ocho proyectos en la segunda edición de su Fondo de Emprendedores



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## Research activities

Micro and Nano Tools group is divided in two working lines:

- Micro and Nano Tools (Team leader: Jaume Esteve)
- Micro and Nano Tools for Cell Biology (Team leader : Jose Antonio Plaza)

### • Micro and Nano Tools

#### Team leader: Prof. Jaume Esteve Tintó

This group division is focused on technology and processes development; as well as on the design, fabrication and characterization of micro and nano actuators, ranging from accelerometers to force and pressure sensors, piezoresistive resonators, and opto-mechanical actuators based on pneumatic elastomers, among others.



#### Relevant Projects:

- NOMS: Nano Opto Mechanical Systems (2009-2012). FP7-NMP-2008-SMALL-2 ,NMP4-SL-2009-2289 16.
- MOEMSWORKS: Development and evaluation of a method to produce MEMS devices in a standard CMOS process. Eurípedes project nºEUR 07-402
- INTRACELL: Intracellular chips to study living cells (2005-2007). Project CSIC- 200550F0241 8
- DELFOS: Development of FBAR technology (2004-2007). EPSON electronics-GmbH, CSIC -CNM, D+T Microelectrónica, Seiko Epson Corporation (EPSON-BRD1 I+D contract).

## • Micro and Nano Tools for Cell Biology

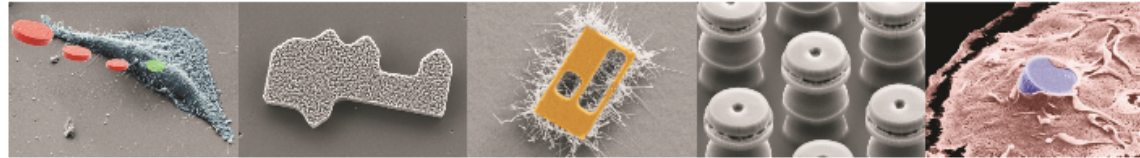
**Team leader: Dr. Jose Antonio Plaza Plaza**

This group division englobes the design, fabrication and characterization of micro and nano systems (MEMS and NEMS) and advanced sensing principles for single cells studies, as well as a wide variety of smart particles. For their characterization, we use finite element analysis as well as different physical and biological microscopy techniques, as SEM, FIB and confocal imaging.

Examples of systems developed in this section can be classified depending of their application as:

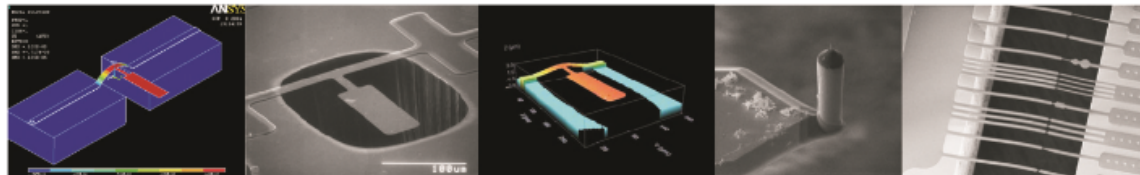
### Intracellular tools:

Silicon and polysilicon Barcodes for cell labeling, micro and nano particles as multifunctional platforms, drug delivery systems, ...



### Extracellular tools:

Micropipettes, mass and force sensors, cantilevers, membranes, magnetic actuators, ...



### **Relevant Projects:**

**MINAHE 1:** Micro and Nano Tools for atomic force microscopy (2002-2005). *This study was financed by the Spanish government through the TIC-2002-04280-C03-02*

**MINAHE 2:** Micro and Nano Tools for living cell studies (2006-2008) *This study was financed by the Spanish government through the MEC-TEC2005-07996-C02-01.*

**MINAHE 3:** Desing and Fabrication of MicroNanotools for study, identification and actuation in living cells (2009-2011) *This study was financed by the Spanish government through the MEC-TEC2008-06883-C03-01.*

**ICCPRESS:** It is possible to fabricate a mechanical microsenser, smaller than a living cell, which can monitor the intracellular pressure? (2010) *This study was financed by the Spanish government through the ACC.PIF-EXPLORA, TEC2009-07687-E.*

**MINAHE 4:** Design and Fabrication of micronanotools for life science (2012-2014) *This study is financed by the Spanish government through the TEC2011-29140-C03-01.*



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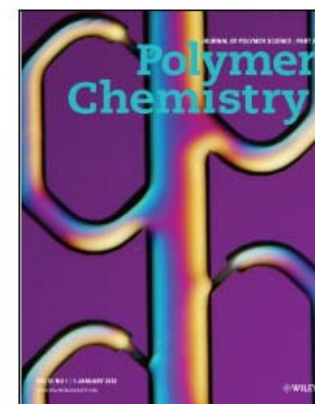
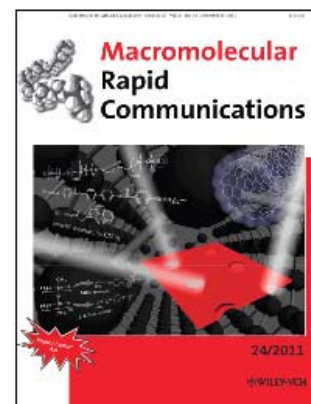
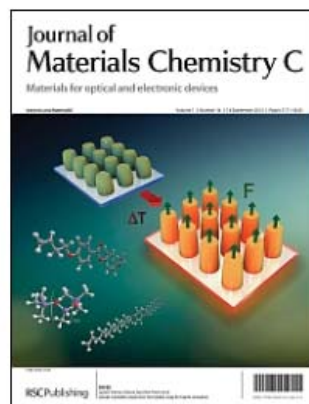
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## Publications



### MNT COVER GALLERY



### Most relevant publications

2014

- N. Torras, J. E. Marshall, K. E. Zivoviev, C. J. Camargo, E. M. Terentjev and J. Esteve. **Gas-Pressure Molding-Based Fabrication of Smart Actuators from Nematic Liquid-Crystalline Elastomers** Macromolecular Materials and Engineering, 299, pps. 7, (2014) Doi:10.1002/mame.201300462
- N. Torras, K. E. Zivoviev, C. J. Camargo, E. M. Campo, H. Campanella, J. Esteve, et al. **Tactile device based on opto-mechanical actuation of liquid crystal elastomers** Sensors and Actuators A: Physical, 208, 104-112, (2014) Doi:10.1016/j.sna.2014.01.012

## 2013

- Rodrigo Gómez-Martínez, Alberto M. Hernandez-Pinto, Marta Duch, Patricia Vázquez, Kirrill Zinoviev, Enrique J. de la Rosa, Jaume Esteve, Teresa Suárez & José A. Plaza

***Silicon chips detect intracellular pressure changes in living cells***

Nature Nanotechnology July 8 517-521 (2013) doi:10.1038/nnano.2013.118. [Front cover](#)

About the Cover:

The development of sophisticated devices to monitor, and eventually interfere with, essential cellular processes is an ongoing challenge. Now, José A. Plaza and colleagues have fabricated silicon chips that are small enough to be internalized inside cells and detect intracellular pressure changes. These devices can be considered the first step towards achieving a broad range of intracellular nanochips. A pseudocoloured scanning microscopy image (on the cover) shows a HeLa cell interacting with a silicon chip pressure sensor.

IMAGE: MARTA DUCH AND JOSÉ A. PLAZA, COVER DESIGN: ALEX WING

\* **Post in Nanowerk** - *the premier and most popular source for nanotechnology information.*

Michael Berger, *Silicon chips inserted into living cells can feel the pressure (w/video)*, July 18 15, 2013

- Klaudia Czaniková, Núria Torras, Jaume Esteve, Igor Krupta, Peter Kasák, Ewa Pavlová, Ivan Chodák, Mária Omastová

***Nanocomposite actuators based on ethylene vinyl acetate copolymer filled with carbon nanotube***

Sensors and Actuators B: Chemical, 186, 701 (2013) Doi:10.1016/j.snb.2013.06.054

- Antoni Sanchez-Ferrer, Núria Torras, Kirill Zinoviev and Jaume Esteve

***Liquid-Crystalline Elastomer Micropillar Array for Haptic Actuation***

Journal of Material Chemistry C, 1:5183-5190 (2013) Doi:10.1039/C3TC31109K. [Front cover](#)

- C.J. Camargo, A. Melendez, J. Robles, J. Esteve and I. Ramos

***Electrospun nanobridges towards self-heated gas sensors with enhanced sensitivity***

Journal of physics: Conference Series (JPCS), 421, 012002 (3/2013)

- H. Campanella, C.J. Camargo, J. Esteve and JM. Tsai.

***Sensitivity of thin-film bulk acoustic resonators (FBAR) to localized mechanical forces***

J. Micromech. Microeng, 23, 065024 (5/2013)

## 2012

- O. Penon, S. Novo, S. Duran, E. Ibñez, C. Nogues, J. Samitier, M. Duch, José A. Plaza, L- Perez-García  
***Efficient Biofunctionalization of Polysilicon Barcodes to the Zona Pellucida of Mouse Embryos***  
Bioconjugate Chemistry, 23, 12:2392-2402 (2012)
- A. Eichler, M. del Álamo Ruiz, A. Bachtold, J. A. Plaza  
***Strong coupling between mechanical modes in a nanotube resonator***  
Physical Review Letters, 109, 025503(2012)
- E. Coronado, A. Forment-Aliaga, E. Pinilla-Cienfuegos, S. Tatay, L. Catala, J. A. Plaza  
***Nanopatterning of Anionic Nanoparticles based on Magnetic Prussian-Blue Analogues***  
Advanced Functional Materials. DOI: 10.1002/adfm.201200067, (2012)
- D. Naumenko, V. Snitika, M.Duch, N. Torras, J. Esteve  
***Stress mapping on the porous silicon microcapsules by Raman microscopy***  
Microelectronic Engineering, 98, 488-491(2012)
- C.J. Camargo, H. Campanella, J.E. Marshall, N. Torras, K. Zinoviev, E.M. Terentjev and J. Esteve  
***Batch fabrication of optical actuators using nanotube-elastomer composites towards refreshable Braille displays.***  
Journal of Micromechanics and Microengineering, 22, 7, 075009. (6/2012). *Invited Paper in highlight in 2012 by JMM.*
- Jean Marshall, Yan Ji, Núria Torras, Kirill Zinoviev, Eugene M. Terentjev  
***Carbon-nanotube sensitized nematic elastomers for IR-visible photo-actuation***  
Soft Mater, (8) 5, 1570-1574 (2012) DOI: 10.1039/c1sm06656k.



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## PhD Thesis

### PhD thesis

Supervisor: Dr. Jose Antonio Plaza

- Title: **MicroNanoDispositivos electromagnéticos de corrientes parasitarias para aplicaciones en bioquímica y biología celular / Electromagnetic MicroNano Devices base on Currents parasites for Biochemical and Cellular biology applications** (2012).

PhD Student: Roberto Raúl Robaina Hernández

University: ISPJAE, Electric Engineering Faculty, Microelectronic Investigations Center (CIME), La Habana, Cuba.

- \* Title: **MicroHerramientas para la biología celular/MicroNanoTools for cell Biology** (2011).

PhD Student: Elisabet Fernández Rosas

University: Autonomus University of Barcelona (UAB), Barcelona

- Title: **MicronanoHerramientas para las ciencias de la vida/MicroNanoTools for life sciences** (2008).

PhD Student: María Jesús López Martínez

University: Autonomus University of Barcelona (UAB), Barcelona

- \* Title: **Desarrollo de microestructuras de vidrio/silicio para la fabricación de sensores de gases con circuitería CMOS asociada / Desing and fabrication of glass/silicon microstructures for on-chip integration of CMOS electronics and gass sensor array** (2004).

PhD Student: María Jesús López Bosque

University: Autonomus University of Barcelona (UAB), Barcelona

- \* Title: **Study and applications of ferrofluids in microfluidics** (2003).

PhD Student: Eng. Raquel Pérez Castillejos

University: Electronic Engineering Department, Polytechnic University of Catalunya (UPC), Barcelona

- Title: **La soldadura anódica vidrio-silicio en los sistemas microelectomecánico / Glass-Silicon Anodic bonding for Electromechanical Systems** (2000).

PhD Student: Eng. Estrella González Rodríguez

University: ISPJAE, Electric Engineering Faculty, Microelectronic Investigations Center (CIME), La Habana, Cuba

\*Co-supervisor.

**Supervisor: Prof. Jaume Esteve**

- Title: **FBAR technology and applications** (2008).

PhD Student: Humberto Campanella

University: Autonomus University of Barcelona (UAB), Barcelona

- Title: **Tecnologías de micromecanización y su aplicación a la fabricación de componentes para microfluídica / Micromechanization technologies and its application for microfluidic components fabrication** (1998).

PhD Student: Maria Cruz Acero

University: University of Barcelona (UB), Barcelona

- Title: **Microacelerómetros de silicio / Silicon microaccelerometers** (1997).

PhD Student: Jose Antonio Plaza

University: Autonomus University of Barcelona (UAB), Barcelona

- Title: **Puesta a punto de una tecnología de micromecanización superficial y su aplicación a la fabricación de sensores y actuadores / Surface micromachining: technology implementation and application for the fabrication of sensors and actuators** (1996).

PhD Student: Maria Ángeles Benítez

University: Autonomus University of Barcelona (UAB), Barcelona

- Title: **Design, fabrication and characterization of resonant silicon accelerometers** (1995).

PhD Student: Christopher Burrer

University: Autonomus University of Barcelona (UAB), Barcelona

- Title: **Fabricación y caracterización de sensores de pH tipo ISFET con contactos posteriores / Fabrication and characterization of ISFET type pH sensors with back contacts** (1993).

PhD Student: Ángel Merlos

University: Autonomus University of Barcelona (UAB), Barcelona

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### Patents

- Title: Enchufe inteligente para uso doméstico e industrial en redes eléctricas inteligentes / Intelligent switch for domestic and industrial uses, for intelligent electric network (September 2011).

Id number: P201131491

Titularity: CSIC

- Title: Encoded microparticles (October 2010).

Id number: PCT/ES2010/054/256

Titularity: UAB, CSIC

- Title: Device for generating electric power from small movements (In process of patent transfer).

Id number: EP10789045.1

Titularity: CSIC, UB

- Title: Micro electromechanical systems (MEMS) package for semiconductor integrated circuit (-).

Id number(s): US2008079142-A1, EP1908727-A1, JP2008091334-A

Titularity: SEIKO EPSON CORP.

- Title: Acelerómetro óptico integrado / Integrated optic accelerometer (April 2002).

Id number: ES9700154

Titularity: CSIC, Ikerlan

- Title: Cubeta tubulat con sensores químicos de estado integrados para aplicación a sistemas de análisis / Tubular tray with integrated chemical sensors for system analysis applications (February 2001).

Id number: ES2152763

Titularity: CSIC, UAB, Biosensores SL

- Title: Procedimiento de fabricación de capas de carburo de silicio (SiC) mediante implantación iónica de carbono y recocidos / Procedure for the fabrication of silicon carbide (SiC) layers through carbon ionic implantation and annealings (March 2000).

Id number: 200000813

Titularity: CSIC, UB

- Title: Método no destructivo para la determinación de la calidad de la soldadura anódica y mejora de contactos / Non-destructive method to determine the quality of the anodic bonding and contacts improvement (March 2000).

Id number: ES2141008

Titularity: CSIC

- Title: Acelerómetro triaxial / Triaxial accelerometer (December 1999).

Id number: ES2137847

Titularity: CSIC

- Title: Soluciones para el ataque de obleas de silicio y método para el ataque con tales soluciones / Solutions for Silicon wafers etching and etching methods using those solutions (December 1999).

Id number: ES9300156

Titularity: CSIC

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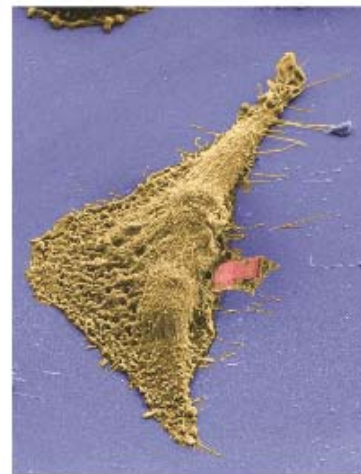
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