

Microtecnología: Desarrollo de BioMEMs

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Biodevices and MEMS Group

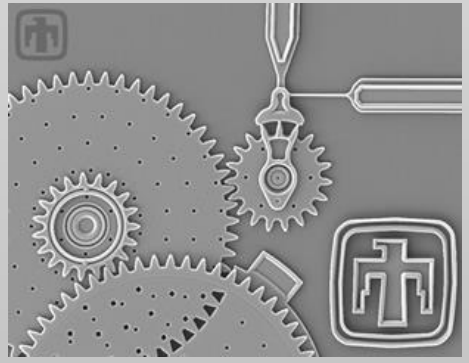
Water & Health Division

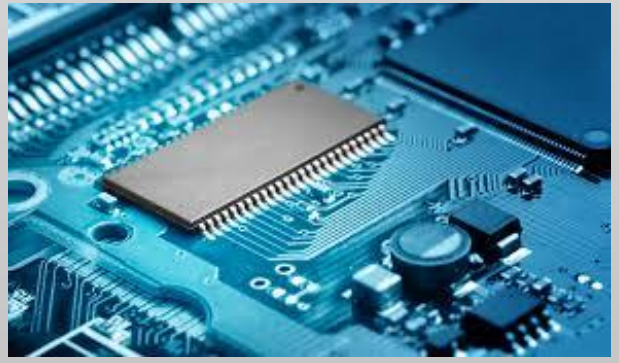


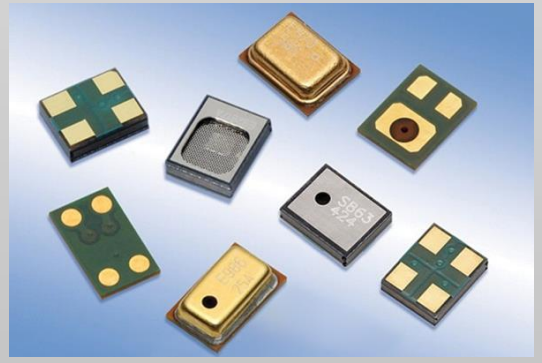
¿Qué son los MEMs?

MEMS: Micro Electro Mechanical Systems

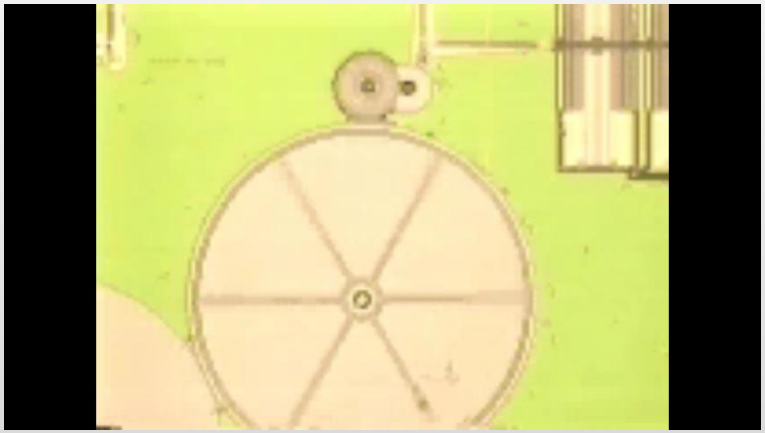
- Micro: estructuras micrométricas (μm) (1 cm = 10.000 μm)
- Electro: incluyen electrónica, ya sea para sensorizar, para “decidir” o para actuar
- Mechanical: pueden incluir estructuras 3D como vigas, microcanales, membranas móviles, etc…

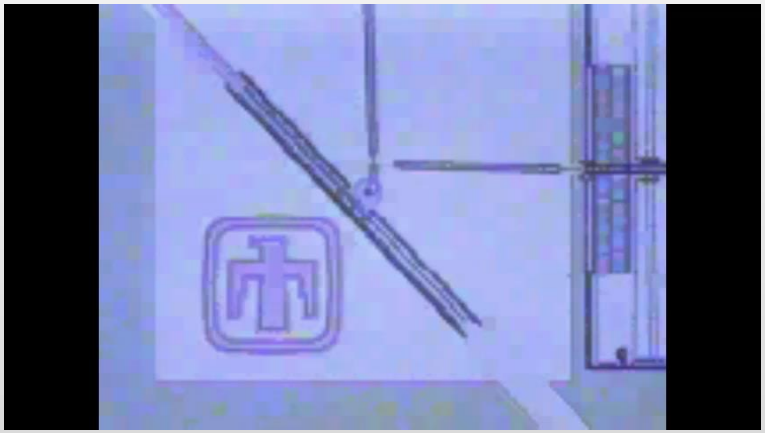


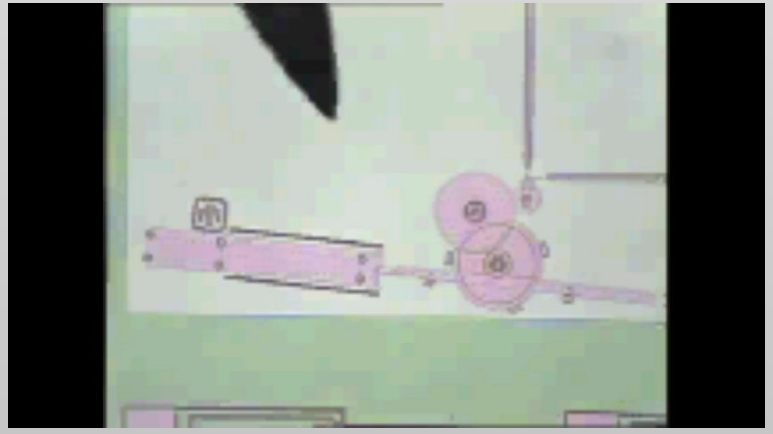


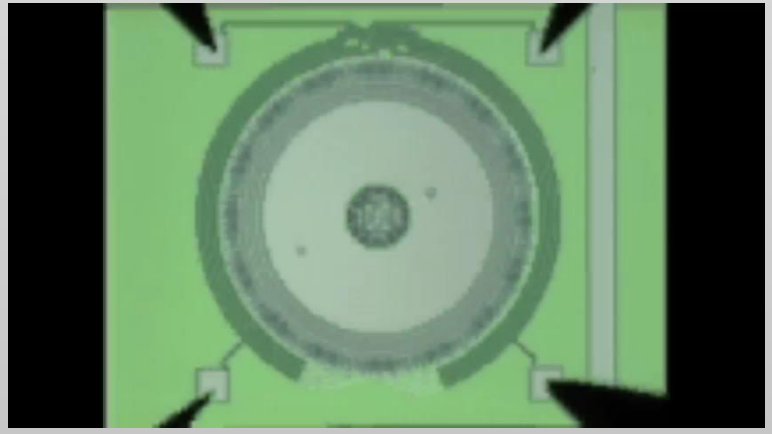


¿Qué son los MEMs?









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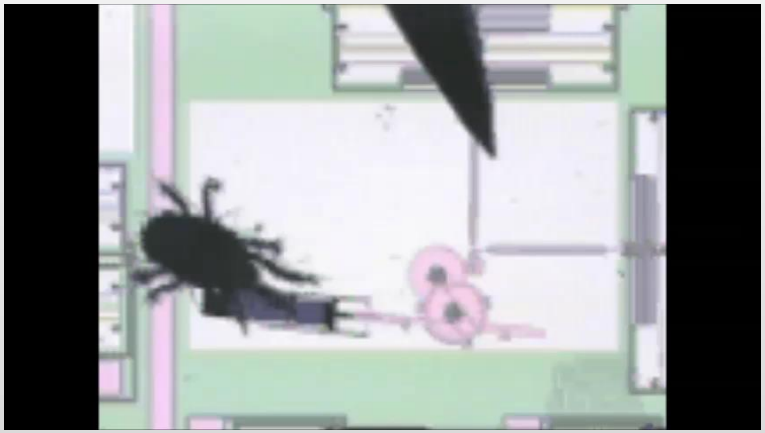
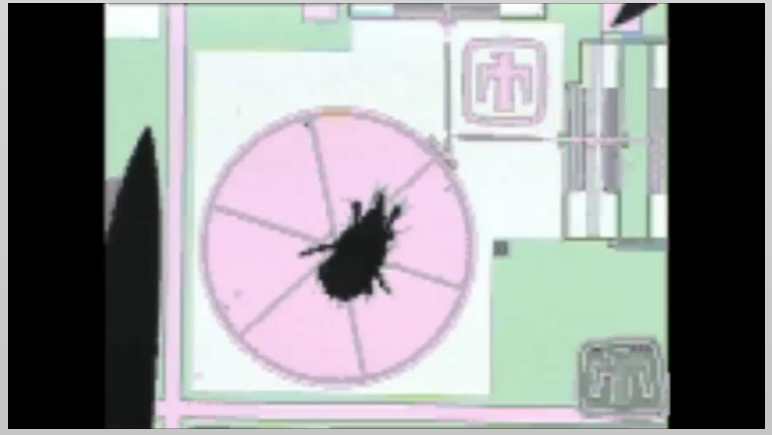
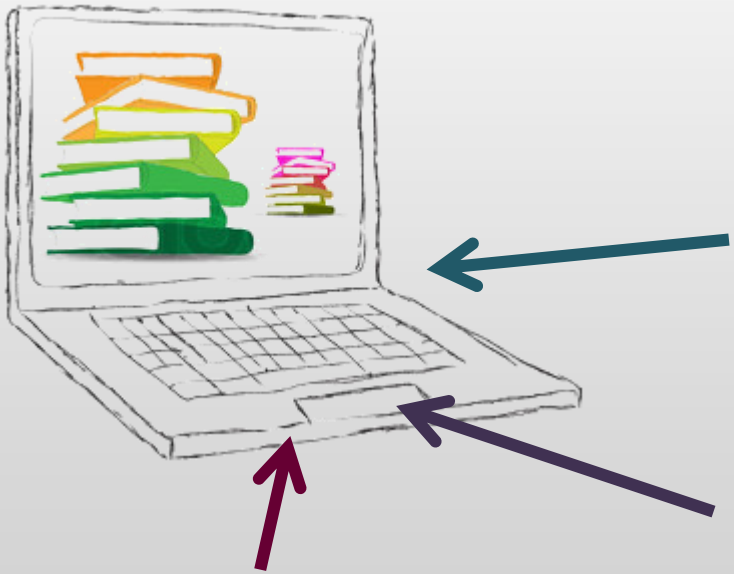
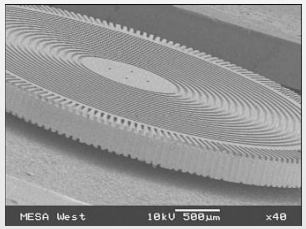




MEMS en el día a día



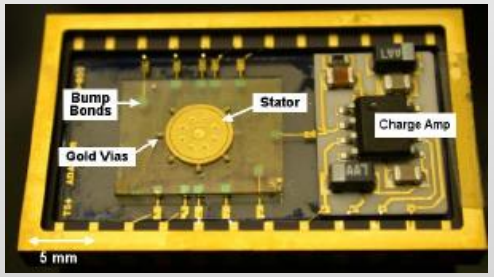
MEMS microphone for VOIP



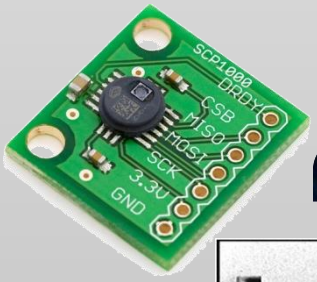


Sandia National Laboratories

Accelerometer for Hard Disc Drive (HDD) protection



MEMS pressure sensor in HDD



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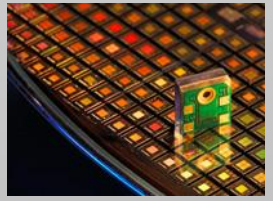

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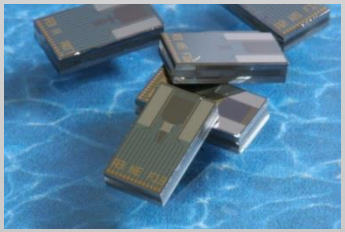
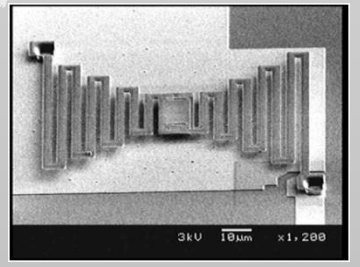


DTU Nanotech
Institut for Mikro- og Nanoteknologi



INO

MEMS en el día a día

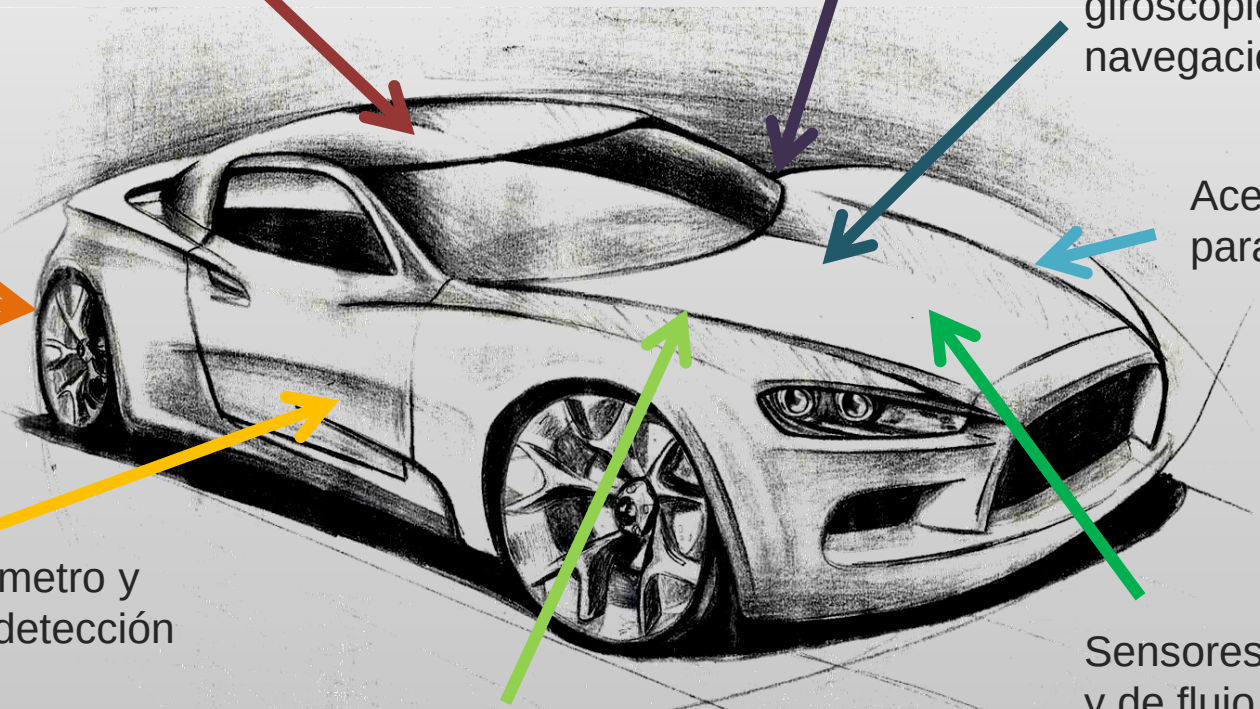
MEMS IR para mejorar la visión del conductor, monitor de carretera, temperatura de la cabina, anti-niebla, etc.

Sensores de flujo para calefacción, ventilación y aire acondicionado

Acelerómetro y giroscopios para ESP, navegación GPS, etc.

Acelerómetros para el airbag

Presión de los neumáticos



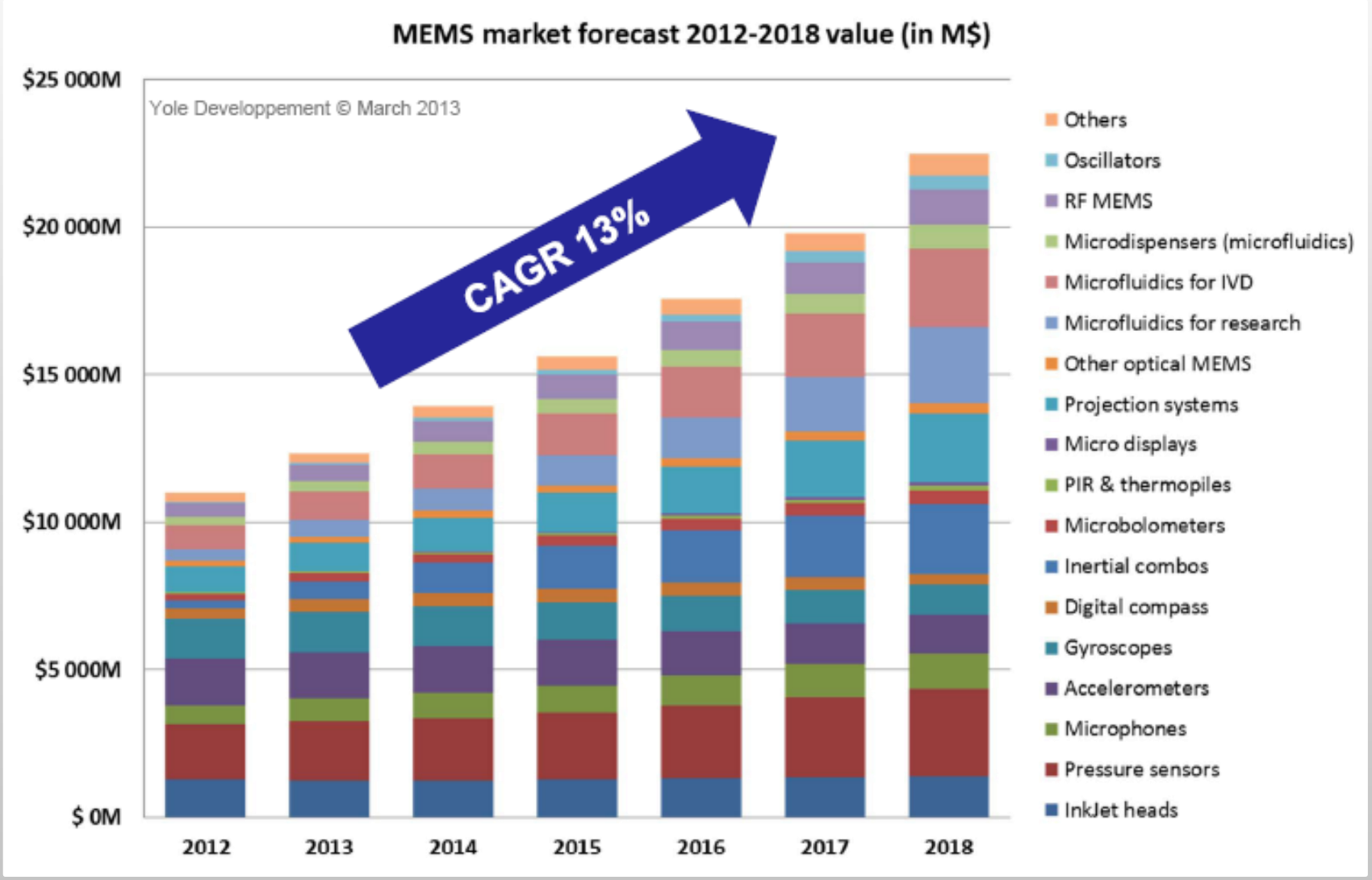
Presión, acelerómetro y giroscopio para detección de airbag lateral

Sensores inerciales, alarma de robo, freno de estacionamiento electrónico, nivel de faros, etc.

Sensores de presión y de flujo para la gestión del motor

[MEMS Journal 2007]

Evolución de los MEMS

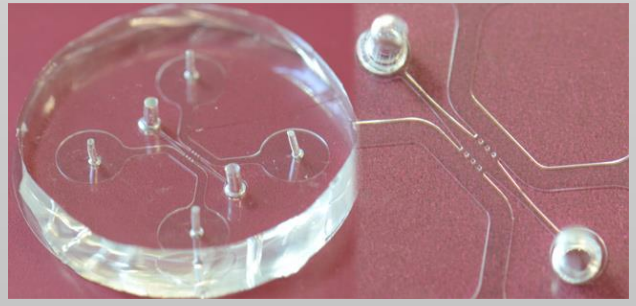


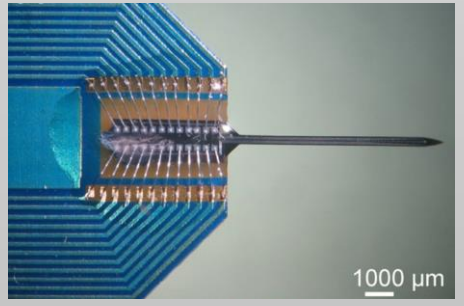
CAGR: tasa de crecimiento anual compuesto

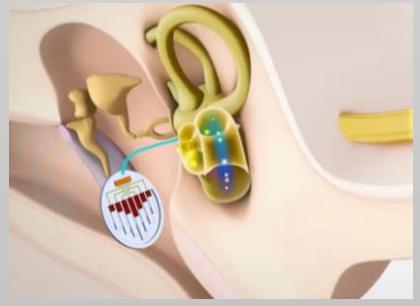
Evolución a los BioMEMs

BioMEMS: Biomedical Micro Electro Mechanical Systems

- Bio: Aplicado en el ámbito de la biología/medicina
- Micro: estructuras micrométricas (μm)
- Electro: incluyen electrónica, ya sea para sensorizar, para "decidir" o para actuar
- Mechanical: pueden incluir estructuras 3D como vigas, microcanales, membranas móviles, etc…



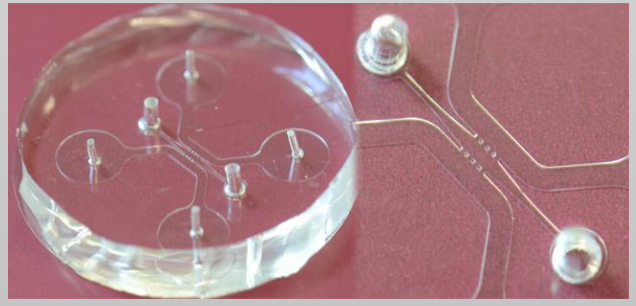


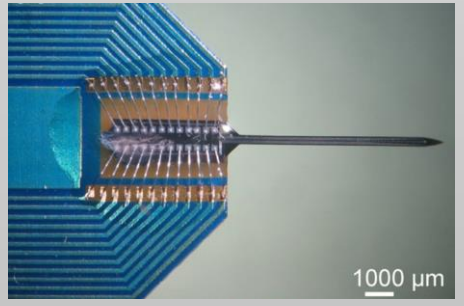


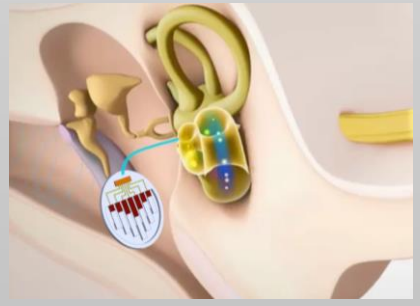
Evolución a los BioMEMs

¿POR QUÉ?

- ✓ Capacidad de diseñar y fabricar estructuras acordes al tamaño del “objetivo”
- ✓ Posibilidad de interactuar con el medio (medida, análisis y actuación inmediata)
- ✓ Gran cantidad de materiales biocompatibles y técnicas posibles, alta versatilidad





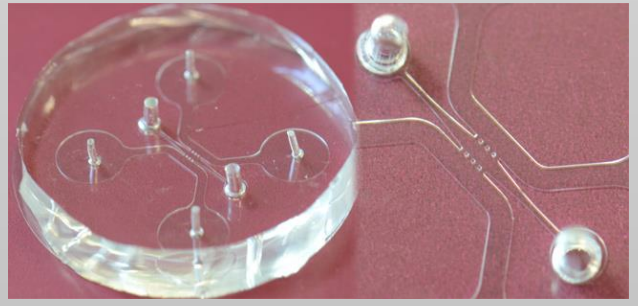


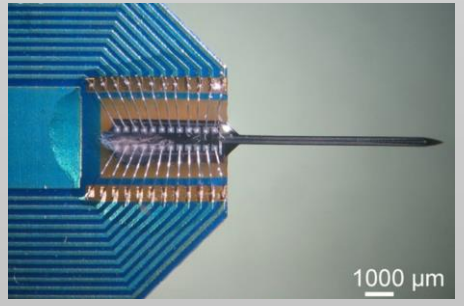
Evolución a los BioMEMs

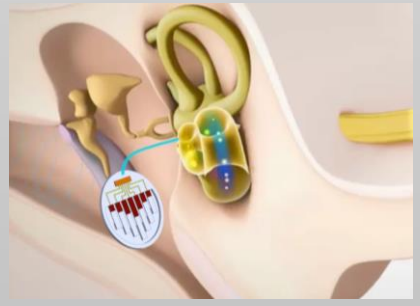
Ventajas



- ✓ Muestran muy alta sensibilidad en biosensórica
- ✓ Al usar microfluídica, los volúmenes empleados se reducen drásticamente (reducción de costes)
- ✓ Los tiempos de procesado se reducen
- ✓ Permiten desarrollar sistemas portables (Point-of-care)

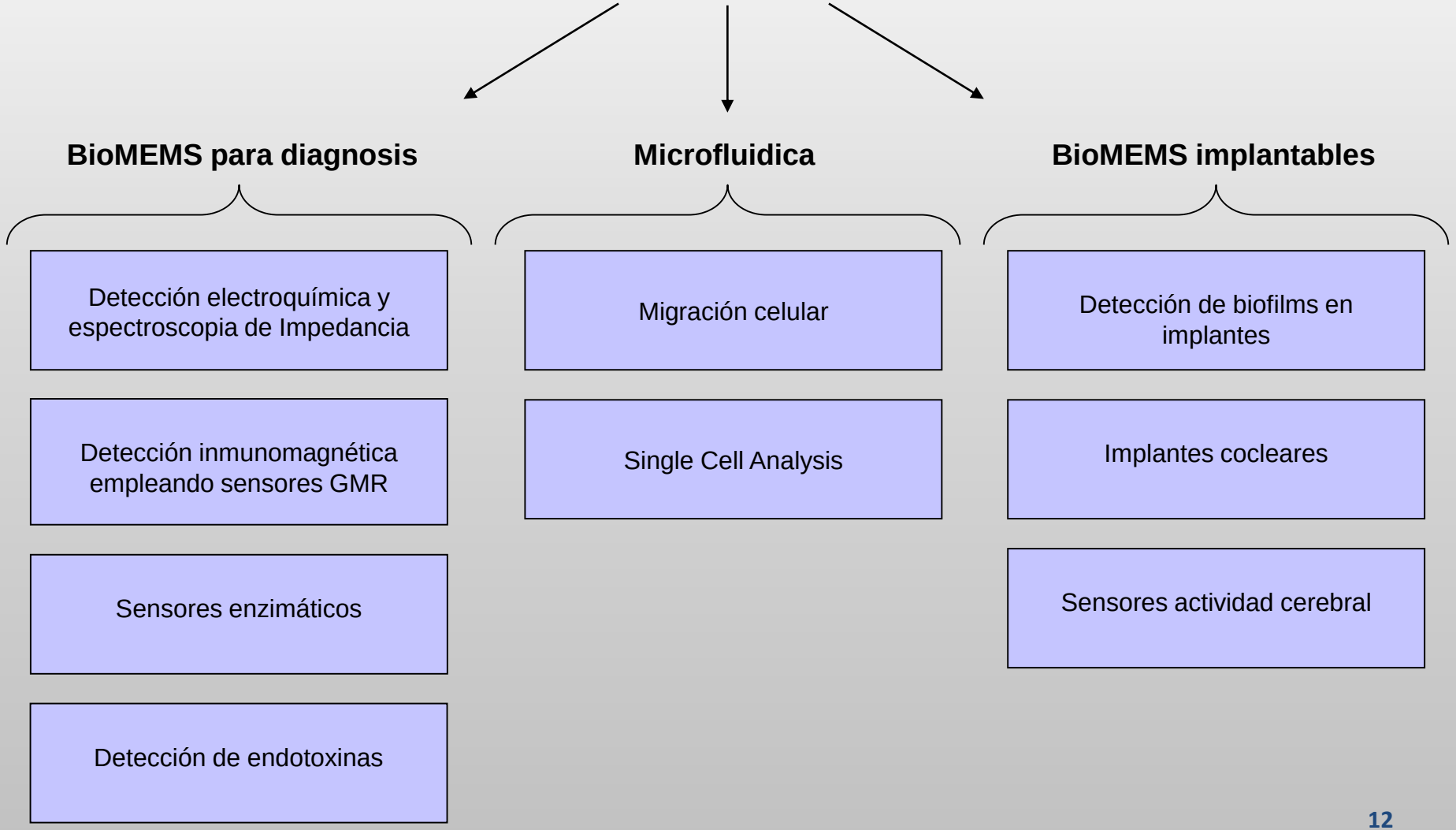






BioMEMs en el CEIT

Se está trabajando en tres amplios campos de trabajo



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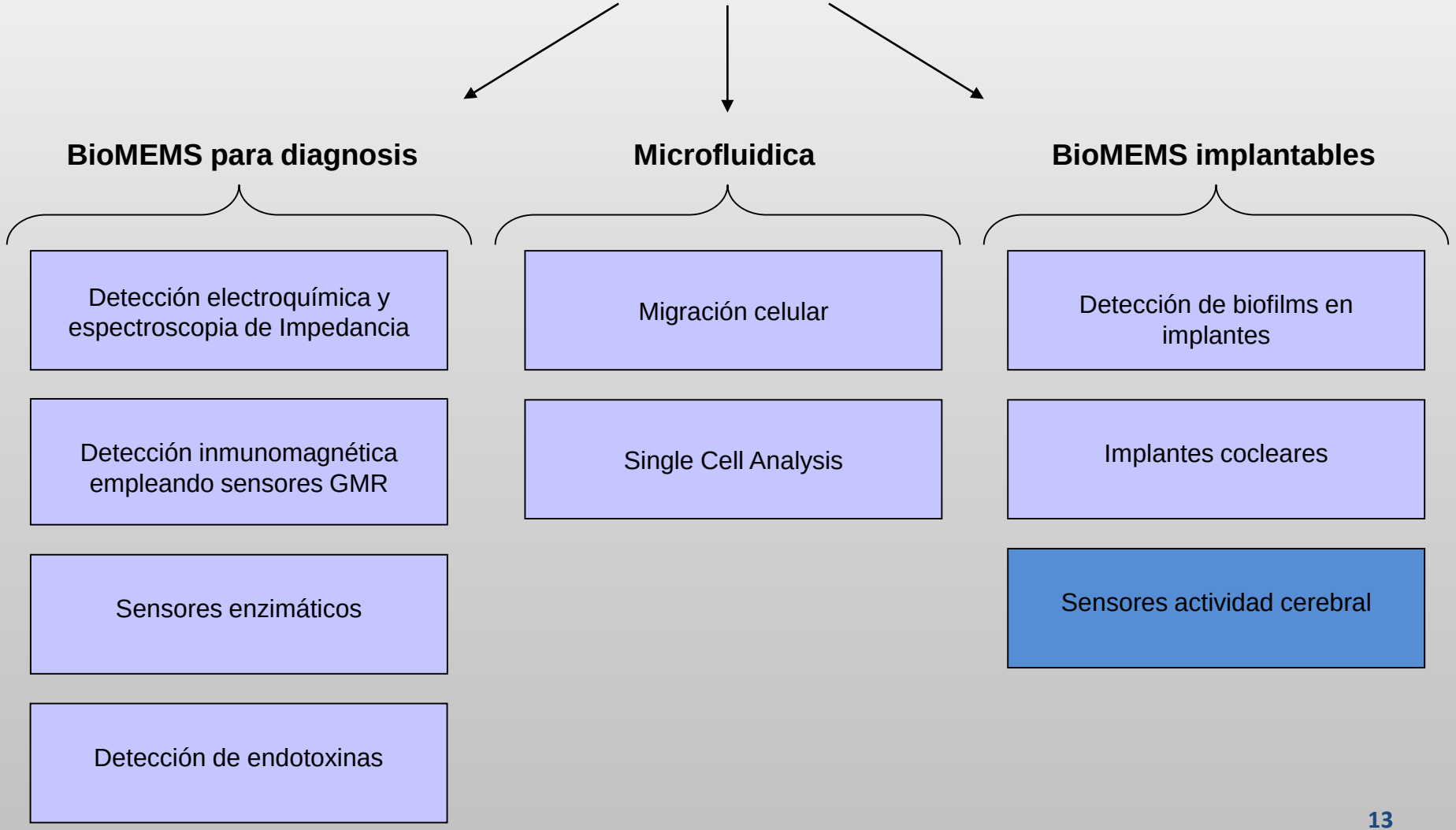

BioMEMs en Neurociencia

"Sensor de polímero blando para registrar la actividad cortical superficial en roedores en libre movimiento"

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Soft polymer sensor for recording surface cortical activity in freely moving rodents

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ABSTRACT

A surface sensor has been developed in order to record the cortical activity in animal models for neuroscience research. The device is made of gold on Cyclic Olefin Polymer (COP) and Cyclic Olefin Copolymer (COC) soft polymers using microsystems technology. The resulting system is flexible, customizable, biocompatible, and fulfills reproducibility standards during the manufacturing process. Impedances are in the range of 100 kΩ, thus making the system suitable for recording field potentials on the cortical surface. This paper explains the implementation process together with the implantation procedures and the results obtained in behaving rats. Results show that COP-based sensors are preferable to COC due to their higher flexibility and ease of manipulation. The versatility of COP polymers offers the possibility to adapt the electrode array to the cortical surface thus increasing surface of contact with the brain tissue. To validate the current approach, 8-contact sensors were implanted bilaterally over the motor cortices of awake, free moving rats. Cortical activity was evaluated on free moving animals and under the effect of different drugs. The quality and features of the recordings was in accordance with that of the current state of art systems thus demonstrating the feasibility of using COP-based systems for electrophysiological recordings in experimental investigation.

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1. Introduction

Most of our knowledge about brain function and how neural processes mediate in motor and cognitive performance comes from information obtained from electrophysiological recordings [1]. In the treatment of some diseases like Parkinson's, schizophrenia or epilepsy some therapies involve the stimulation and recording of deep brain structures. These techniques constitute a valuable opportunity not only to treat these diseases but also to investigate about their origin and evolution. The implantation of deep brain stimulators and subdural arrays of electrodes has allowed obtaining the activity of several structures of human brain. Nevertheless, and due to ethical issues, it is not possible to record from other brain areas apart from the therapeutic targets. Alternatively, and in order to investigate the physiology/pathophysiology of the mammalian brain, approximations based in the use of animal models must be used.

There are two main modalities for obtaining electrophysiological recordings [2]. Records can reach structures deep in the brain, or they may be restricted to the cortical surface. In this second case, the method most frequently used involves making small craniotomies in which screws are set, soldered to conductive wires and connected to the recording system. This is a suitable option for its simplicity in implementation and low cost, at the same time it is not overly invasive or painful for the animal. However, there are situations where it is required to record electrophysiological activity of large regions of the cortical surface with a good spatial resolution. In these scenarios screw-based approaches cannot be used. Implementations using electrode arrays can be a good alternative for covering the areas of interest. Inspired in the systems used for patients with epilepsy, there are some commercial solutions that could be adapted for sizable animals (eg. in monkeys) [3]. In recent years, different solutions have been proposed for the modeling of large-scale neuronal networks in mouse models using needle-type electrode clusters for spatial mapping technique [4]. Choi et al. reported a new method for high-resolution EEG mapping in freely behaving mice using a nanofrabricated microelectrode [5] and McCall et at. proposed the implementation of nano-fabricated

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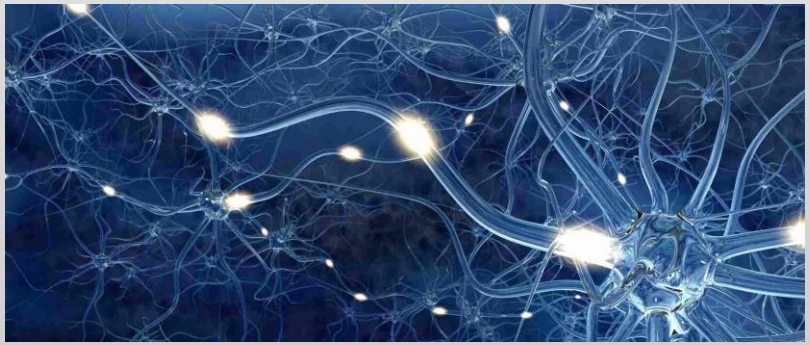
BioMEMs en Neurociencia

Introducción

“La neurofisiología tiene como objetivo comprender el funcionamiento del sistema nervioso.”





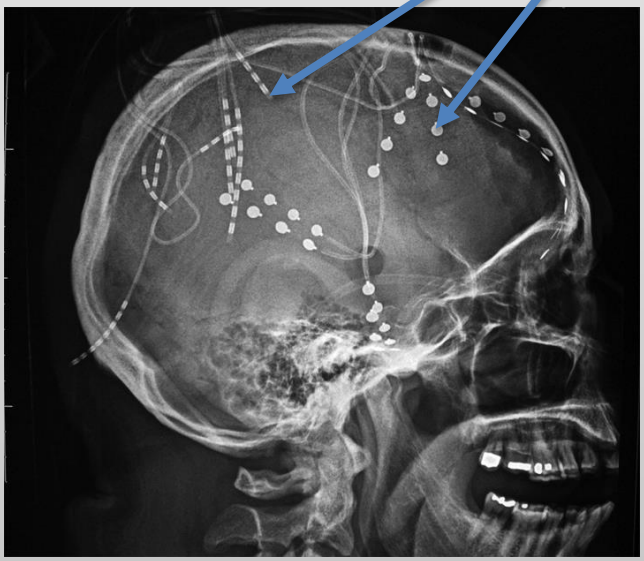
“Los potenciales eléctricos son los mecanismos básicos para la comunicación entre neuronas.”

“La neurofisiología trata de estudiar el comportamiento de neuronas o grupos de neuronas aisladas.”

BioMEMs en Neurociencia

Introducción

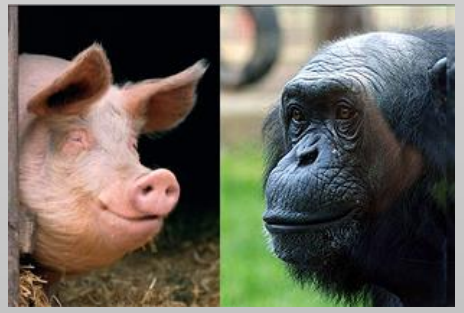
Electrodos



En investigación…







BioMEMs en Neurociencia

Motivación

Registros en superficie cortical (*procedimiento habitual*)**:**

- Realización de craneotomías para la fijación de tornillos.

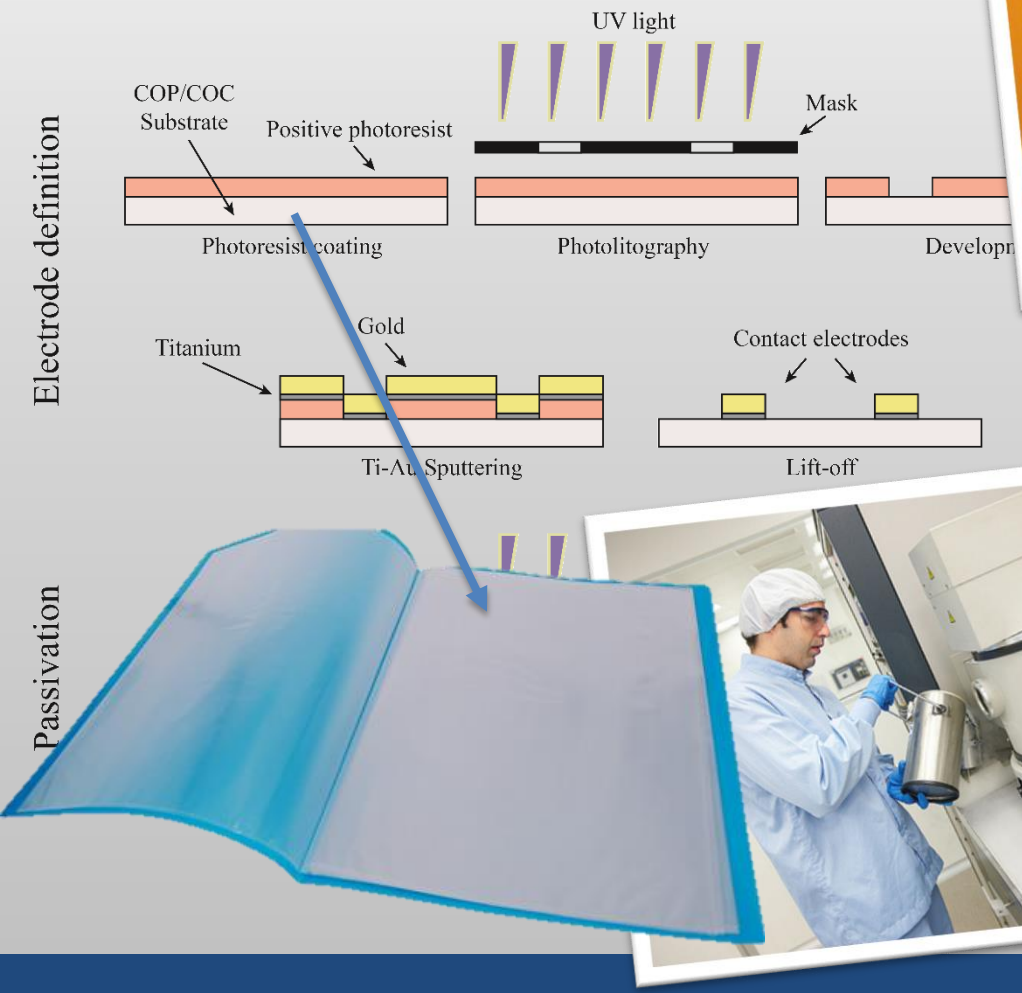
Ventaja	Desventaja
• No es excesivamente invasivo ni doloroso. • Sencillo. • Bajo coste.	• Imposibilidad de registro en localizaciones cercanas.

Introducción de BioMEMS en Neurociencias:

- Implantes crónicos.
- Mayor cobertura de la superficie cortical.
- Alta precisión.
- Implantación sencilla
- Rápida recuperación.
- Mayor calidad de registro de actividad.

BioMEMs en Neurociencia

Material y métodos

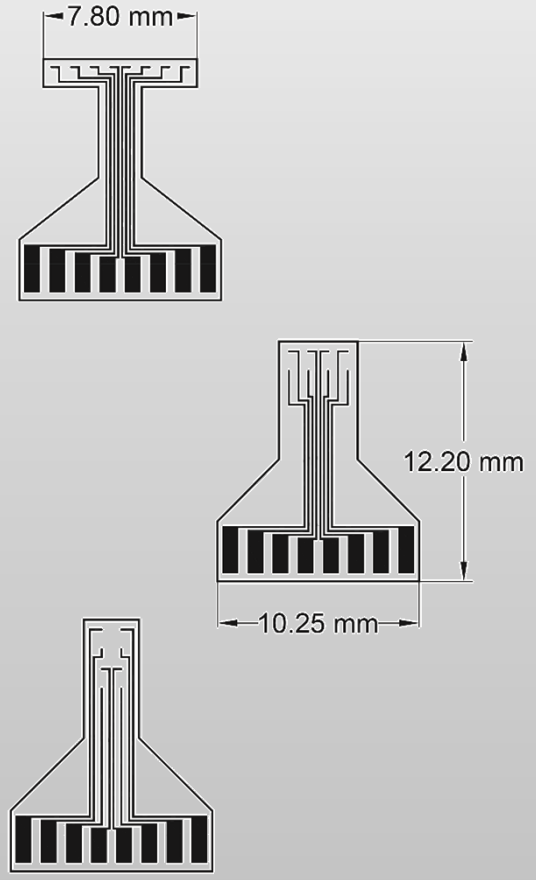


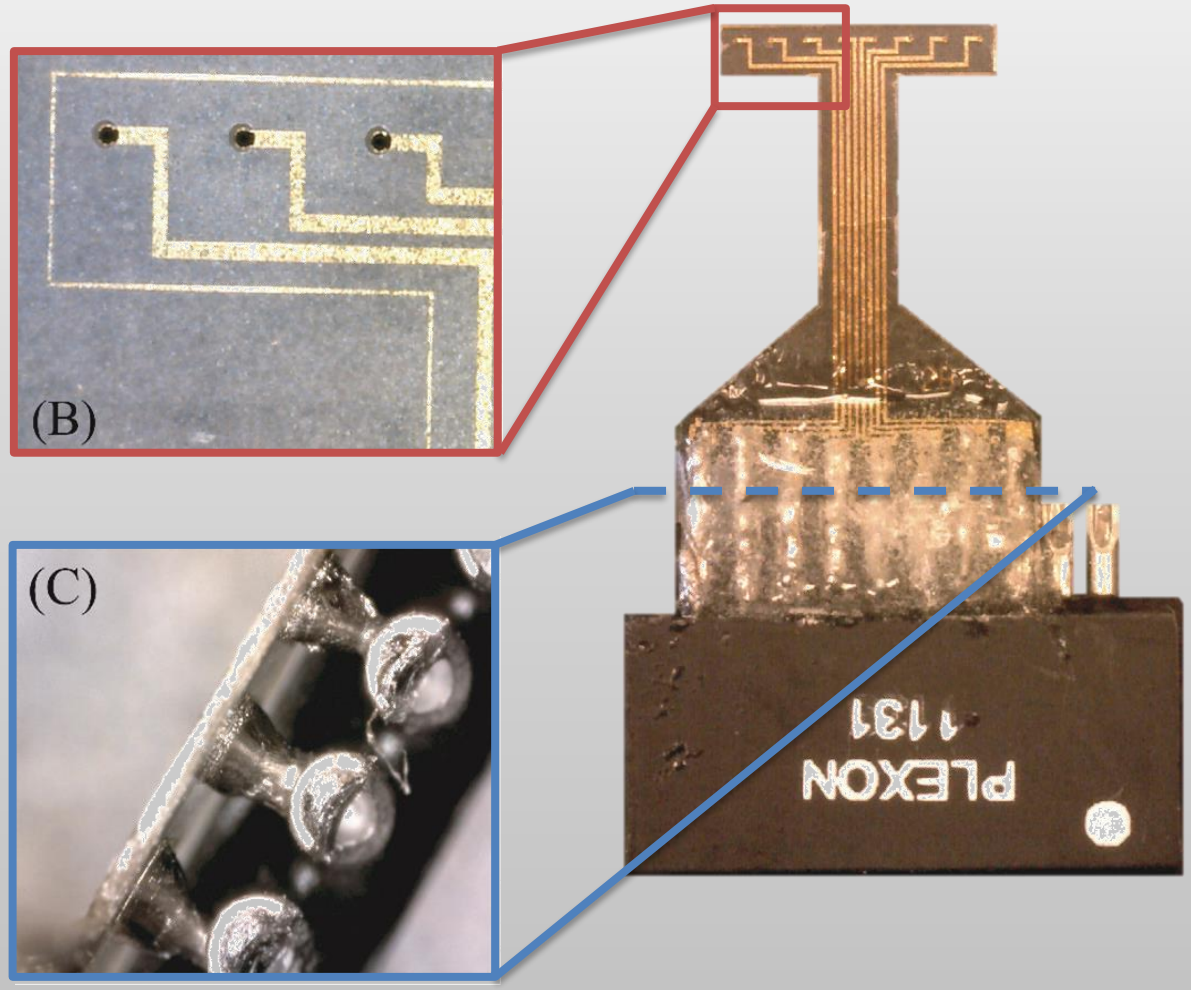




BioMEMs en Neurociencia

Material y métodos

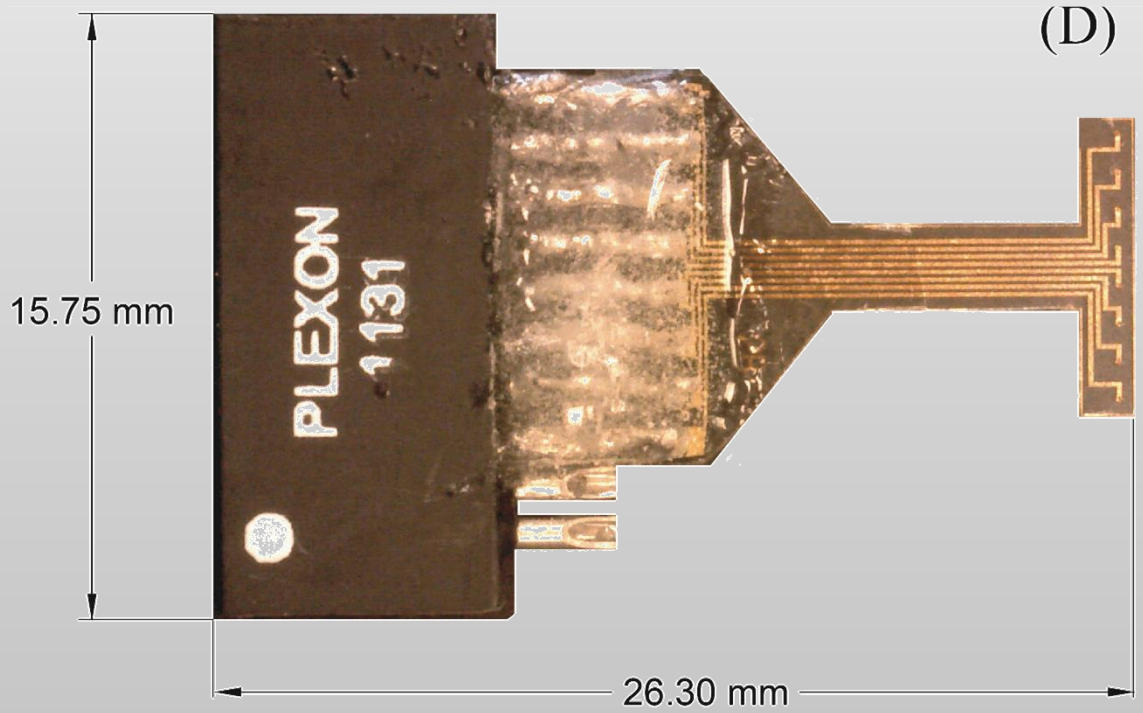




BioMEMs en Neurociencia

Material y métodos

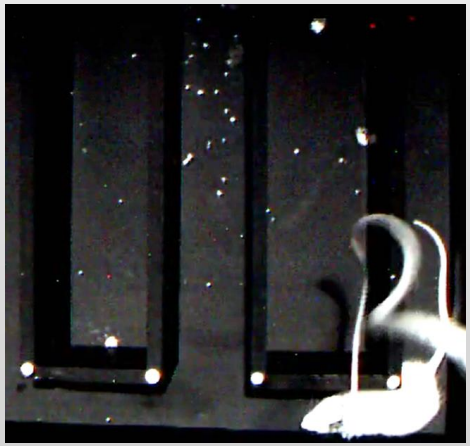




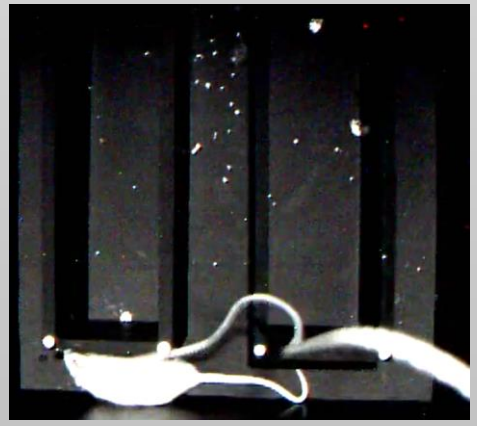
BioMEMs en Neurociencia

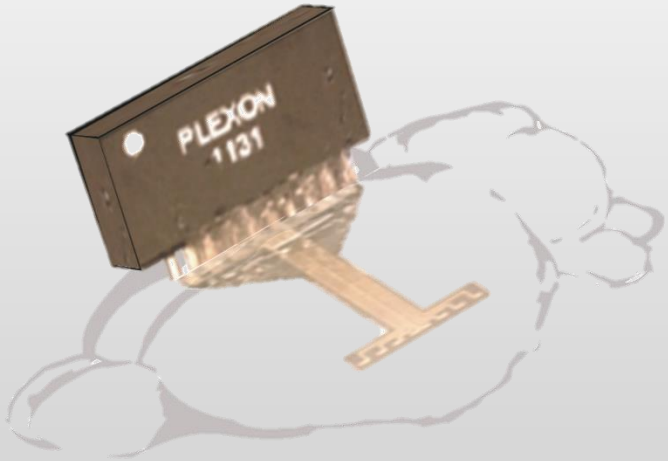
Material y métodos







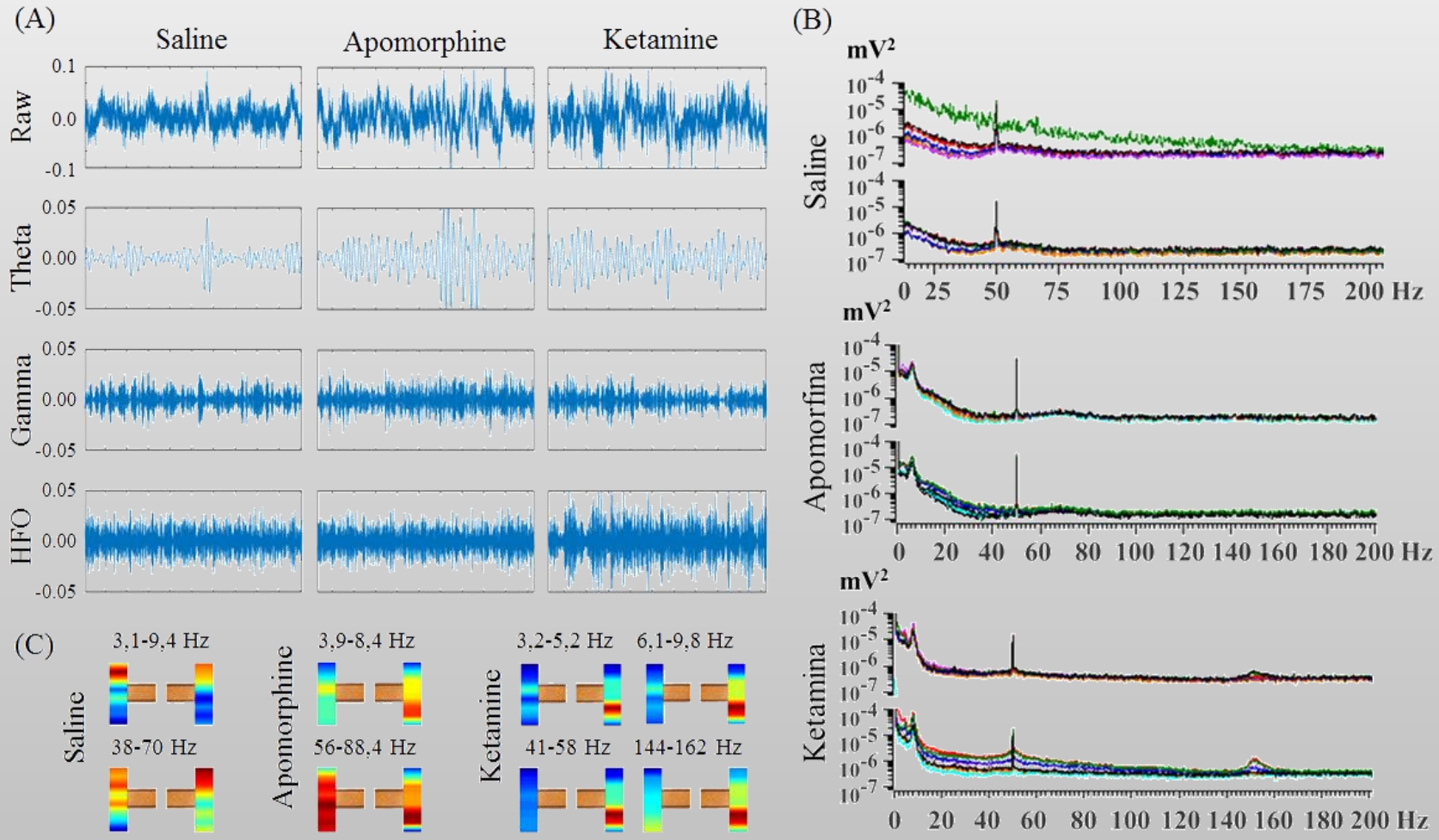






BioMEMs en Neurociencia

Resultados



BioMEMs en Neurociencia

Conclusiones

Materiales:

- **COP:** Flexibilidad requerida para poder ser implantados durante un largo periodo de tiempo. Además, es biocompatible, fácilmente adaptable y precio asequible.

Proceso de micro-fabricación:

- Simple y rápido.
- Alta reproducibilidad: morfología y características físicas y eléctricas.

Testeo *in vivo* de los sensores:

- Animales de experimentación.
- Registros en el entorno de investigación en neurociencias.
- Uso en la rutina de investigación que desarrolla el grupo de Neurofisiología (CIMA).

Resultado de las pruebas:

- Calidad similar a la de los sensores especializados.



Microtecnología: Desarrollo de BioMEMs

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IMANOL TUBIA ANTILLERA