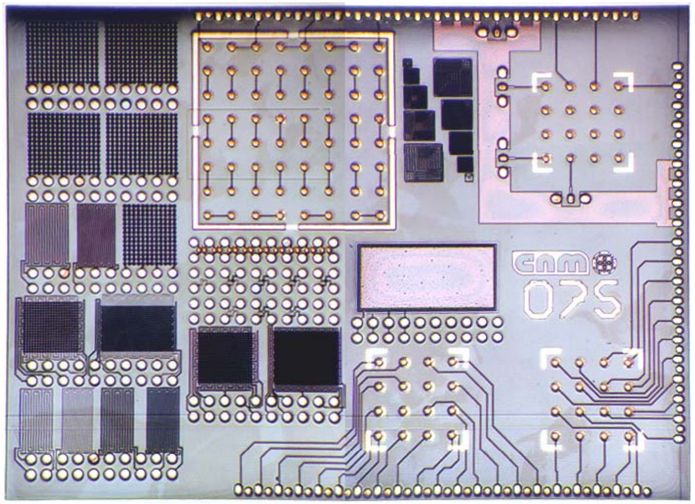
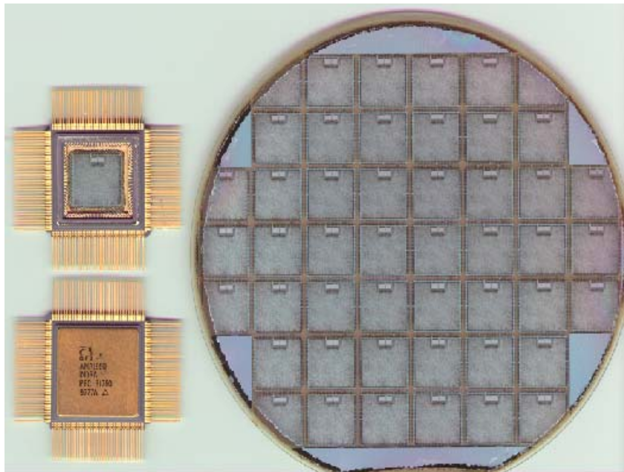
CENTRO NACIONAL DE MICROELECTRÓNICA (CNM)

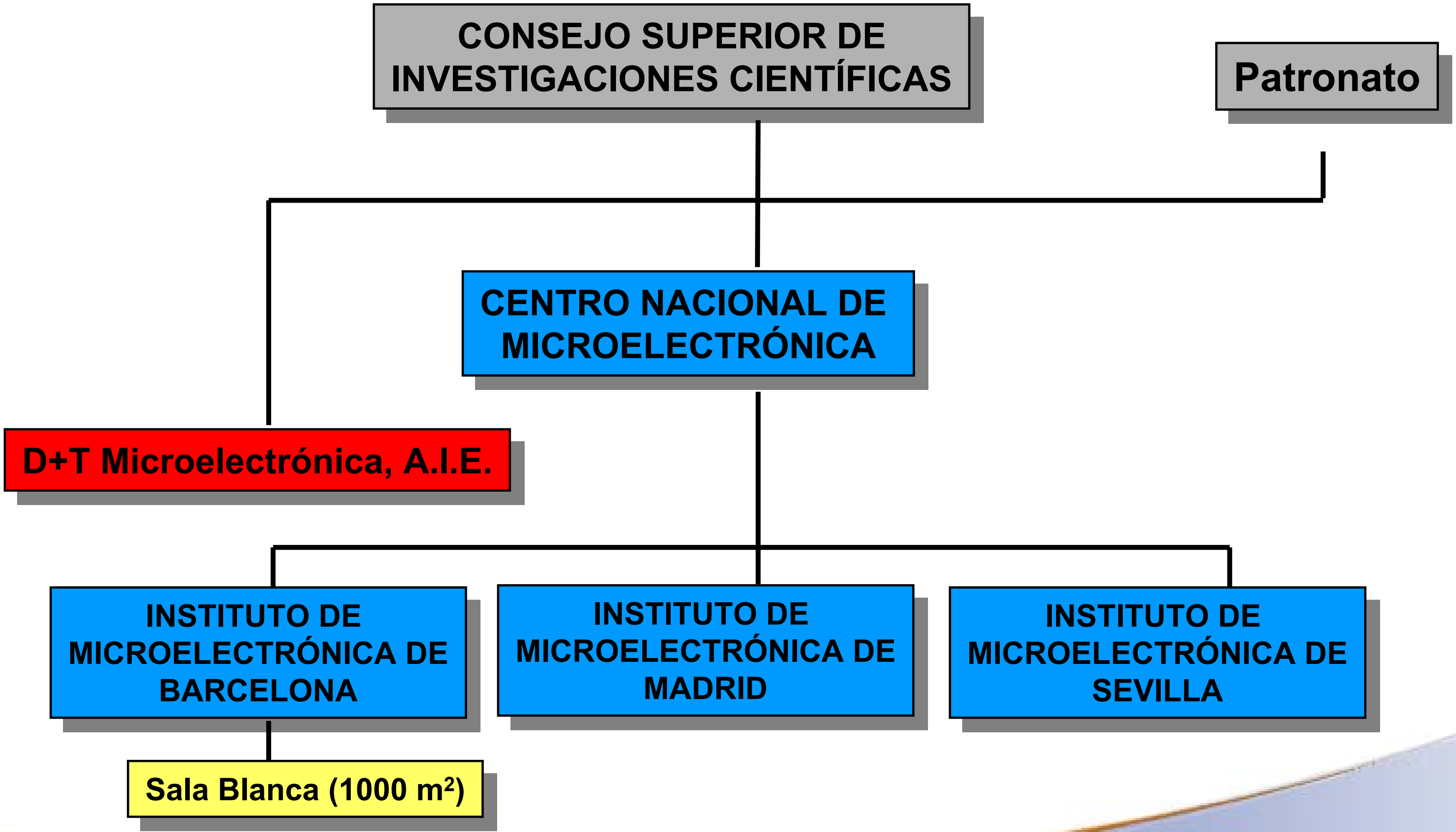
TESEO:

Tecnologías MEMS para Sensores

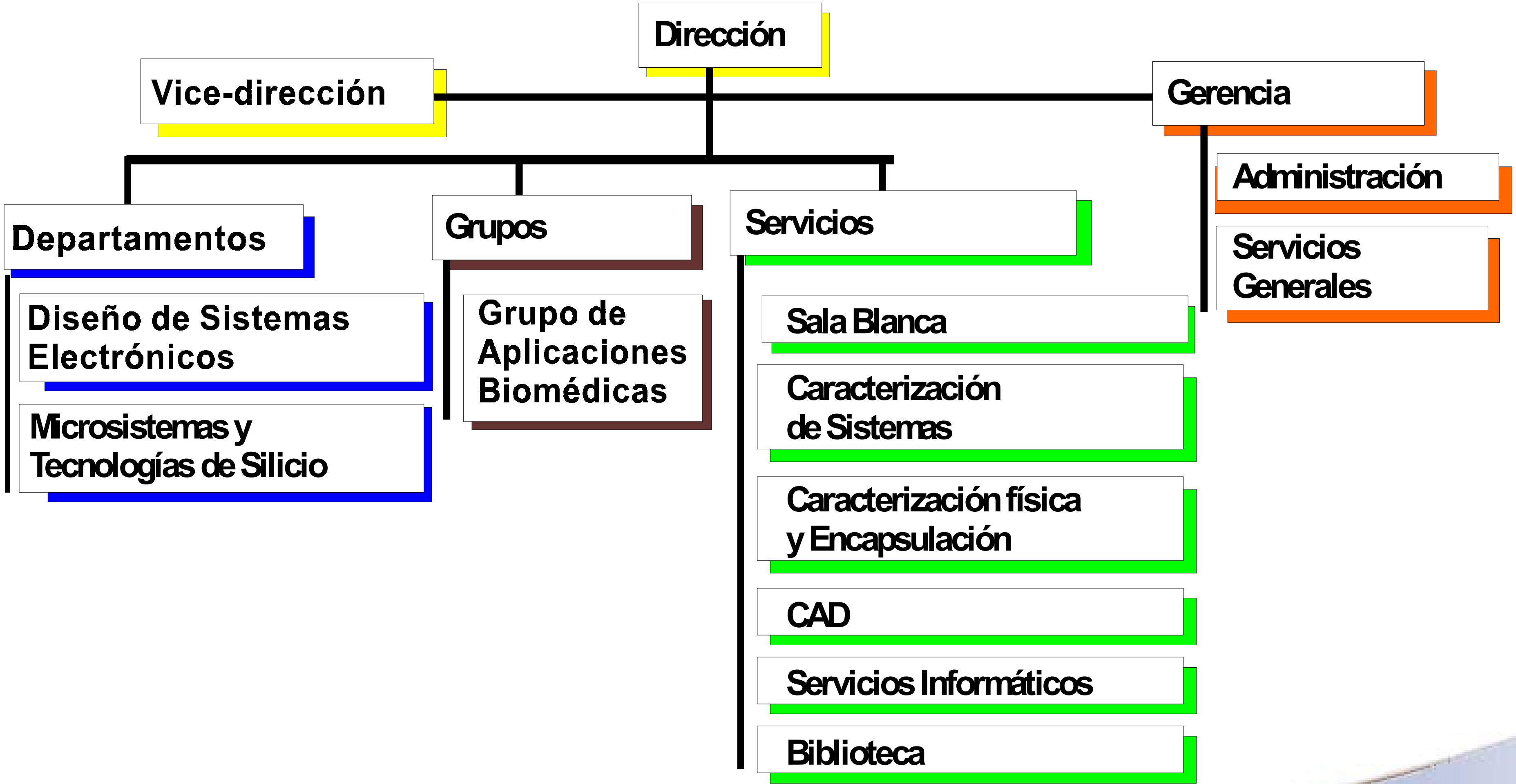




Organización del IMB-CNM



Organización del IMB-CNM



PERSONAL CNM-IMB (2000)

	Investigadores	42
	Becarios	22
	Investigadores Visitantes	8
• Sala Blanca		
	Ingenieros de Procesos	5
	Ingenieros Técnicos	3
	Técnicos	12
• Servicios		
	Ingenieros	7
	IngenierosTécnicos	5
• Gerencia, Administración y Servicios Generales		17
	Total	121

CNM-IMB

Presupuesto anual (2000):	6.142 M€
Recursos externos:	62 %

Proyectos (activos en 2000):

Financiación UE:	11
Nacional:	14
CCAA:	3
Industrial:	9
Total	37

Distribución de ingresos por proyectos:

UE:	73.0%
Nacional:	21.0%
CCAA:	0.9%
Industrial:	5.0%
Patentes y Formación:	0.1%

PUBLICACIONES CNM-IMB

	1999	2000
Libros y Capítulos de libros:		
Libros	-	1
Capítulos de libros	-	2
Artículos en revistas científicas:		
Internacionales	43	35
Nacionales	8	1
Artículos en revistas de divulgación:	2	-
Ponencias en Congresos Científicos:		
Internacionales	45	56
Nacionales	47	12
Conferencias, Seminarios, Cursos:		
Conferencias Invitadas	6	2
Seminarios, Cursos	7	-
Tesis,Tesinas, Trabajos fin de carrera:		
Tesis Doctorales	5	0
Proyectos fin de carrera	0	3
Patentes:	1	1
Reports internos:	3	3

Líneas de investigación

- Microsistemas
- Transductores químicos
- Dispositivos y sistemas de potencia
- Aplicaciones biomédicas
- Diseño de circuitos electrónicos y sistemas
- Módulos multichips
- Desarrollo de tecnologías de Si

Clean Room Characteristics

1000 m² total surface.
House in house structure.
Class 100 to 10.000.

Air control T=21°±1° C and humidity 40% ± 5%.

D. I. Water system 18 MΩ.cm, 26 m³/day. Maximum flow: 1.6 m³/h.

Ultrapure gas distribution. Stainless steel electropolished pipeline 316 L.

Power supply: 25 kV and 3000 kVA.

Waste treatment.

Security system: gas detectors, fire and intruder protection.

Clean Room Equipment

Thermal processes and CVD equipment

11 tubular furnaces for oxidation, annealing and diffusion thermal processes.

3 LPCVD furnaces for poly and nitride deposition.

2 PECVD furnace for passivation layer deposition (oxide and nitride).

1 atmospheric CVD furnace for doped oxides deposition.

Metallisation equipment

1 DC magnetron sputtering, manual loading, 1 cathode.

1 DC/RF sputtering, automatic loading, 4 independent cathodes.

1 sputtering with three independent cathodes, automatic loading.

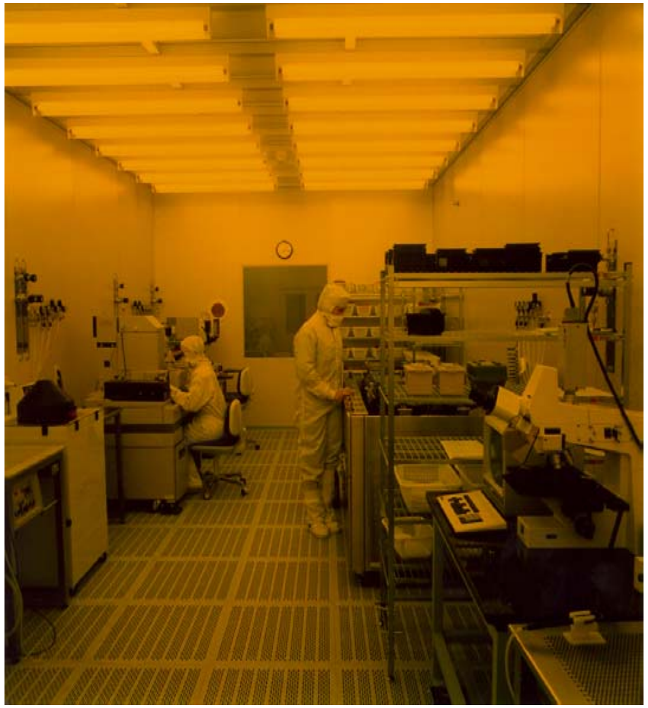
1 sputtering with three independent cathodes, manual loading.

1 sputtering with 1 DC cathode, manual loading.

Ion Implantation equipment

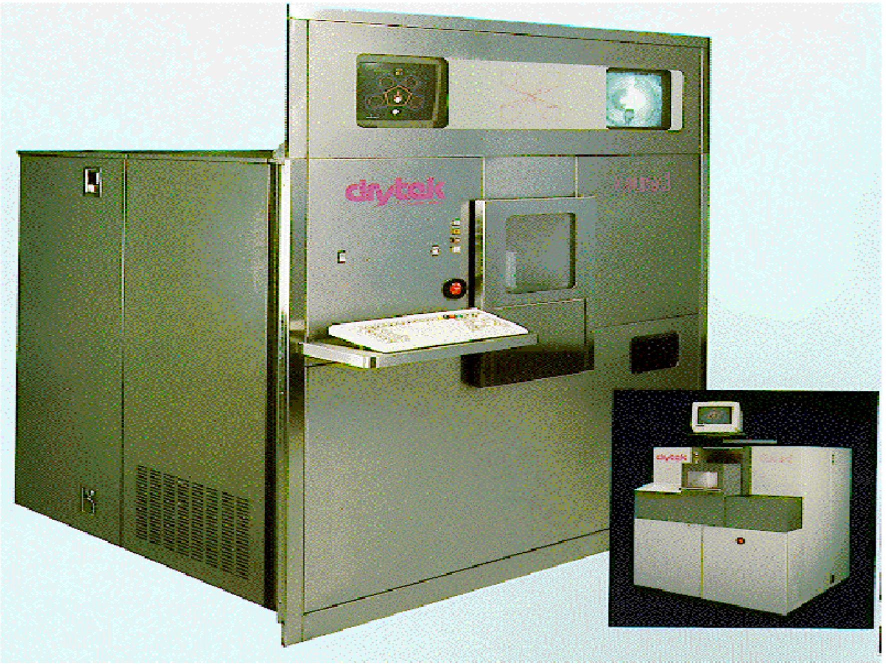
1 medium current implanter for B, P, As, N and Ar

Photolithographic equipment



- 1 5:1 stepper 0.8 µm resolution.
- 1 5:1 stepper 0.5 µm resolution.
- Contact/proximity mask aligner.
- Double side contact/proximity mask aligner.
- 2 automatic tracks for photoresist deposition and developing.
- Mask cleaner.
- Manual spinner for photoresist deposition.
- Critical dimension measurement system.

Dry etching equipment



1 manual RIE, one chamber.

2 hexode RIE.

2 plasma barrels.

1 Deep Etcher.

1 automatic RIE with 4 chambers for Aluminium, oxide, polysilicon, nitride etching and photoresist removal.

Wet etching and cleaning equipment

10 semiautomatic wet benches.

4 spinners for wafer rinse/drying.

1 bench for anisotropic etching.

In line test equipment

3 inspection microscopes.

1 sheet resistance measurement system.

2 profilemeter.

1 optical interferometer.

1 elipsometer.

1 FT-IR spectrometer.

1 Optical Dimensions measurement system.

Processes

✓Wet and dry oxidations

✓ Ion implantation of B, P, As, N and Ar

✓Diffusion (several ambients)

✓ CVD (nitride, polysilicon, oxide, BPSG)

✓ Metallization (Al-Si, Al-Cu, Al-Cu-Si, TaSi, Ti, Ni, Au*)

✓ Polyimide

✓ Wet and dry etching

➢ Surface and bulk silicon micromechanization

➢ Anodic bonding

➢ Packaging (die bonding, wire bonding, SMD)

➢ In line test (elipsometer, optical interferometer, profilemeter, four point probes)

➢ Photolithography (proximity, step and repeat, double side)

TECNOLOGÍAS

Material estándar: Substratos de Si, 100mm diámetro

TECNO	*TIPO*	*CARACTERISTICAS*	*APLICACION*
CNM-25	CMOS 2.5 μm	2 poly - 2 metal	Analógico/ digital
CNM POTENCIA	DMOS lateral & vertical	Doble difusión	Dispositivos de potencia
CNM μSISTEMAS	Sensores y actuadores de Si	μmecanización de Si en volumen y superficie	Micro-sistemas
MCM	Substratos de Si	Substratos activos y flip-chip	Módulos Multichip

* Capacidad de *rerouting* de obleas de 125, 150 mm

TECNOLOGÍAS EMERGENTES

MST: Micro System Technologies

- **Bulk and Surface Micromachining**
- **Micro Electro Mechanical Systems (MEMS)**

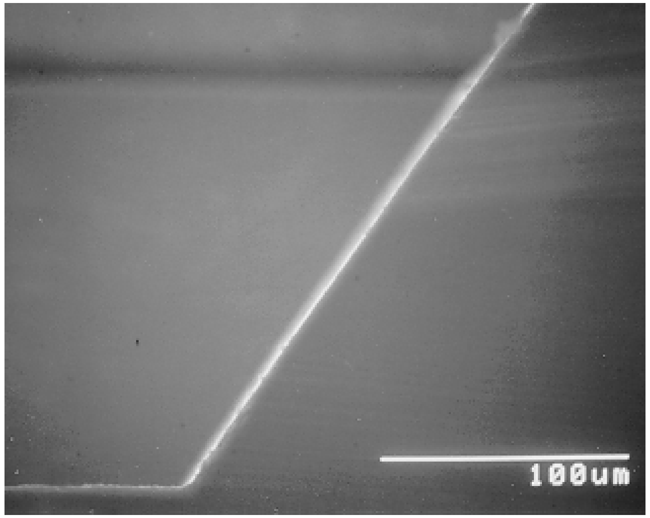
MECS: Micro Electro Chemical Systems

- **Micromachining of Electro Chemical Transducers**

MOMS: Micro Optical Mechanical Systems

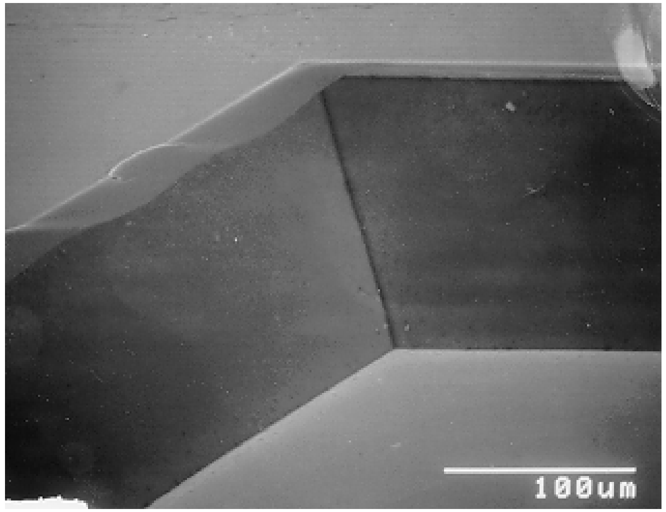
MiNaS: Micro Nano Systems

Bulk Silicon Micromachining



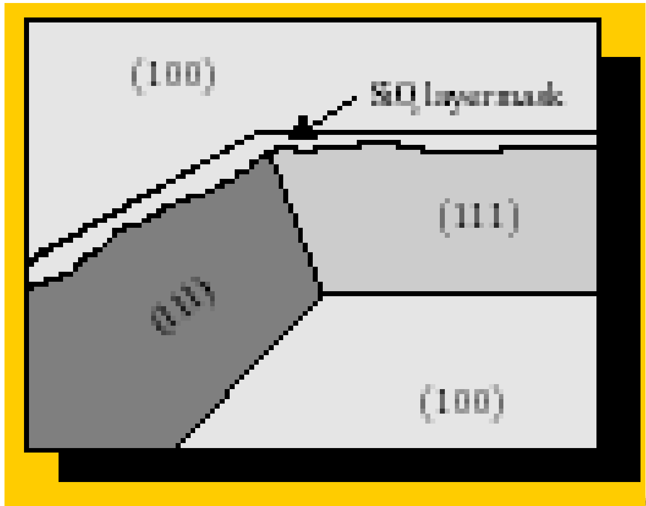
Wet Solutions:

- **KOH**
- **TMAH**



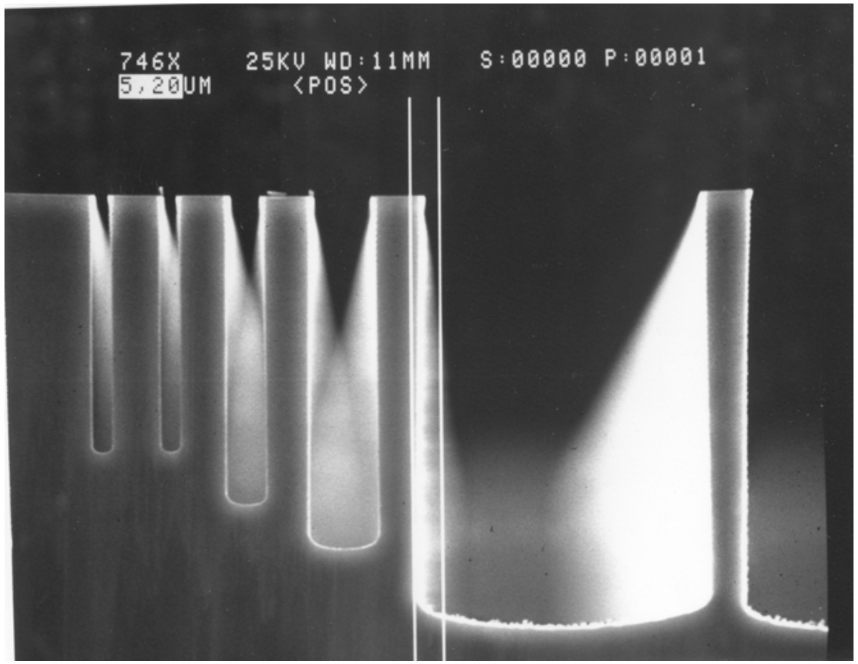
Etch Stop:

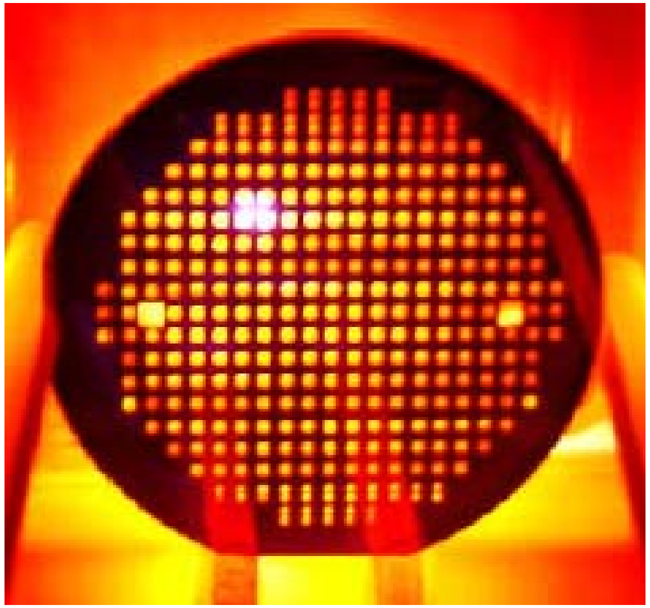
- **Si3N4**
- **p/n (electrochemical)**
- **BSOI**



Bulk Silicon Micromachining

Deep Dry Etching:
- μ- **Wave RIE**

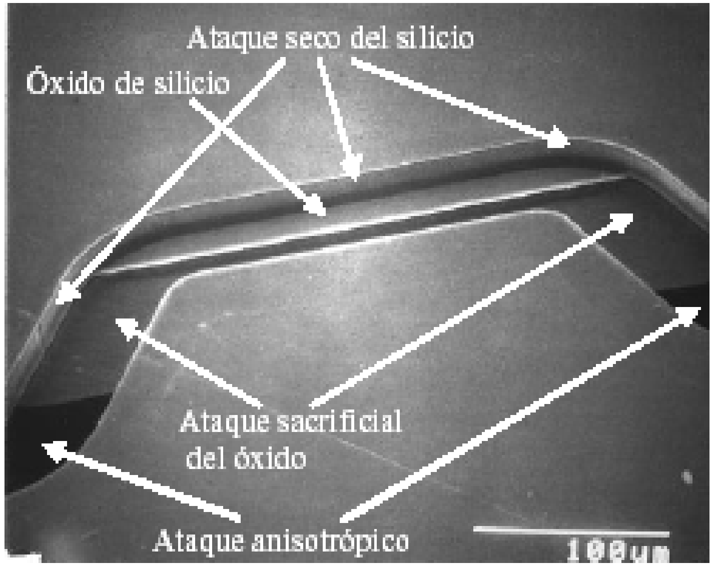


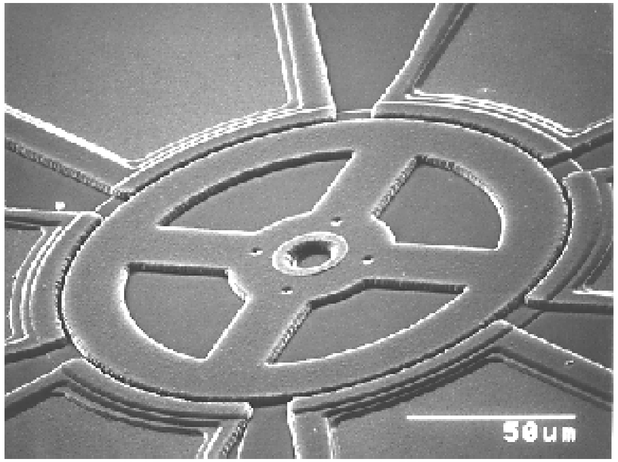


Etching Masks:
- **Photoresist**
- **Aluminium**
- **Silicon oxide**

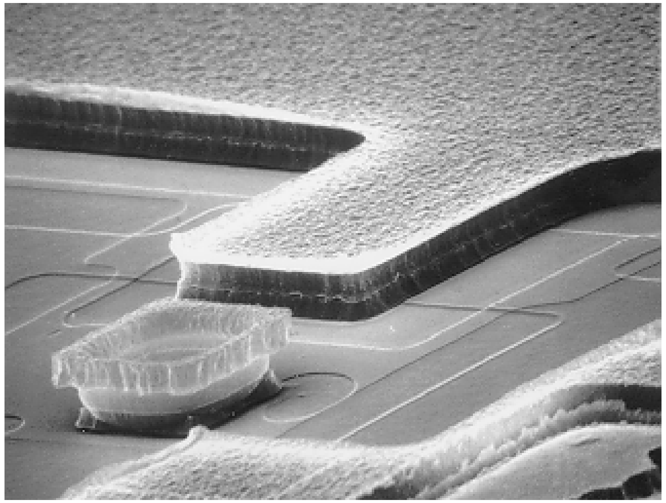
Surface Micromachining

Process:
- **2 poly-Si levels**

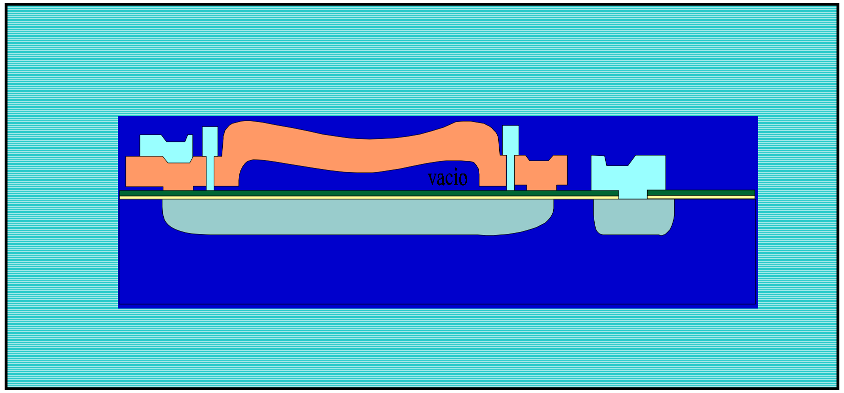




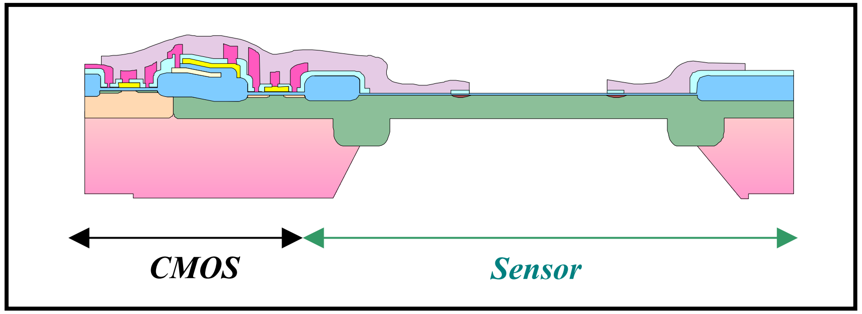
Wet Etching:
- **Silicon oxide**



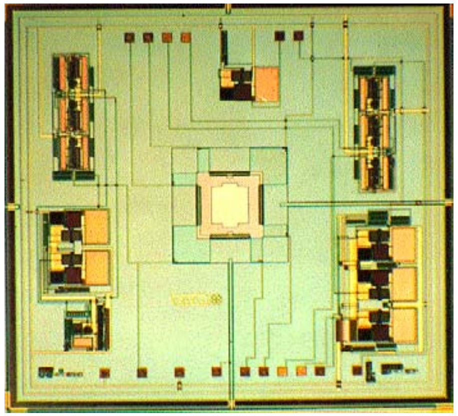
Pressure

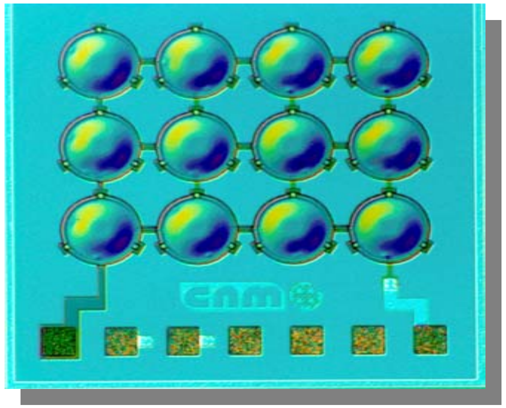


Capacitive



Piezoresistive



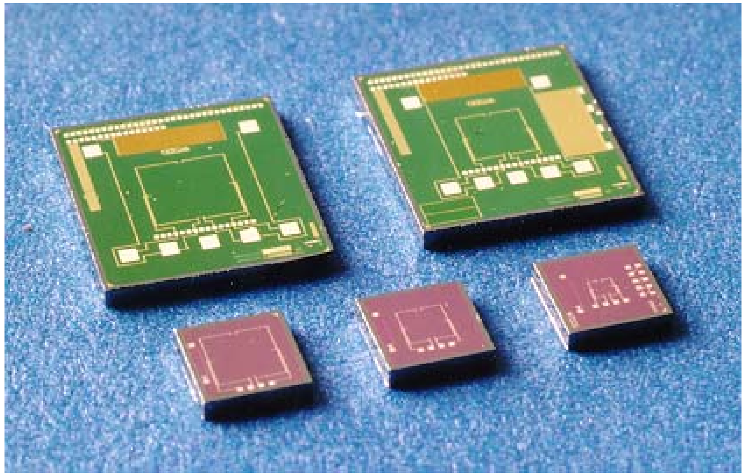


Sensores de presión piezorresistivos

- **Diseño y fabricación de sensores de presión piezorresistivos de silicio.**
- **Desarrollo de una tecnología de fabricación robusta y de alto rendimiento basada en el uso de substratos BESOI y micromecanizado en volumen.**

Características:

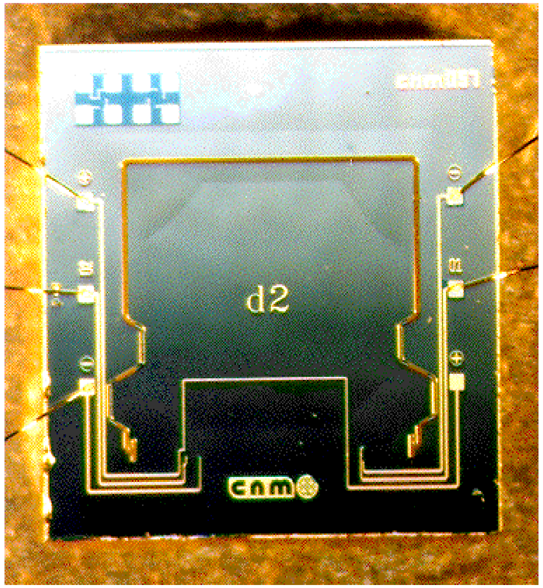
- Dimensiones (mm^2): 31.5, 6.4
- Rango de presión (mbar): 35, 250, 1500
- Sensibilidad (mV/bar):1625, 625, 210
- Tensión de alimentación (V): 5
- No-linealidad: < 1%FS



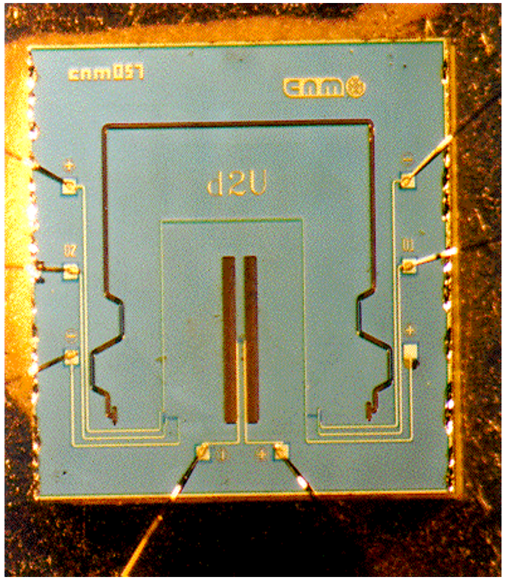
Acelerómetros Piezorresistivos BESOI

- Sistema de protección contra sobrechoques en todos los dispositvos
- Un diseño con sistema de auto-test

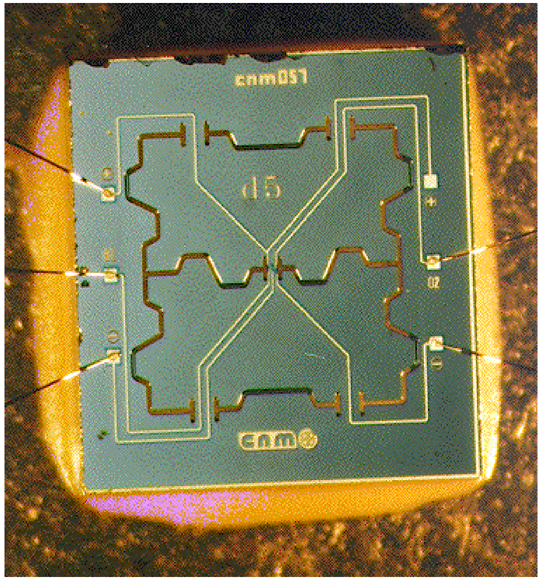
- Buena No-linealidad (< 1%)
- Buena histéresis (< 1%)
- Buena repetibilidad (< 1%)



Acelerómetro *Cantilever*



Acelerómetro *Cantilever* con sistema auto-test

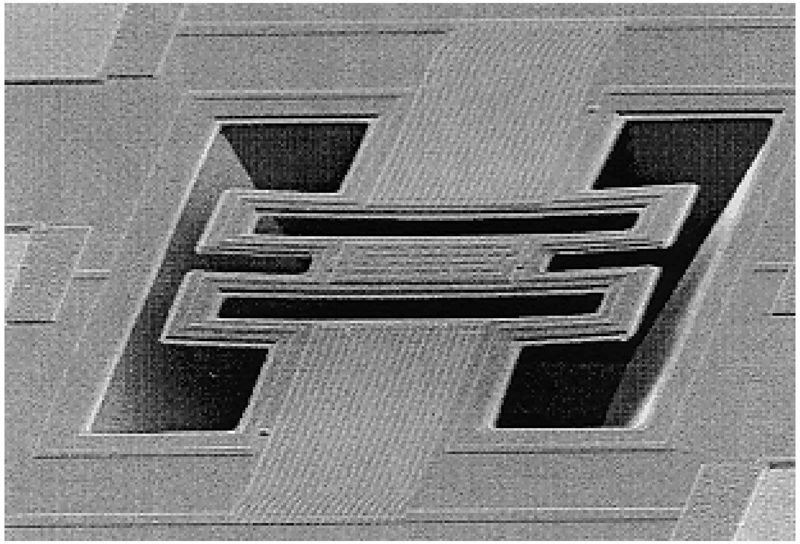


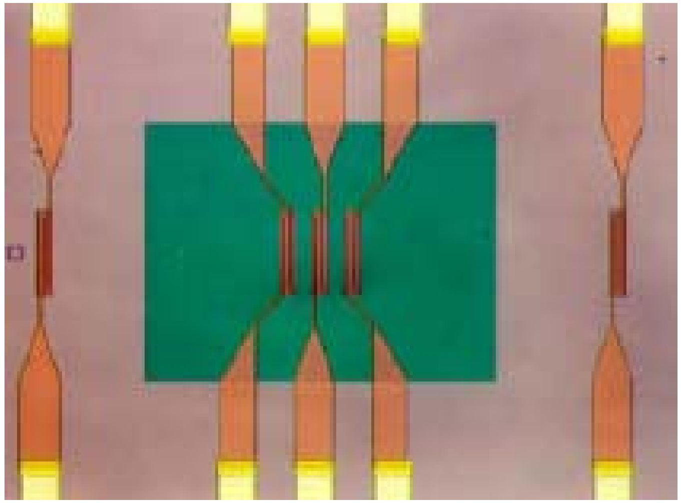
Acelerómetro *Twin-mass*

Flow

Technology:

- Bulk silicon micromachining
- Nitride membrane
- Polysilicon, Ni or Pt based heater and sensing elements
- Low power consumption (17 mW)
- Compatible with gas sensor devices for Microsystem integration



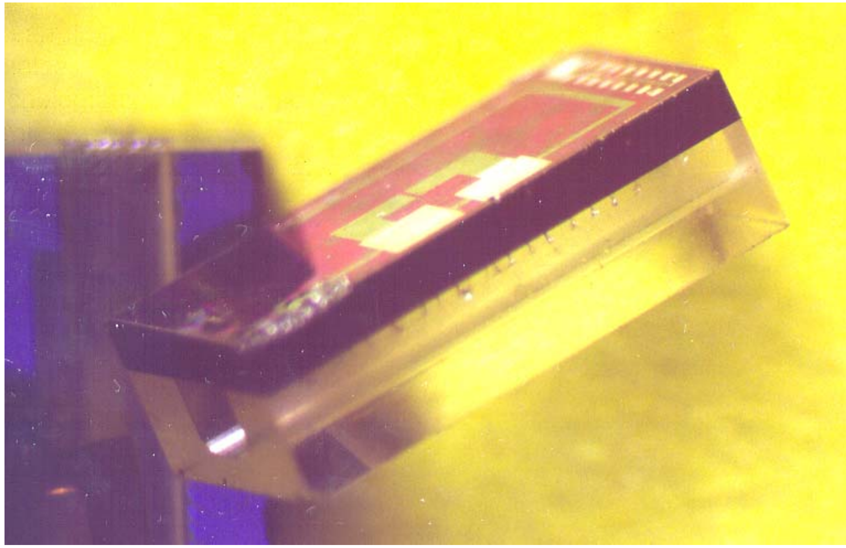


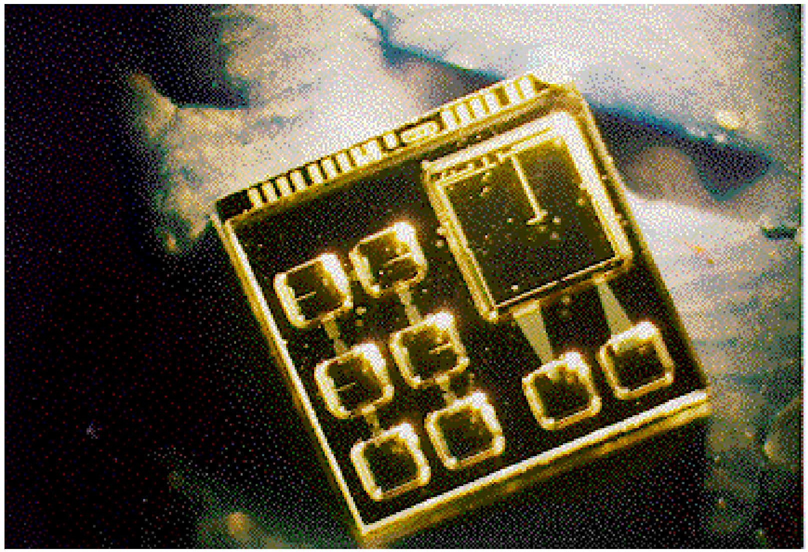
Mass Flow Controllers:

- Thermal difference
- Flow range: 0 - 2.0 m/s

Microfluidic

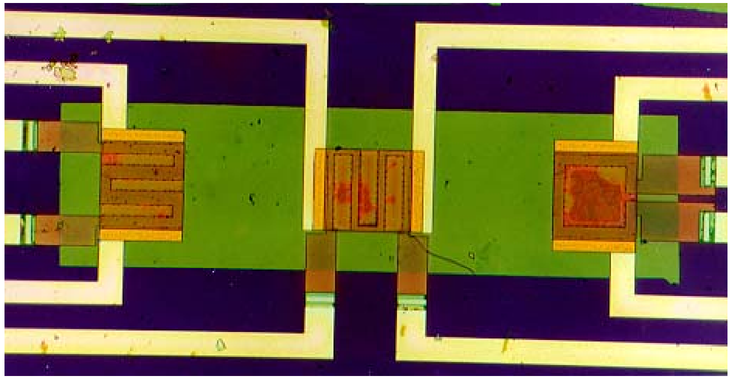
Silicon-Glass
Anodic Bonding

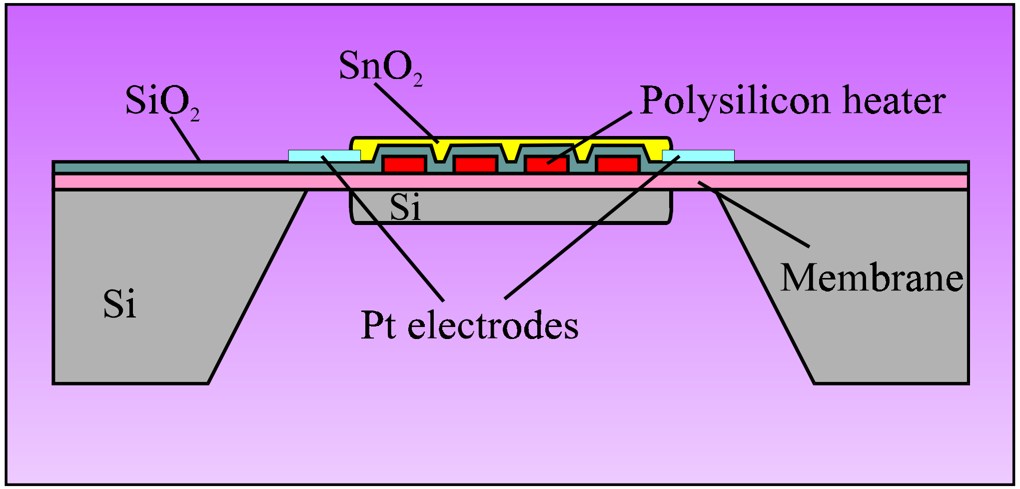


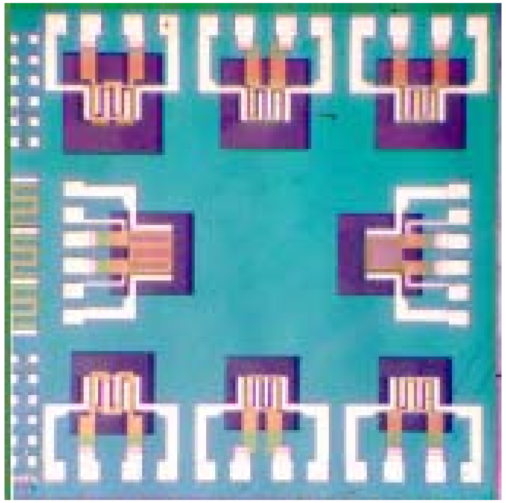


Small Volumes
Low Power

Gas Sensor





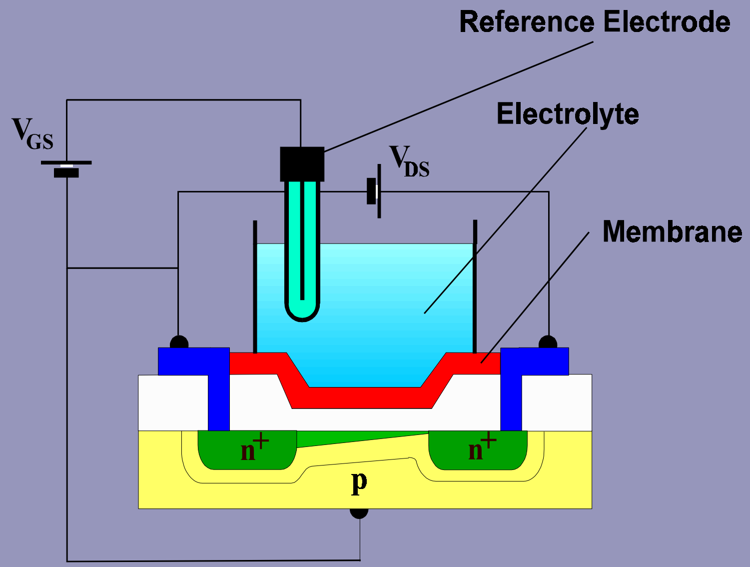


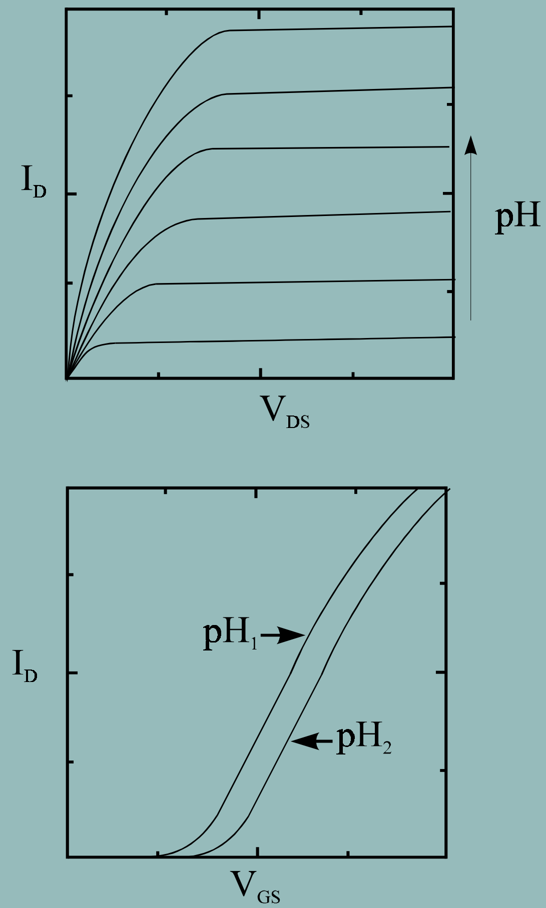
Gases:

- **Hydrocarbons**
- **$CO2$**
- **CO**

ISFETs / NMOS Technology

Floating Gate FET

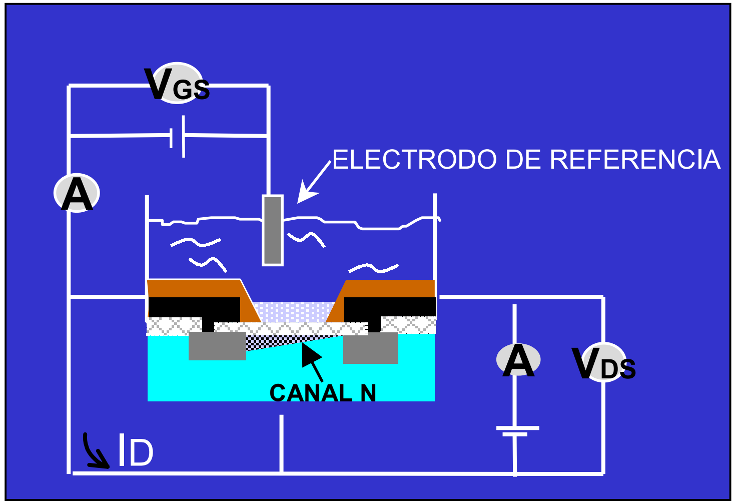


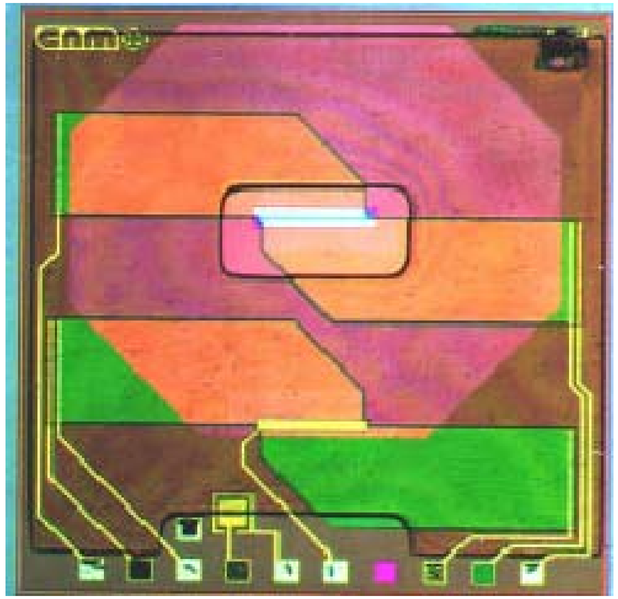


Membranes:

- Inorganic (Si_3N_4, Ta_2O_5, ZrO_2)
- Polymeric (ionophor, enzyme)

pH-ISFETs Fabricados en el CNM





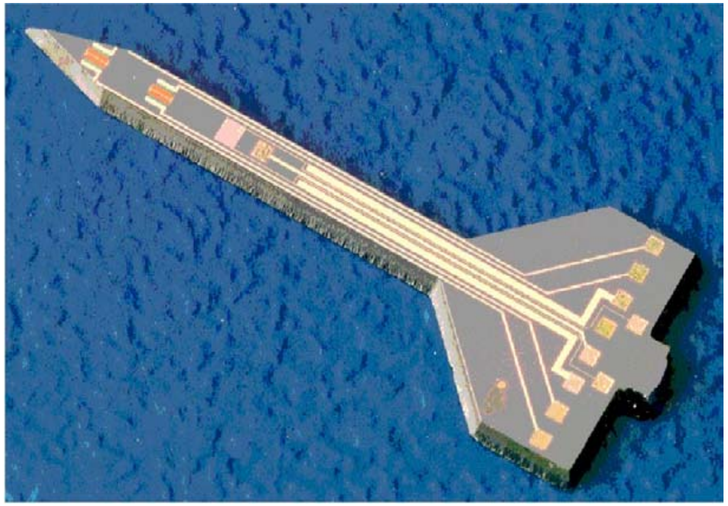
- Especificationes Químicas
  - Sensibilidad a pH, S, ≥ 50 mV / pH
  - Rango lineal, 1 - 13 pH
  - Precision 0.05 pH

(Parámetros estandar para puerta dieléctrica de nitruro de silicio).

NMOS / Micromecanización

MICROCARD

Aguja de Si que constituye un microsistema multifuncional para la monitorización de la isquemia miocárdica aguda durante la cirugía cardíaca extracorpórea.



- Objetivos
  - Medida simultánea de los cambios en el tejido miocárdico (impedancia, [K+] y pH).
  - Desarrollo y puesta a punto de la fabricación de microsondas de silicio con electrodos de Pt y sensores ISFET activos.

Packaging Procedures

Conventional Processes

Epoxy or silicone resins

Manual and slow process

High temperature cured

Not compatible with ISFET technology

Poor interfase adhesion

Low yield, operator dependent

Alternative processes

Lamination

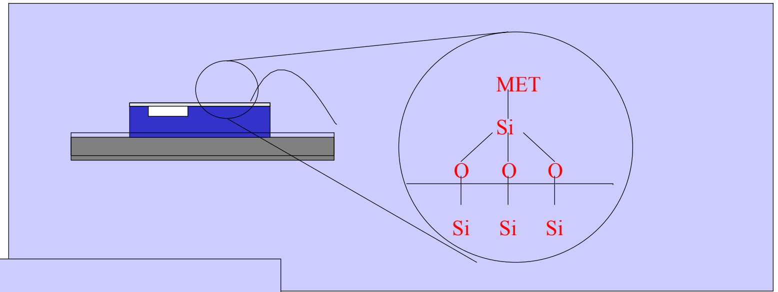
Anodic bonding

Lift-off process

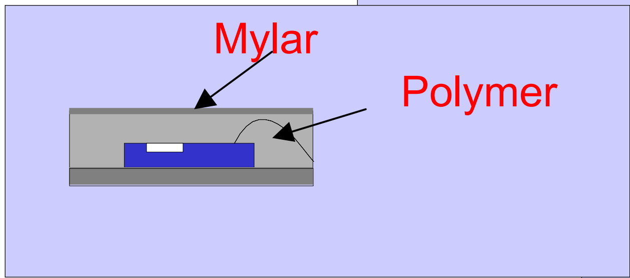
IMB - Packaging

Photocurable Polymers

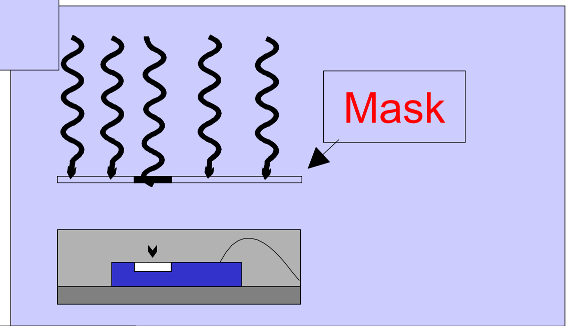
- Surface modification.
- Adhesion promoter



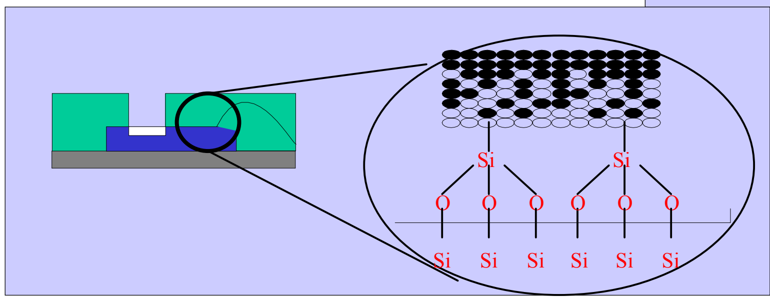
- Polymer deposition.



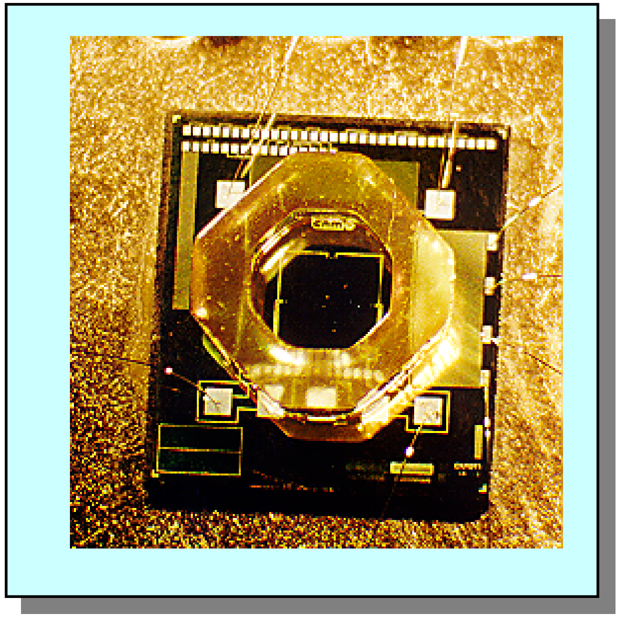
- UV exposition

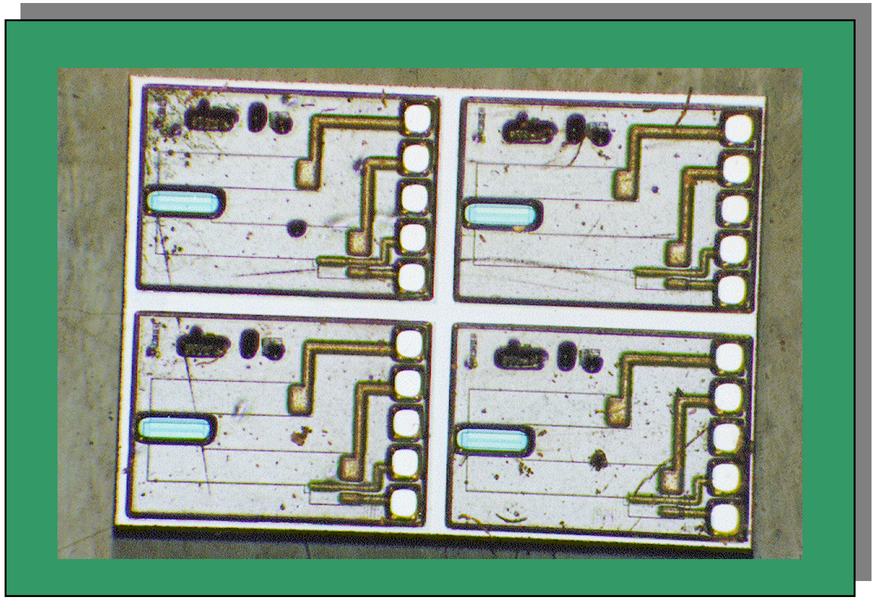


- Development

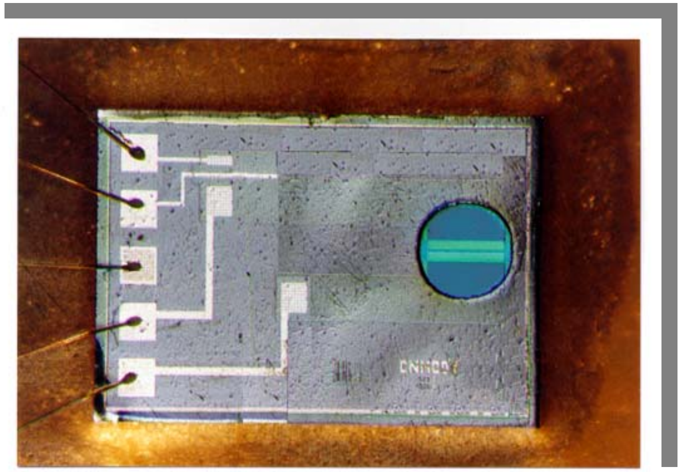


Single chip



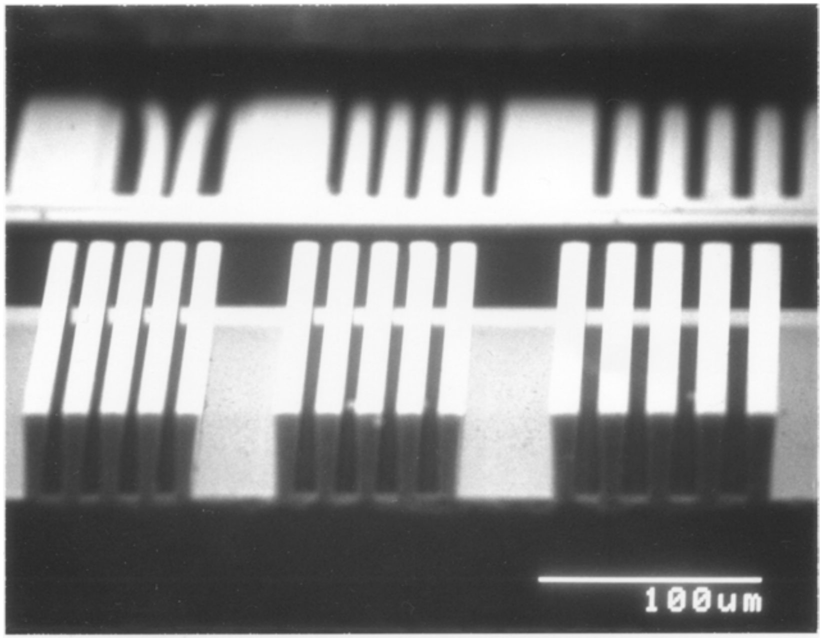


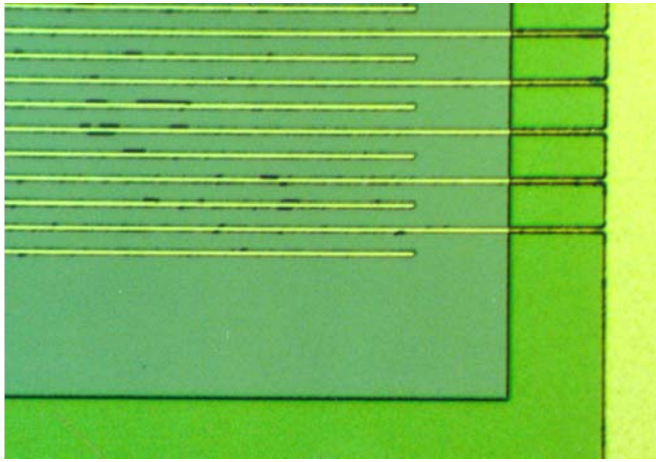
Wafer level



μ - Electrodos / Metal Patterning

Lift-off Process:
- SU8 Resist
- Positive Resist

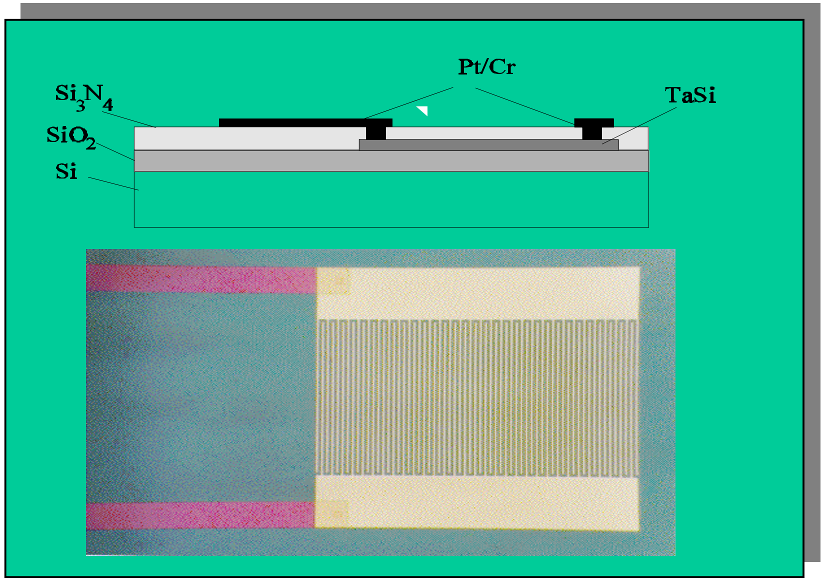


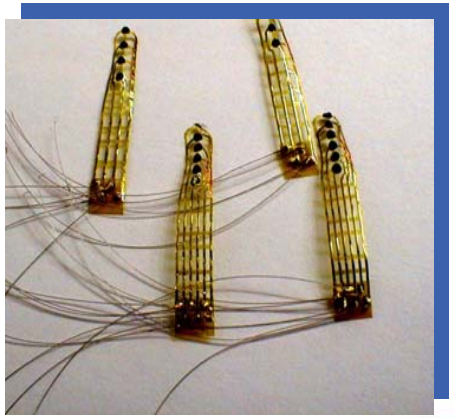


μ - Electrodos

Electrodos interdigitados

- Medidas conductometricas
- Sensor de temperatura
- Determinación de la constante dieléctrica
- Espectroscopia de impedancias





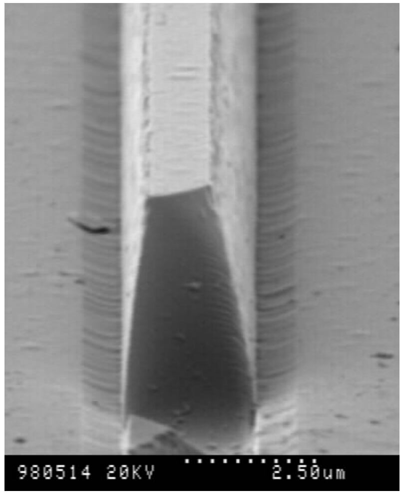
μ-Electrodos implantables

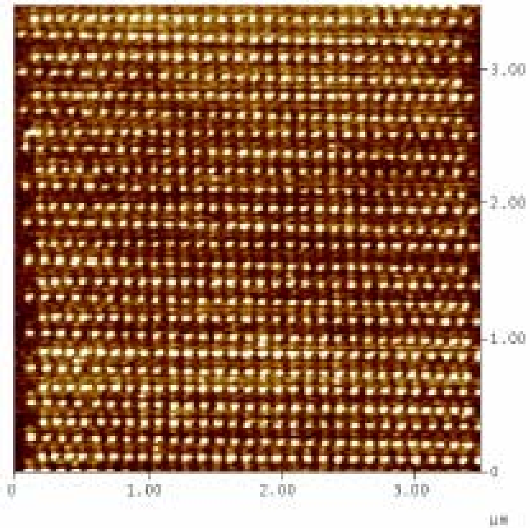
- Estimulación del nervio
- Medidas bioeléctricas
- Dispositivos biocompatibles

Nuevas Tecnologías

TOI: Óptica Integrada

- Componentes Ópticos
- Transductores Optoquímicos
- Transductores Optomecánicos
- Fuentes en silicio





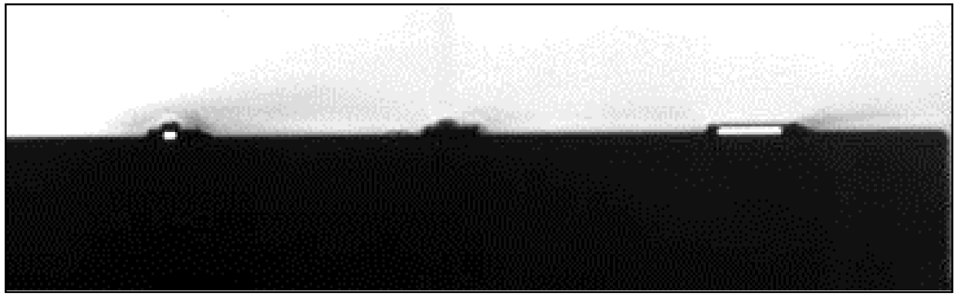
NanoTec: Nano Tecnología

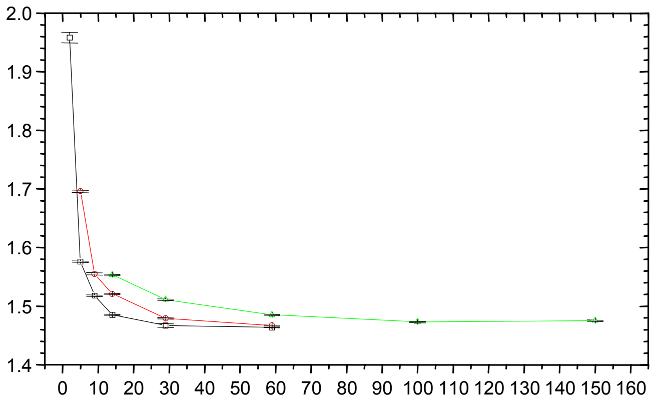
- Nano-Litografía
- Nano-Mecánica
- Dispositivos sensores

Tecnología Óptica Integrada

Procesos:

- PECVD
- RIE
- Litografía UV





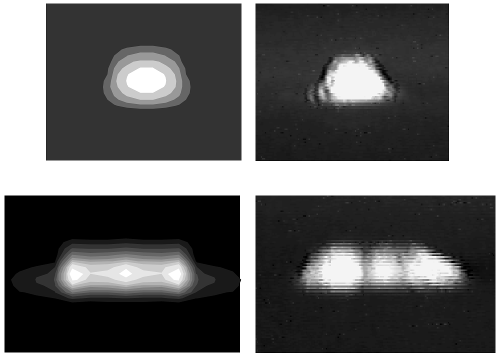
Materiales:

- Óxidos no estequiométricos
- Silicio nano-cristalino

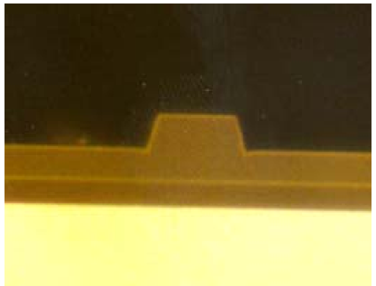
Sensores Optoquímicos

•**Diseño, fabricación y caracterización de dispositivos ópticos integrados basados en estructuras ARROW y compatibles con la tecnología CMOS estándar.**

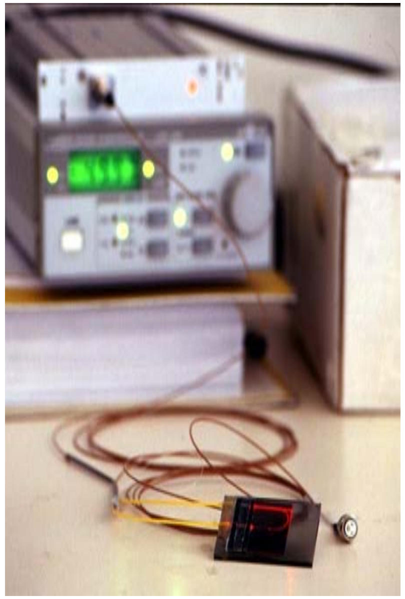
- Guias de onda rectas y curvas
- Interferómetros Mach-Zehnder
- Sensores de absorción en U
- Acopladores direccionales



Simulación y medida del perfil modal en guías ARROW de diferente anchura



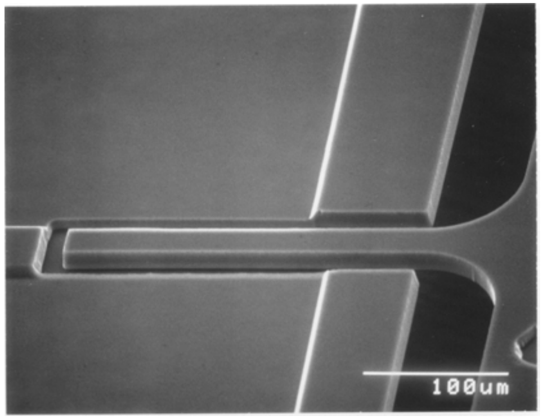
Corte transversal de una guia ARROW

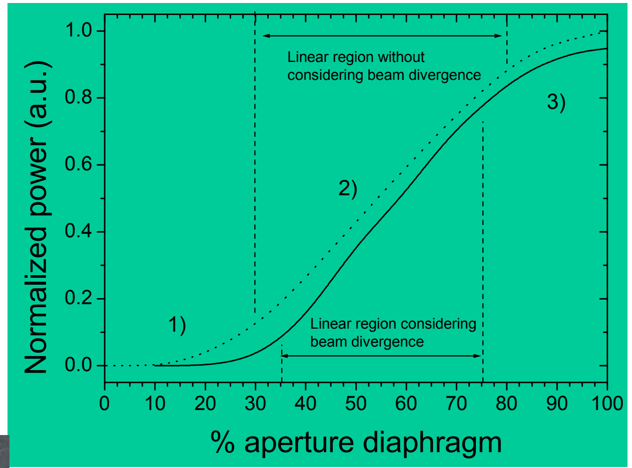


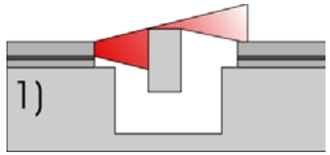
Caracterización de un sensor de Absorción en U

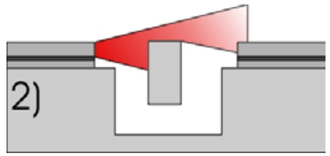
Sensores Optomecánicos

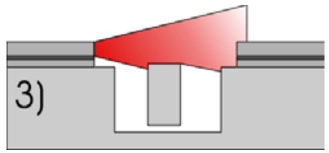
Acelerómetro Óptico Uniaxial de Diafragma

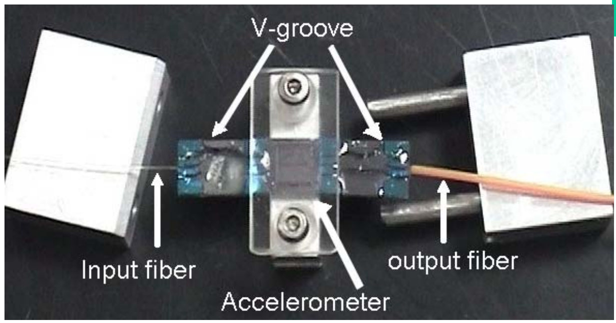




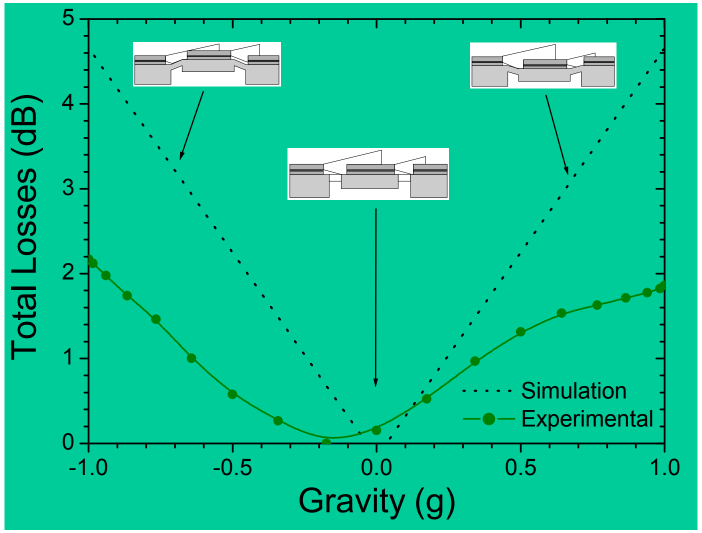


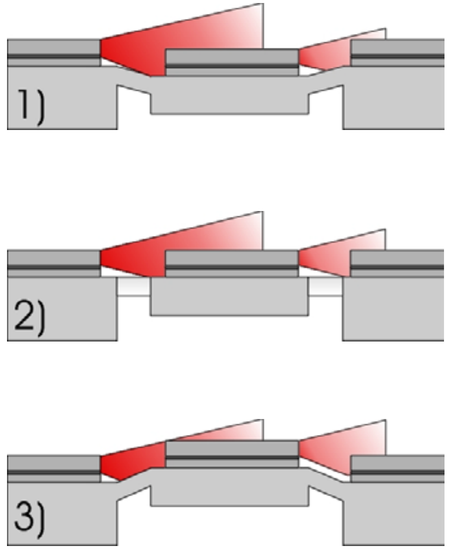


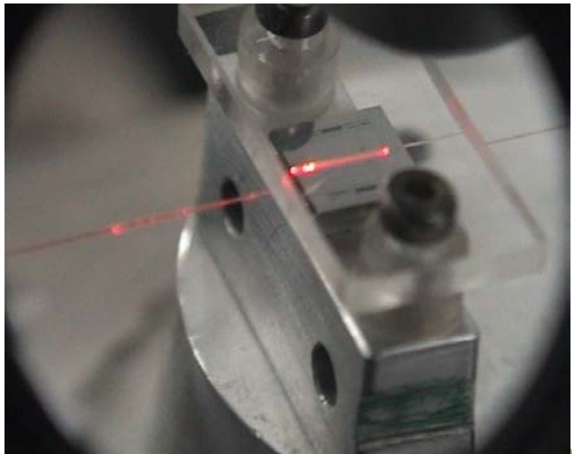




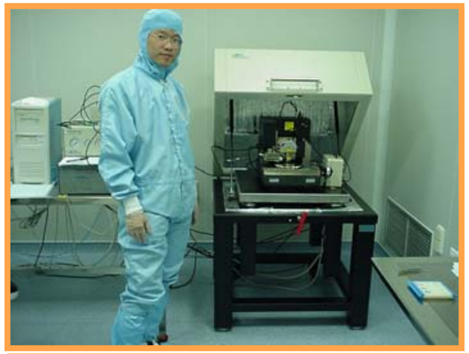
Acelerómetro Óptico de Desalineamiento







Nanofabrication process laboratory



Infrastructure

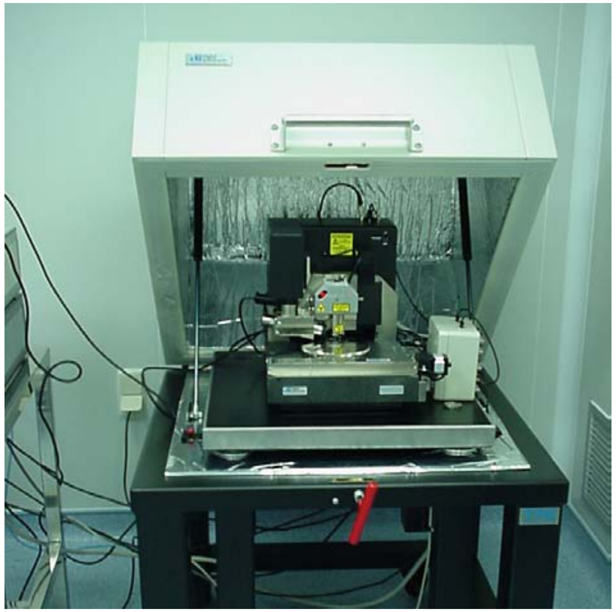
Approach: To combine IMB clean room facilities with nanotechnology equipment

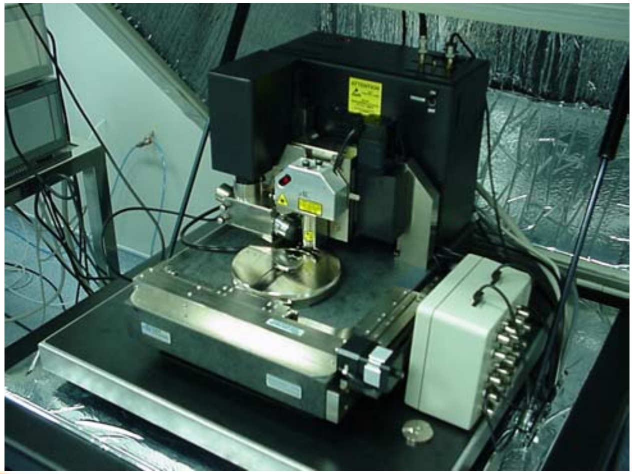
Nanofabrication process laboratory

The Nanofabrication Process Laboratory at the IMB offers access to 'state-of-the art' techniques for nanometer-scale fabrication and inspection, in a controlled ambient (CLASS 100)

- Clean (class 100) laboratory
- Atomic Force Microsope (Nanoscope IV + Dimension 3100)
- e-beam nanolithography system (Leo 1530 + Raith Elphy plus)
- *Near future: Nanoimprint lithography*

Atomic Force Microscopy (AFM)



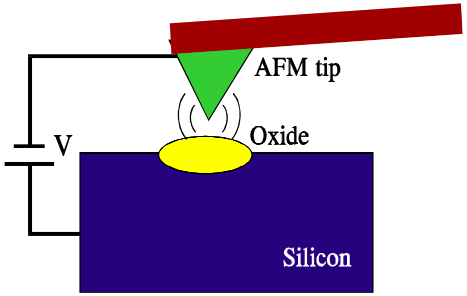


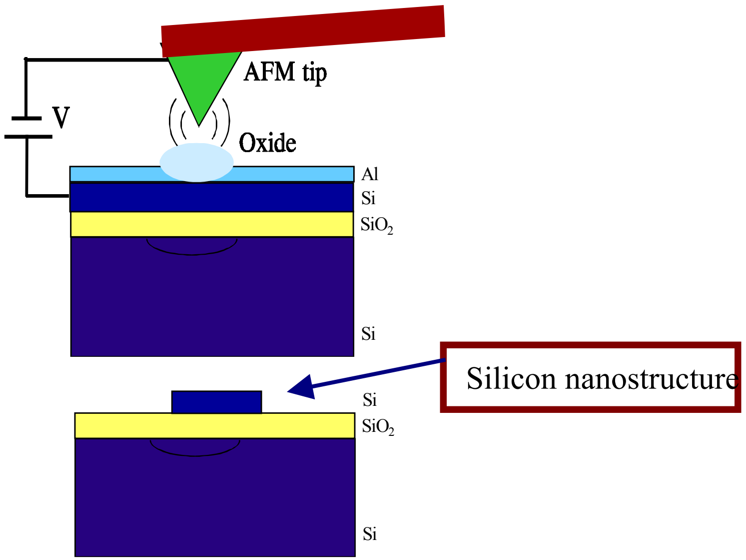
- Company: Digital Instruments / Veeco
- Model Dimension 3100 &
  Nanoscope IV controller

Main features:
- Sample size up to 6'' wafer
- Maximum image range: 60 um x 60 um x 4 um
- Contact and non contact modes

Additional features:
- Electrical measurements:
  Tunneling current (0.01 pA)
  Scanning Capacitance Microscopy
- SThM: Scanning Thermal Microscopy,
  nanometer scale temperature mapping
- Nanolithography capabilities

AFM nanolithograhy: AFM nano-oxidation





Advantages:

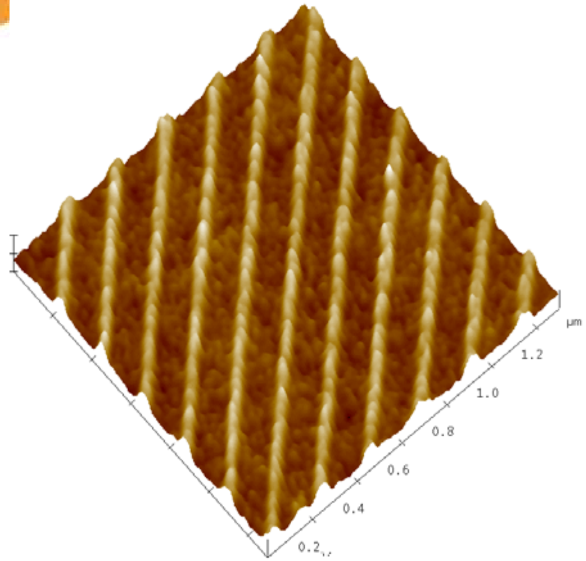
- Simple and reliable technique
- CMOS compatible
- **Resolution below 10 nm**

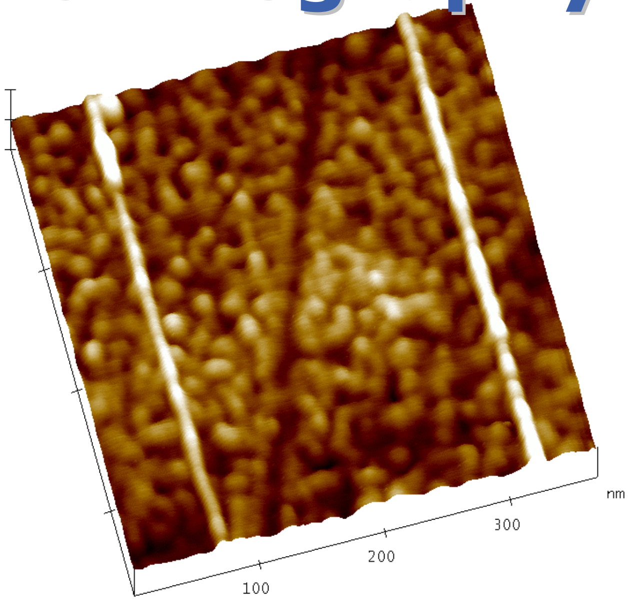
Disadvantages:

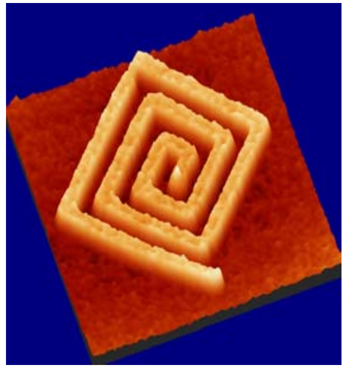
- Slow
- Resolution limited by "resist" thickness

Adequate for prototyping

AFM Nanolithography

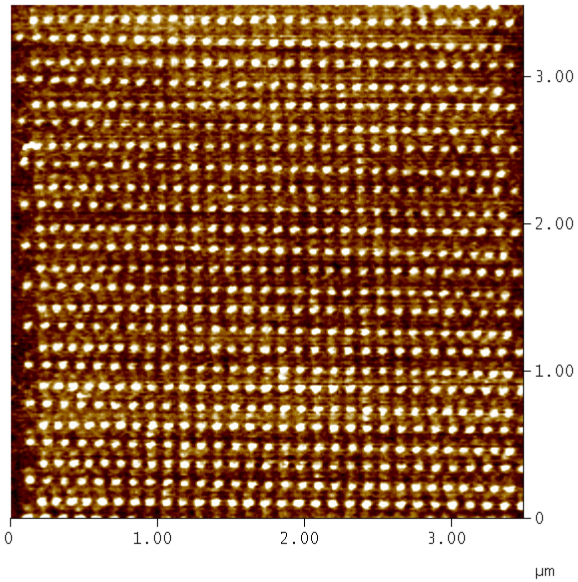


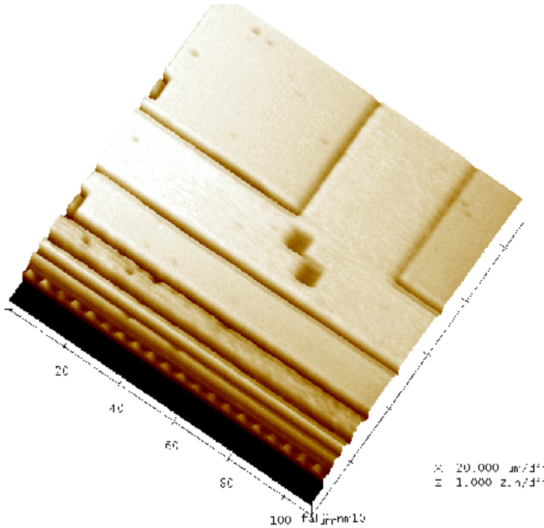




AFM nanolithography on silicon

AFM nanolithography on





Scanning electron microscopy and e-beam lithography

- Company: LEO Electron Microscopy
- Model: LEO 1530 (Field Emission SEM)

Main features:

- Ultra high resolution: (1nm @ 20 kV,
  2.1nm @ 1 kV)
- Voltage range: 0.1 kV - 30 kV
- Sample size up to 4'' wafer

- Extension for e-beam nanolithography:
    - Beam blanker
    - Beam control: RAITH ELPHY PLUS

e-beam nanolithography

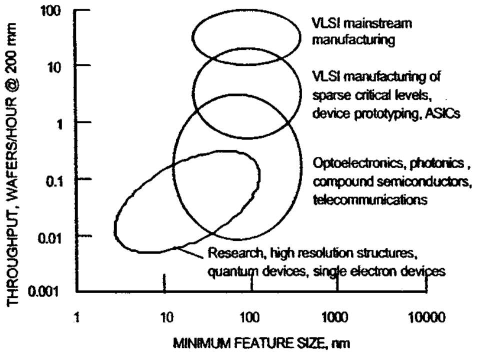


Figure 1. E-beam applications

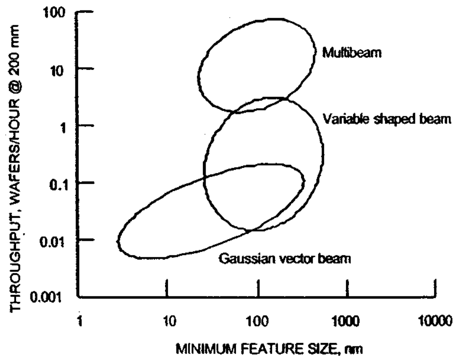


Figure 2. E-beam systems

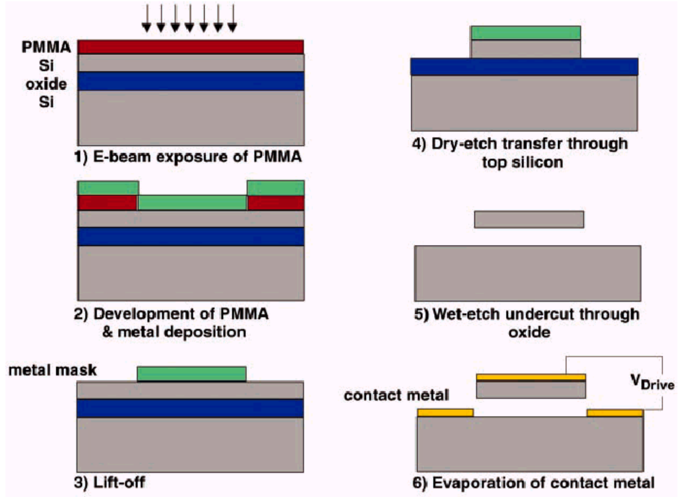
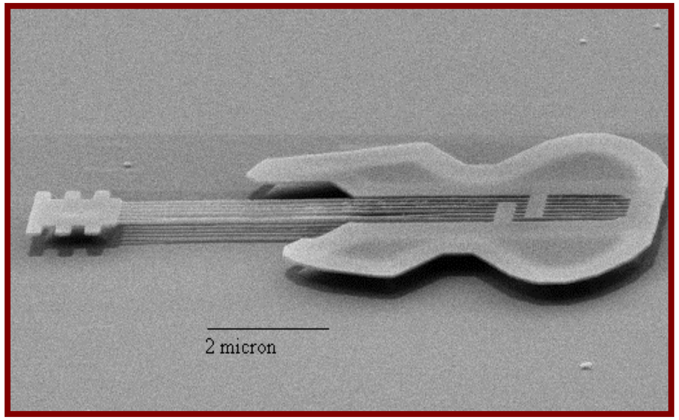
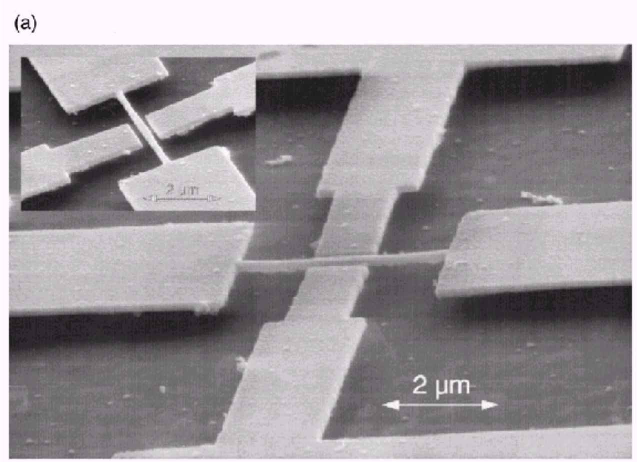


Fig. 2. Schematic of surface micromachining approach used to nanofabricate NEMS devices. Th pattern shapes are created by a scanning electron beam (E-beam) exposing a polymeric poly methylmethacrylate (PMMA) resist. The motion may be actuated by applying a voltage (V_{Drive}) between the electron on the moving element and the electrode on the substrate.



Nano-guitar (Cornell Unviersity)

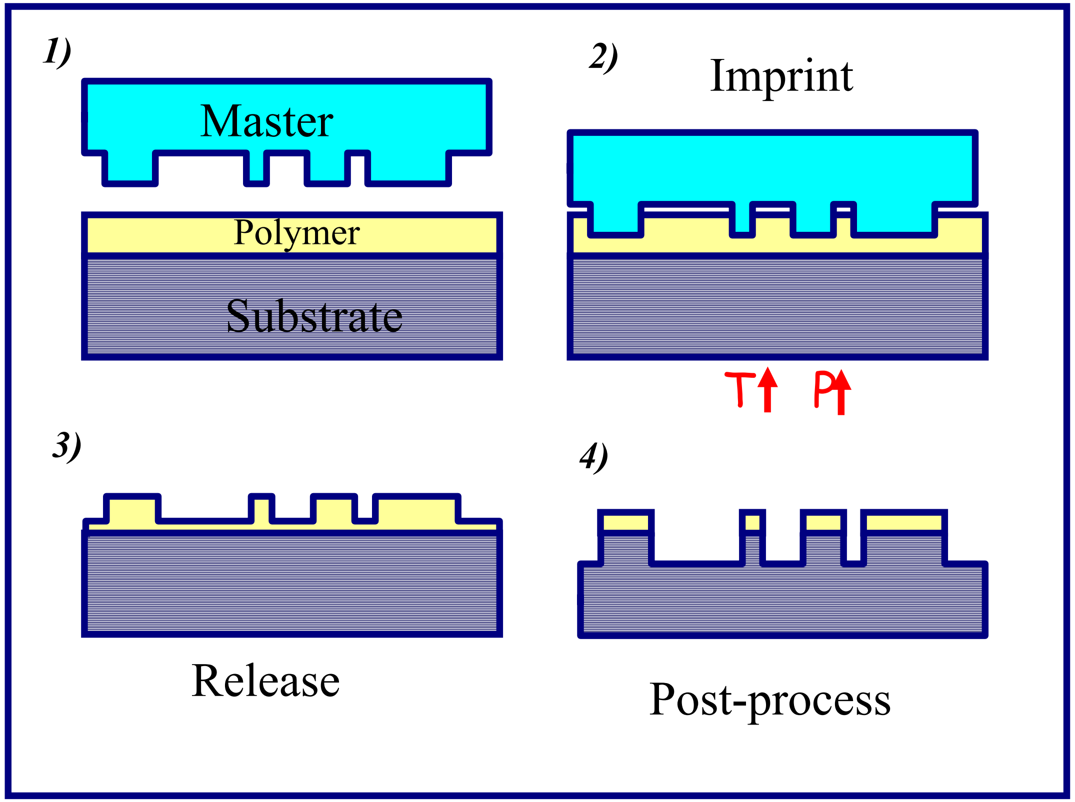


(Nano-oscillators: Cornell University)

e-beam nanolithography and nanomechanics

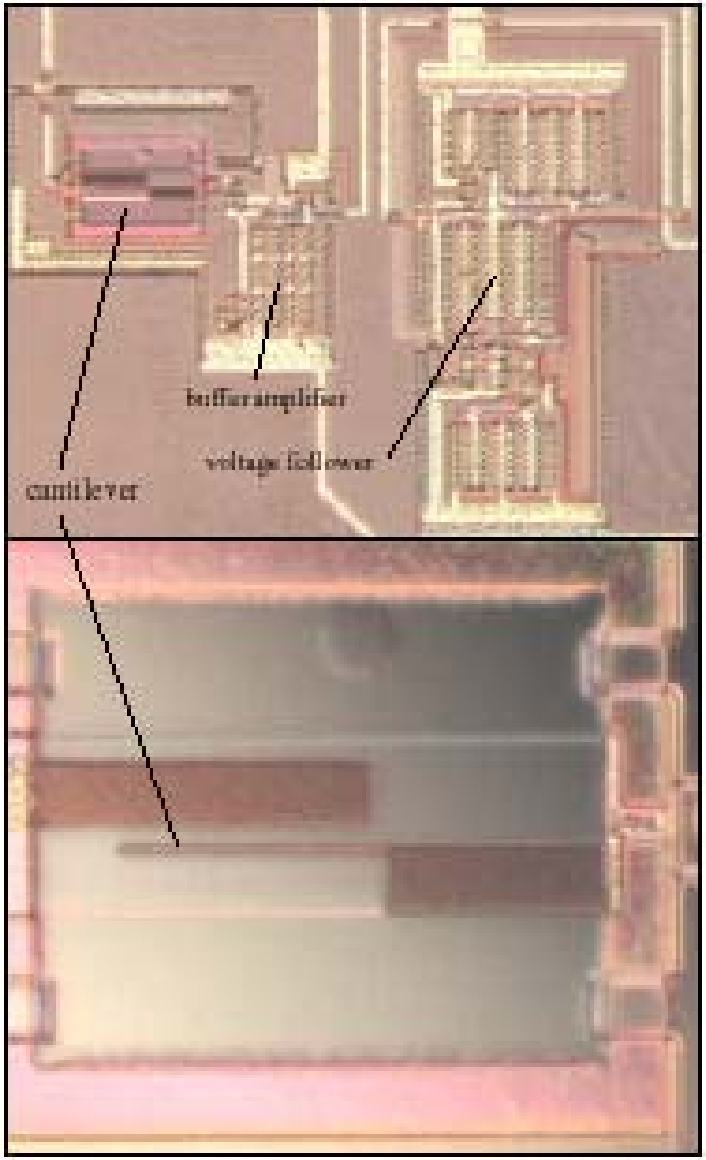
Nanoimprint lithography

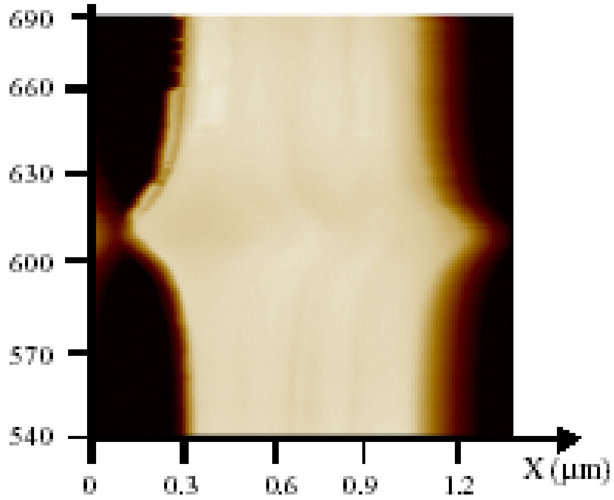
New technology, similar to the one used to fabricated CD

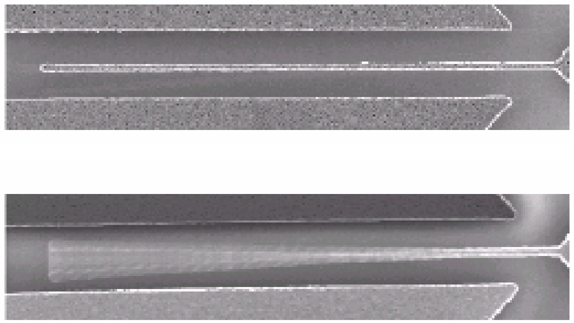


- Company: OBDUCAT
- Model: Imprint 4''
- Resolution: better than 25 nm

It is the only technique that allows to define nanostructures in parallel and at low cost







48 um x 0.78 um x 1.8 um