

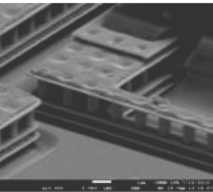
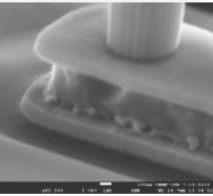
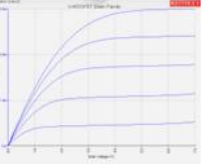
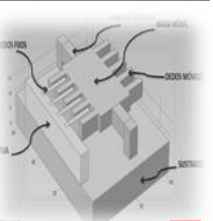
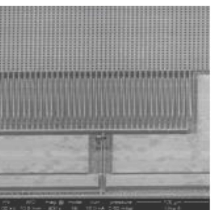
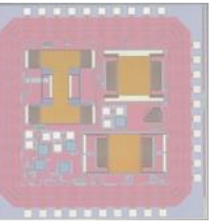
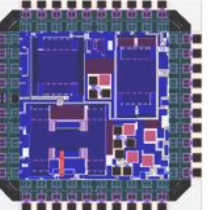
GRUPO DE SISTEMAS VLSI  
Dr. Mario Alfredo Reyes Barranca

[mreyes@cinvestav.mx](mailto:mreyes@cinvestav.mx)

Tel.: +(52) 55 5747 3776

# Línea de Investigación

## Dispositivos y Sistemas MEMS



10kV

x3,700

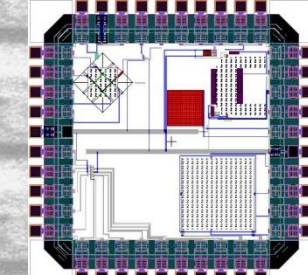
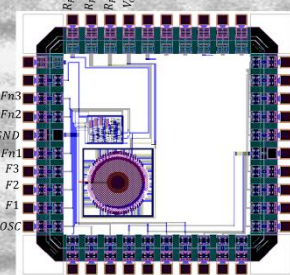
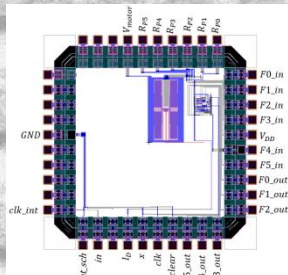
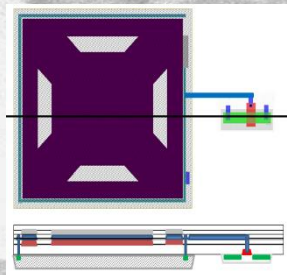
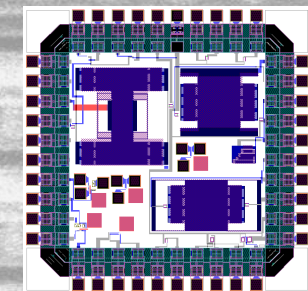
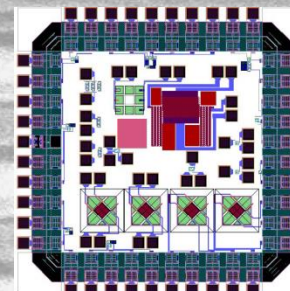
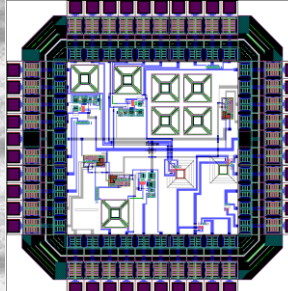
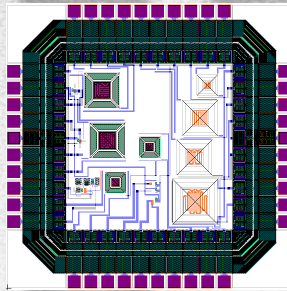
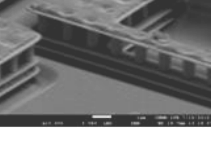
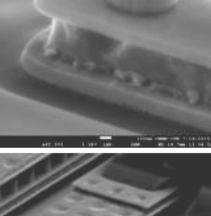
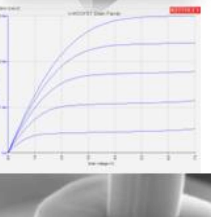
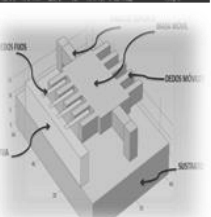
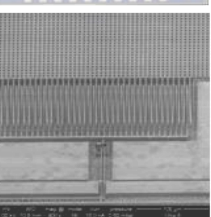
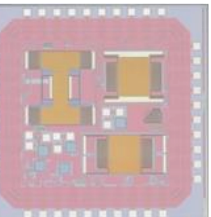
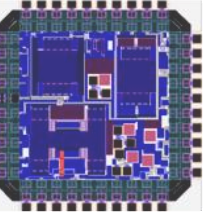
5μm

2015/07/08

18 40 SEM\_SEI

# Línea de Investigación

## Diseño, fabricación y caracterización de MEMS



10kV

x3,700

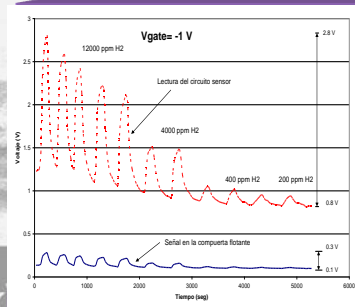
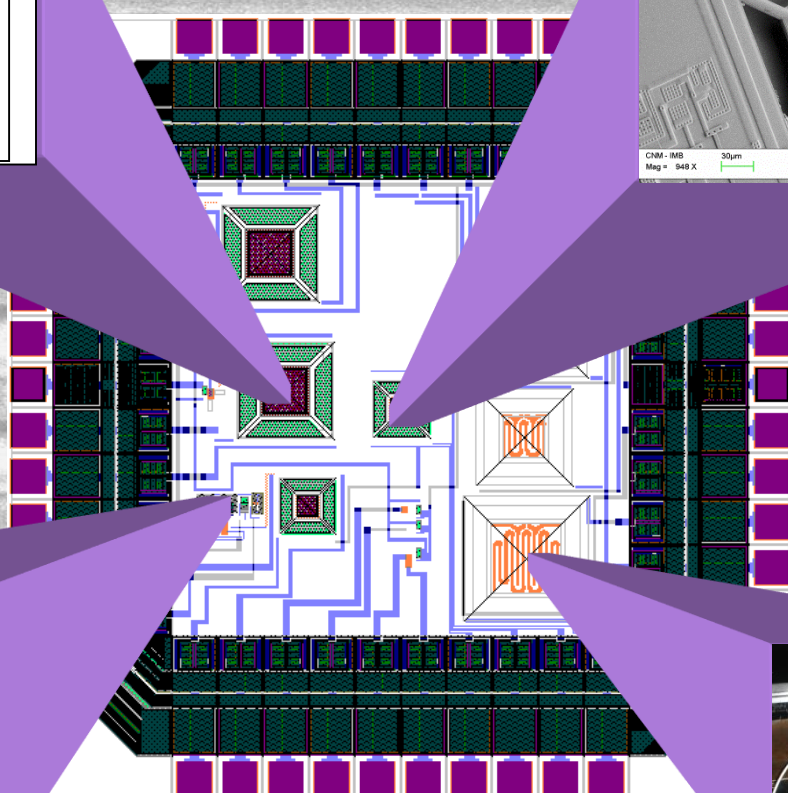
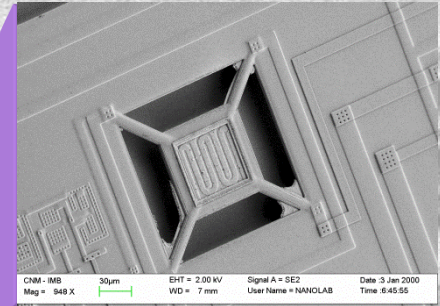
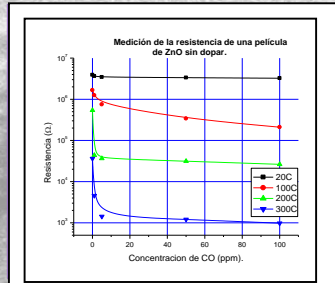
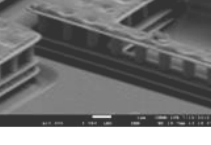
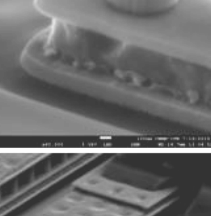
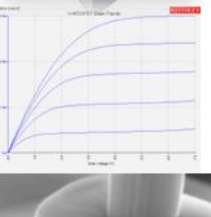
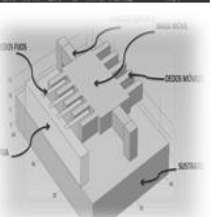
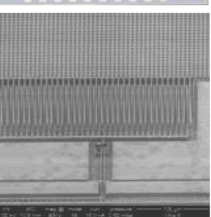
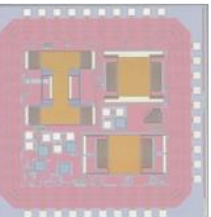
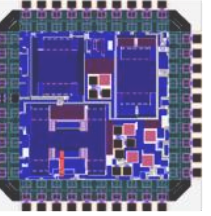
5 $\mu$ m

2015/07/08

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# Línea de Investigación

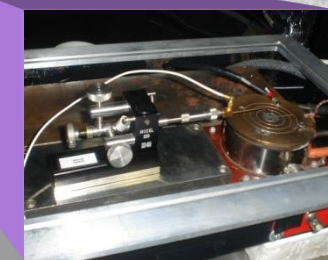
## Dispositivos y Sistemas MEMS.



10kV

5µm

2015/07/08

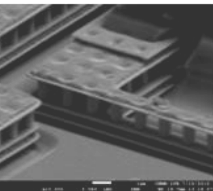
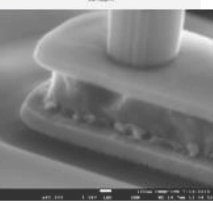
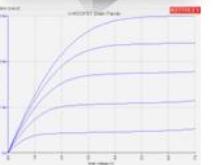
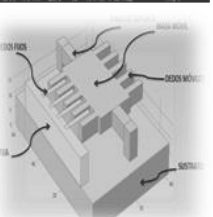
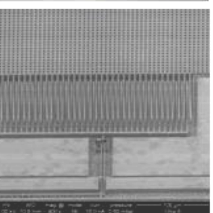
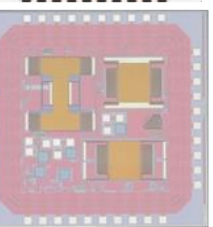
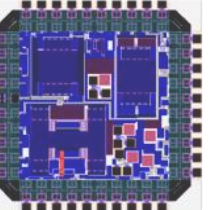


10.10 SEM SEI

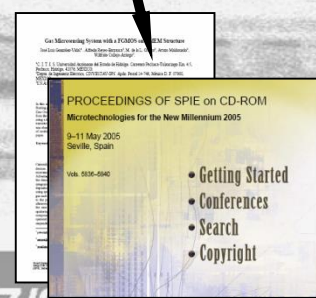
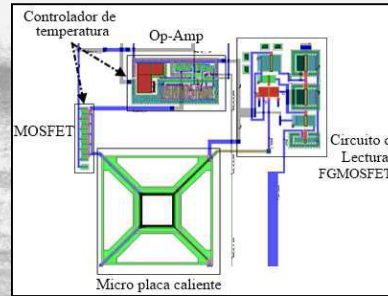
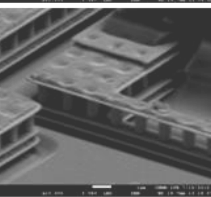
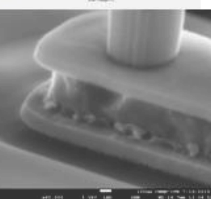
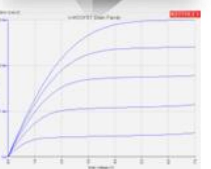
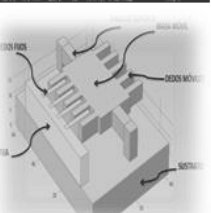
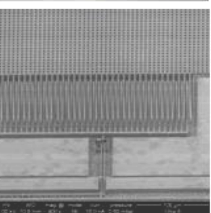
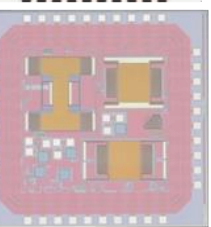
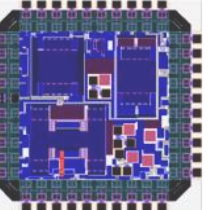
# Línea de Investigación

## Sistemas con Sensores MEMS y Dispositivos con FGMOS.

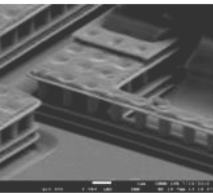
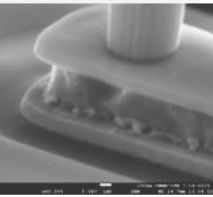
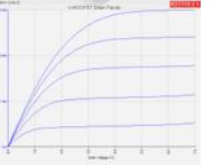
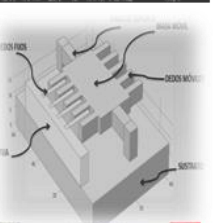
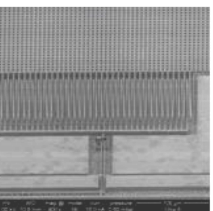
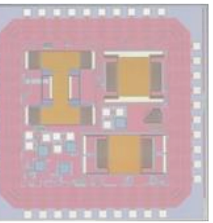
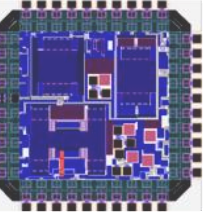
- Ejemplo de lo que son MEMS
- Sistema de detección de gases
- Acelerómetro CMOS-MEMS
- Micro-celdas sobre FGMOS
- Transistores MOS de Compuerta Flotante



# DISEÑO DE ESTRUCTURAS CON BASE AL FGMOS



# DEPARTAMENTO DE INGENIERIA ELECTRICA SECCION DE ELECTRONICA DEL ESTADO SÓLIDO



10kV

x3,700

5 $\mu$ m

2015/07/08

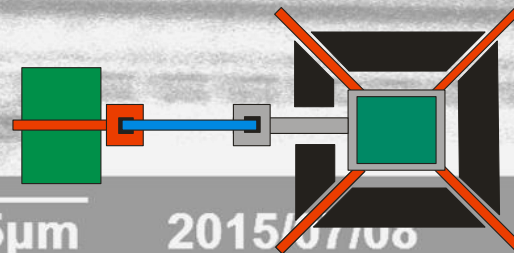
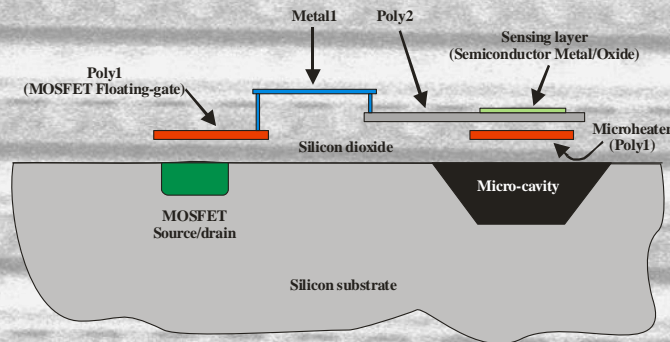
18 40 SEM\_SEI





# Dispositivos

- Diseño de los dispositivos y fabricación tecnológica
- Sensores de gas
  - Gases inorgánicos
  - Aromáticos
- Microplaca caliente (calefactor)



10kV

x3,700

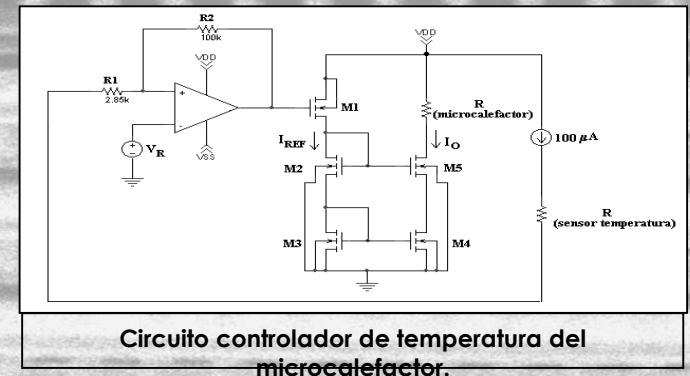
5µm

2015/07/06

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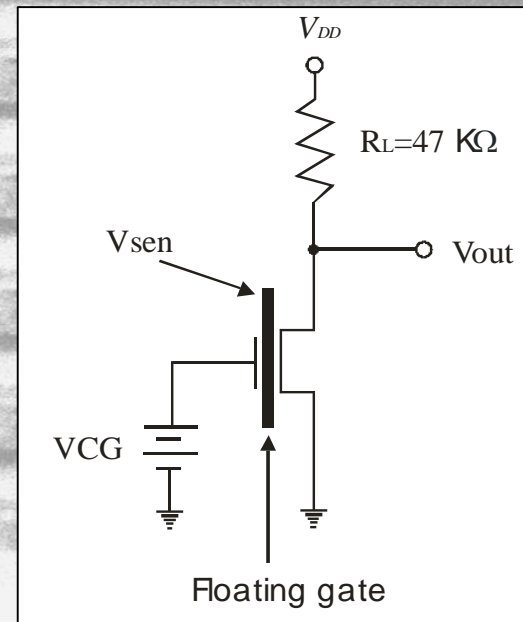
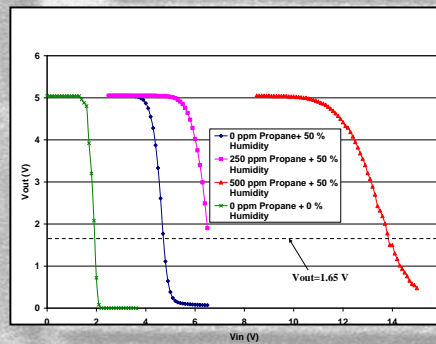
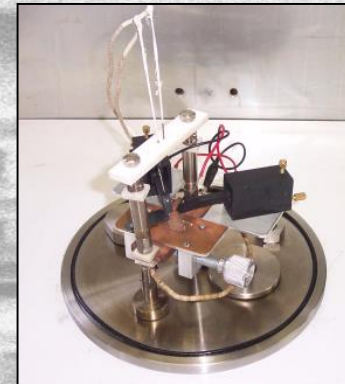
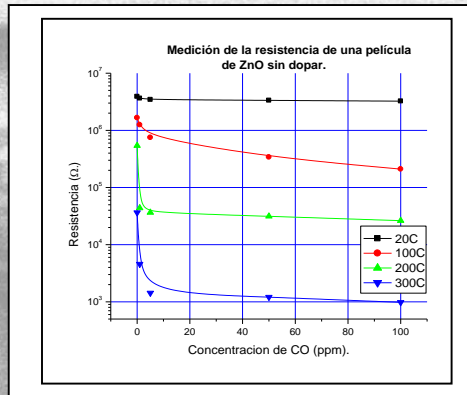
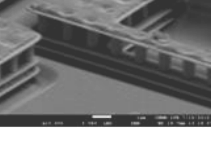
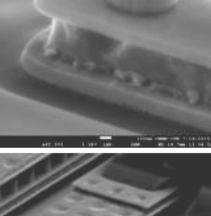
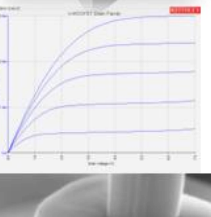
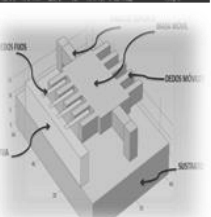
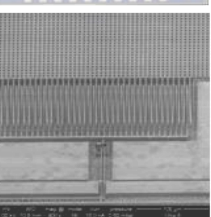
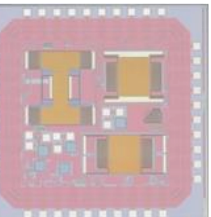
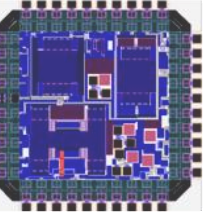
# Sistemas

- Diseño de circuitos VLSI y procesamiento de señal
- Circuitos de lectura de gas
  - Analógicos
  - Digitales
    - FPGAs
    - DSPs
    - Neurodifusos
  - Mixtos



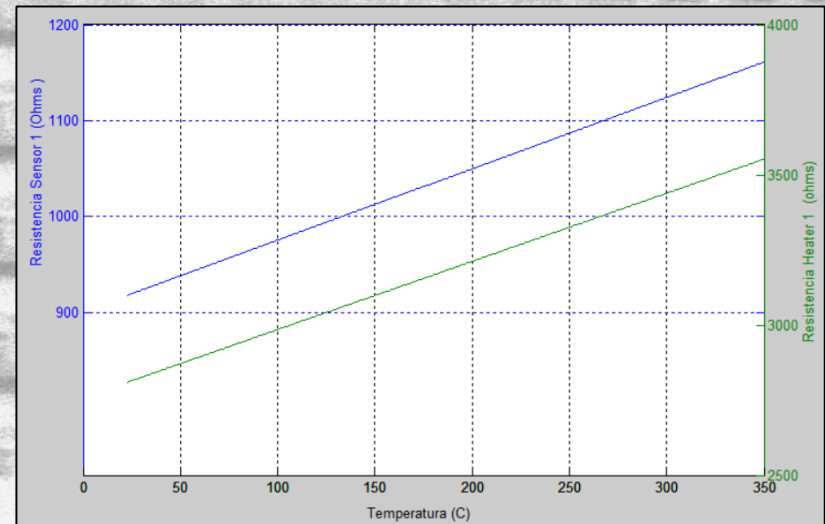
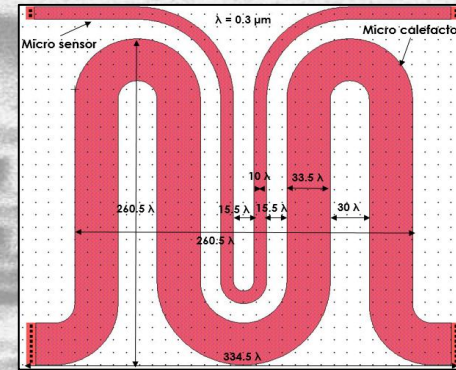
# Caracterización

Propiedades de óxidos semiconductores (Estática y Dinámica)



# Caracterización

Coeficiente de Resistencia Térmica (TCR) de materiales calefactores y sensores



10kV

x3,700

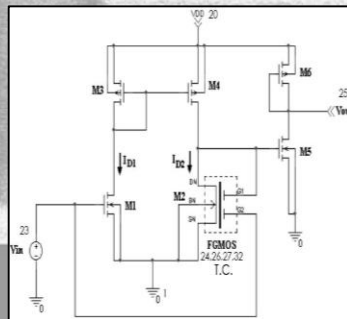
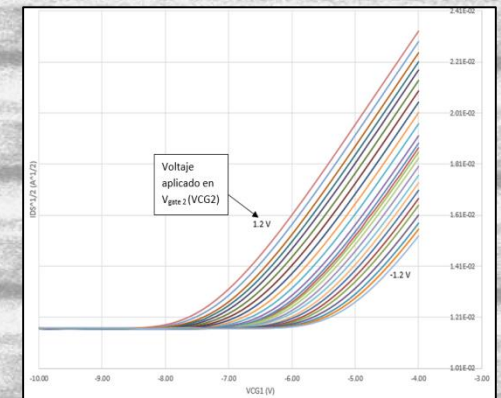
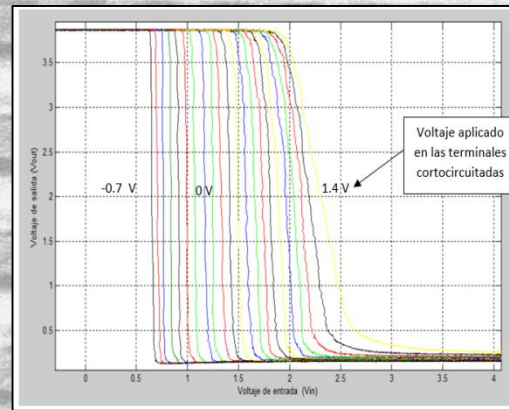
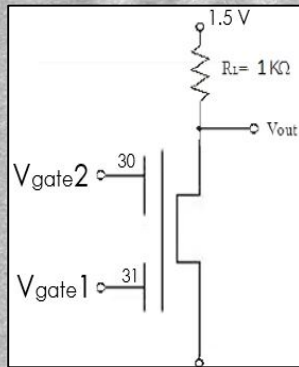
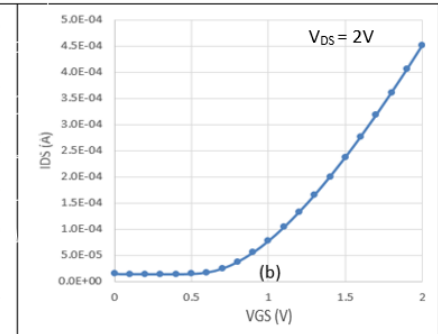
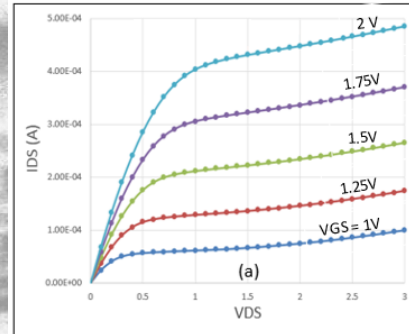
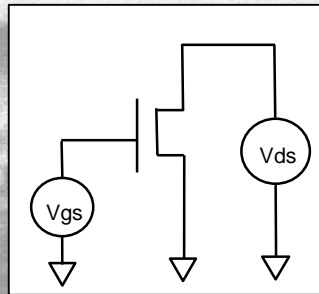
5 $\mu\text{m}$

2015/07/08

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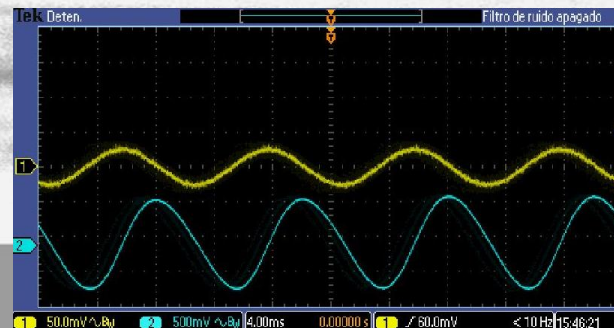
# Caracterización

Características I-V de los dispositivos integrados y de los sistemas sensores



10kV

5μm

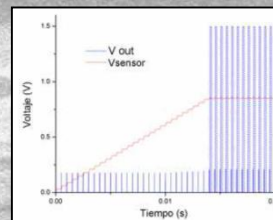
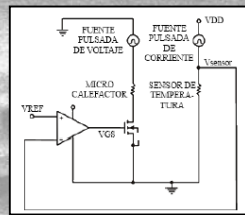


40 SEM\_SEI

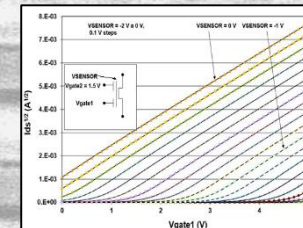
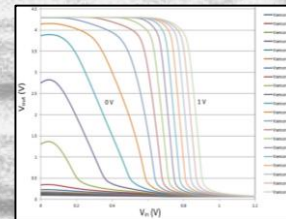
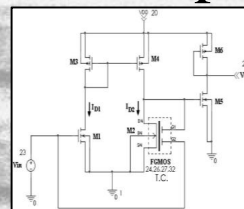
# Simulación por computadora

## ■ Sistema electrónico (PSPICE)

- Circuitos de control térmico

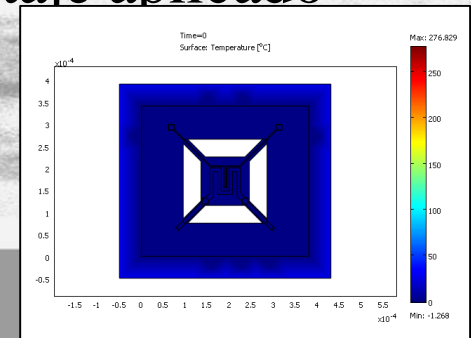
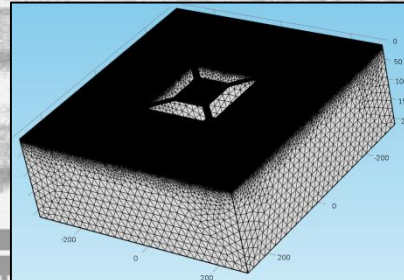
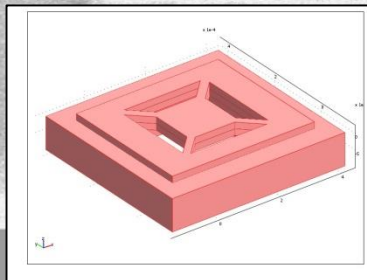


- Circuitos de procesamiento de señal



## ■ Comportamiento electro-térmico (COMSOL)

- Respuesta térmica de los materiales
- Temperatura en función del voltaje aplicado



10kV

x5,700

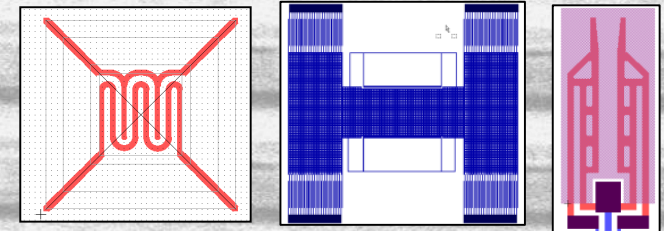
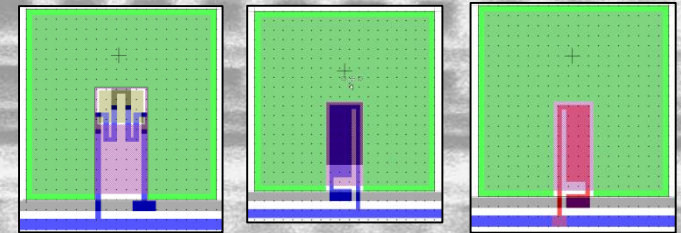
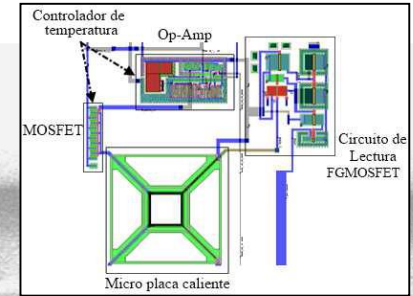
5µm

2015/07/00

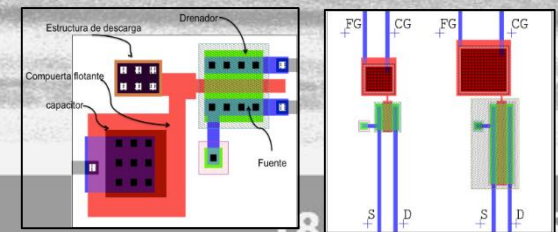
SEI

# Diseño topológico

- Amplificadores
- Circuitos de procesamiento de señal
  - Digitales
  - Analógicos
- Motivos de prueba
- Microcalefactores, acelerómetros (sensores) y micropinzas (actuadores)



- Transistores MOS de Compuerta Flotante



10kV

x3,700

5 $\mu$ m

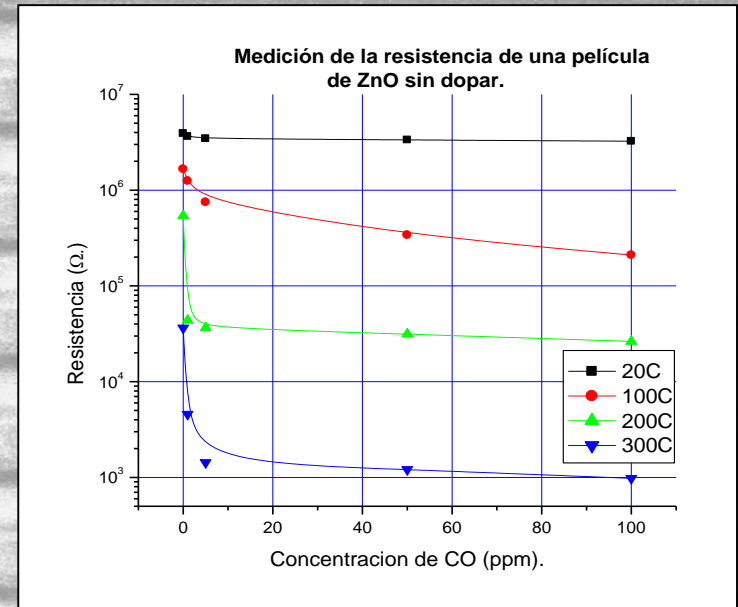
2015/07/08

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# Procesos tecnológicos

## ■ Depósito de películas sensoras

- Óxidos semiconductores
- Ferritas

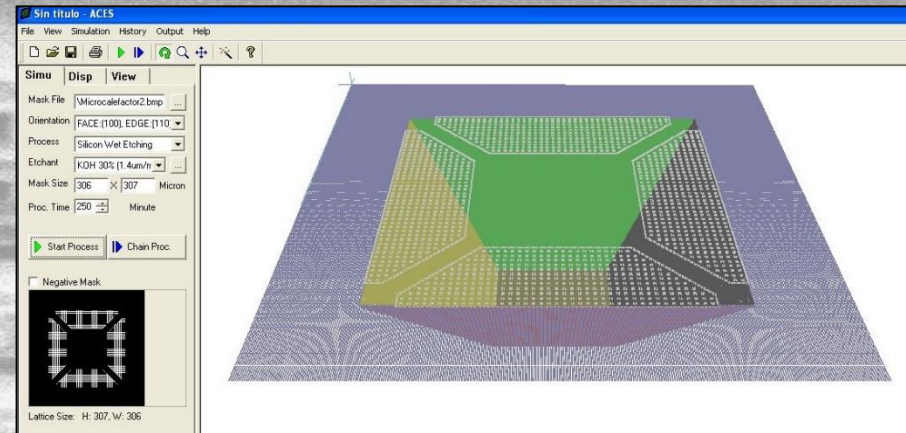
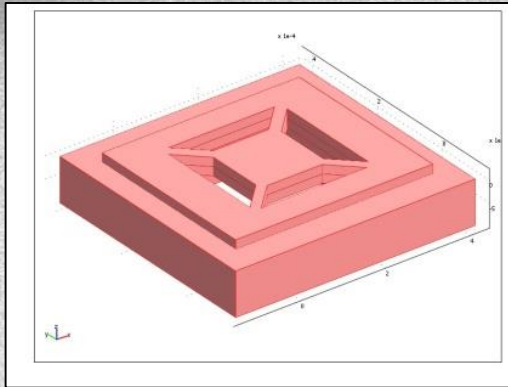




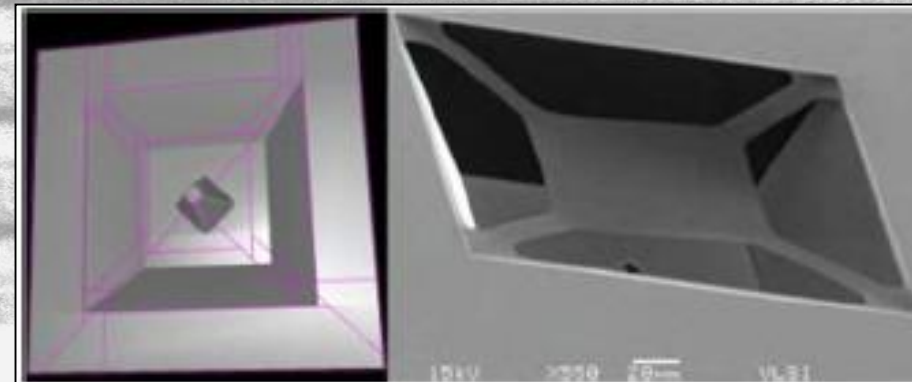
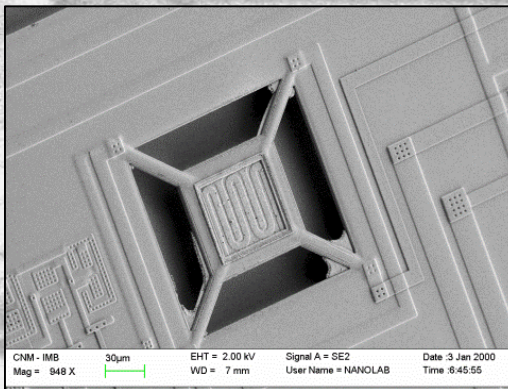
# Procesos tecnológicos

## ■ Micromaquinado Volumétrico

### Simulación



### Experimental



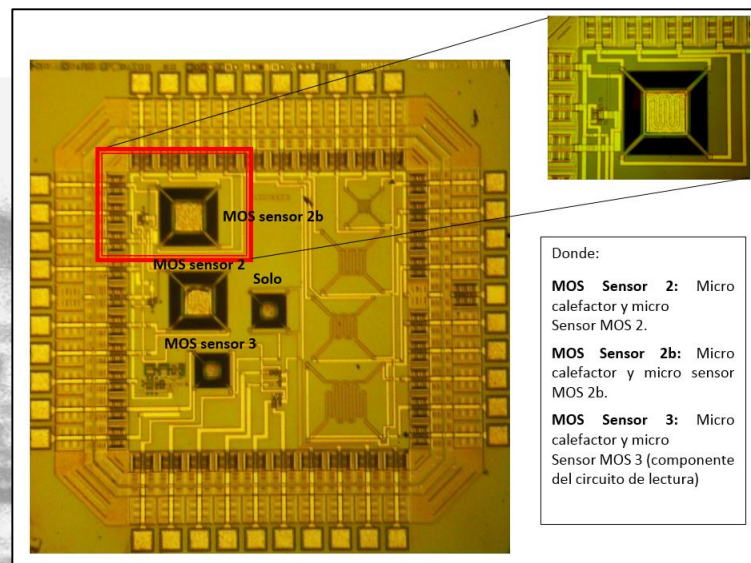
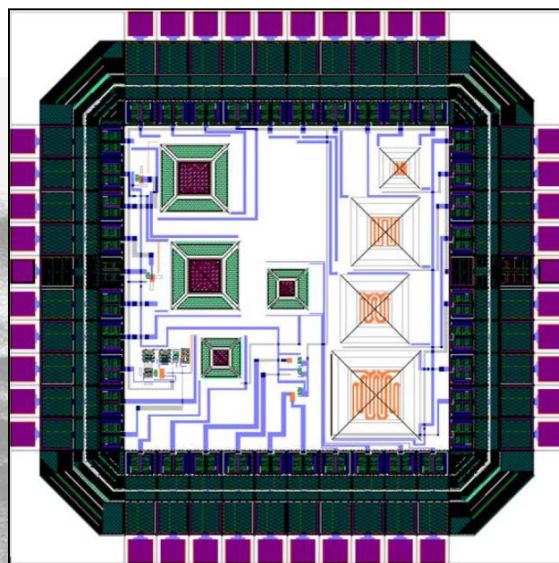
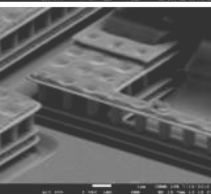
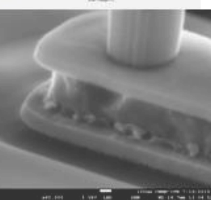
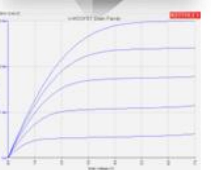
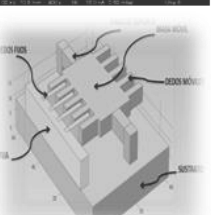
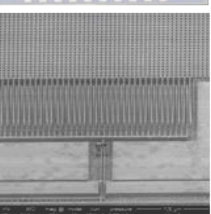
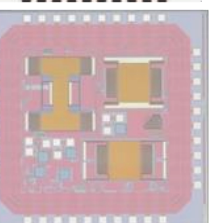
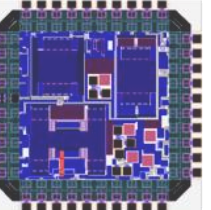
10kV

x3,700

5µm

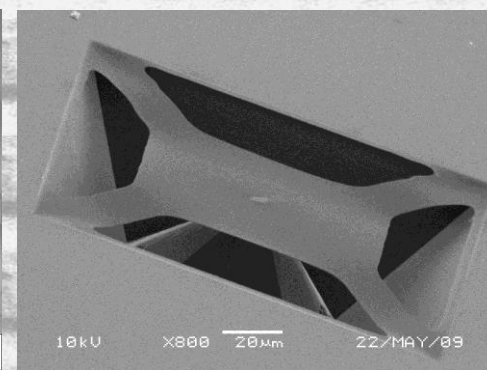
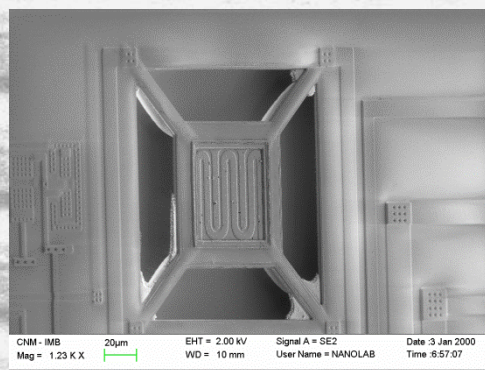
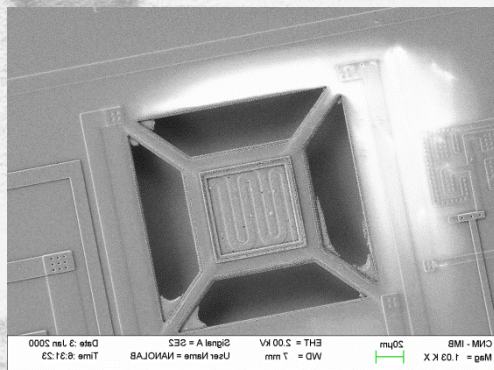
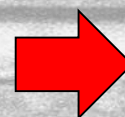
2015/07/08

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Donde:

- MOS Sensor 2:** Micro calefactor y micro Sensor MOS 2.
- MOS Sensor 2b:** Micro calefactor y micro sensor MOS 2b.
- MOS Sensor 3:** Micro calefactor y micro Sensor MOS 3 (componente del circuito de lectura)



# Microfotografías (SEM) de Grabado de Fosos

10kV

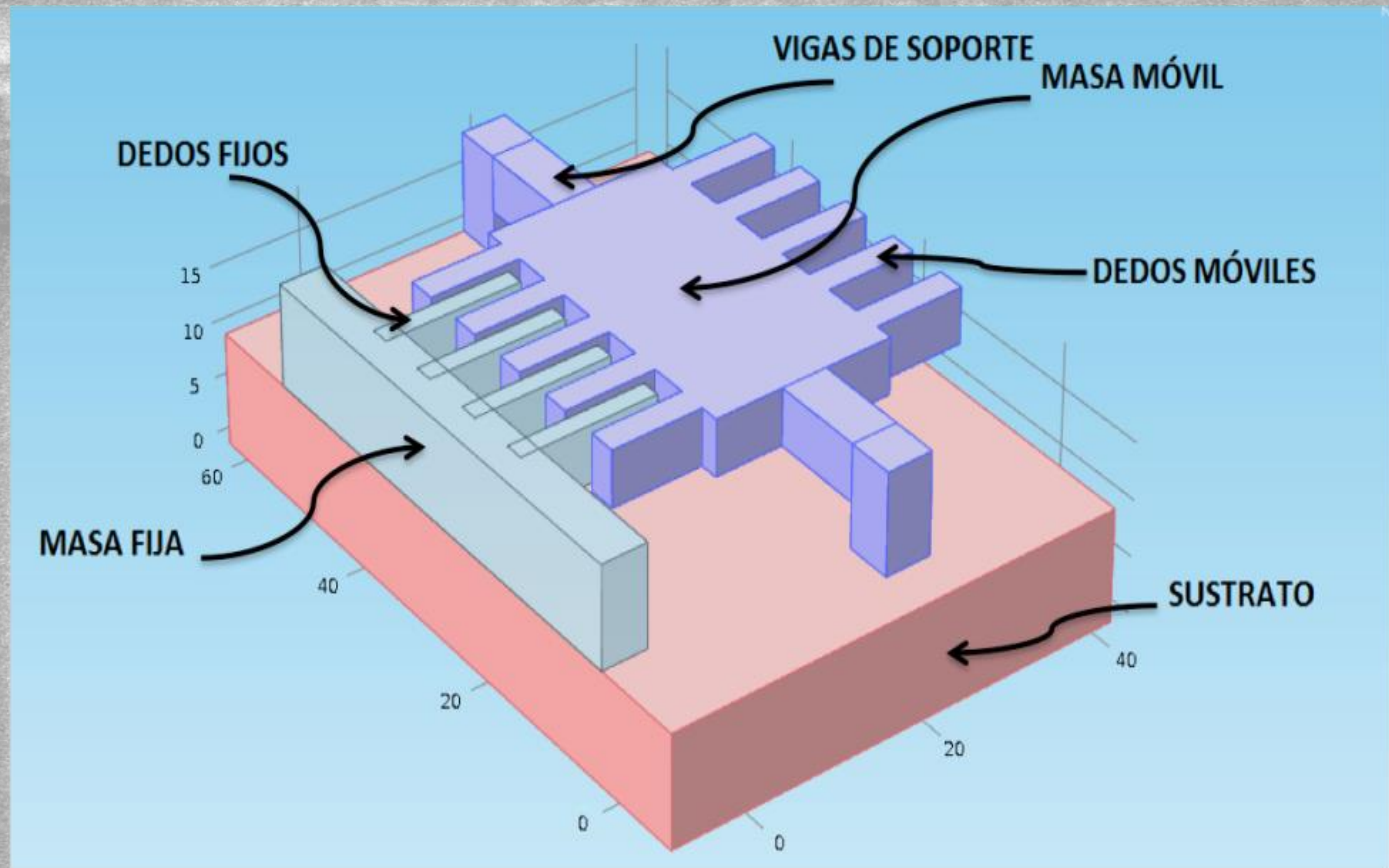
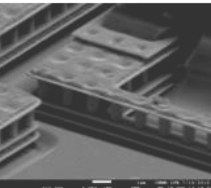
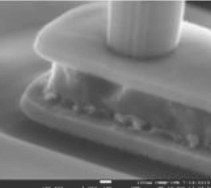
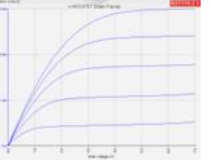
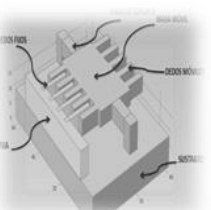
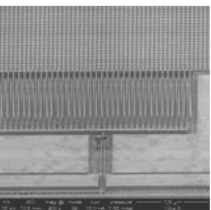
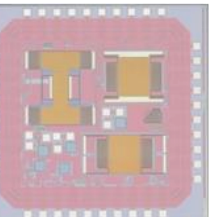
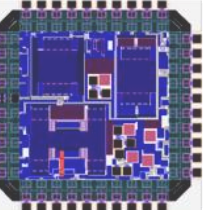
x3,700

5µm

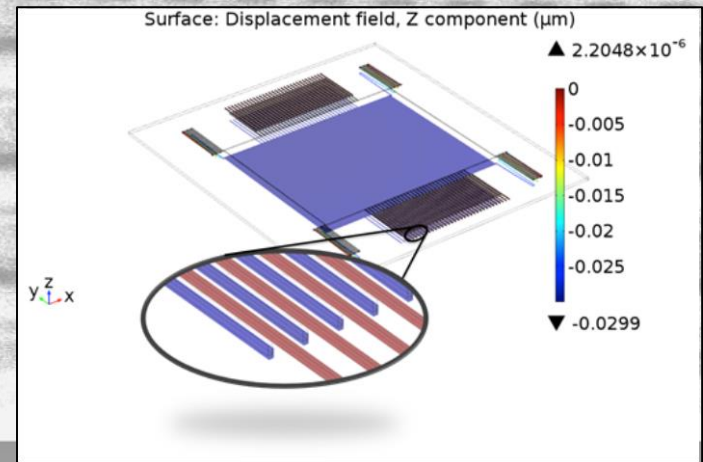
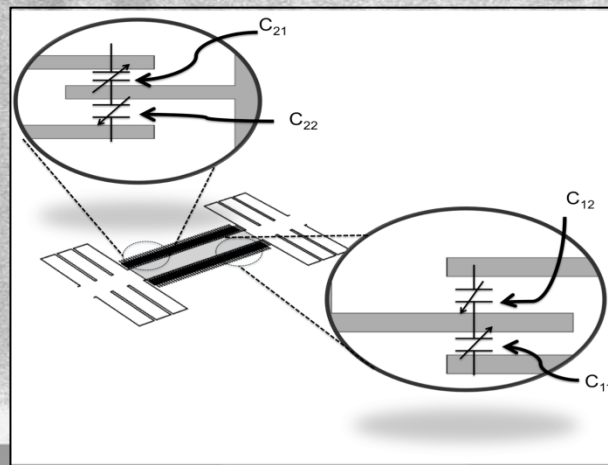
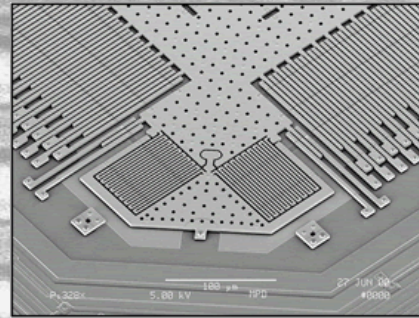
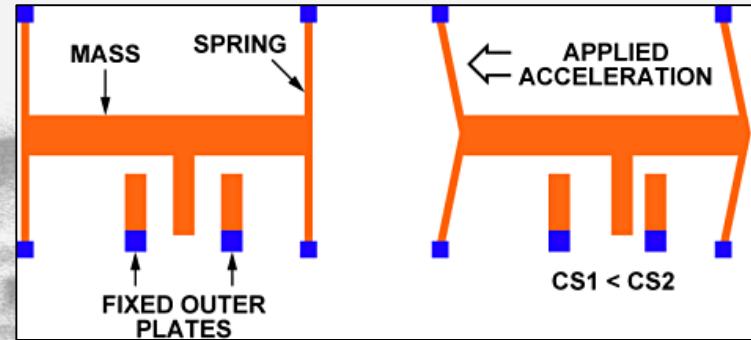
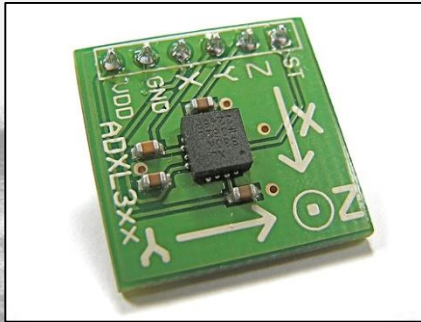
2015/07/08

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# Acelerómetro CMOS-MEMS



# Acelerómetro CMOS-MEMS



10kV

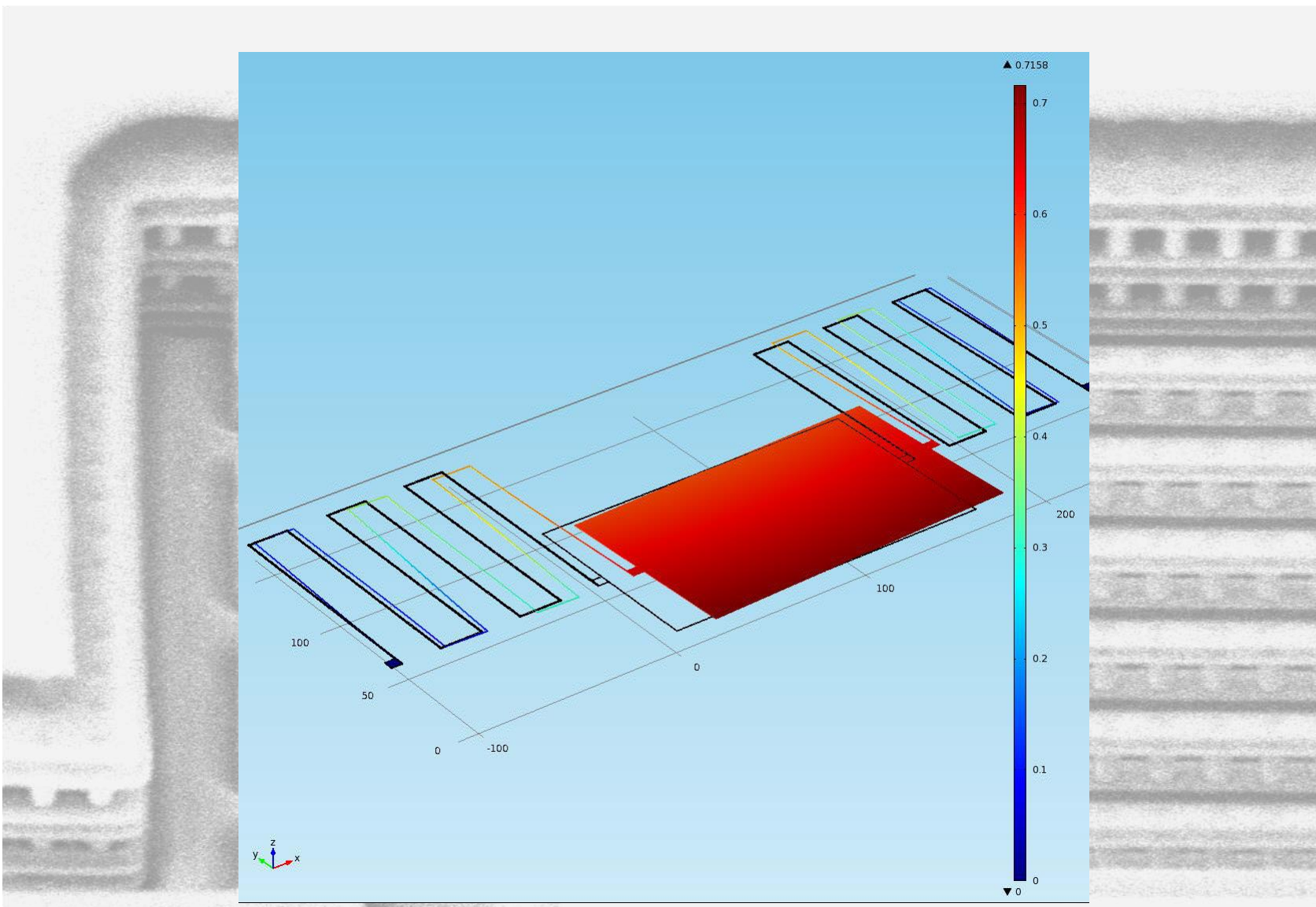
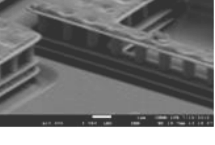
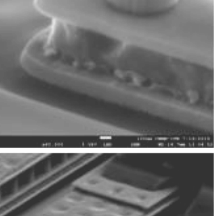
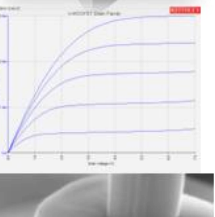
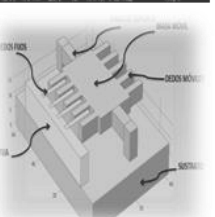
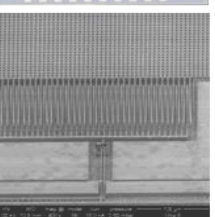
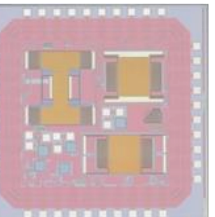
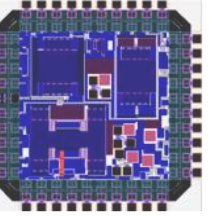
x3,700

5μm

2015/07/08

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# Acelerómetro CMOS-MEMS



10kV

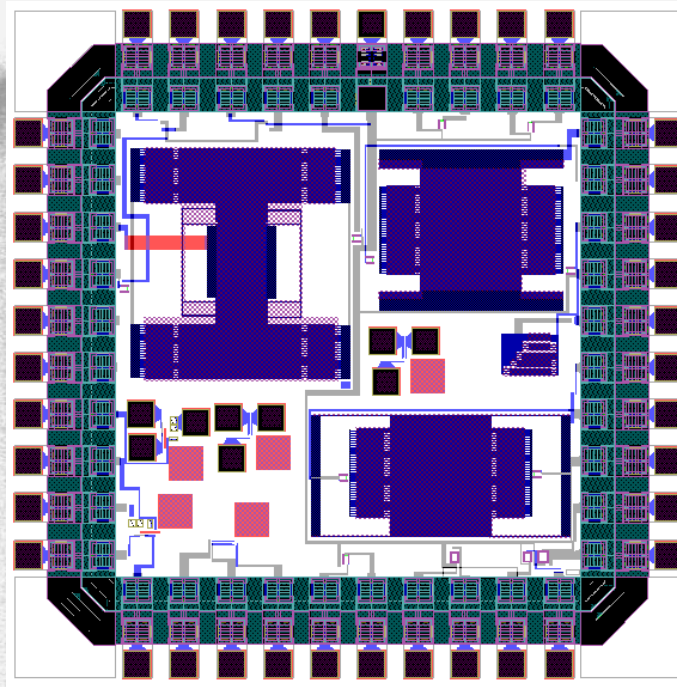
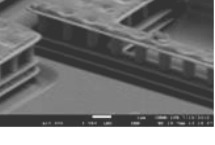
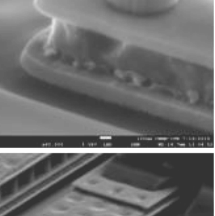
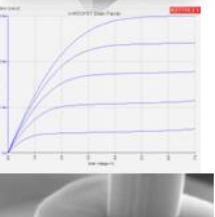
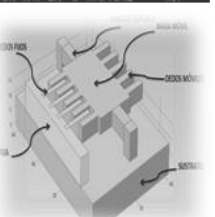
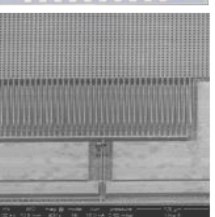
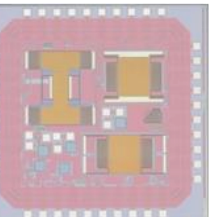
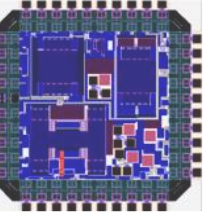
x3,700

5 $\mu$ m

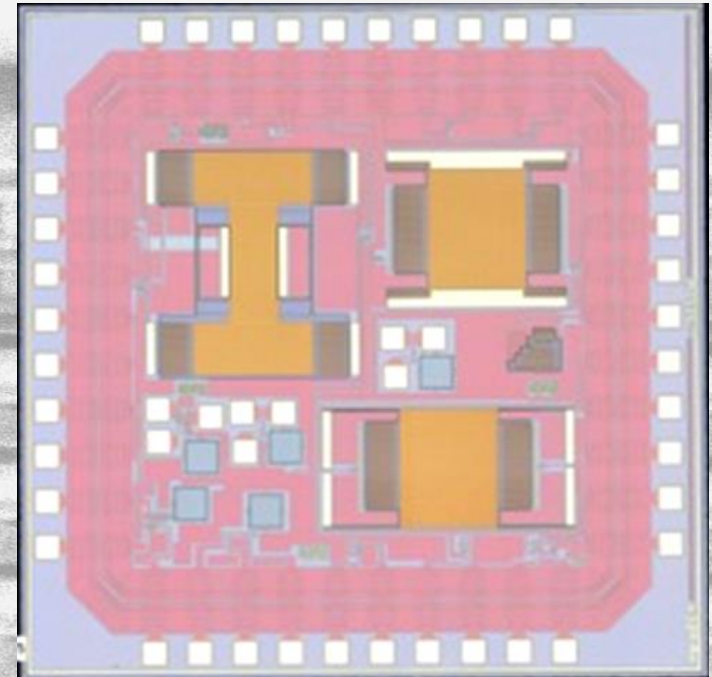
2015/07/08

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# Acelerómetro CMOS-MEMS



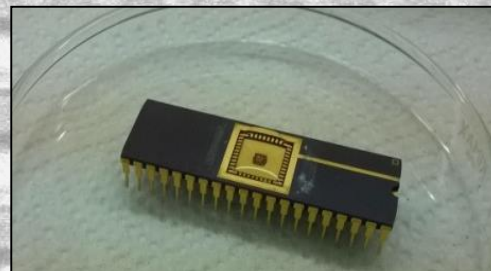
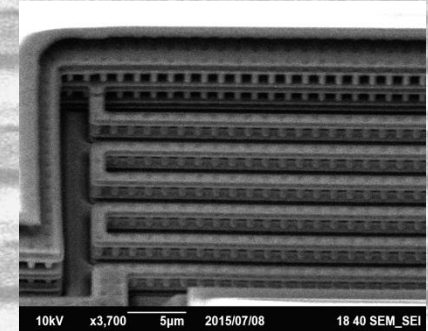
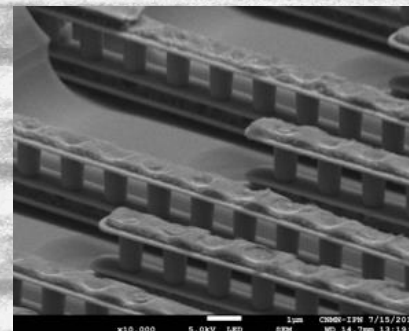
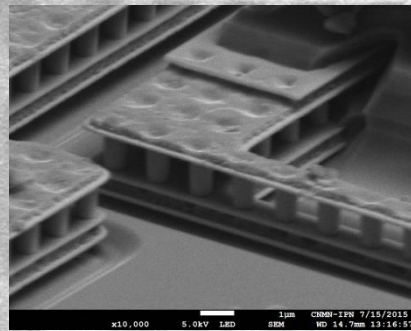
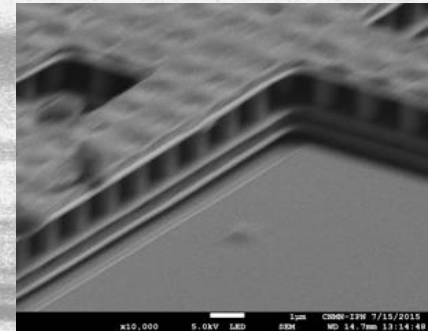
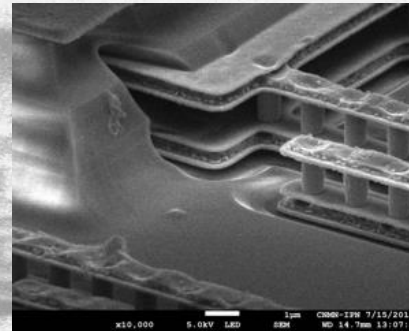
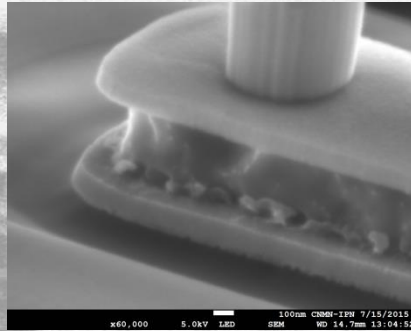
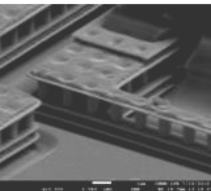
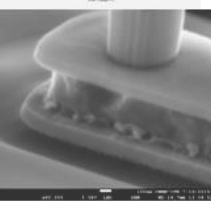
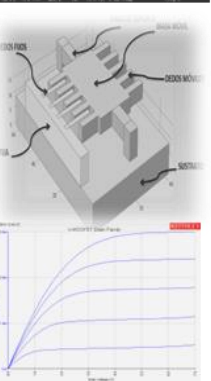
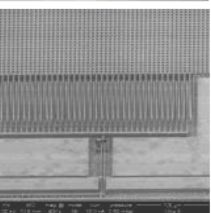
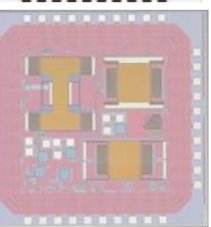
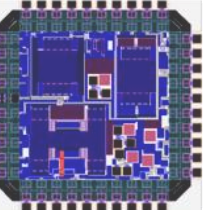
Layout



Chip fabricados

# Procesos tecnológicos

## ■ Micromaquinado Superficial



10kV

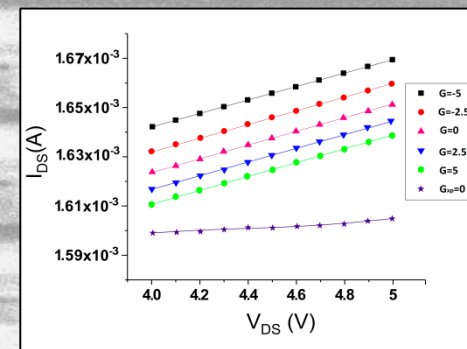
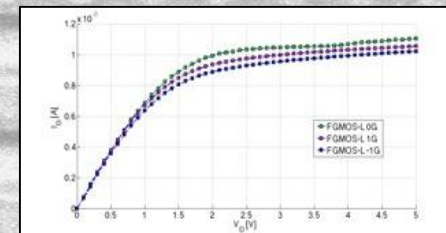
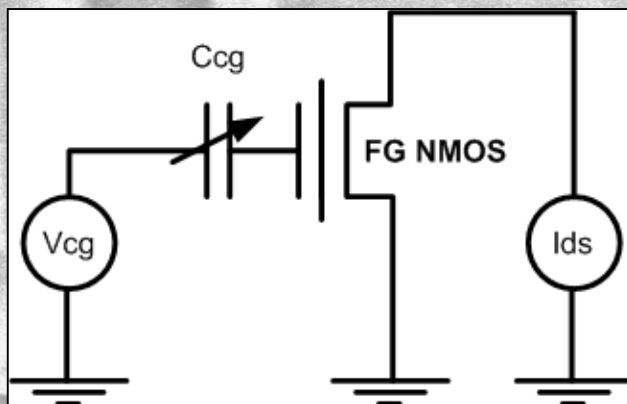
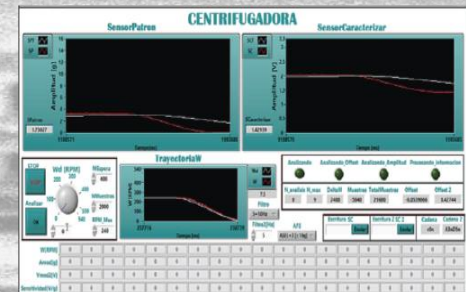
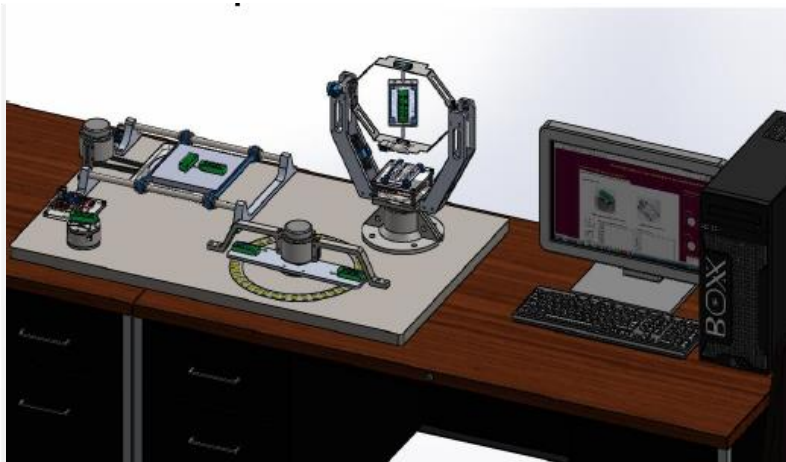
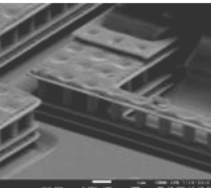
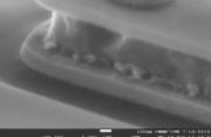
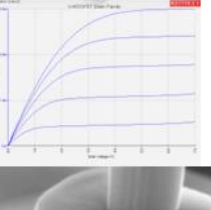
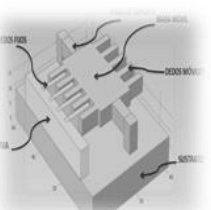
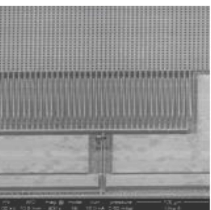
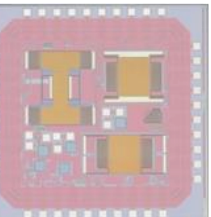
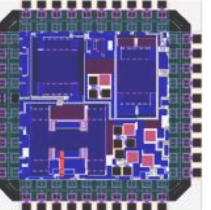
x3,700

5µm

2015/07/08

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# Caracterización eléctrica



10kV

x3,700

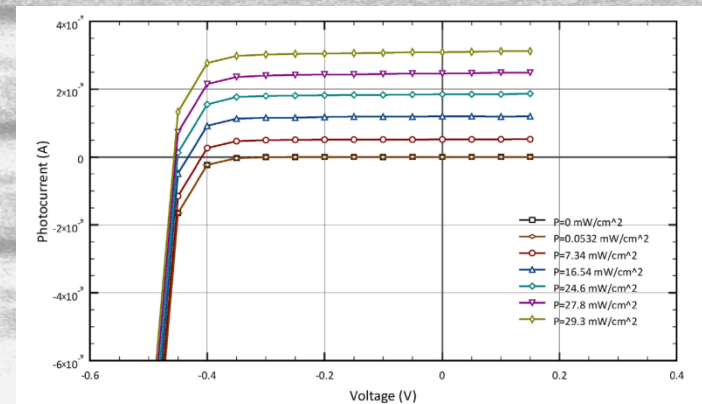
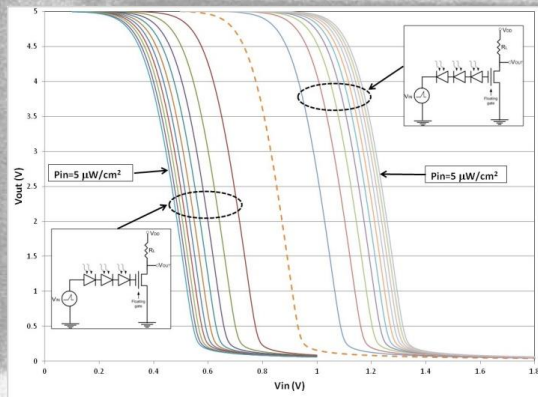
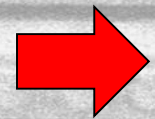
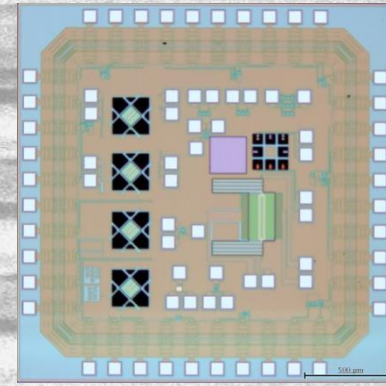
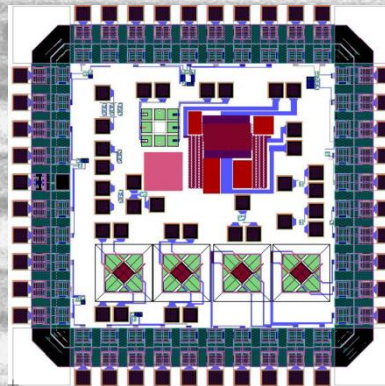
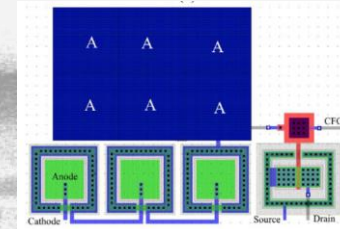
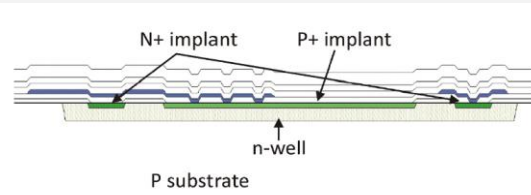
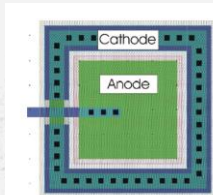
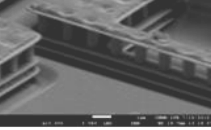
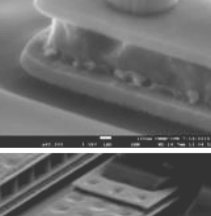
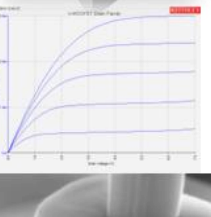
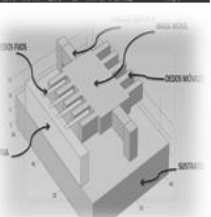
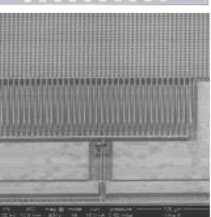
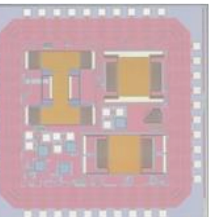
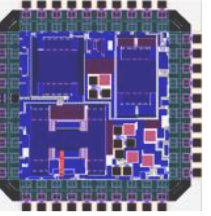
5 $\mu$ m

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# Foto sensor como compuerta de control de un FGMOS



10kV

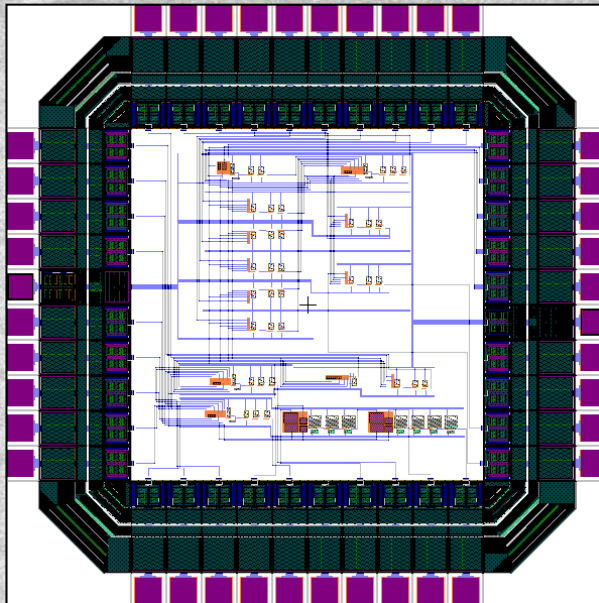
x3,700

5 $\mu\text{m}$

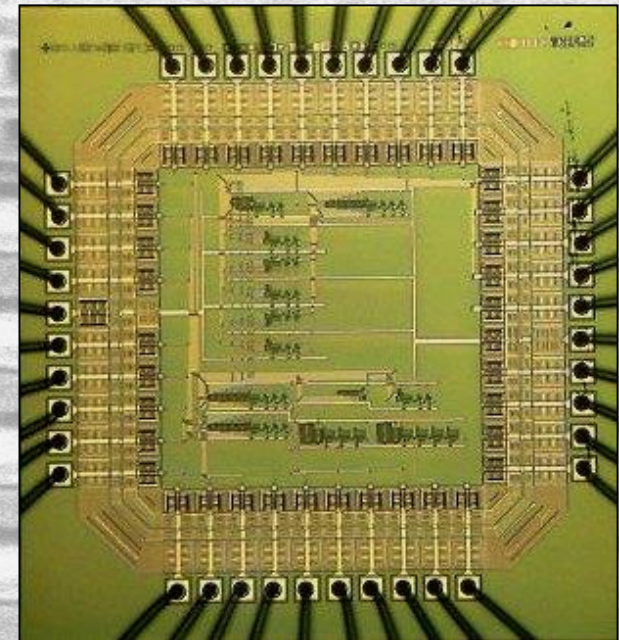
2015/07/08

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# Línea de Investigación: Transistores MOS de Compuerta Flotante

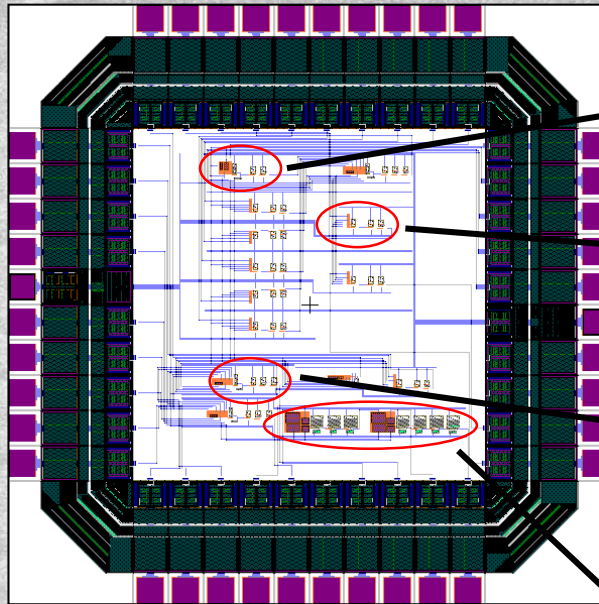


Diseño topológico de un circuito v-MOS con compuerta flotante

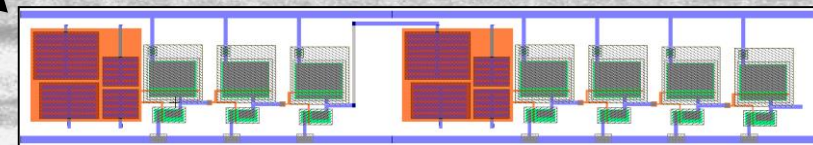
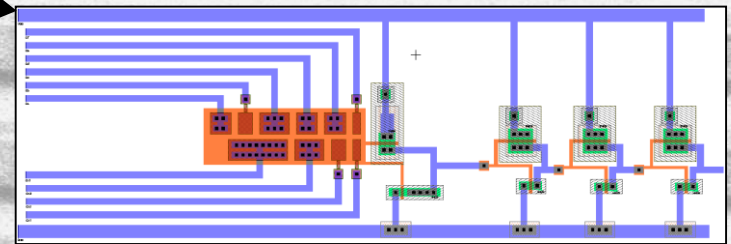
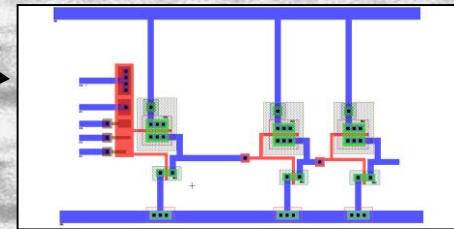
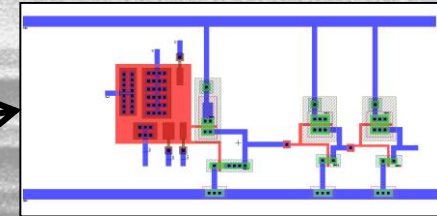


Microfotografía del circuito v-MOS con compuerta flotante, fabricado con tecnología de 1.5 μm

# Línea de Investigación: Transistores MOS de Compuerta Flotante



Diseño topológico de un circuito v-MOS con compuerta flotante



Celdas integradas conteniendo transistores v-MOS

10kV

x3,700

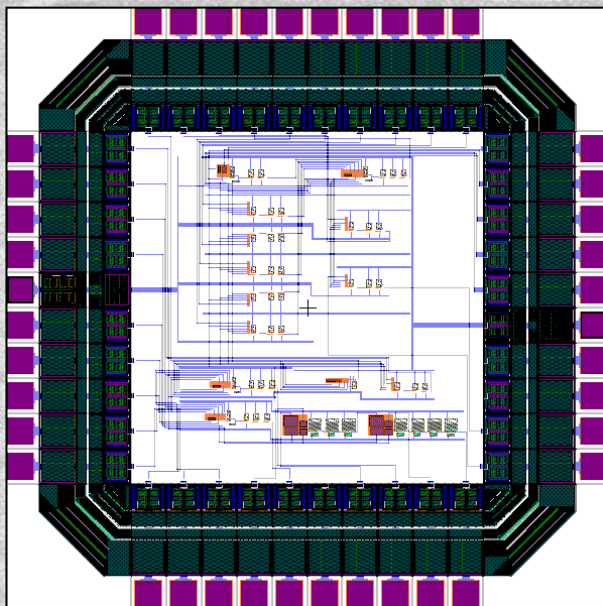
5 $\mu$ m

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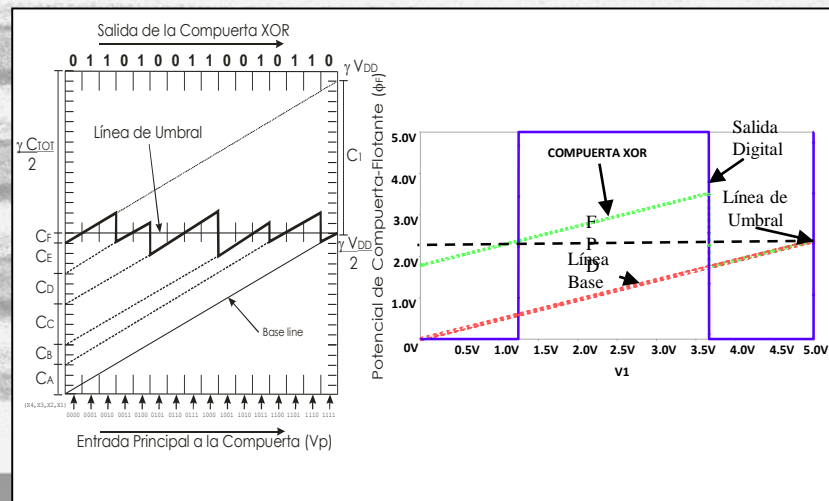
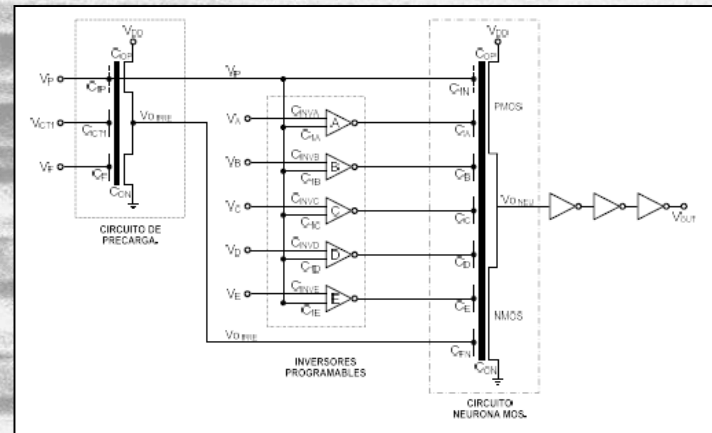
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# Línea de Investigación: Transistores MOS de Compuerta Flotante

Esquemático de una compuerta Universal programable

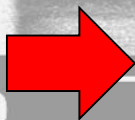


Diseño topológico de un circuito  $\gamma$ -MOS con compuerta flotante



10kV

x3,700



5 $\mu$ m

2015/07/09

Diagrama de Potencial en Compuerta Flotante y respuesta de una compuerta XOR de cuatro bits

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