

# Des MEMS aux NEMS : évolution des technologies et des concepts aux travers des développements menés au LETI

*Ph. Robert*

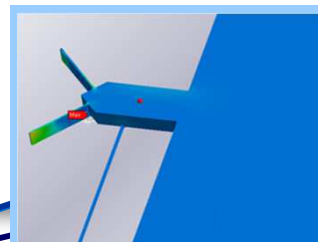
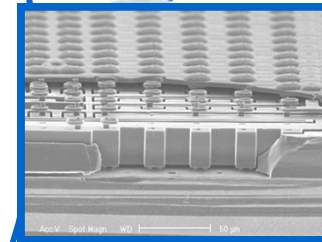
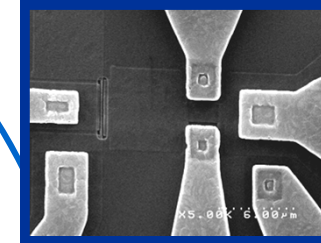


# Content

## LETI at a glance

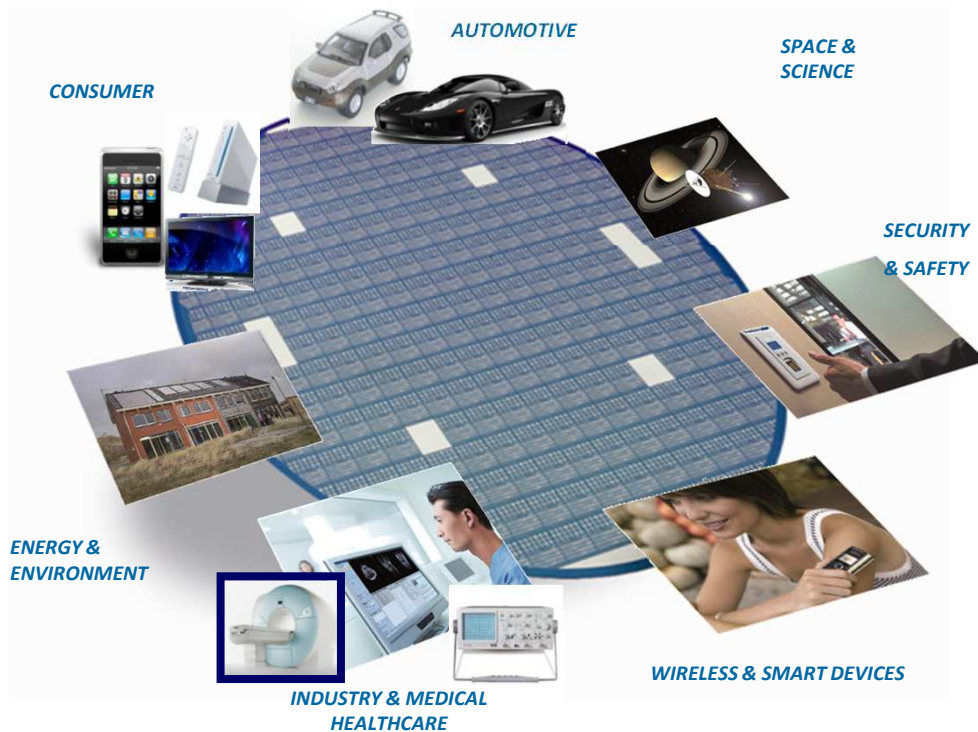
From MEMS to NEMS: 30 years of technological evolution

MEMS/NEMS activity overview



# Leti at a Glance

- R&D in Micro & Nano-technologies
- Applications Driven
- Technology Transfer
- Licensing

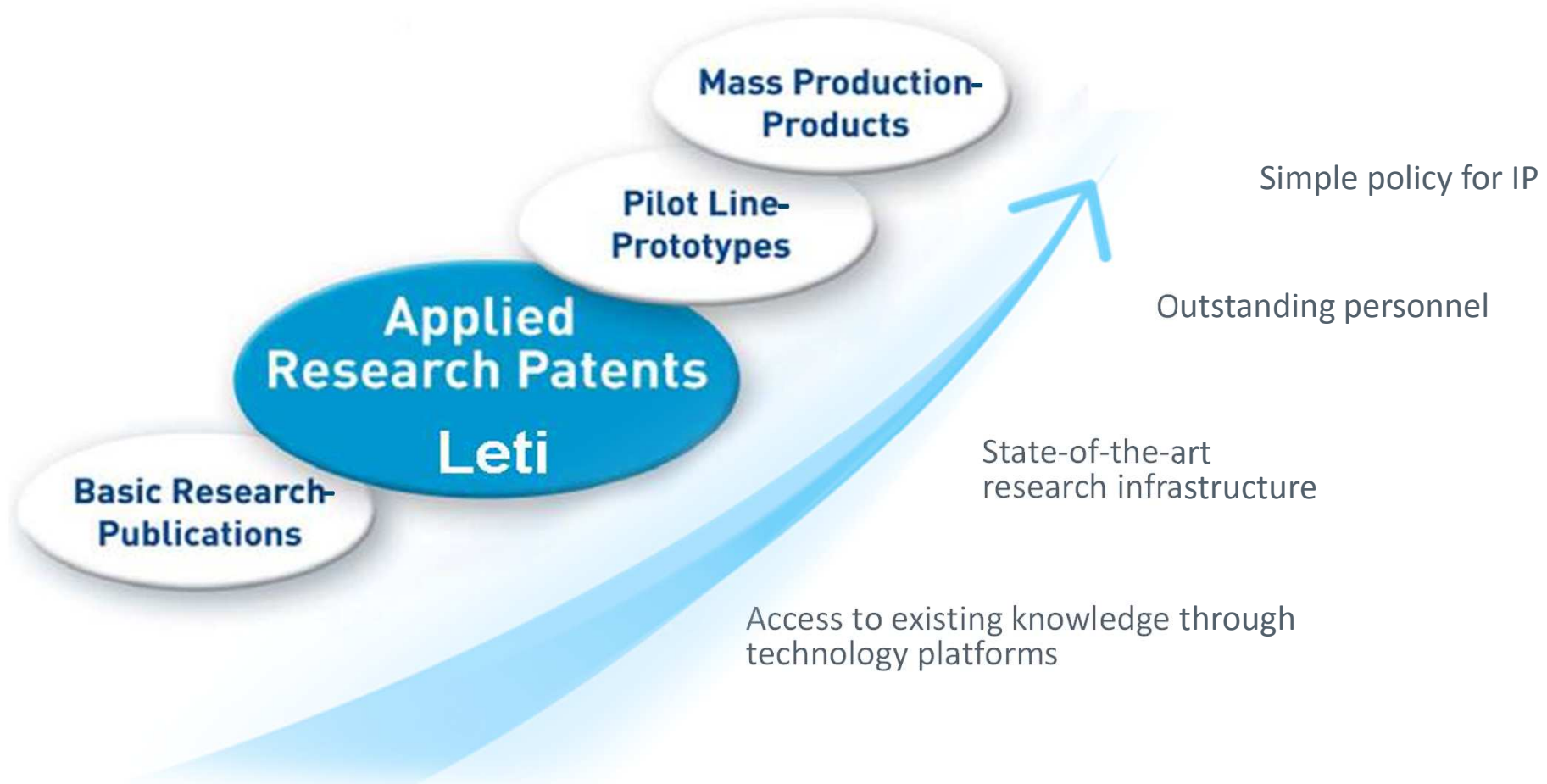


**1 700 employees**  
1 300 on LETI payroll

**260 M€ budget**  
~ 35 M€ CapEx

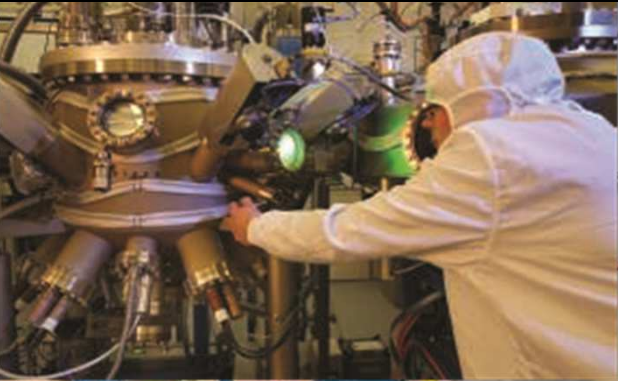
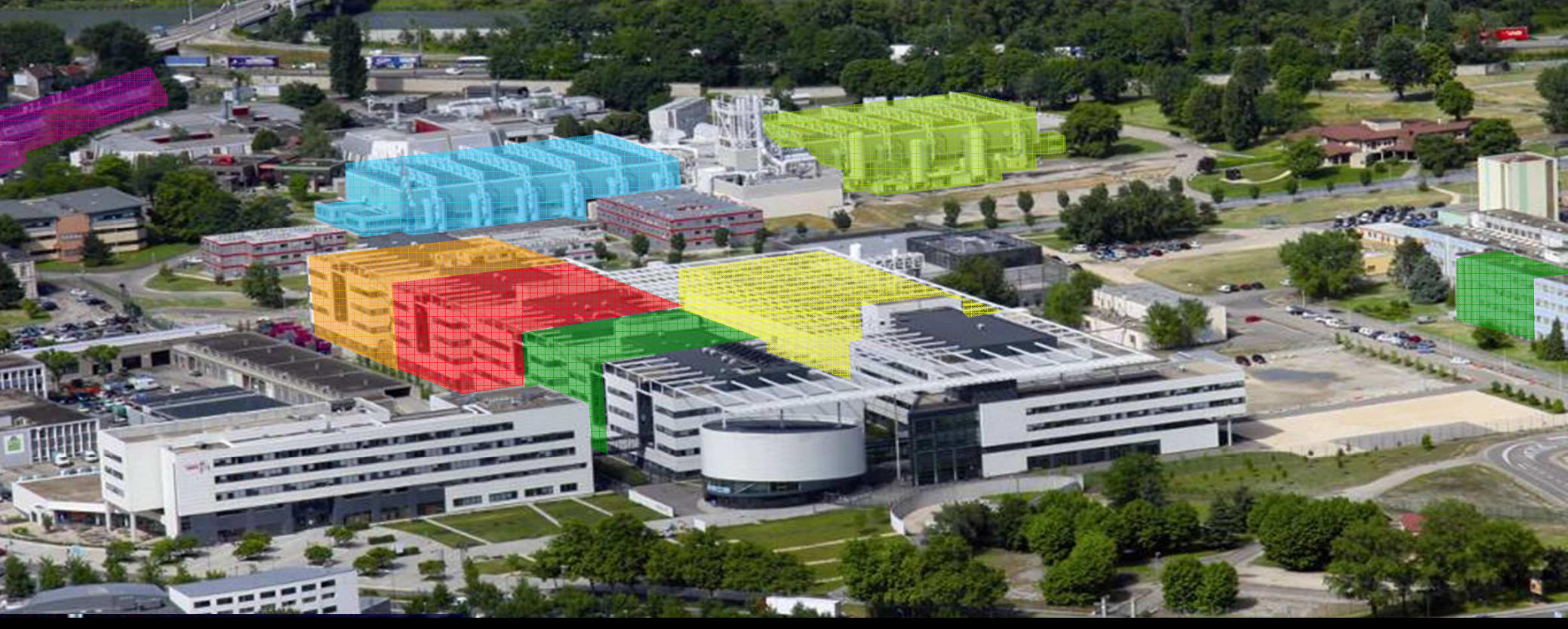
**> 275 new patents/year**  
**Portfolio > 1,700 patents**  
**33 start-ups**









# Leti's Value Proposition



**Our Mission:  
Create Innovation and Transfer it to Industry**

# A Complete Set of Research Platforms



-  Nanotec 300
  -  Advanced CMOS 200
  -  MEMS 200
  -  Nanoscale Characterization
-  Integrative Industries
  -  Design
  -  Integrative Chemistry & Biology
  -  Photonics

# Platforms | MEMS 200

> 200 mm MEMS clean room capabilities

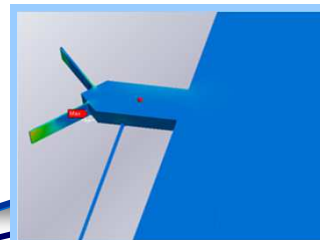
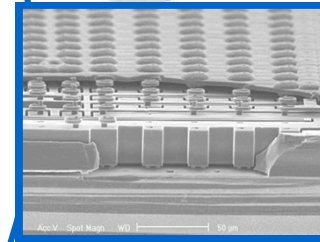
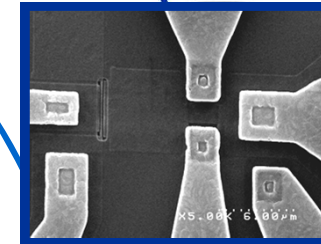


# Content

LETI at a glance

**From MEMS to NEMS: 30 years of technological evolution**

MEMS/NEMS activity overview

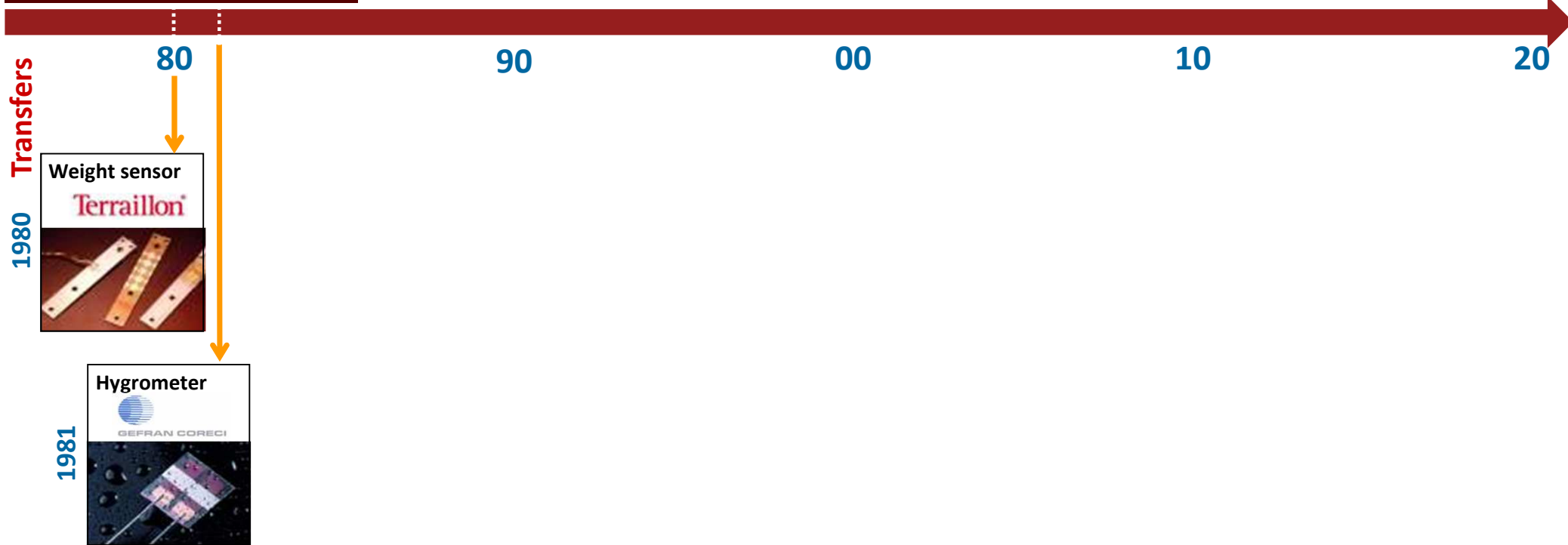


# 30 years background

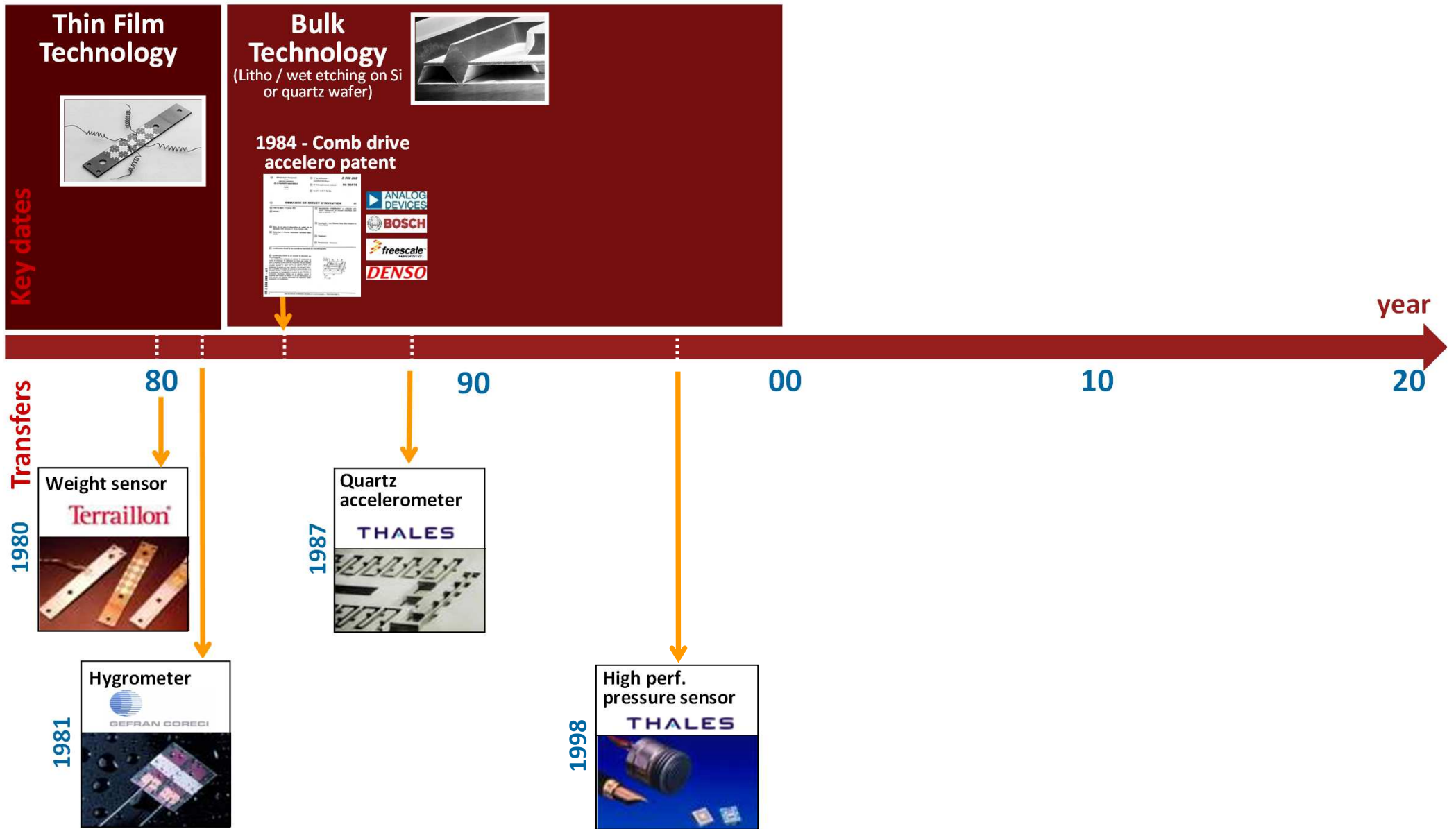
**Thin Film Technology**  
(Vacuum deposition through a shadow mask on glass wafer)



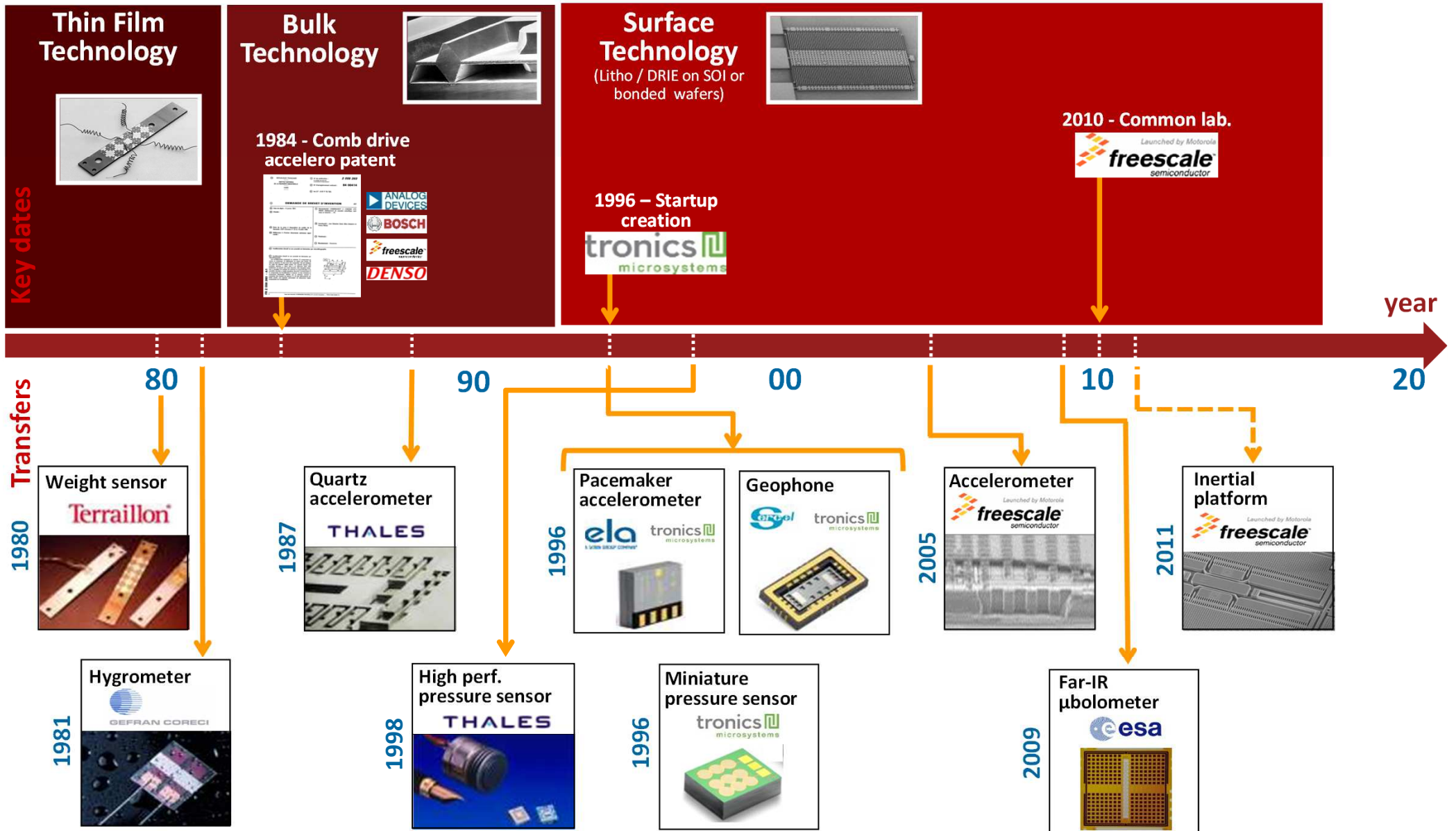
**Key dates**



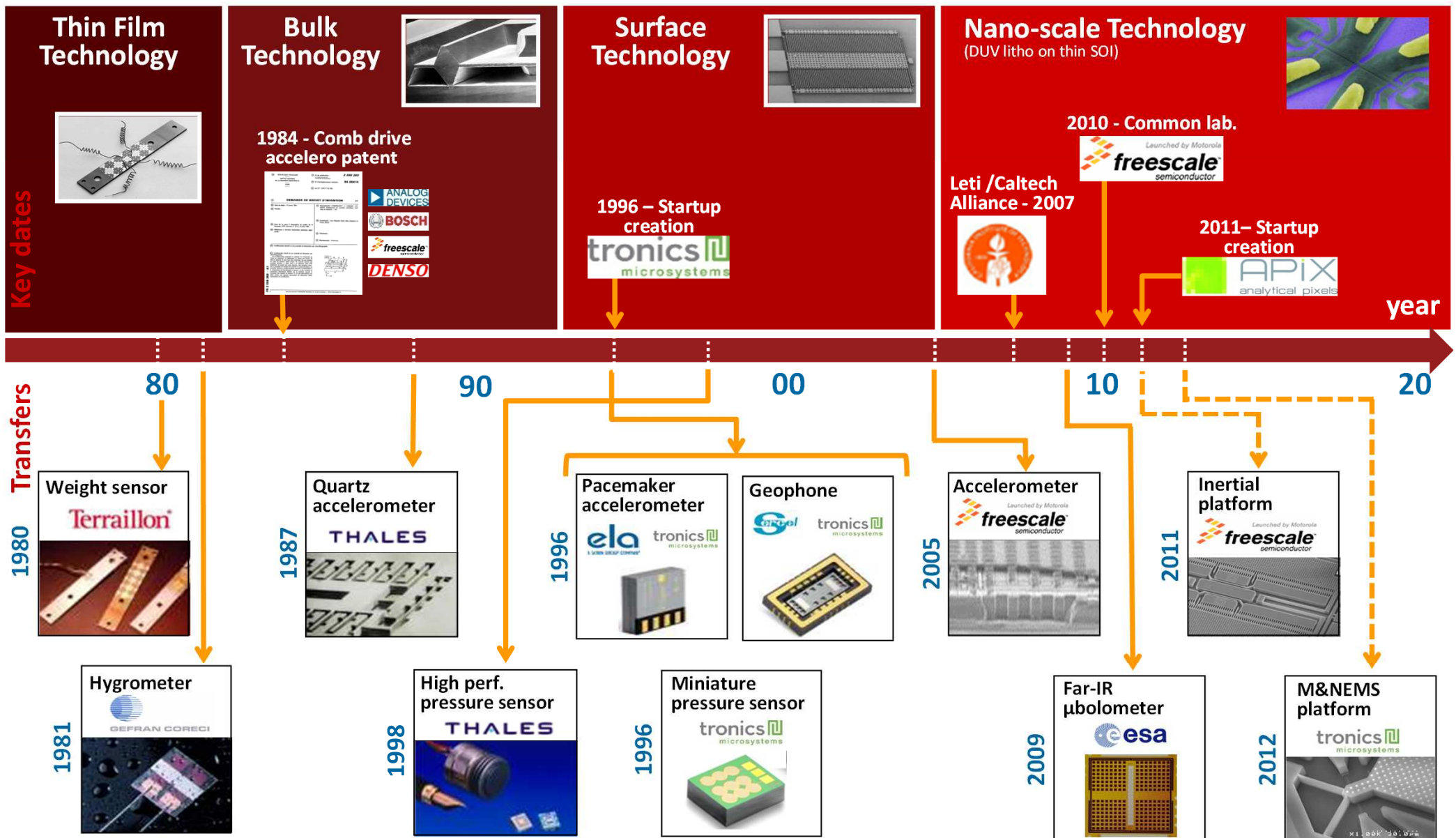
# 30 years background



# 30 years background



# 30 years background

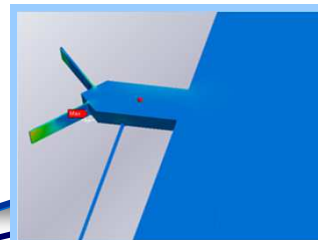
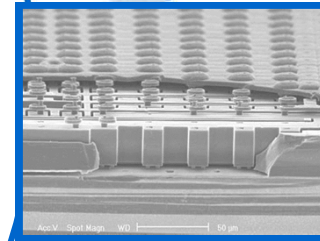
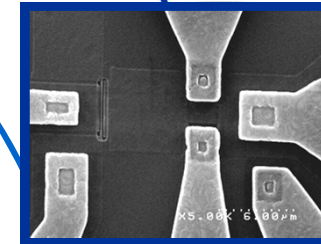


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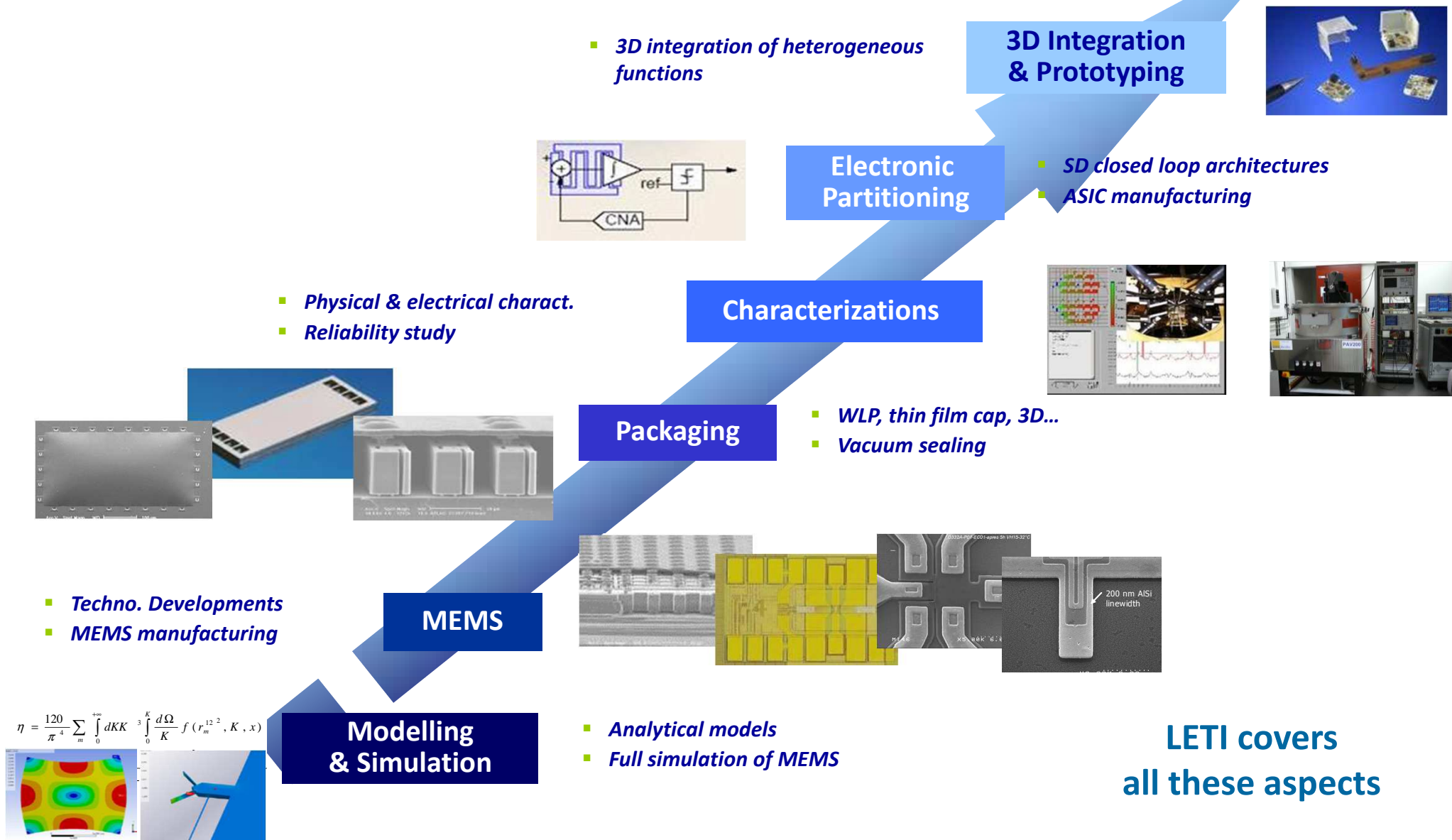
LETI at a glance

From MEMS to NEMS: 30 years of technological evolution

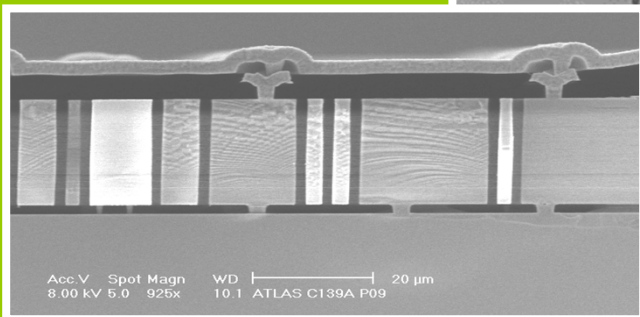
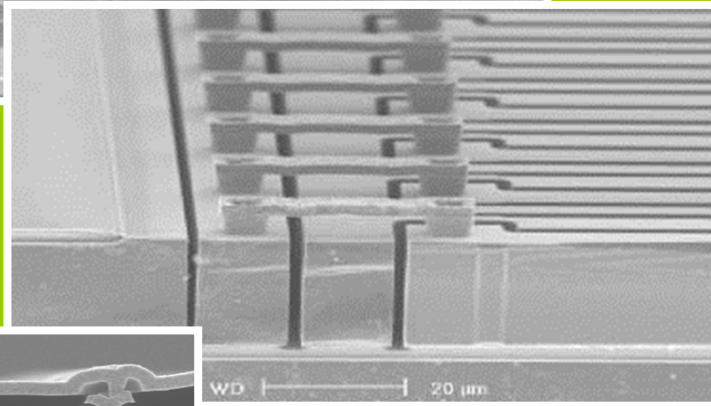
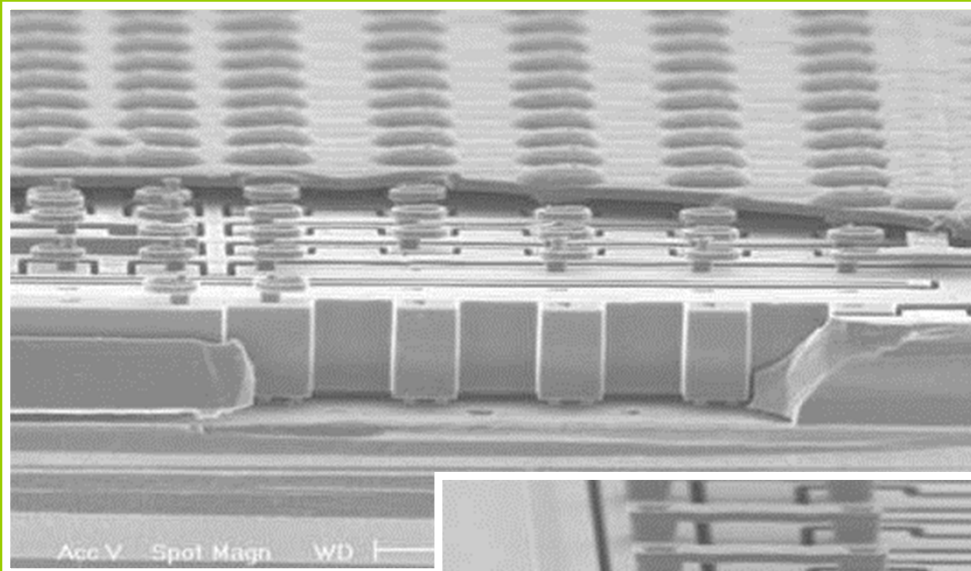
**MEMS/NEMS activity overview**



# From MEMS design to system integration



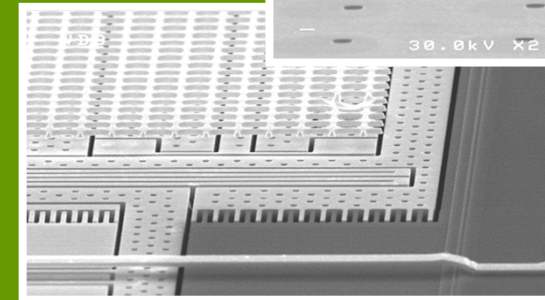
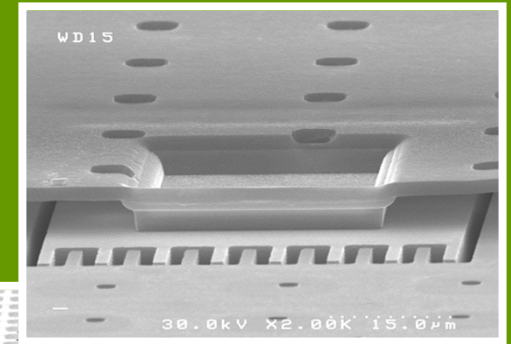
# Expertise on Inertial Sensor



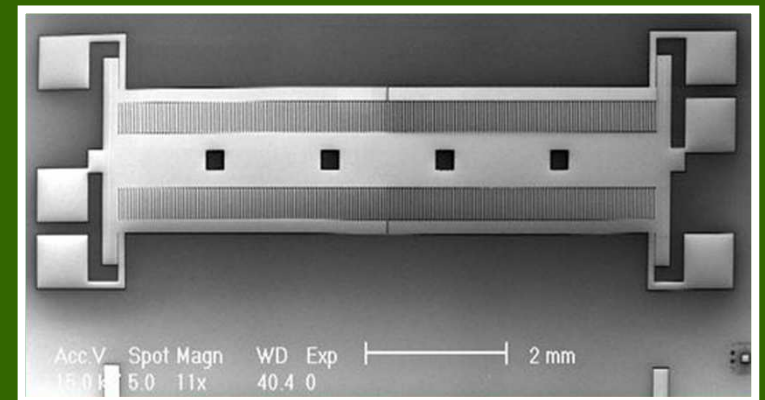
## Accelerometer



## 3D Gyro



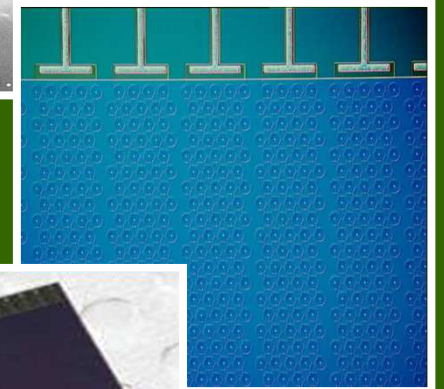
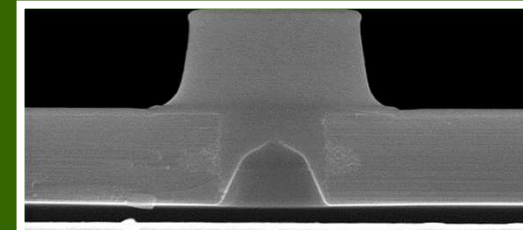
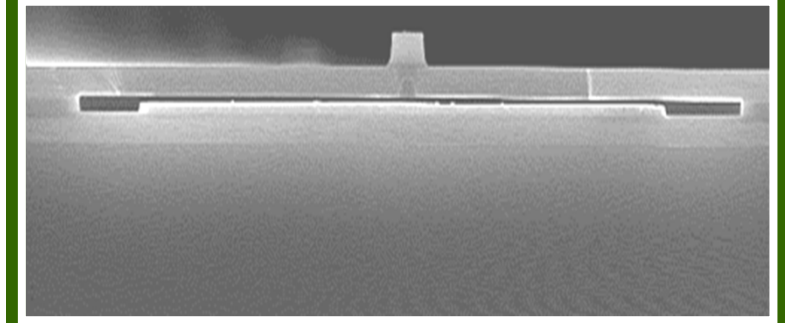
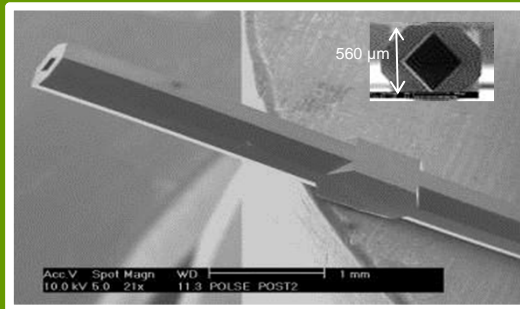
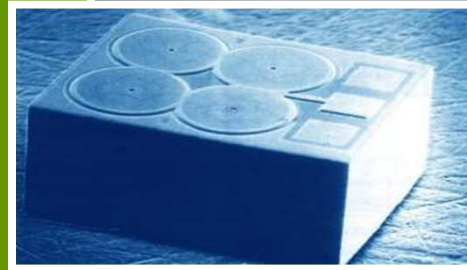
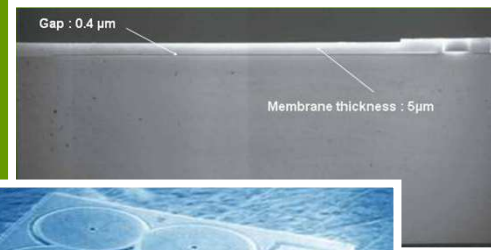
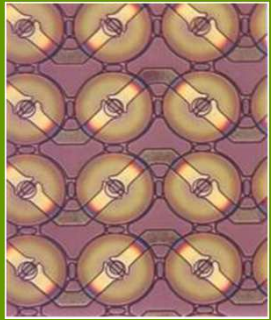
THALES



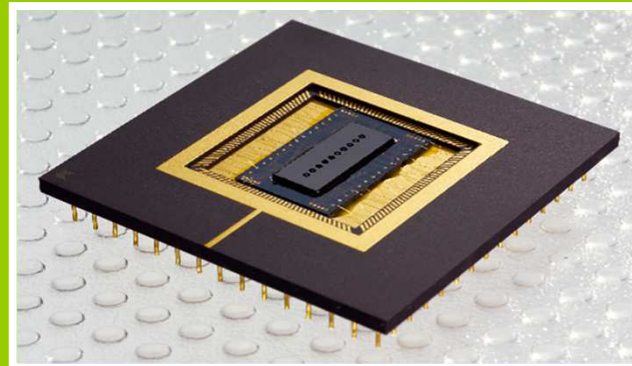
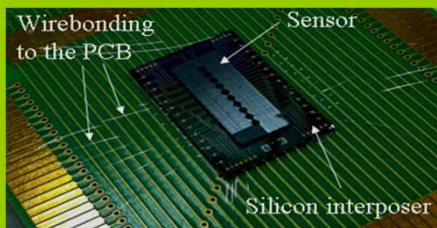
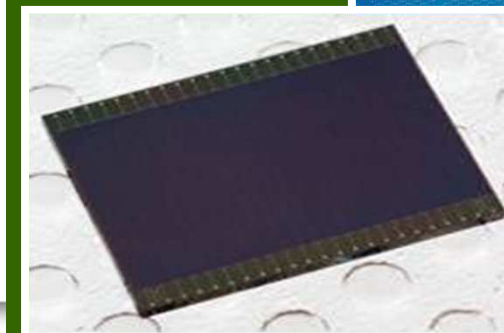
## Geophone

# Expertise on pressure and force Sensor

## Pressure sensor

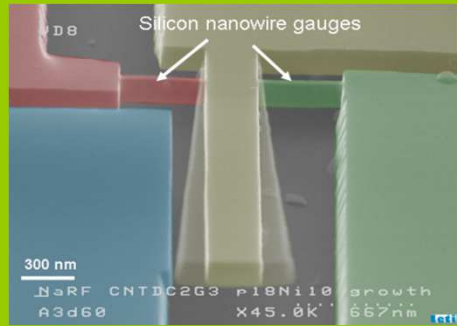


## cMUT

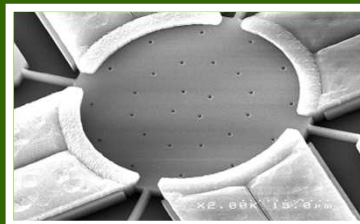
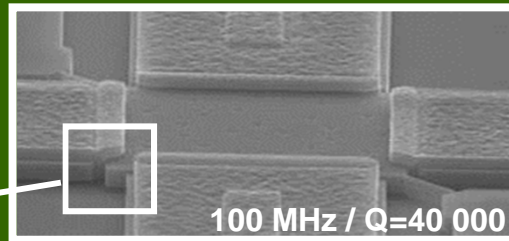
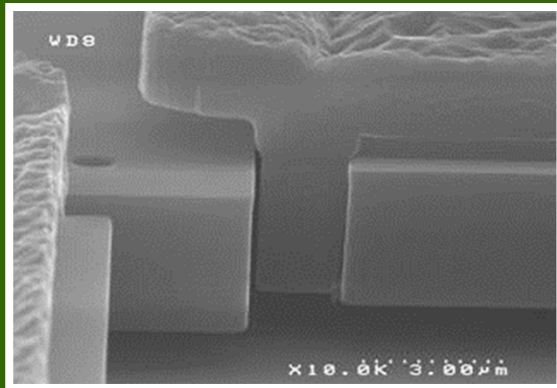
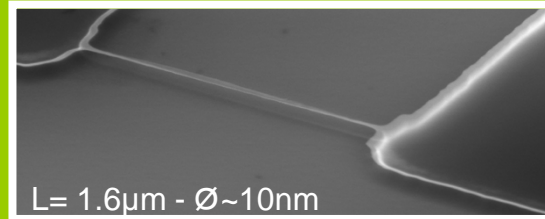


## 3D Force sensor

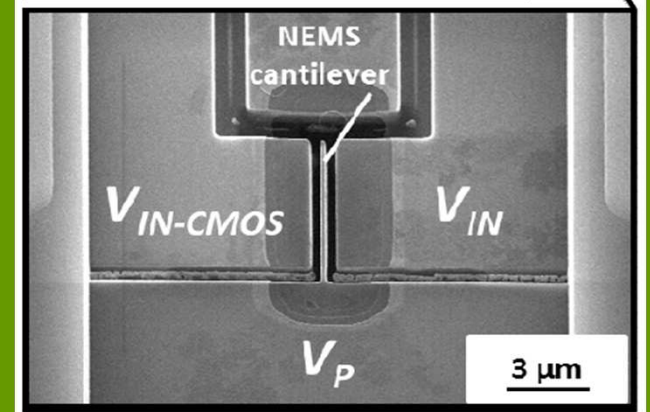
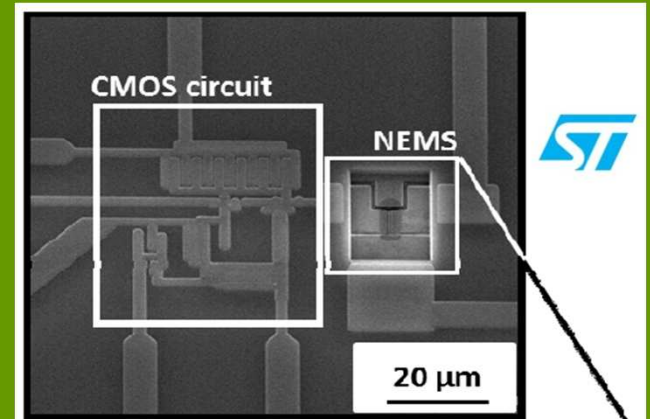
# Expertise on Nano-Scale Sensors & Co-integration



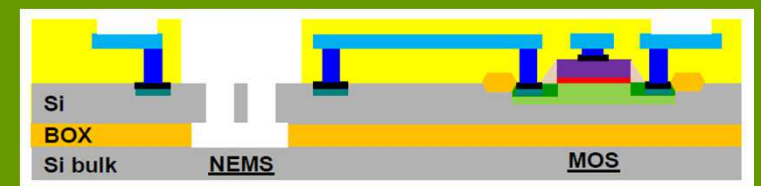
**NEMS**



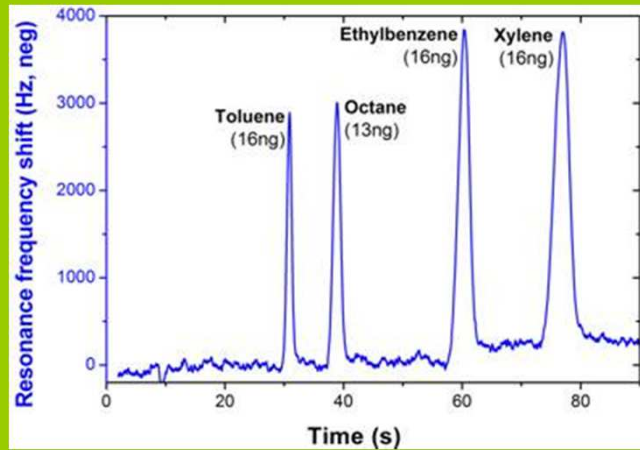
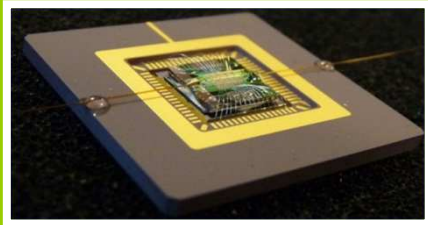
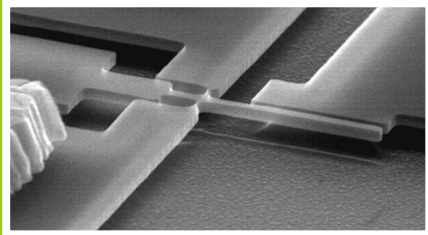
**Nano gap (80nm)**



**CMOS Co-integration**



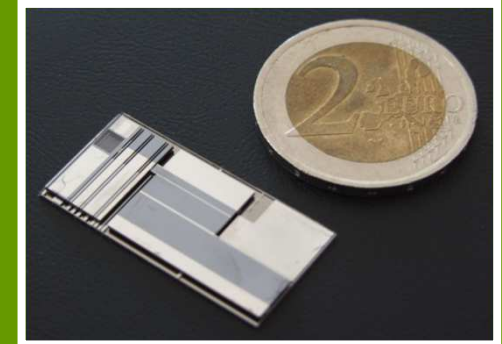
# Expertise on Bio-Chemical MEMS based Sensors



**NEMS-based chemical sensor**

## $\mu$ -TOF Mass-spec for NRBC gas detection

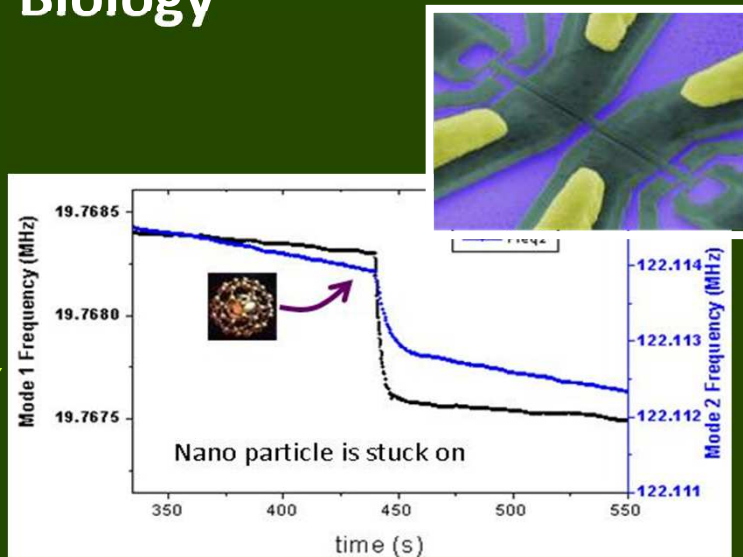
Mass range targeted :  
1Da – 1.5 kDa  
(1 Da =  $1.6 \times 10^{-24}$  g)



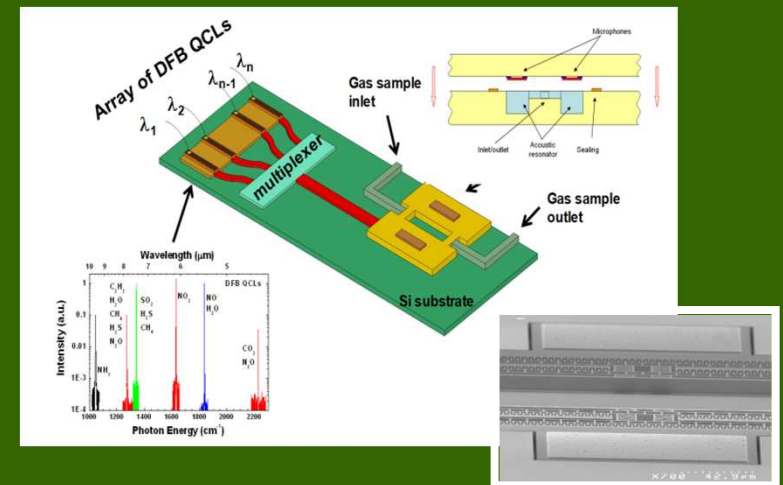
## Mass-spec for Biology applications

Mass range targeted : 100 kDa to 10 GDa  
(1 kDa =  $1.6 \times 10^{-21}$  g)

1 nano particle (400 kDa) detected

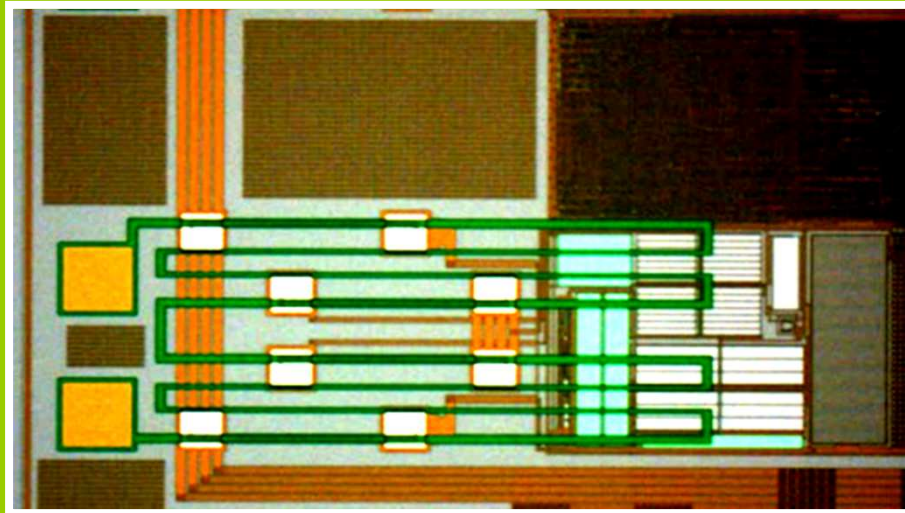
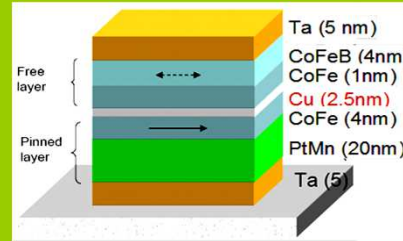
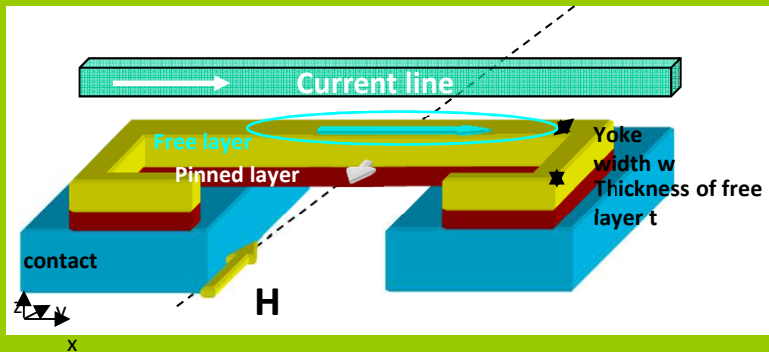


## Photo-acoustic chemical sensor

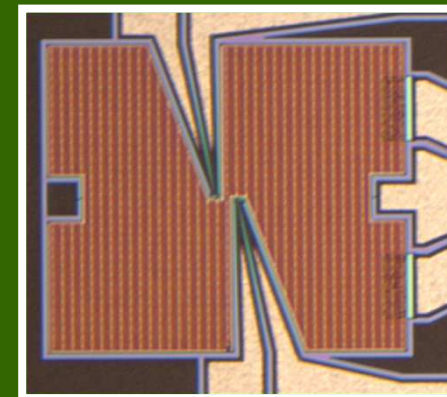
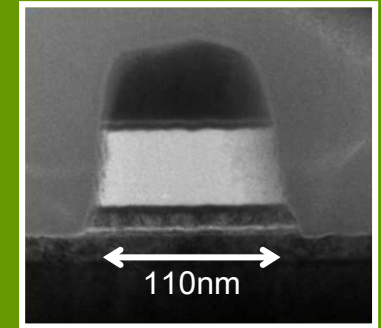
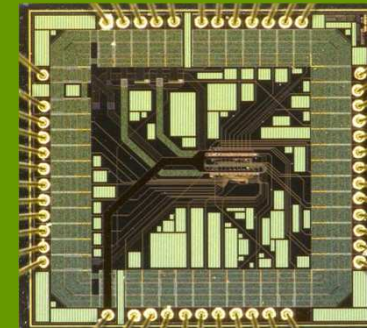


# Expertise on Spintronics & Magnetic Sensors

## Above-IC GMR current sensors

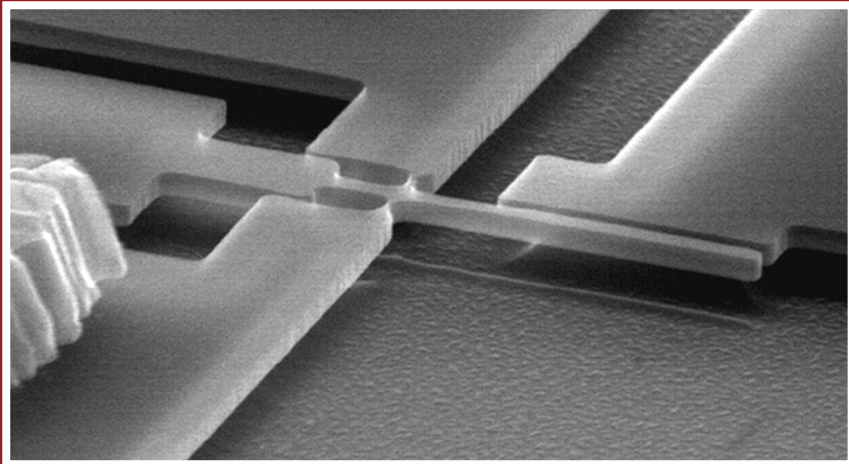



## Magnetic Tunnel Junction (TMR, MRAM)



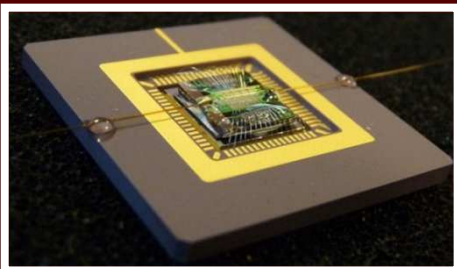
## MEMS Magnetometer

# NEMS sensors “platform”



- Generic sensor platform based on resonant NEMS array detectors
  - High efficiency patented NEMS resonator using :
    - Electrostatic actuation
    - Piezoresistive silicon nano-wire gauge
- 
}
 Very high SNR  
 Not sensitive to parasitic  
 Suitable for high frequency application  
 Low power consumption
- Well controlled technology compatible with DUV lithography

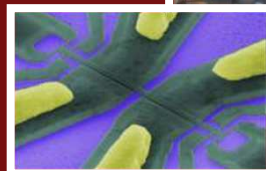
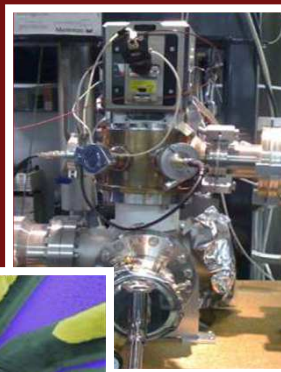
## Gas detection



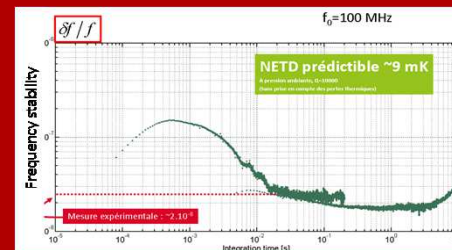
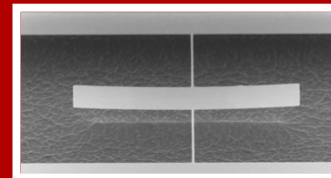
APX  
Analytical Pixels



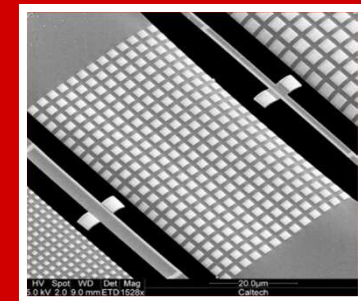
## Mass-spec for Bio applications



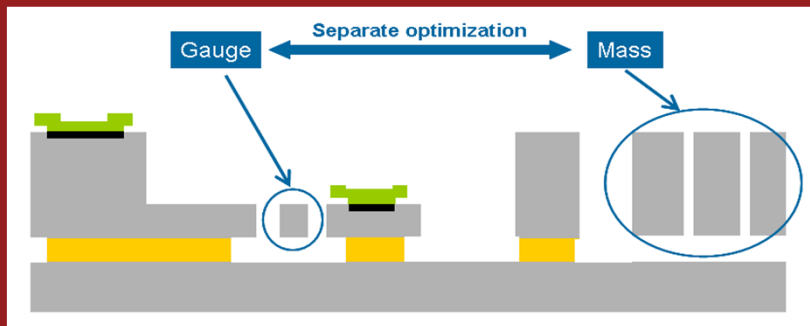
## μbolometer



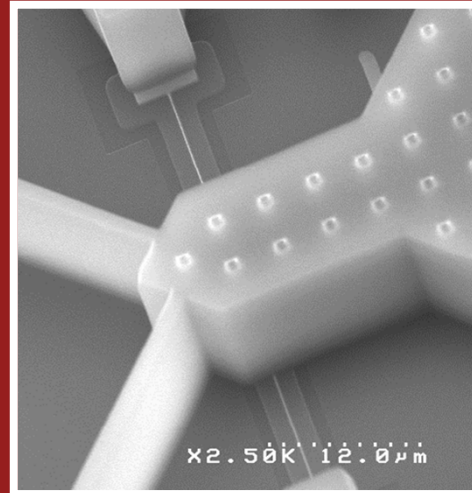
## Cellular force sensor



# M&NEMS sensors “platform”

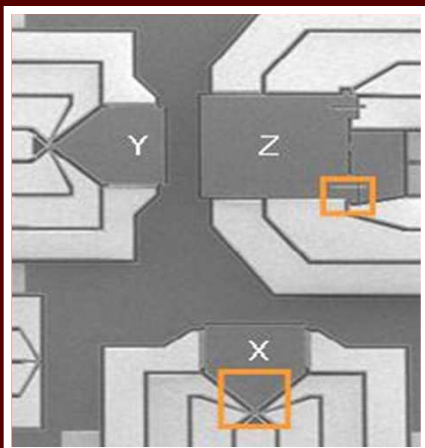


MEMS size inertial mass  
+  
Nano-size piezoresistive gauge

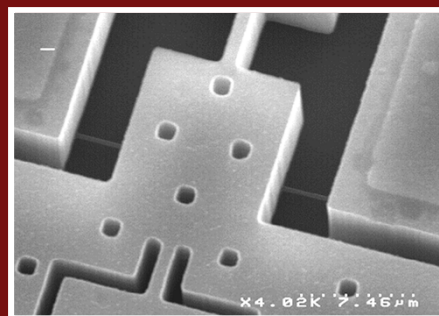


- Miniaturized sensors
- Generic platform
  - ↳ sensors fusion + 1 common electronic
- Not sensitive to parasitics
- An approach for low-power consumption
- + 15 patents

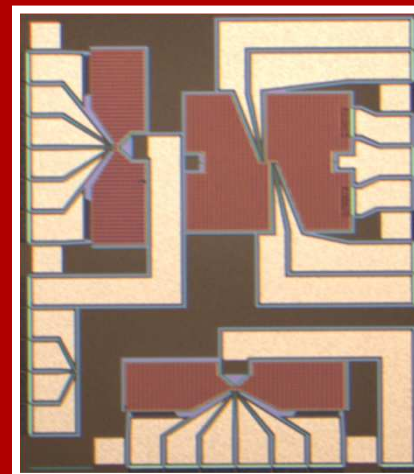
## 3D Accelero



## 3D gyro



## 3D magneto



## Microphone & Pressure sens.