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

- State-of-the-art research infrastructure
- Outstanding personnel
- Simple policy for IP
- Access to existing knowledge through technology platforms
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

1980
Weight sensor

1981
Hygrometer

Transfers

80

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30 years background

**Thin Film Technology**
- 1984 - Comb drive accelerato patent

**Bulk Technology**
- Litho / wet etching on Si or quartz wafer
- 1998 - High perf. pressure sensor

Key dates:
- 1980 - Weight sensor "Terraillon"
- 1981 - Hygrometer
- 1984 - Comb drive accelerato patent
- 1987 - Quartz accelerometer
- 1998 - High perf. pressure sensor
Content

LETI at a glance

From MEMS to NEMS: 30 years of technological evolution

MEMS/NEMS activity overview
From MEMS design to system integration

- **Modelling & Simulation**
  - Analytical models
  - Full simulation of MEMS

- **MEMS**
  - Techno. Developments
  - MEMS manufacturing

- **Characterizations**
  - Physical & electrical charact.
  - Reliability study

- **Package**
  - WLP, thin film cap, 3D...
  - Vacuum sealing

- **Electronic Partitioning**
  - 3D closed loop architectures
  - ASIC manufacturing

- **3D Integration & Prototyping**
  - 3D integration of heterogeneous functions

- LETI covers all these aspects
Expertise on **Inertial Sensor**

- **Accelerometer**
- **3D Gyro**
- **Geophone**
Expertise on pressure and force Sensor

Pressure sensor

3D Force sensor

cMUT
Expertise on **Nano-Scale Sensors & Co-integration**

**NEMS**
- L = 1.6µm - Ø ~10nm

**CMOS Co-integration**
- 100 MHz / Q = 40 000
- Nano gap (80nm)
Expertise on **Bio-Chemical MEMS** based Sensors

**NEMS-based chemical sensor**

Mass-spec for Biology applications

Mass range targeted: 100 kDa to 10 GDa

(1 kDa = 1.6x10^{-21} g)

1 nano particle (400 kDa) detected

**μ-TOF Mass-spec for NRBC gas detection**

Mass range targeted: 1 Da – 1.5 kDa

(1 Da = 1.6x10^{-24} g)

**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

- Well controlled technology compatible with DUV lithography

- Gas detection
- Mass-spec for Bio applications
- μbolometer
- Cellular force sensor
M&NEMS sensors “platform”

- Miniaturized sensors
- Generic platform
- Sensors fusion
- Not sensitive to parasitics
- An approach for low-power consumption
- + 15 patents

**MEMS size inertial mass**

**Nano-size piezoresistive gauge**

**3D Accelero**

**3D gyro**

**3D magneto**

**Microphone & Pressure sens.**