

# Advanced multi-purposes MEMS and NEMS platforms at CEA-LETI

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# Outline |

**I. Introduction: overview of CEA-LETI and its main M/NEMS platforms**

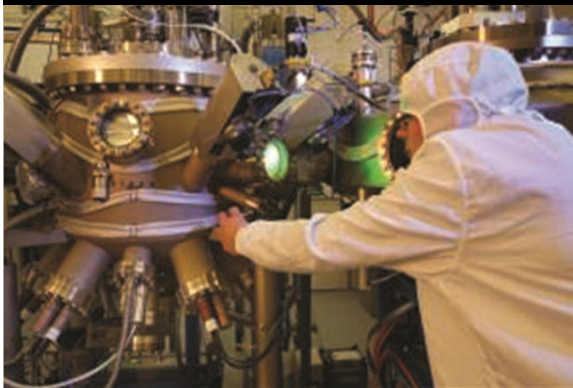
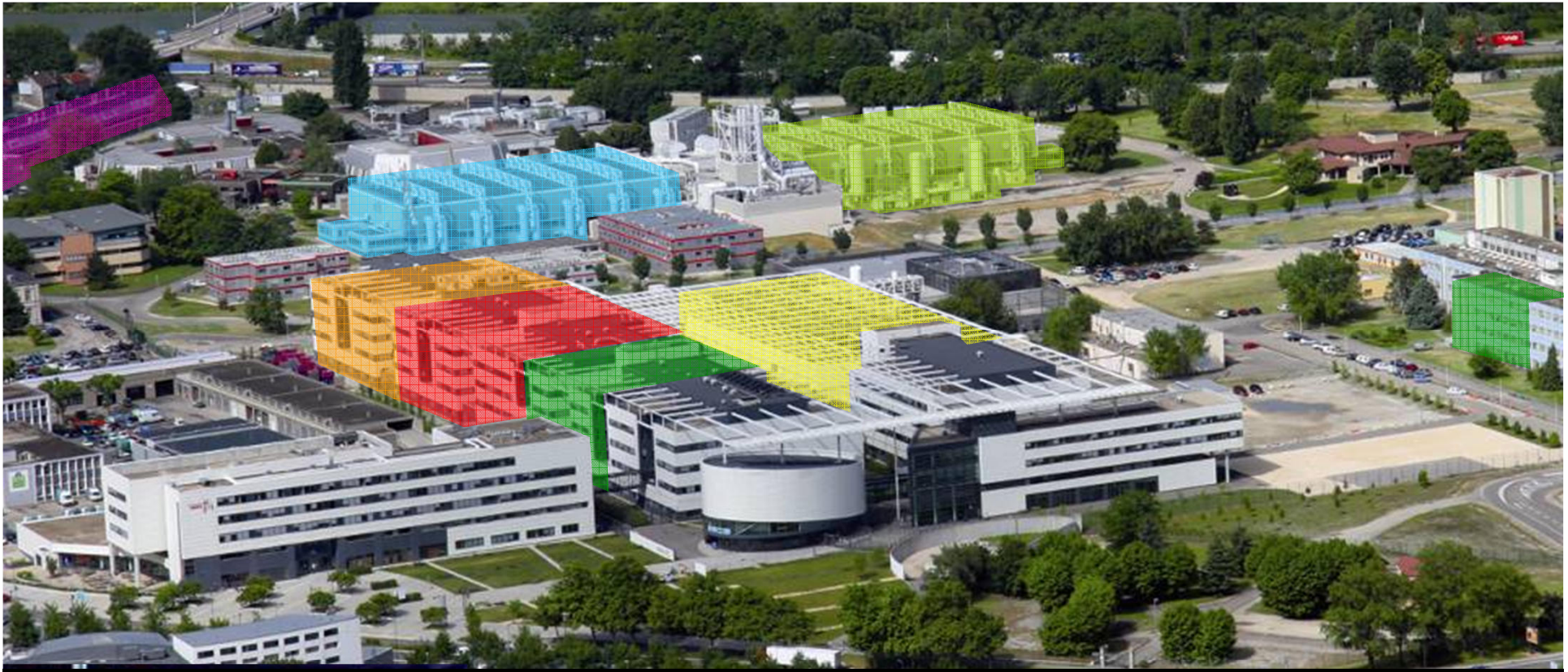
II. Multi-purposes piezoelectric platform

III. M&NEMS platform for multi-axis sensing

IV. NEMS platform for bio- and chemical sensing

V. Perspectives

# LETI: a complete set of Research Platforms |



Nanotec 300



Advanced CMOS 200



MEMS 200



Nanoscale  
Characterization



Smart System Integration



Design

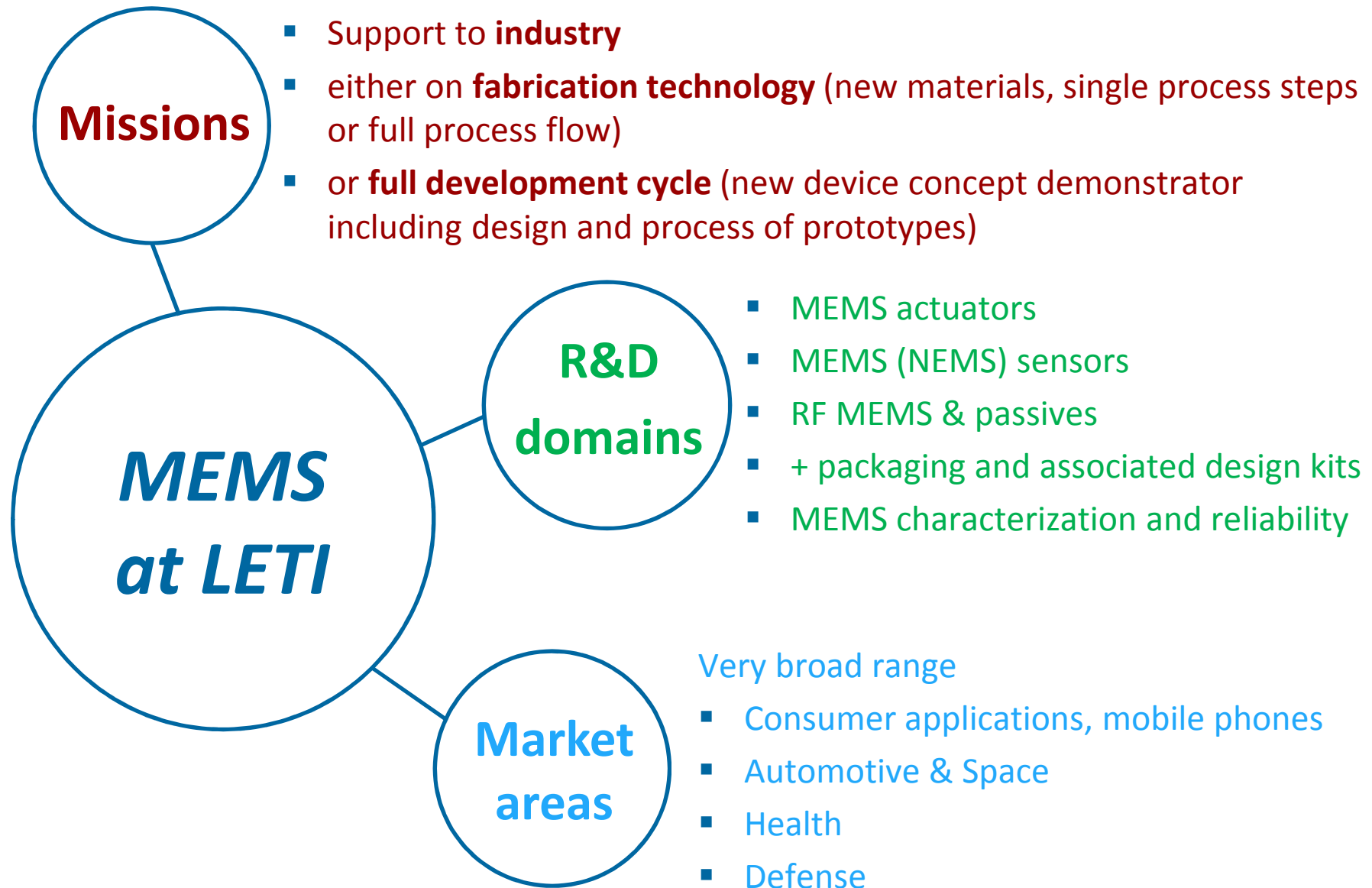


Integrative Chemistry & Biology



Photonics

# MEMS activities at LETI: missions & scope |



# MEMS activities at LETI: main figures |

- Some statistics: **the largest R&D MEMS lab in Europe**

  - ~**150** engineers, technicians, PhD students and Post-docs

  - ~**30** patents and around **100** publications each year

  - 5** common labs with industrial companies

- Covering the whole chain: **from MEMS design to system integration**

  - MEMS design (modeling and simulation) and prototyping

  - Fabrication and packaging

  - Electrical and functional characterization

  - Integration with analog and digital electronics

- **Main industrial partners**



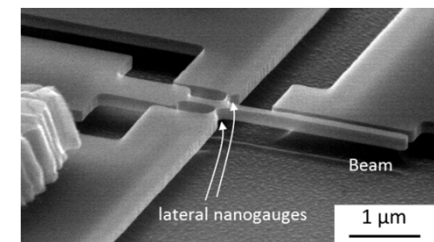
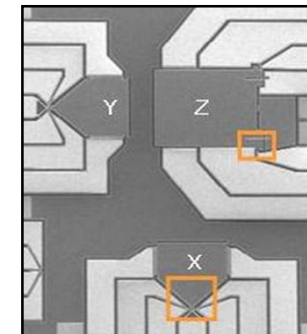
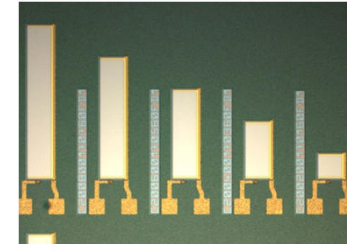
# MEMS 200 platform |

> 200 mm MEMS clean room capabilities



# LETI's main thrusts in MEMS |

- Multi-purposes piezoelectric platform
- M&NEMS platform for multi-axis sensing
- NEMS platform for bio- and chemical sensing



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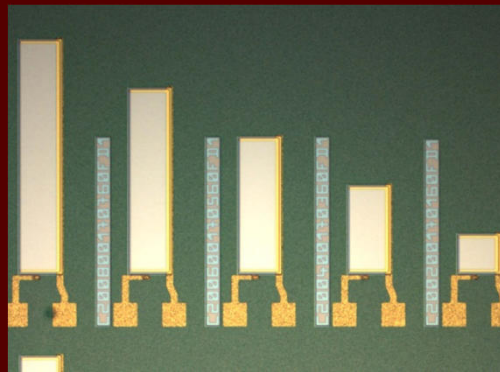
# Three main types of PZE materials |

PZT

Sol-gel deposition



High K, High piezo

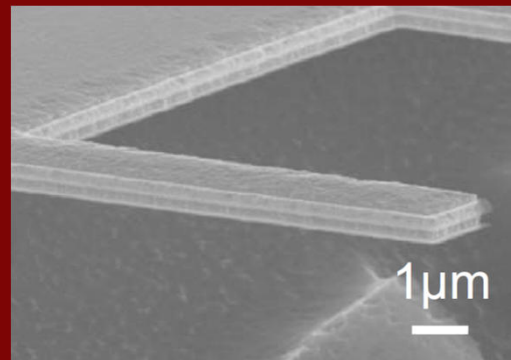


AlN

Sputtering deposition

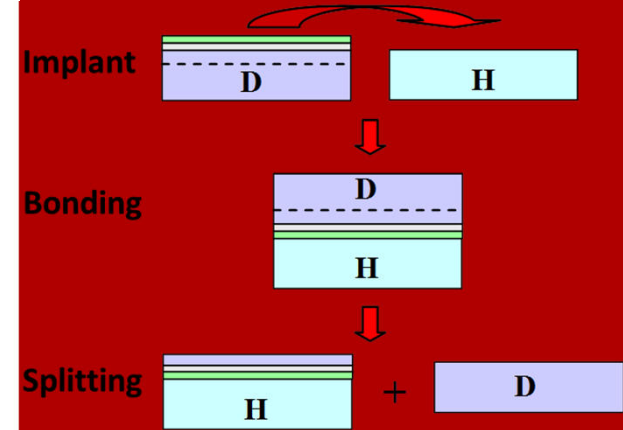


Piezoelectric NEMS

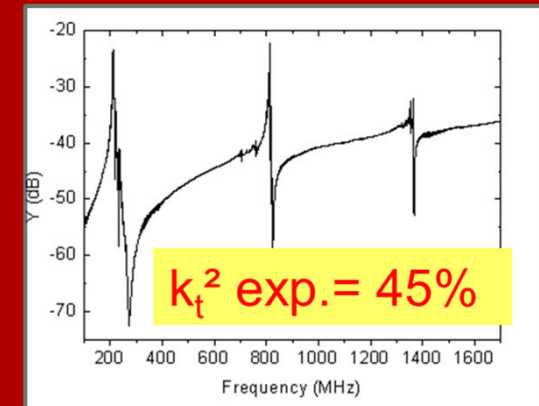


LNO

Smart Cut transfer



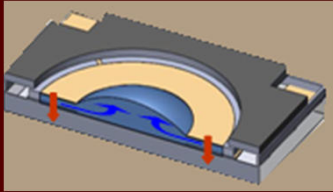
Very-high electromechanical coupling



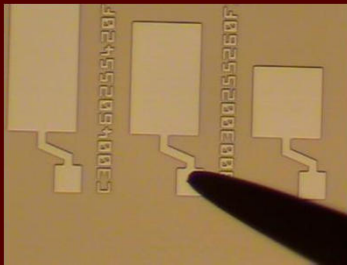
# Three main applications for PZE devices |

## Actuators

Varifocal lens



Actuated membranes

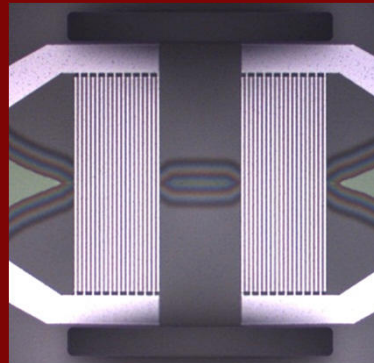


Digital loudspeaker

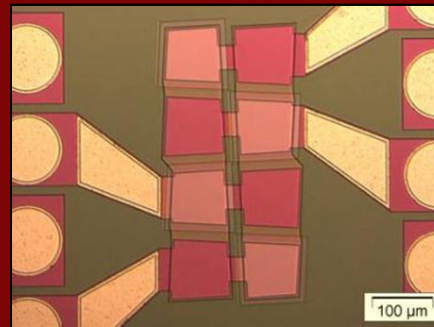


## RF Devices

Phononic crystals

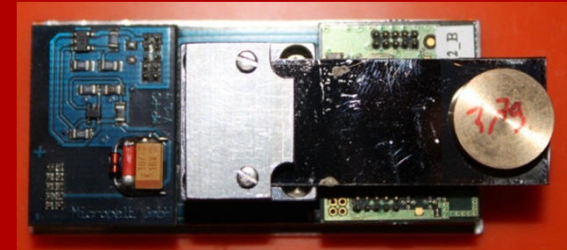


Acoustic filters

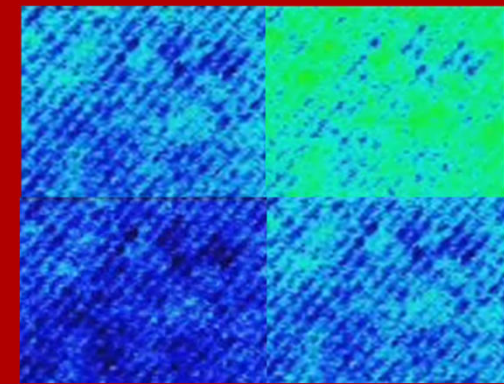


## Energy management

Energy harvesting for autonomous sensors



Micro-cooling unit  
Electrocaloric effect



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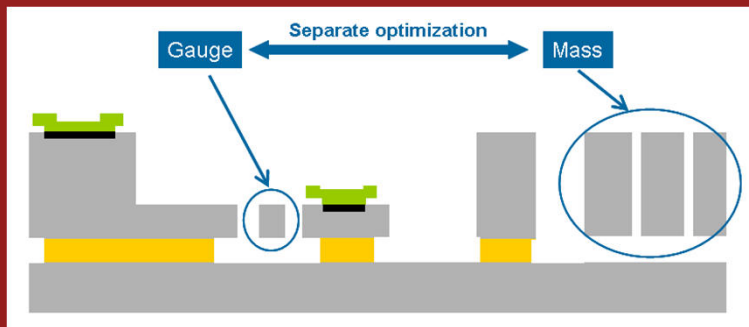
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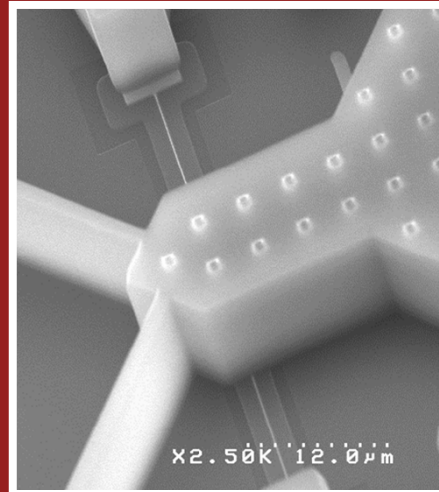
IV. NEMS platform for bio- and chemical sensing

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# M&NEMS sensors “platform”

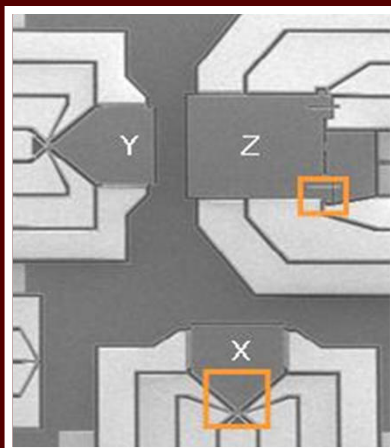


MEMS size inertial mass  
+  
Nano-size piezoresistive gauge

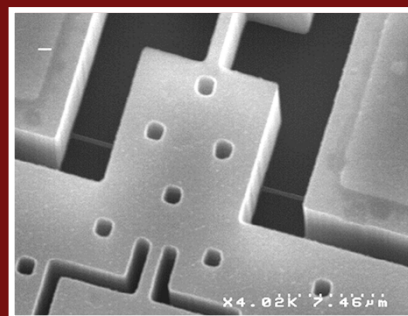


- Miniaturized sensors
- Generic platform
  - ↳ sensors fusion + 1 common electronic
- Well known and robust piezoresistive detection
- Not sensitive to parasitics
- Strongly differentiated approach (+15 patents)

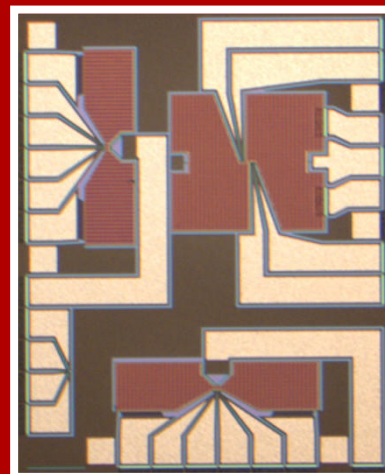
## 3-axis accelero



## 3-axis gyro



## 3-axis magneto



## Microphone & Pressure sensor

*To be published*

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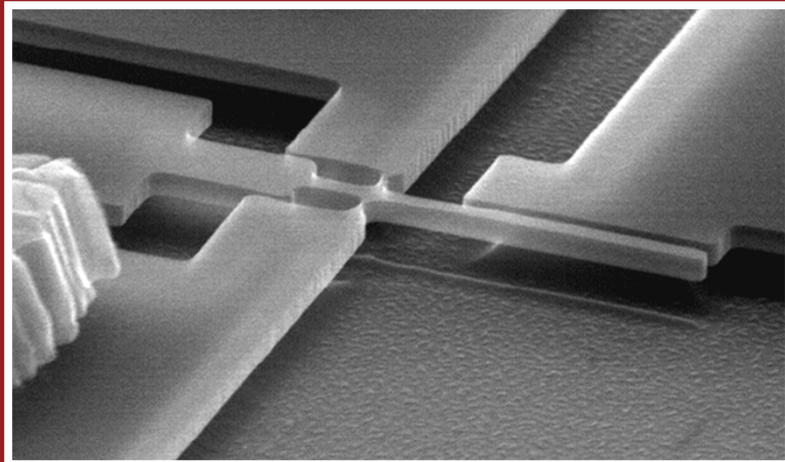
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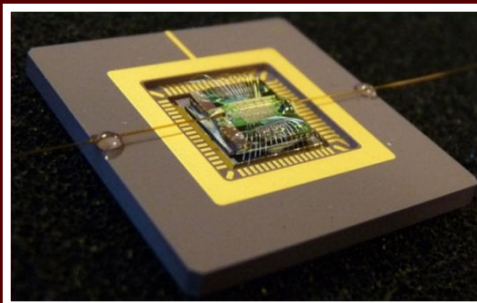
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# NEMS sensors “platform”



- 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

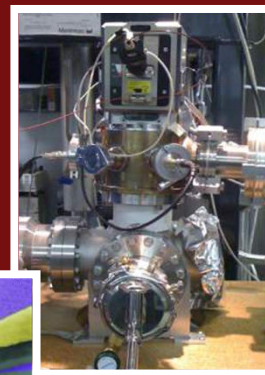
## Gas detection



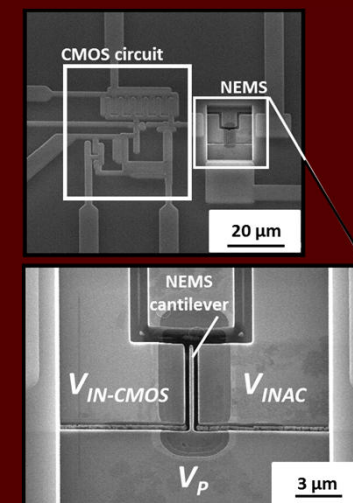
**APX**  
Analytical Pixels



## Mass-spec for Bio applications



## Co-integration with CMOS



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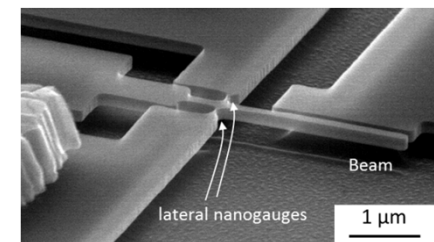
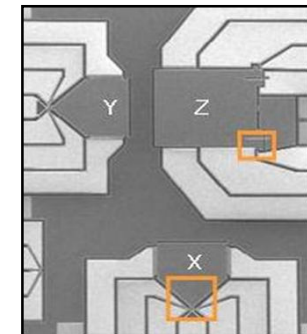
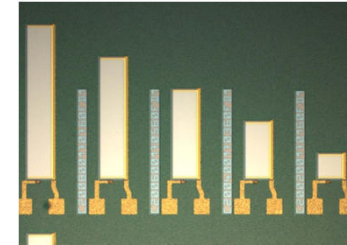
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# Future perspectives |

- **Multi-purposes piezoelectric platform**
  - Low-cost polymer piezoelectric materials
  - Energy harvesting
- **M&NEMS platform for multi-axis sensing**
  - Extension of M&NEMS platform to other kinds of sensors
- **NEMS platform for bio- and chemical sensing**
  - Promoting NEMS-based mass spec as a disruptive approach





# SAVE THE DATE



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