

# Goals & Methods

## Design, develop & test innovative devices:

- Power-MEMS : generators, actuators, sensors, supply & control
- Bio-Mag-MEMS :  $\mu$ fluidics for biomedical applications

## Approach:

- Creativity, innovation, pioneering...
- Scale reduction laws & magnetic interactions

## Analytical calculation tools and MEF:

- Dimensioning / optimisation of Mag-MEMS

## Technologies:

- Prototypes, demonstration modules, models
- Integration of materials:  $\mu$ -magnets, active hybrid materials
- Integration of functional devices

# Magnetic $\mu$ SYSTEM

MAG-MEMS :  
MAGNETIC MICROSYSTEMS

## Scientific activities

### • Micro-energy:

Energy harvesting,  $\mu$ -sources of energy  $\mu$ -actuators /  $\mu$ -motors/  $\mu$ -generators

### • Bio-Mag-MEMS:

$\mu$ -fluidics for biomedical, lab-on-chip,  $\mu$ TAS

Diamagnetic levitation: digital  $\mu$ Fluidics,  $\mu$ Objects

## Experimental facilities

Embedded within CIME Nanotec @ MINATEC:

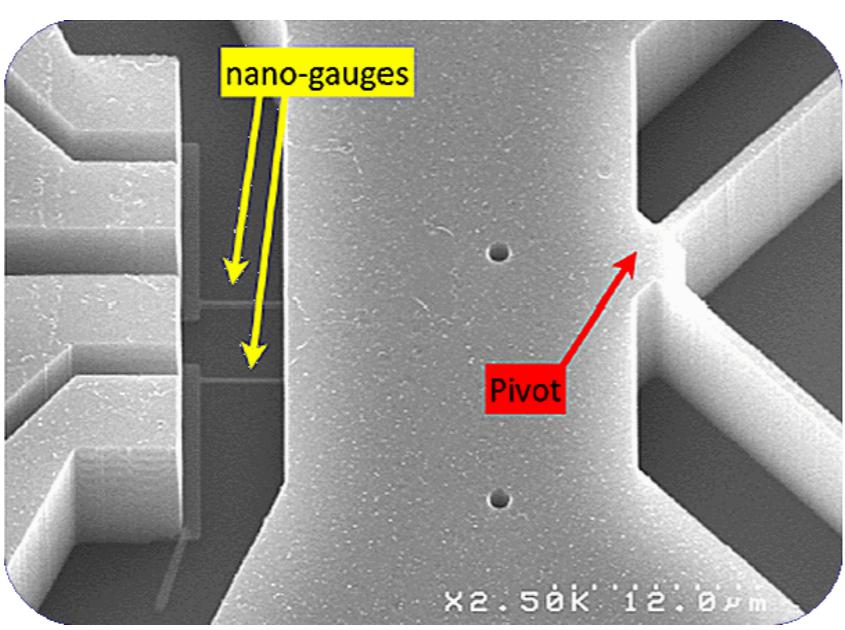
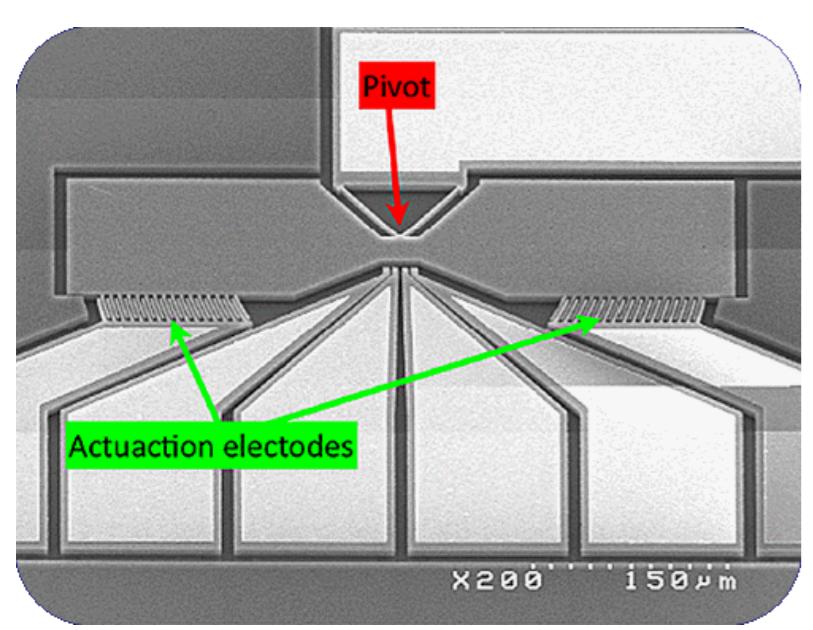
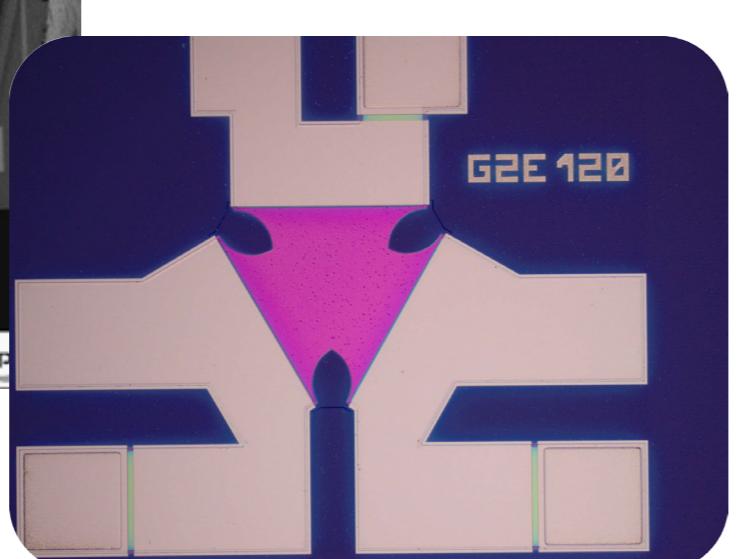
- Microsystems shared platform ( $C^2\mu$ )  
(characterisation, prototypes, tests)
- PTA clean room
- Nano-Bio &  $\mu$ -fluidic shared platforms

We benefit from the pioneering know-how of Institut Néel & CEA-LETI: creation & integration of functional materials, Si micro-technologies...

## Integrated active materials



Hybrid transducers for voltage controlled actuation piezoelectric / magnetostrictive multilayers (@ CEA-LETI)



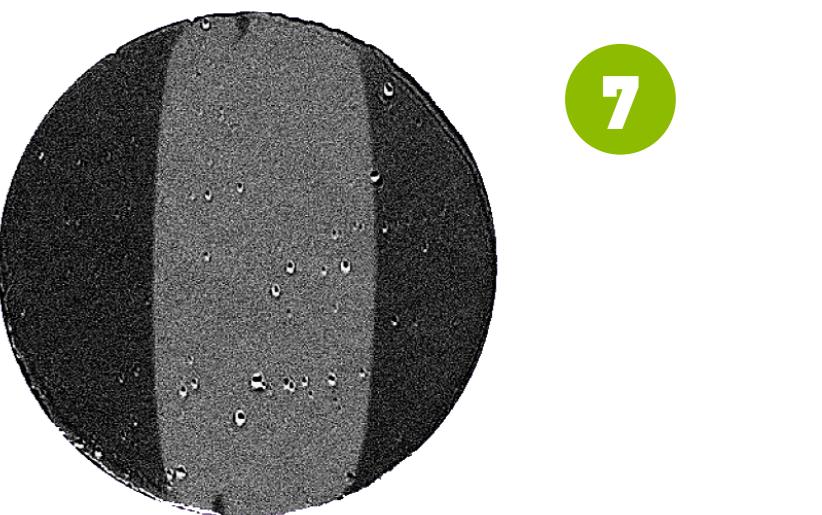
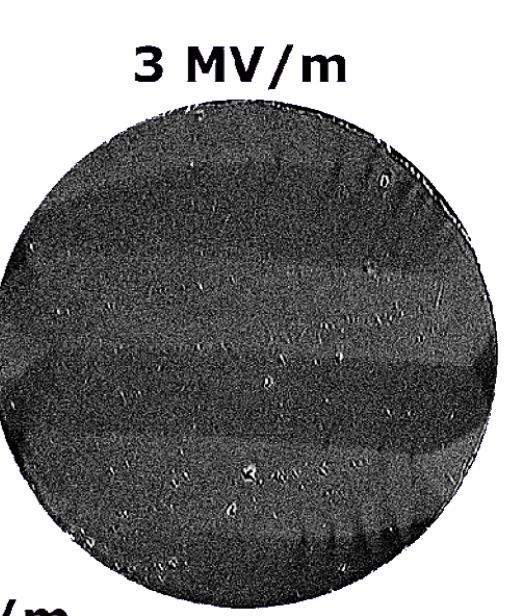
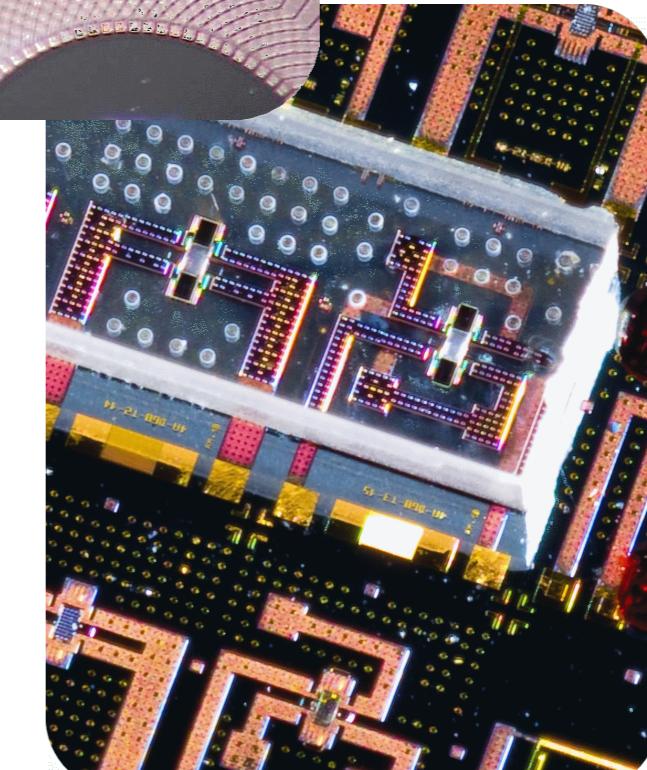
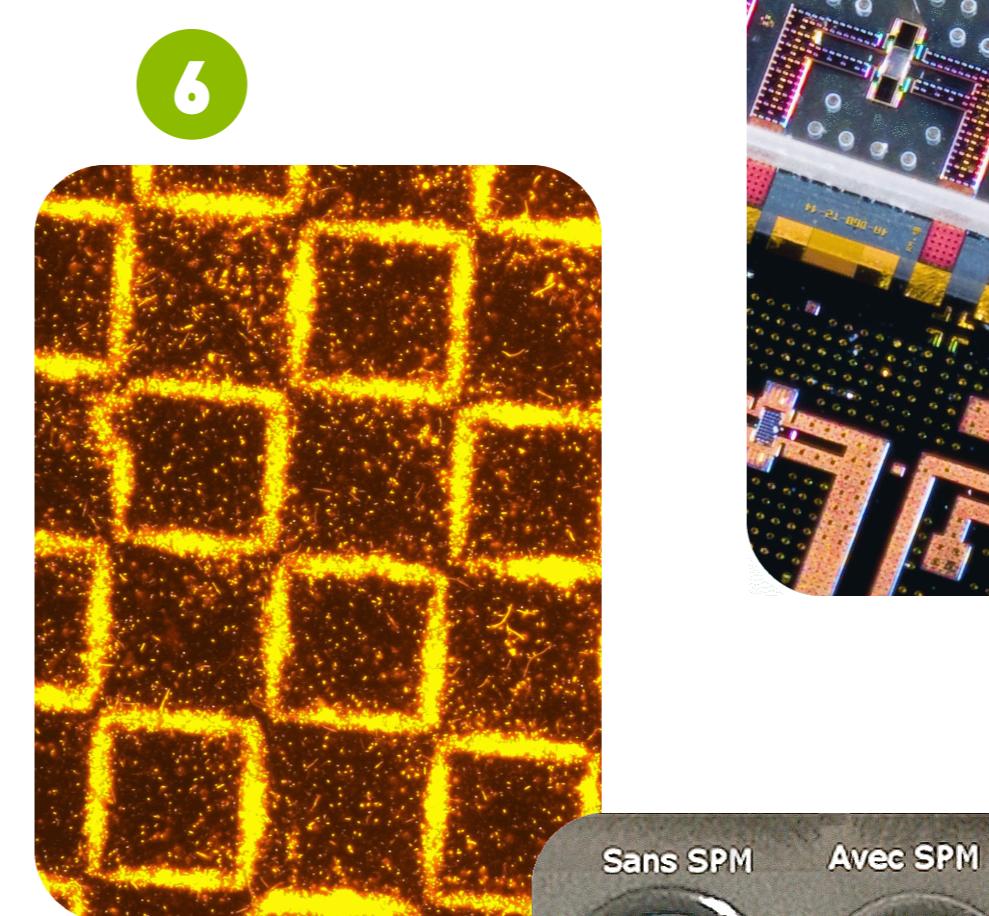
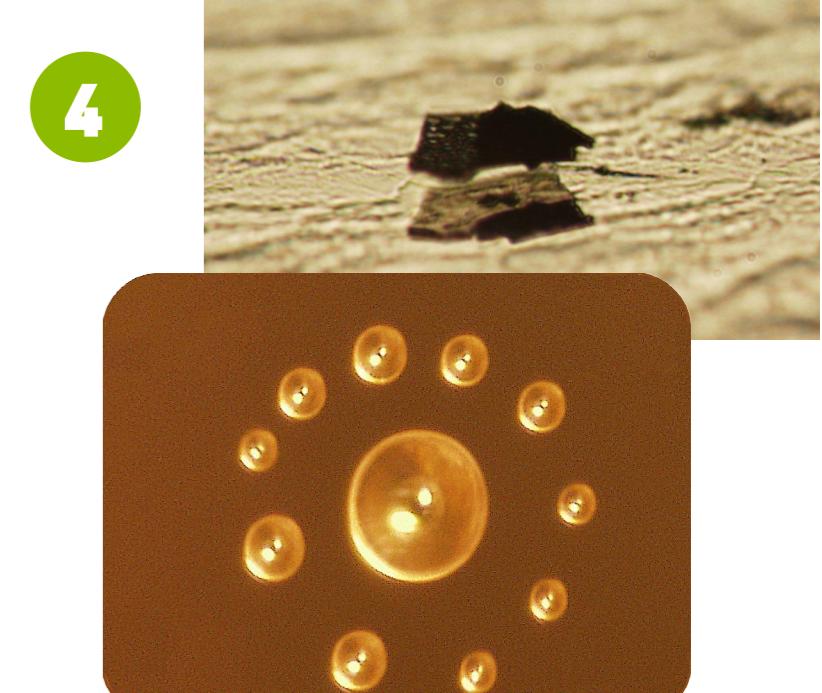
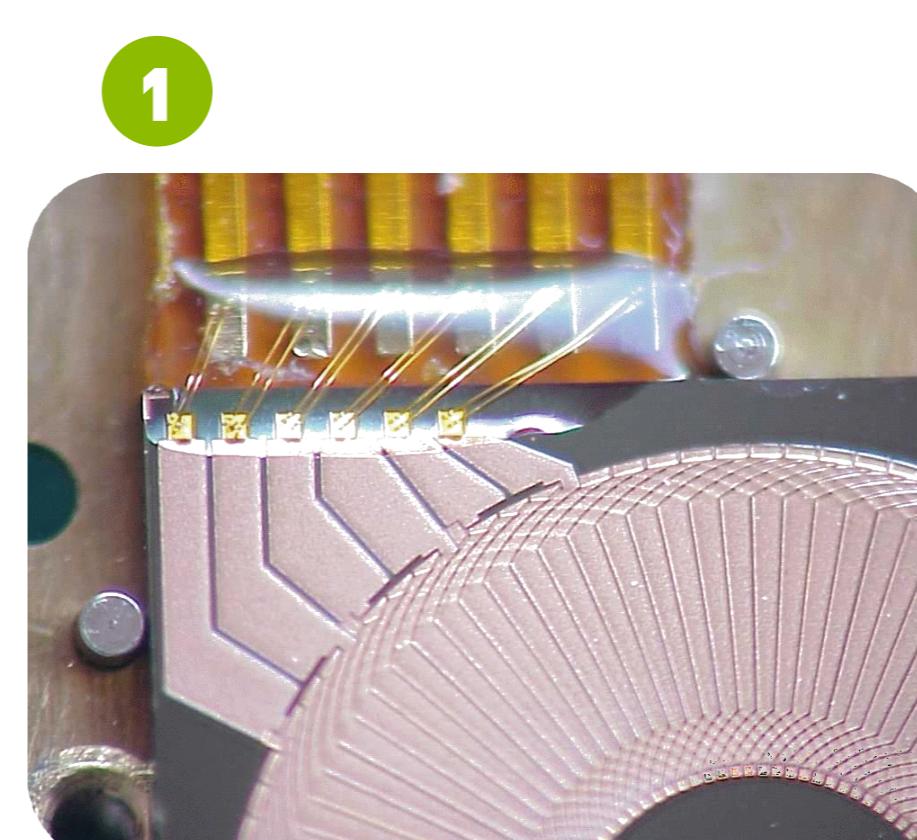
M&NEMS multi-modal sensor (directional magnetic & inertial) : Co-integration of nano-structured anti-ferromagnet multilayer, nanometric strain-gauges, & electrostatic feedback control (@ LETI)



Integrated high-performance magnets : thick NdFeB  $\mu$ -magnet layers (30  $\mu$ m) deposited onto textured Si substrate (Institut Néel, with LETI)

## Productions

- 1- Integrated 8 mm Ø 3-phase dual-layer stator on Si for planar  $\mu$ -machine /  $\mu$ -generator (with LETI for DGA)
- 2- Array of 1 mm<sup>2</sup>  $\mu$ -switches (bistable, 30~120  $\mu$ m out-of-plane) Integrated FeCoP magnets, Si / Glass flip-chip-assembly (w/ CEA-LETI)
- 3- diamagnetic  $\mu$ -droplets (H<sub>2</sub>O 30~150  $\mu$ m) in levitation in a magnetic pit, in electrostatic repulsion (w/ CEA-LETI)
- 4- NdFeB magnet flake (thickness 5  $\mu$ m) in levitation over diamagnetic HOPG graphite substrate (with I. Néel)
- 5- Bio-chemical reaction enhanced by superparamagnetic tagging.  $\mu$ -fluidics for easy & fast diagnostics (with LMGP+Néel)
- 6- Bacteria tagged by magnetic nano-beads, trapped on 50  $\mu$ m  $\mu$ -magnet array (with I. Néel & Ampère / Lyon, for ANR Emergent)
- 7- Voltage control of magnetic easy axis orientation in nano-structured piezo-magnetic multilayer (with CEA-LETI)



## Collaborative projects

### MINATEC / $C^2\mu$

micro-characterization, clean room (CIME Nanotec)

### Institut Néel

integration of high performance magnets, exotic magnetic materials, diamagnetic levitation, bio-medical devices

### LETI-CEA

integration on Si,  $\mu$ -fabrication clean room, integrated active materials:

- PZT, magnetostrictive, shape memory

LMGP micro-fluidic bio-medical applications  
TIMA energy harvesting, Ultra-Low-Power

### Ampère-Lyon (& Biomis)

micro-manipulation of cells :

- superparamagnetic nanoparticles tagging
- diamagnetic trapping & selection

### G2E Lab

- SYREL MEMS sensors for Smart Grid supervision
- MAGE analytical design of Mag-MEMS design & constrained optimization
- EP smart power management
- MDE energy harvesting electrostatics for  $\mu$ -fluidics & droplets