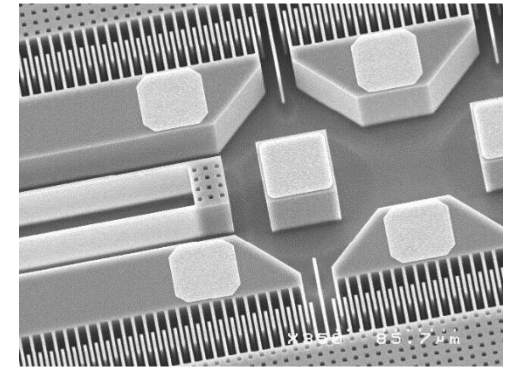
leti ceatech



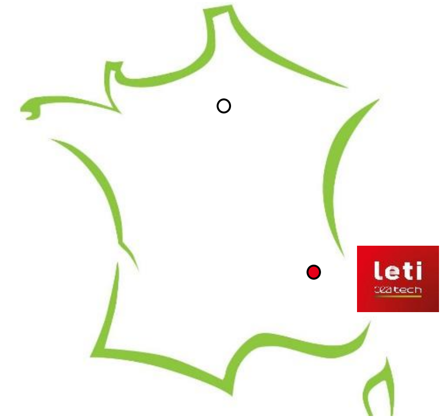
CEA-LETI, YOUR PARTNER FOR MEMS R&D

Jean-Philippe POLIZZI
jean-philippe.polizzi@cea.fr

Leti MEMS Workshop, June 25 2019, Estrel Congress Center, Berlin

CEA- Leti

→ *Founded in 1967*



1,900 researchers

250 PhD students + 40 post PhD
with 85 foreign students (35%)

2700 patents

311 generated in 2017
40% under license

318 M€ budget (80% contract R&D)

~ 40M€ CapEx

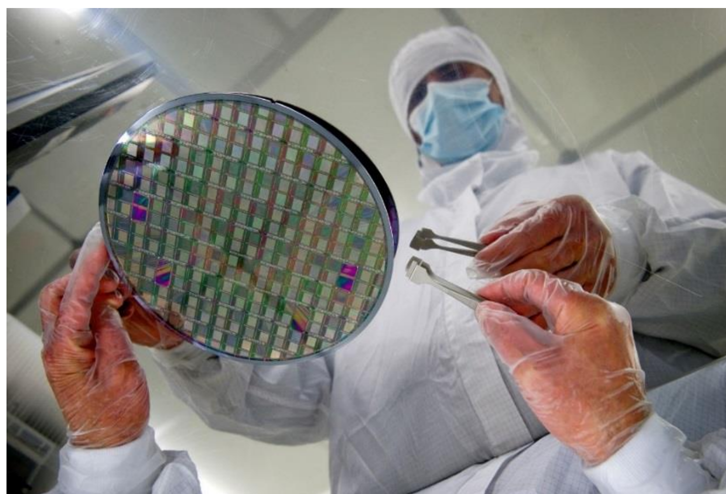
54 start-ups
& 365 industrial partners

leti ceatech

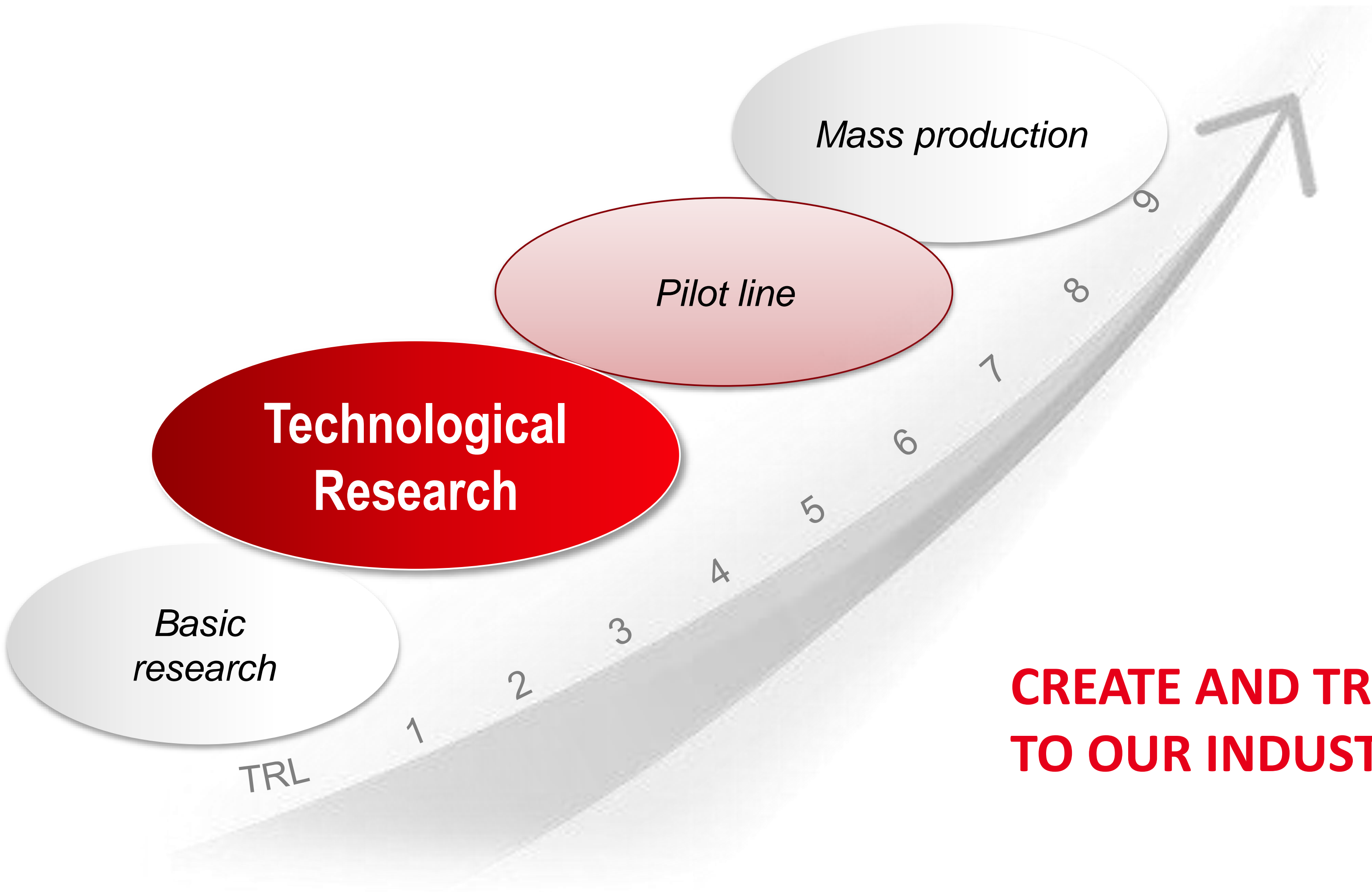
MICRO-TECHNOLOGY PLATFORMS

> 300 mm clean room capabilities

> 200 mm clean room capabilities



Mission



CREATE AND TRANSFER INNOVATION TO OUR INDUSTRIAL PARTNERS

40 YEARS BACKGROUND ON MEMS & PACKAGING

Key dates

1984 World 1st "Comb drive" accelero patent

1996 Spinoff – tronics

2007 Caltech Alliance on NEMS

2005 World 1st MEMS 200 cleanroom

2011 Spinoff – Primo1D

2011 Spinoff – APIX ANALYTICS

2013 Spinoff – Wavelens

2014 Startup – elichens

2015 Startup – mirsense

2015 World 1st 300mm MEMS wafer

80s | 90s | 00s | 10s

industrial transfers

1980 Weight sensor – Terraillon

1981 Hygrometer – GEFRAN CORECI

1987 Quartz accelero – THALES

1996 Geophone

Pressure

Accelero

tronics microsystems

1998 High perf. pressure – THALES

2005 Accelerometer – freescale semiconductor (Launched by Motorola)

2008 TSV for imager – ST

2011 Inertial platform – freescale semiconductor (Launched by Motorola)

2012 Above-IC GMR sensor

2013 Thin Film pack.

2013 PZT Solgel – ST

SiO2 TiAu PZT

2013 300mm HD interposer – SHINKO

2013 100µm MEMS wafer thinning – OMRON

2016 Capacitance stacking – muRata

2016 PZT variable focus lens – Wavelens

2017 PZT Solgel

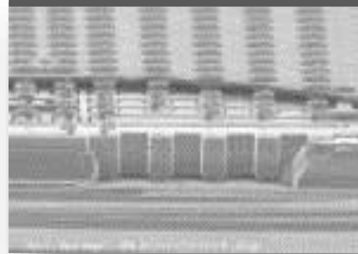
2018 Magnetic stack layer

2018 IR micro-source – elichens

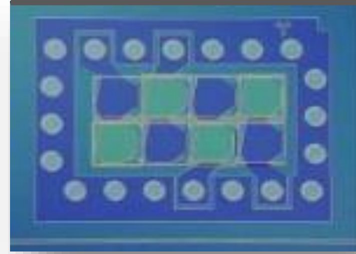
2018 AlN Technology

MICROSYSTEMS ACTIVITY

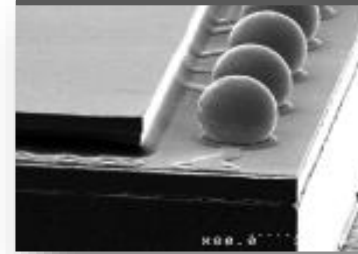
LCMA Lab.
Actuators Components



LCMC Lab.
Sensors Components

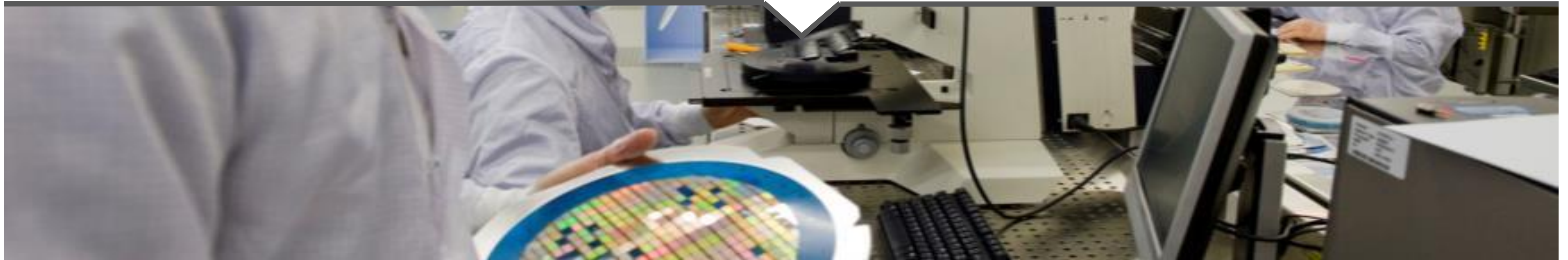


LCRF Lab.
RF Components



LP3D Lab.
Packaging & 3D

LCFC Lab.
Charact. & Reliability



TECHNOLOGICAL PLATFORM

- MEMS 8”(1000 m²) + FE 8”(3000 m²) Cleanrooms
- Specific MEMS equip. : DRIE, HF-vapor, bonder…
- 5 shifts working: 7days/week – 24h/days

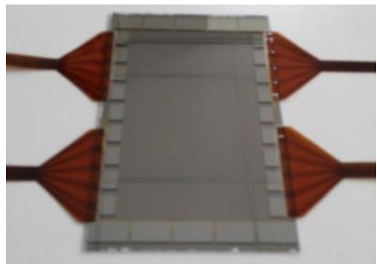
Overall MEMS activities > 200 persons

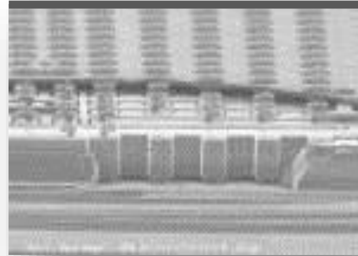
MICROSYSTEMS ACTIVITY

LCMA Lab.
Actuators Components

MEMS Actuators for
- Optics,
- Acoustics
- Haptics
- Biology

Specific Technologies
- PZT, AlN

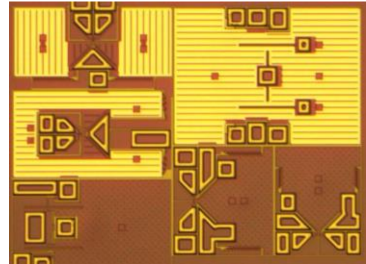


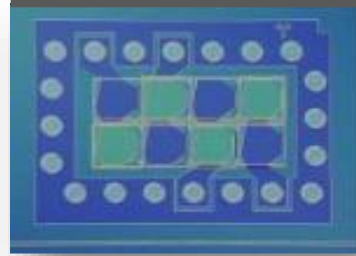


LCMC Lab.
Sensors Components

MEMS Sensors for
- Inertial, Pressure, Magnetic
- Acoustics, Ultrasonic
- Gas and Biology…

Specific Technologies
- Nano-scale
- Optomechanics

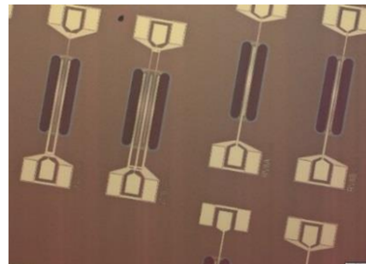


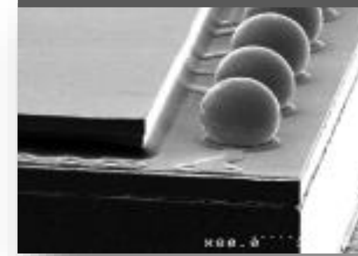


LCRF Lab.
RF Components

Passive Components
- Magnetic Inductors
- High density Si Capacitors
- EMI Filters…

RF Devices
- Acoustic filters
- RF switches and inductors



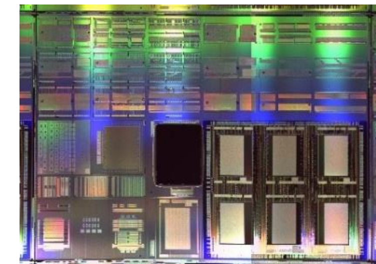


LP3D Lab.
Packaging & 3D

3D IC
- High density interposers

Heterogeneous integration
- TSV-Last, RDL, WL integration

Packaging
- Microsystem in Flex
- Power 3D Module, SiP

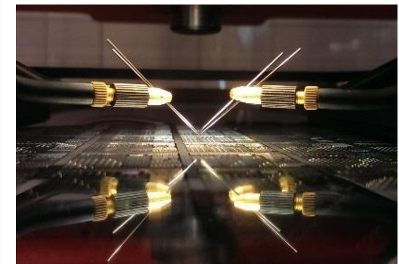


LCFC Lab.
Charact. & Reliability

MEMS/NEMS Test
- Electric & Environmental test

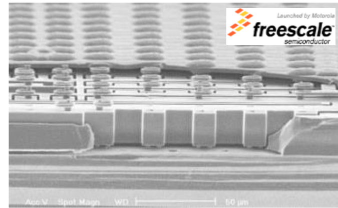
Reliability
- 3D (electromigration…)
- MEMS (thermal cycling…)

Specific expertises
- RGA/TDS, Nano-indenter…

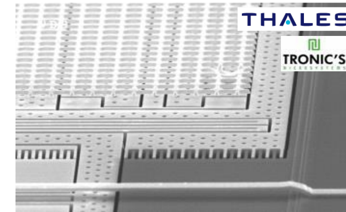


A LARGE PANEL OF SENSORS TECHNOLOGIES (1/2)

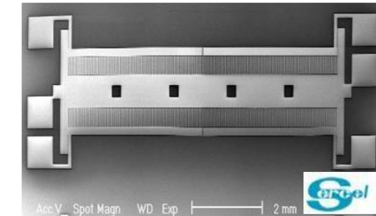
Inertial Sensors



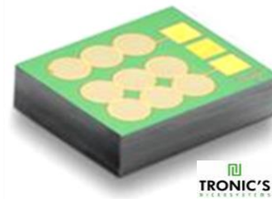
3-axis Accelerometer



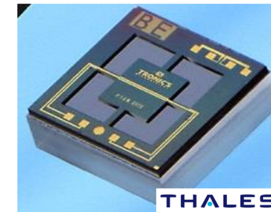
3-axis Gyroscope


Geophone

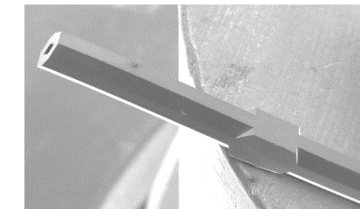
Pressure sensors



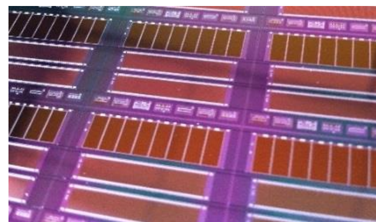
Capacitive pressure sensor

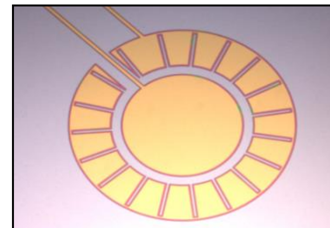


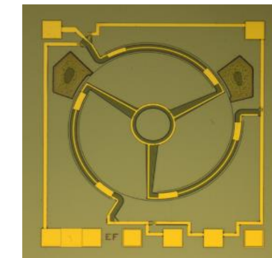
Piezoresistive pressure sensor

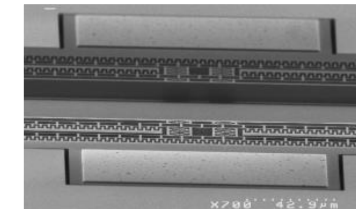

High temperature P sensor

Acoustic sensors

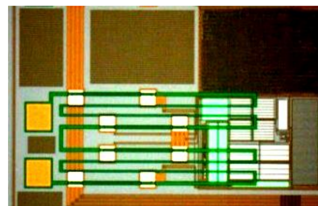

cMUT

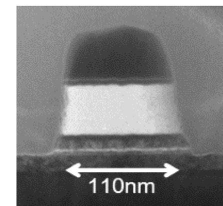

pMUT

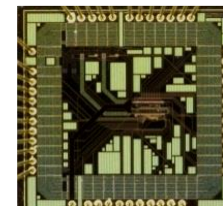


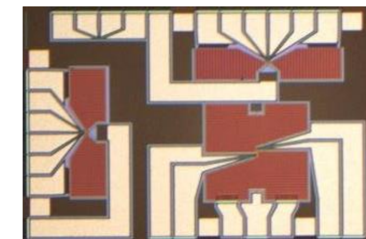

High SNR Microphone

Magnetic sensors


Above-IC GMR sensor



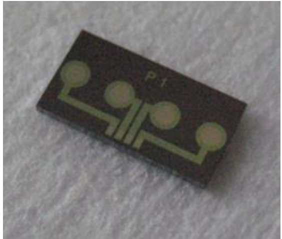

TMR sensor and resonator

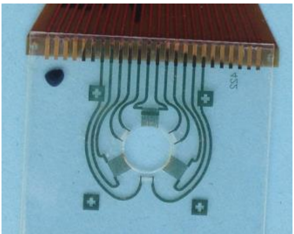

3-axis Compass

A LARGE PANEL OF SENSORS TECHNOLOGIES (2/2)

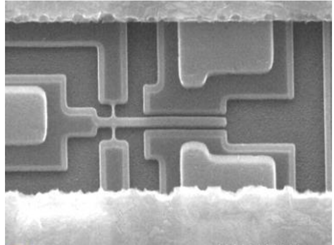
Chemical Sensors

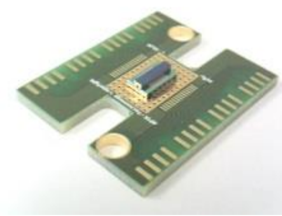
Ionic sensors

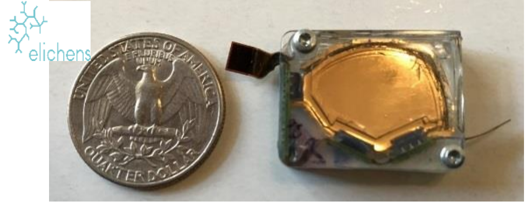

Conductivity


Multi parameter metabolic sensor

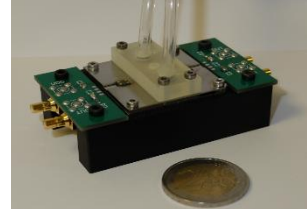
Gas sensors



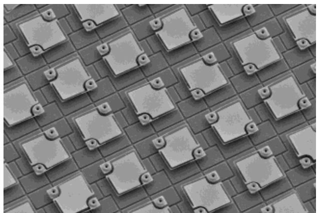

NEMS-based

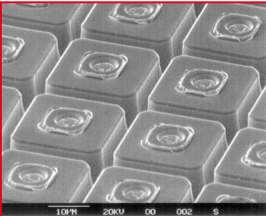


NDIR CO_2 sensor


Photoacoustic detector

Imaging sensors


IR bolometer

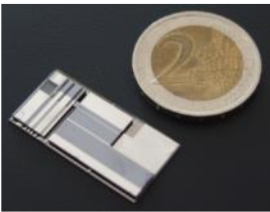

Cooled IR MCT PD

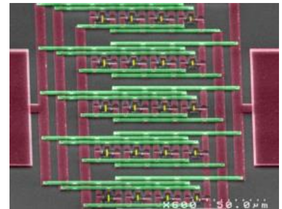
VIS cMOS cameras

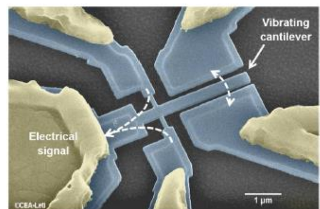
X-rays

Other sensors

3-axis force sensor


µ-TOF Mass-spec for NRBC

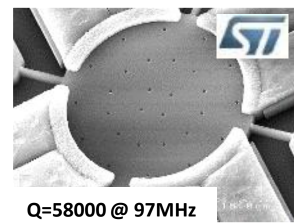


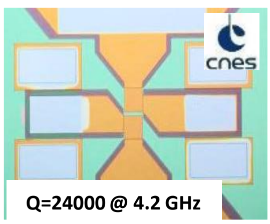


NEMS based Mass-spectrometry

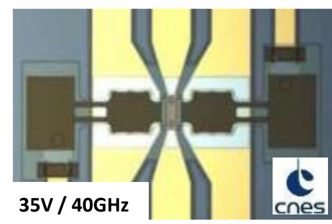
OTHER MEMS

RF

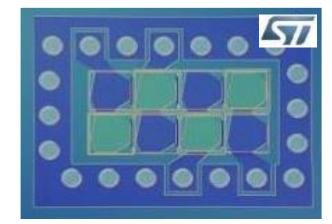




high-Q resonator (Si and HBAR)

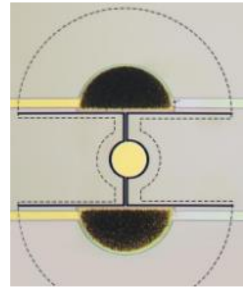


Micro-switch



BAW filter

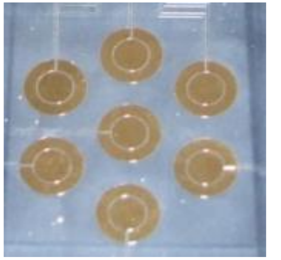
Actuators



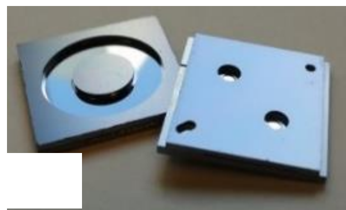
Optical scanner

PZT-based variable lens

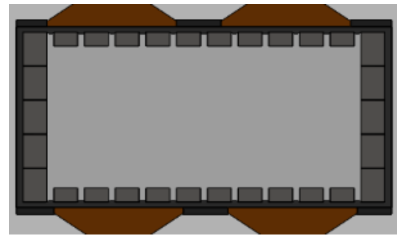
PZT ultrasonic transducers
(Digital-loudspeaker, pMUT)



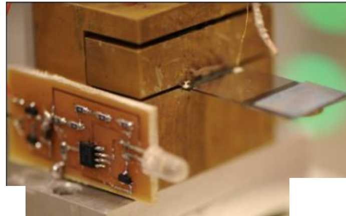
Micro-valve



Haptic actuators

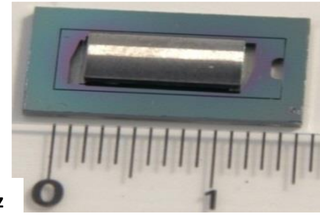


Energy harvesting



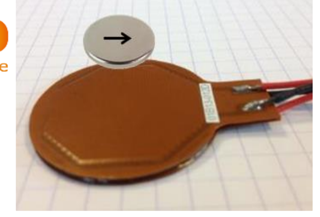
200µW/cm³ @ 200 Hz

Piezoelectric AlN harvester



1cm³ / 10µW @ 20 Hz

Electret-based harvester



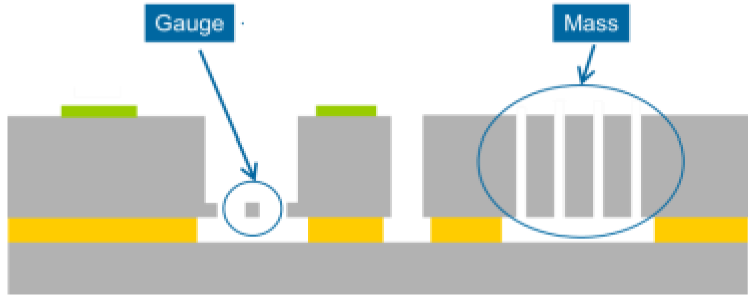
1cm²x1mm
1mW @ 60rpm (1Hz)

Breakthrough concept

leti
cea tech

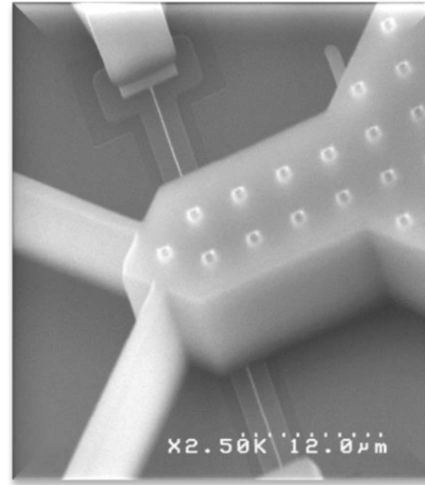
M&NEMS GENERIC PLATFORM

PATENTED



MEMS size mechanical part

Nano-size piezoresistive gauge



- **Generic** platform
- **Miniaturized** sensors
- Well known and **robust** piezoresisitive detection
- Not sensitive to parasitics
- Very **short duty cycle** and multiplexing
- **Simple electronics** common for all the axis

3-axis Accelero

Y Z X

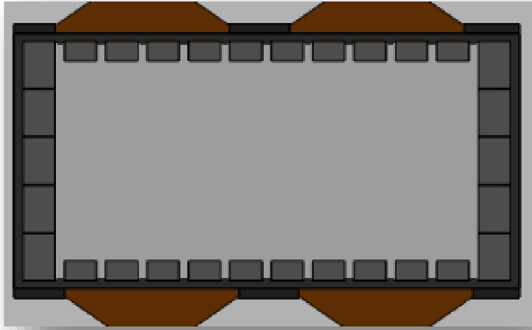
3-axis Gyroscope

3-axis Magneto

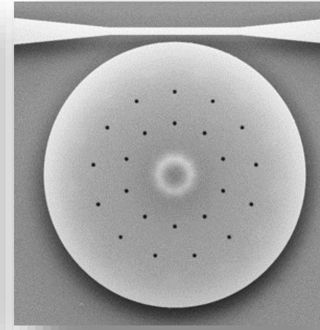
Pressure sensor

Microphone

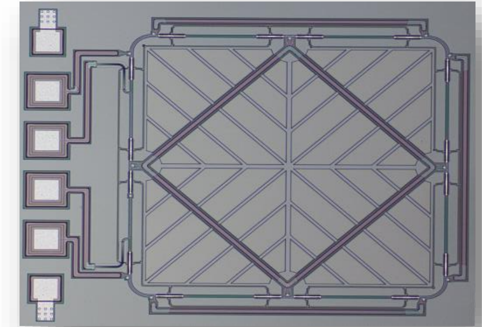
6 HOT TOPICS IN DEVELOPMENT



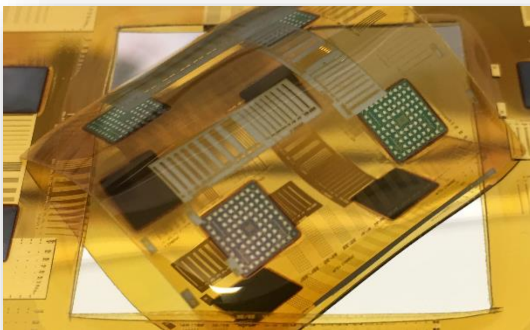
HAPTICS
(Time reversal)



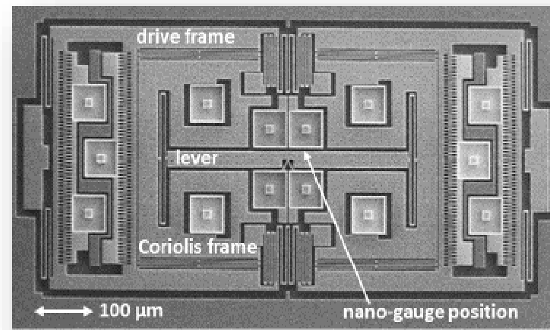
BIO-SENSOR
(Zika, Ebola… virus detection)



80dB-SNR MICROPHONE
(innovative architecture)



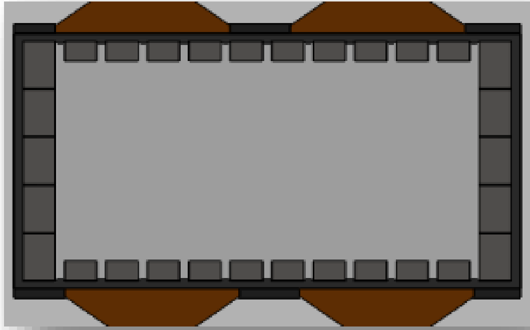
SILICON INTEGRATION IN FLEX
(In-Flex Fan-Out)



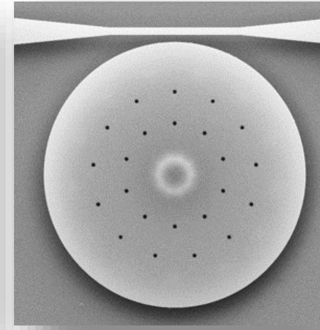
HIGH-PERF GYROSCOPE
(M&NEMS platform for ADAS)

PIEZO TRANSFER & TRANSPARENCY
(Piezo on glass for haptics, force sensor…)

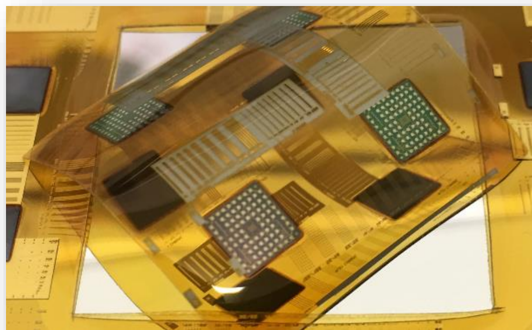
6 HOT TOPICS IN DEVELOPMENT



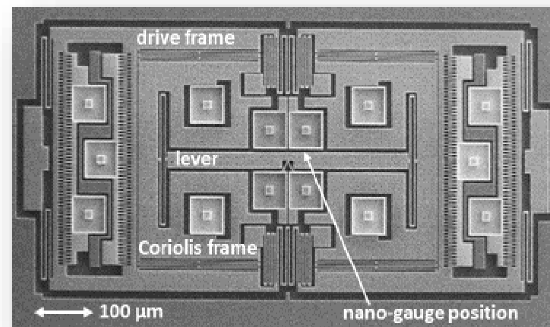
HAPTICS
(Time reversal)



BIO-SENSOR
(Zika, Ebola… virus detection)



SILICON INTEGRATION IN FLEX
(In-Flex Fan-Out)



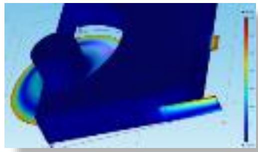
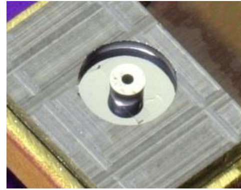
HIGH-PERF GYROSCOPE
(M&NEMS platform for ADAS)

- LIDAR Scanner
- Variable focus lens
- Micropump
- Piezo Loudspeaker
- Bio cell manipulation
- High perf accelerometer
- High perf pressure sensor
- pMUT/cMUT
- 3-axis force sensor
- Magnetic sensor
- TCD gas sensor
- Photo-acoustic gas sensor
- NEMS-based gas sensor
- Mass spectrometer
- PCM switch
- Time reference resonator

PARTNERSHIP BUSINESS MODEL

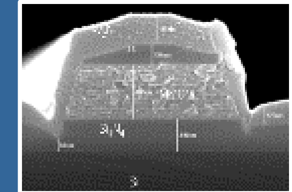
Component development

- From design to characterization

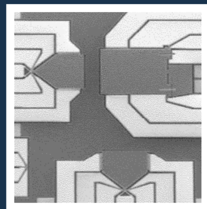
Process development

- Full process
- Process steps (magnetic, piezoelectric materials…)



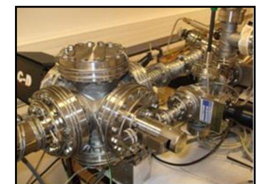
MEMS prototyping

- Using one of Leti MEMS platforms



MEMS reliability and characterization

- Vacuum probing
- RGA test bench



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Worldwide Industrial partnerships in Microsystems

esa
ThalesAlenia Space
Sercel
APIX Analytical Pixels
freescale semiconductor
ipdia
ST
KYOCERA
enerbee
SORIN GROUP
GDF SUEZ
Primo1D
EPCOS
SENSEOR
SAFRAN Sagem
ams
EVEON
tronics ENVISION MEMS | DELIVER MEMS
cnes
e2v
Wavelens
OMRON
BOSCH

+ Confidential relationships

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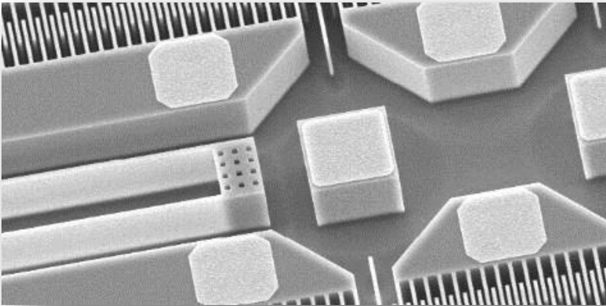
CEA-LETI
THE LEADING MEMS R&D LAB WORKING FOR INDUSTRY

- **30+** years experience in MEMS
- **200+** people involved in MEMS
  (sensors, actuators, RF, packaging, process, characterization)
- **All 8”** MEMS/NEMS technologies in-house



- **330** patents portfolio in the MEMS field
- **35%** under license or co-ownership
- **30** new patents and **65** publications/year

- **25** ongoing industrial collaborations
- **20+** industrial transfers
- **7** startups creation

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Thank you for your attention

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INSTITUT CARNOT Leti