FONDAZIONE BRUNO KESSLER
SENSORS AND DEVICES

IPCEI on Microelectronics

IPCEI (Important Projects of Common European Interest) on Microelectronics & FBK - Sensors & Devices Centre

Prof. Richard Hall-Wilton
FBK-SD director

World Manufacturing Forum 2022

eit Manufacturing CLC SOUTH

Co-funded by the European Union


David Selbert, pexels

Fondazione Bruno Kessler

About us

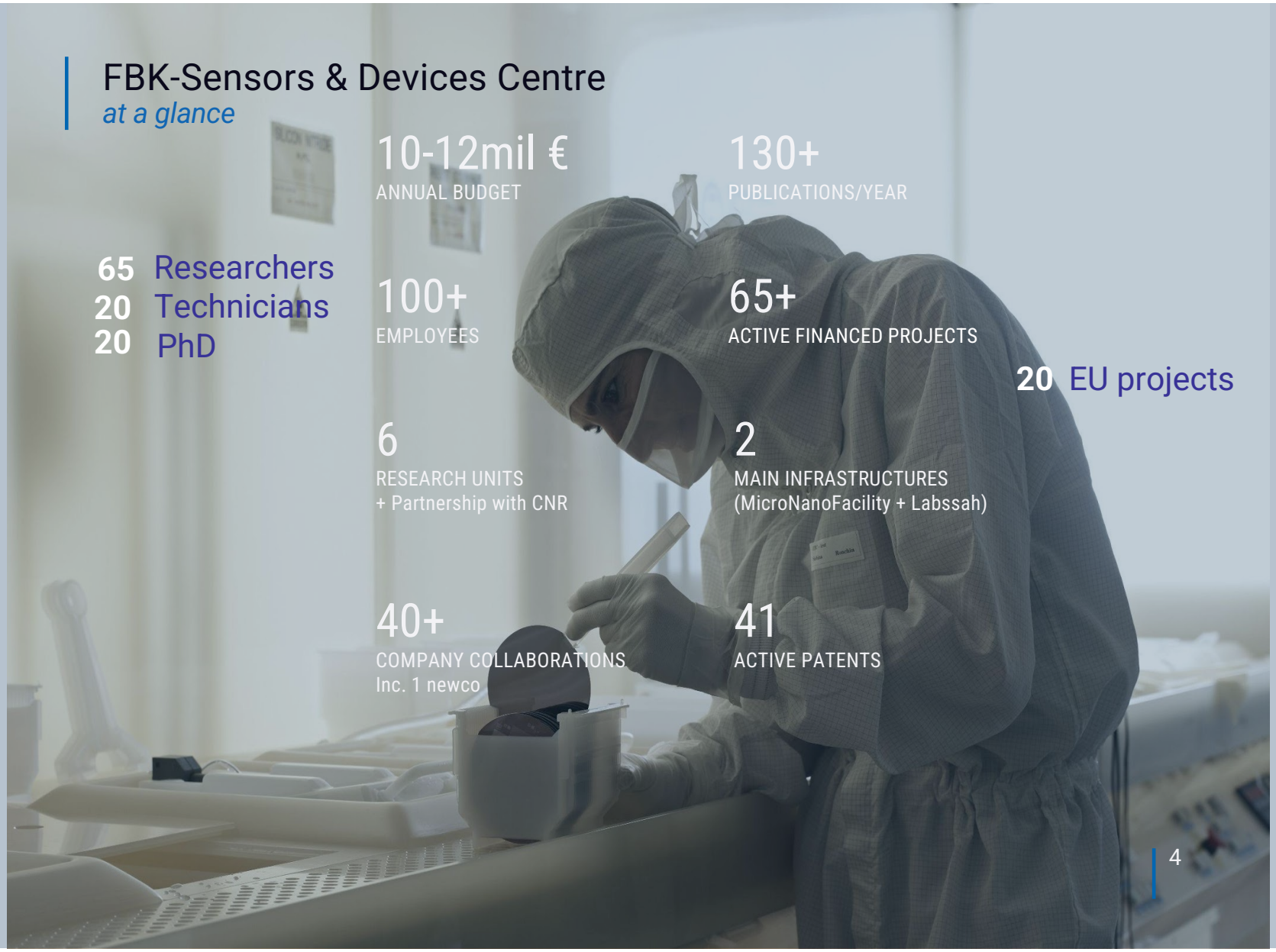
PROFILE

Fondazione Bruno Kessler (FBK) is a research not-for-profit public interest entity result which is 60 years old

MISSION

FBK aims to excellence in science and technology with particular emphasis on interdisciplinary approaches and to the applicative dimension.

FBK-Sensors & Devices Centre
at a glance



10-12mil €
ANNUAL BUDGET

130+
PUBLICATIONS/YEAR

65 Researchers
20 Technicians
20 PhD

100+
EMPLOYEES

65+
ACTIVE FINANCED PROJECTS

20 EU projects

6
RESEARCH UNITS
+ Partnership with CNR

2
MAIN INFRASTRUCTURES
(MicroNanoFacility + Labssah)

40+
COMPANY COLLABORATIONS
Inc. 1 newco

41
ACTIVE PATENTS

Sensors and Devices Centre

sensors

a device that is used to record that something is present or that there are changes in something

devices

an object or machine that has been invented for a particular purpose: an electronic device

Cambridge English dictionary

Bleeding Edge Sensors and Devices based around technological platforms

Scalable: silicon et al. fabrication techniques

Contribution across the development chain: ideation to fabricate in-house to bring to market

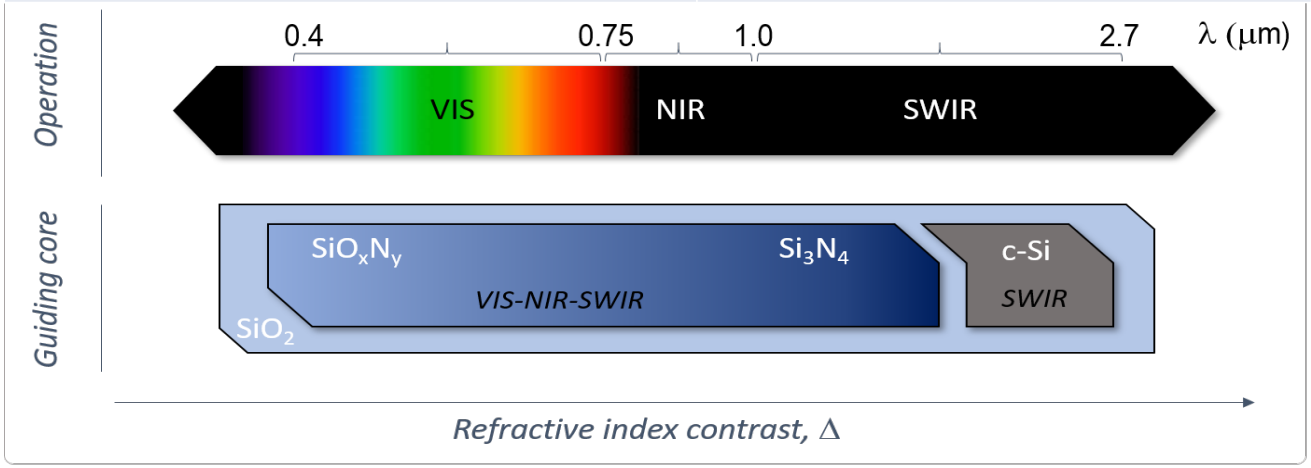
For science and society

Development Philosophy:
Unique capability

I&QO Custom Products

Photonics and Quantum Technology

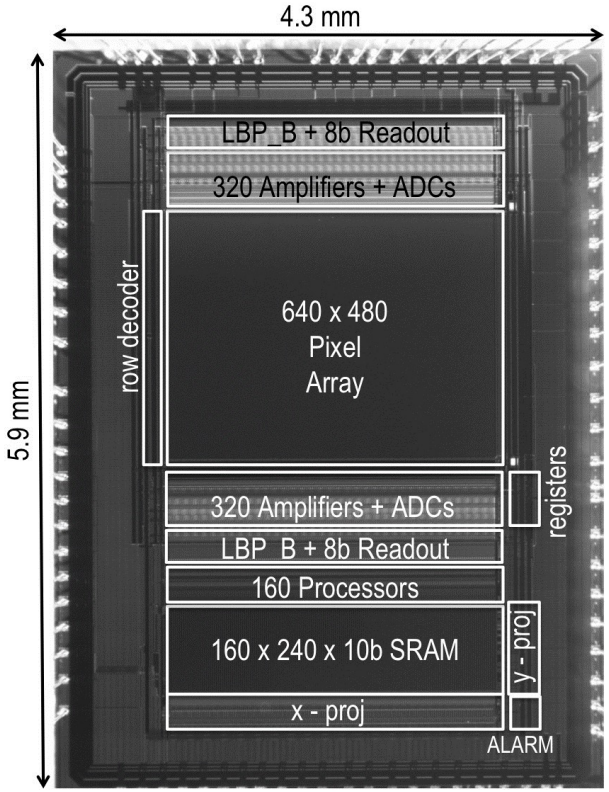
Nanomaterials	**Upconversion nanoparticles** TRL 5-6 Nanodiamonds and bulk **diamond with NV centers** TRL 3-4	
Integrated Optics	Integrated **spectral shaper** TRL3 **Evanescent microring biosensors** TRL 3-4 PICs* with **integrated photodetectors** TRL 3 PCB boards, **electrical control circuits** for heater TRL 3-4	SOI based PICs TRL 2 Si3N4 and SiON based PICs TRL 3
Quantum Optics	PiCs for **linear quantum optics** TRL2 PiCs with **integrated single photon counter** TRL2	SOI PICs with **entangled photon generation** TRL 2 Si3N4 and SiON based PICs TRL 3



* PIC Photonic integrated circuit

Integrated Readout ASICS and Image Sensors products

IRIS
INTEGRATD READOUT ASICS AND IMAGE SENSORS

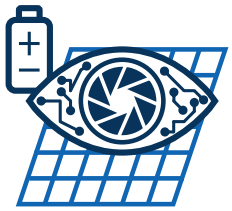


Example of a low-power vision sensor for battery-operated surveillance systems.

Single-photon Imagers

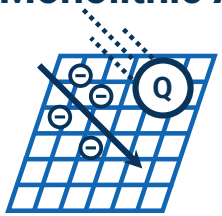
They combine single-photon detectors and high-speed electronics to count photons and measure their arrival time in parallel for each pixel.

Low-Power Vision Sensors



They gather extra information from the scene at chip- or pixel-level to perform complex tasks using a small amount of power.

Monolithic Active Pixel Sensors

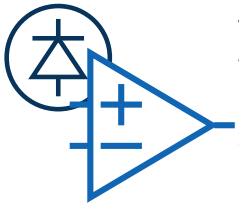


MAPS exploit the interaction of charged particles with matter to measure their energy, position and direction with a low energy budget.

Multispectral, X-ray and THz

They add the wavelength as another variable capable of increasing the information carried by an image, to see things our eye cannot see.

Readout ASICs



They extract the useful signal from custom detectors (SiPM, SDD, strip detectors, 3D SiPM, ...), minimizing noise and distortions.

IRIS Technology / Application matrix

IRIS
INTEGRATD READOUT ASICS AND IMAGE SENSORS

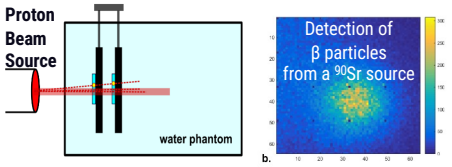
	Quantum S&T	Space S&T	Science	Bio-/Medical Food, Health	Security	Industrial / Automotive	Consumer / IoT
Single-Photon imagers	Quantum & ghost QRNG Quantum comm.	[1] **Solid-state LiDAR** Scientific imaging HDR imaging	Time-resolved img Quanta imaging	FLIM, PET, hadron therapy Raman, SPECT, …		LiDAR/d-ToF	3D imaging Depth sensing 2D imaging
Low-Power Vision Sensors		Star-tracking			[3] **Low-power video-surveillance**	High-speed vision	AI-enhanced imaging, HDR
Multispectral, X-ray and THz			Multi-spectral (THz) imaging	X-ray imaging for dental appl.	THz / MIR sensing	[4] **Quality control with THz**	
Monolithic Active Pixel Sensors			Particle tracking for HEP	[2] **Particle tracking for hadron therapy**			
Readout ASICs	Readout ASICs for quantum detectors & photonic circuits	Readout ASICs for SiPM, SDD, InGaAs	Readout ASICs for SiPM, SDD, InGaAs	Air quality monitoring		Self-mixing interferometry	Self-mixing interferometry

TRL LEVEL

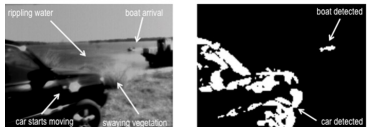
Examples

[1] Solid-State LiDAR
Direct Time-of-Flight depth sensing based on single-photon detectors

[2] Particle tracking for hadron therapy
Direct detection of charged particles with a low material budget

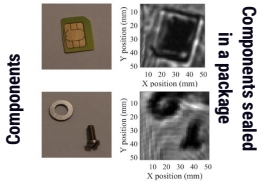


[3] Low-power video-surveillance
Surveillance of large areas with battery operated devices



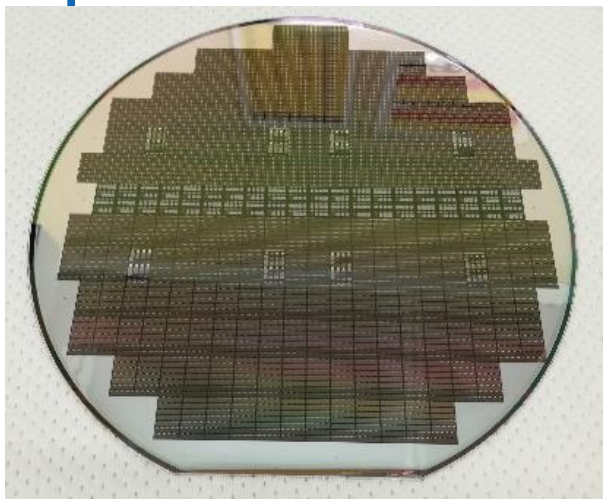
Smart motion detection insensitive to standard background variations (sea waves, trees moving)

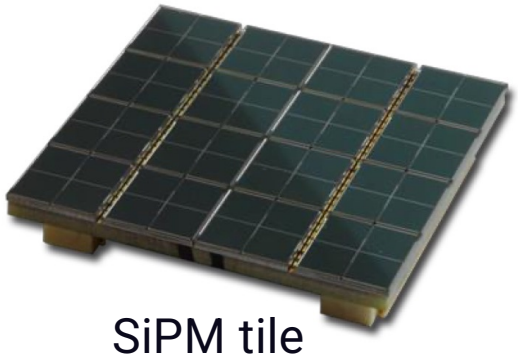
[4] Quality control with THz
Multi-spectral analysis of packaged components



Custom Radiation Sensors at a glance

CRS
CUSTOM RADIATION SENSORS



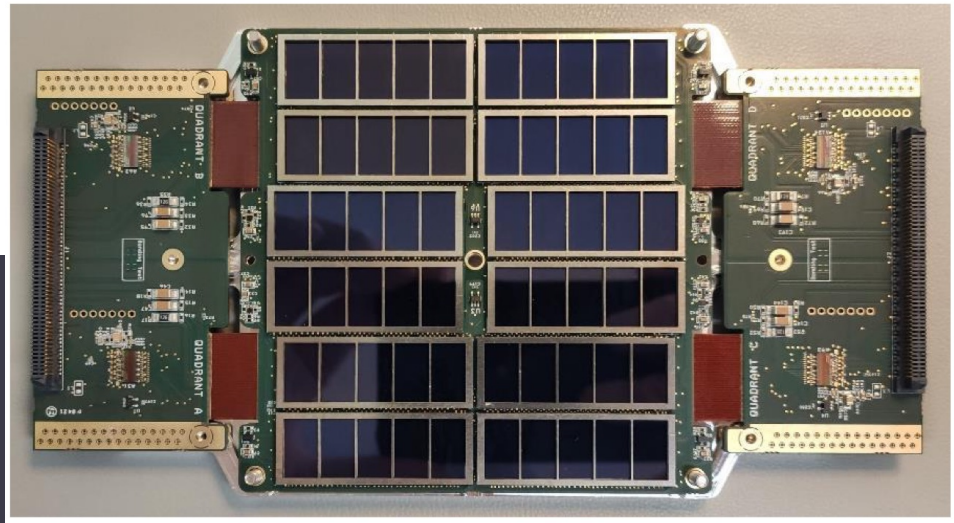


SiPM tile

Applications (amongst others):

Medical Physics

Big Science: High Energy Physics, neutrino physics, …



X/Gamma sensors (SDD produced at FBK) integrated on PCB in FBK with space compliant components (payload of nanostallite constallation)

Space Industry

Mission: Sensors designed and realized to meet your needs

Our mission is highest quality research in the field of radiation sensors to stay at the forefront of the worldwide understanding of the physical processes and the technological developments to provide our partners with leading-edge devices.

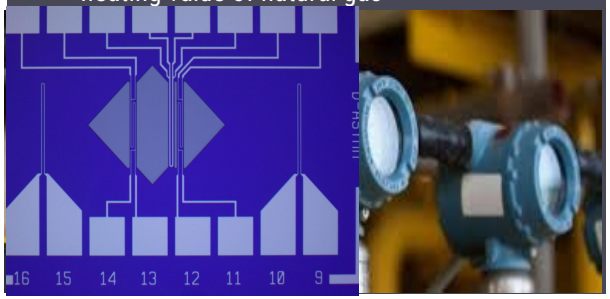
FONDAZIONE BRUNO KESSLER | SENSORS AND DEVICES | MST MICROSYSTEMS TECHNOLOGY

MEMS Technology

Flow sensors for Gas Energy metering

Objectives

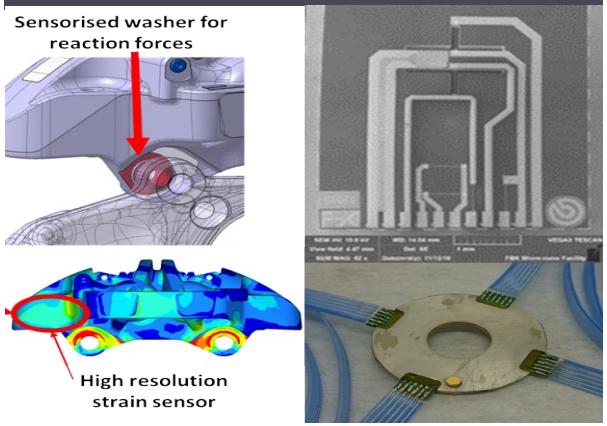
- Measurement of gas quality at the point of delivery, also in the perspective use of hydrocarbons / hydrogen mixtures for residential or industrial use.
- A multisensor MEMS device and an artificial intelligence approach to measure the higher heating value of natural gas



Stress Sensors for the automotive sector

Objective

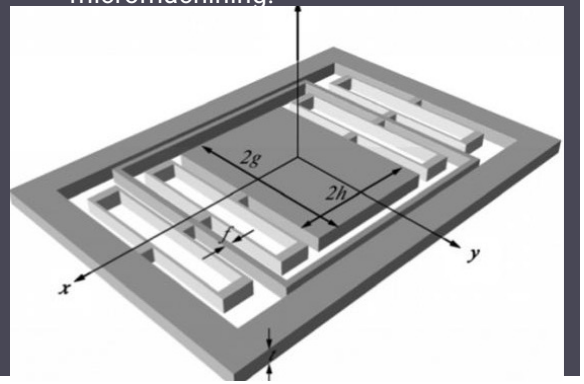
To study MEMS sensors for direct measurement of braking torque.



Nano-g accelerometer for Space satellite (MST/MNF)

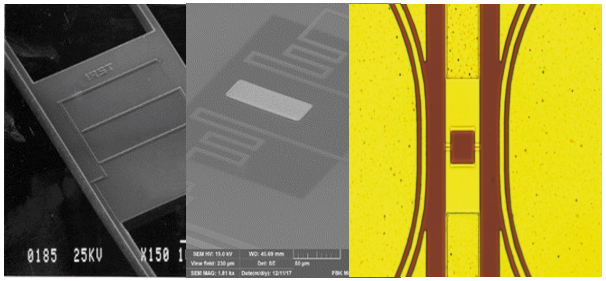
Objectives

- The accelerometer will be based on an inertial sensor on silicon "capacitive comb" with transversal movement, realized through a process of bulk micromachining.

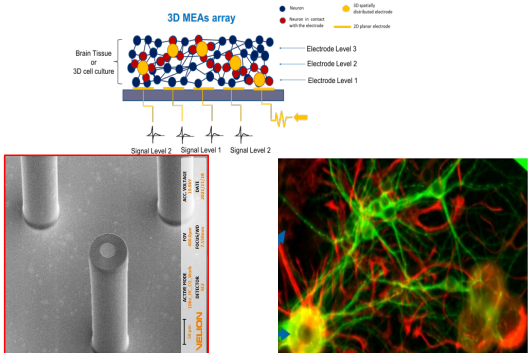


Technologies for Quantum Devices

Superconducting devices such as SQUIDs, Josephson Junctions, Josephson Parametric amplifiers

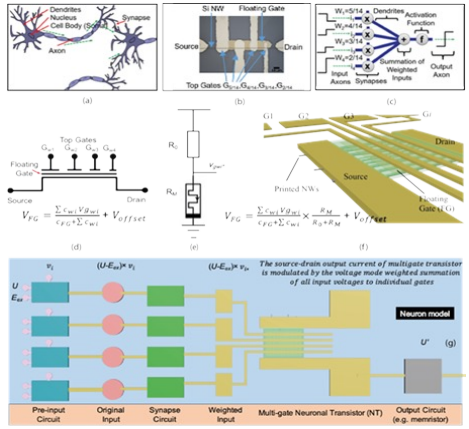


Brain Organoids - On Chip

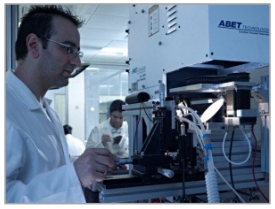


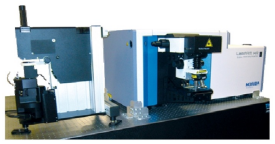
Brain Inspired Devices

Adaptive Memories for AI



Micro and Nano fabrication Facility
IPCEI1: 1200m^2 moving to >2000m^2 semiconductor ISO4-6 cleanrooms





6” Microfabrication Area

Clean Room Detectors

700 m^2; Class 10/100 0,8 um CMOS pilot line: Ion Implantation, Oxidation, Diffusion, RIE, Deep RIE (silicon and oxide), Lithography (stepper 0.35 um and mask aligner), metal sputtering, optical profilometry

Clean Room MEMS

500 m^2 Class 100/1000 diffusion, lithography (mask aligner), wafer bonding, electroplating, Si bulk micromachining, metal evaporation, RIE, mechanical and optical profilometry,

Testing Area

300 m^2 manual parametric testing, automatic parametric/functional testing, optical testing (spectral responsivity, quantum efficiency), solar cells efficiency characterization, gas and pressure sensors test benches

Integration Area

100 m^2 clean room Class 1000 Microassembly station; screen printing, bonding (ball & wedge bonder), Shear-Pull Tester, reflow oven, CNC micro-mill, pick and place

Nano- and Micro- Analytical Facility

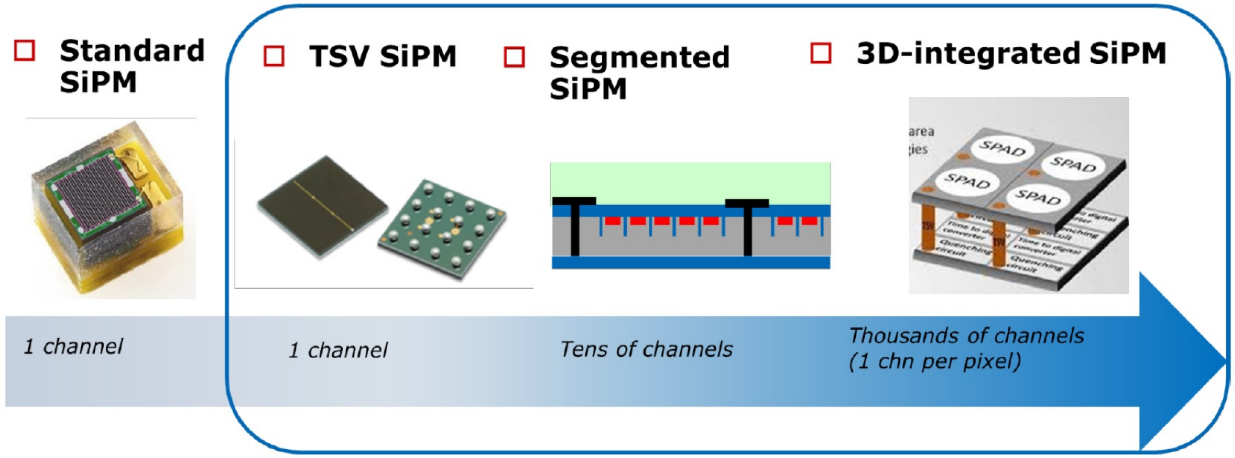
Nano Ramen, FIB-SEM-EDX-EBSD, D-SIMS, TOF-SIMS, XPS, AFS, XRD/XRF

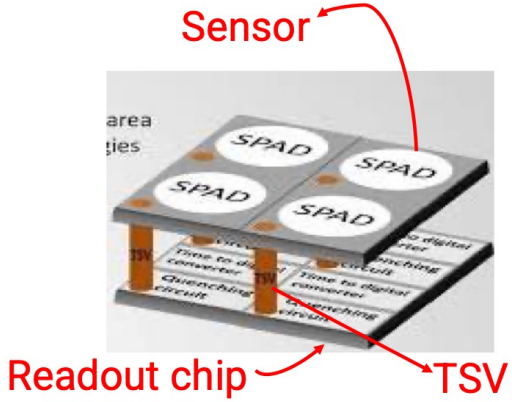
IPCEI ME 1: improve European competitivity in microelectronics
Improve production of devices in Europe

IPCEI: Key strategic instrument with regard to the implementation of the European Union Industrial Strategy
IPCEI ME (Microelectronics) 1: 32 companies and RTOs from FR/DE/IT/AU on 43 sub-projects
Ecosystem: Up to 425 indirect partners involved
5 technology fields: energy efficient chips, power semiconductors, *sensors*, advanced optical equipment and compound materials

IPCEI ME1 for FBK:

- Ongoing 2021-2024
- Equipment, people, research effort to achieve this
- Technical target: towards 3D integration with through silicon vias (sensor + readout chip).





IPCEI ME/CNT: improve European competitivity in microelectronics
Improve production of devices in Europe

IPCEI ME continuation - *if approved* - expected to be:

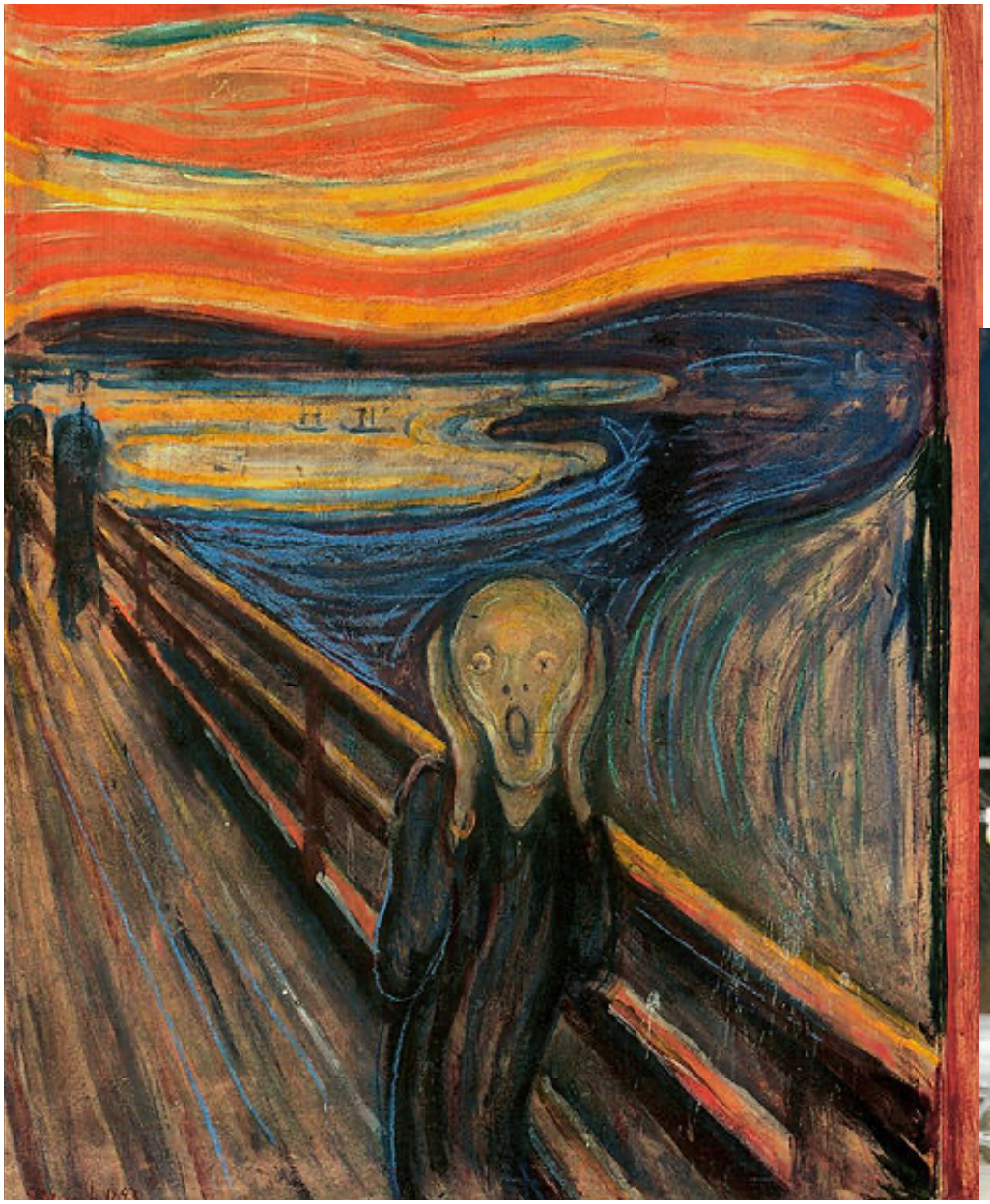
- 20 States
- More than 100 members
- Coordination

- Future connection with the CHIPS ACT?

- Achieving sustainability by updating equipment, expertise, techniques, research and investing in personnel
- *Sustainability by strengthening the ecosystem*

IPCEI ME/CNT for FBK:

- 3D integration -> heterointegration
- SiC & Ge on Si – with attention to space, QT, environment, automotive sectors



Crisis or opportunity … ?


IPCEI
on Microelectronics
Summary
Trento, Italy
• Semiconductor ecosystem is integrated, global, complex, and affects everything in modern life
• Strengthening and building on the existing ecosystem has many key aspects: ideation, research, capacity (big and small), training, …
• Sensors & Devices centre at FBK as example of a part of this ecosystem in the niche of sensors and devices
• IPCEI Microelectronics as an example of strengthening the roots of this ecosystem
• Longer term view on research and setting the parameters to address societal and manufacturing challenges
• Collaboration on nurturing complex ecosystems is something that Europe can do well …
• Nurture and build all parts of this ecosystem
• Less cyclical: Smooth out the peaks and troughs
• Skills, training, and personnel are a huge challenge: research institutes part of the answer
• Chips crisis or opportunity?
eit Manufacturing
CLC SOUTH
Co-funded by the
European Union