Advanced Micro and nano fabrication Capabilities at the IMB-CNM-CSIC Clean Room

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MICRO nano FABS Red Española de Salas Blancas de Micro y Nano Fabricación

www.imb-cnm.csic.es

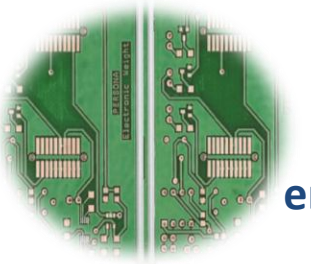
Cleanroom & ICTS facilities at IMB-CNM

Associated laboratories

Electrical characterization

Packaging

Printed electronics



Electronics systems

\+ Reverse engineering

Key figures

100-10,000	21±1ºC	45±5%	8:00-20:00
Class		Rel. Humidity	Open hours

Integrated cleanroom: 1500m²

Services: 3x600m²

Packaging: 40+35m²

IMB-CNM cleanroom capacities

KEY FIGURES												
>150	13	45	1130	315	13117	5289	2342	4582	106
Process tool	Process areas	Staff	Runs & Mini-runs	For third parties (28%)	Single steps	Processed wafers	External access	Hours	Individual users

IN 2024

Areas

Thermal processes and CVD
Ion implantation
PVD
Photolithography
Cleaning and wet etching
Dry etching (RIE)
Microsystems
Nano-fabrication
On-line characterization
Electrical characterization
Packaging
Reverse engineering
Printed electronics

CMOS Not-CMOS	150 mm 100 mm	Self-service Per assignment
Compatible processes	Wafer & dies	Work orders

Deposition and more

Thermal process and CVD

- Oxidation, annealing y RTP
  - 8 tubes + 3 RTP
- B and P diffusion (doping)
- LPCVD
  - 5 tubes: polySi & a-Si, Si_3N_4, SiO_2
- PECVD
  - 3 tools: Si_3N_4, SiO_2, BSG
- ALD
  - 2 reactors: Al_2O_3, HfO_2, TiO_2, SiO_2
- Pyrolysis chamber: parylene

PVD

- 5 sputtering tools
  - Al, Al/Cu, Ti, W, Si, AlN, TiN, Si3N4, SiO2, Ta, TaSi2, Ni, Au
- 2 evaporation tools (E-beam, Joule)
  - Ag, Al, Al2O3, Au, B, C, Cr, Cu, Fe, ITO, Mo, Nb, Ni, Pd, Pt, Sn, Ta, Ti, W, ZnO, Zr…

Ion implantation

- 1 ion implanter
  - B, P, As, N, Ar, Al, Si, Mg, O, He…

& more (micro-systems)

- Electroplating & electroless
  - Materials: Ni, Cu, Au…
- Anodic & thermal bonding

Cleaning and etching

Cleaning

- 7 wet benches:
  - Piranha, HF, RCA…
- 1 spray etcher
- 2 resist ashers
- Rinsers & dryers

Wet etching

- 16 wet benches:
  - Si, SiO2, Si3N4, AlN, HfO2, Al, Ti, Ni, Cr, W, Au, …
  - Anisotropic etching of Si
- Bulk & surface micro-machining
- Critical point dryer

Lift-off

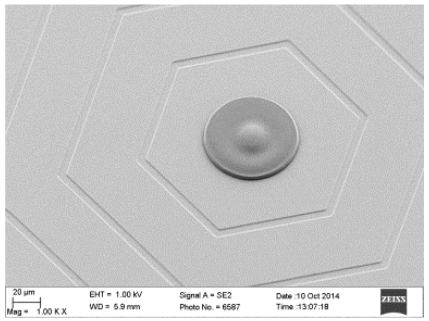
Dry etching

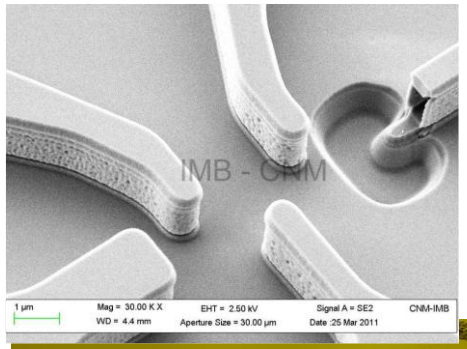
- 8 RIE tools:
  - Chemistry: F, Cl, Bosch process…
  - Materials: Si, polySi, SiO2, Si3N4, Al, ...

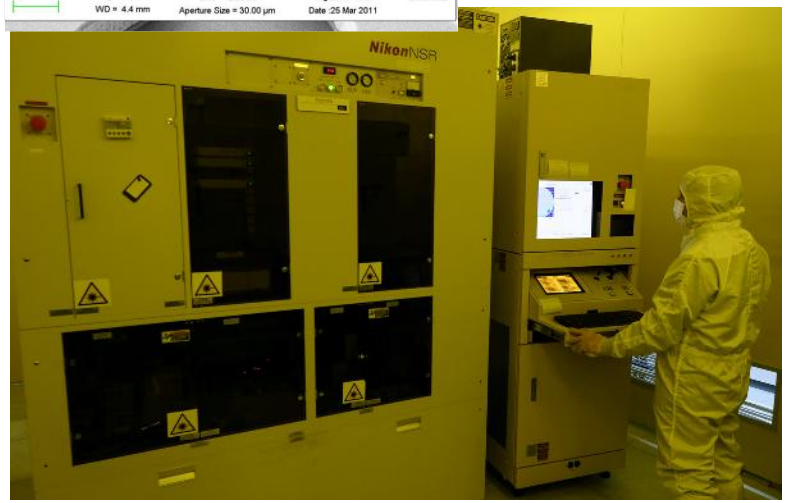
Lithography

Photolithography

- 3 mask aligners
  - Contact and double-side mask aligners
- 1 (maskless) direct write laser
- 1 automatic coater-developer tool
  - Resolution > 1,5µm





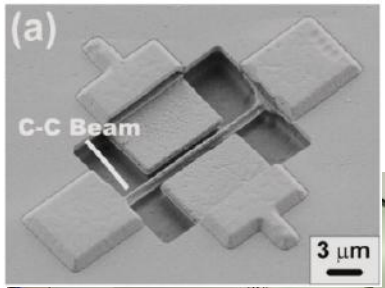


Stepper

- 1 i-line stepper
  - Resolution ~ 0,5µm

Nanolithography

- 1 Electron-beam lithography tool
  - Resolution < 50nm
- Block copolymers technology
- Nanopatterning by AFM



Characterization and Packaging

Characterization

In-line characterization

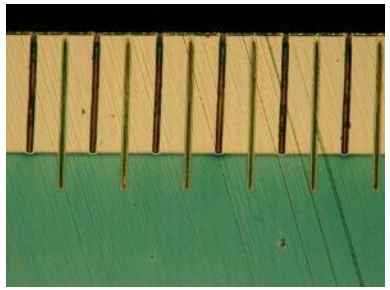
Optical microscopy
Scanning Electron Microscopy
Confocal microscopy
Interferometry
Ellipsometry
FTIR
Raman
Sheet resistance
Wafer thickness & bow
Lifetime measurement
Profilemeter
Atomic Force Microscope

Semiconductor characterization

I(V), C(V), …

Post-process analysis

Reverse engineering, FIB

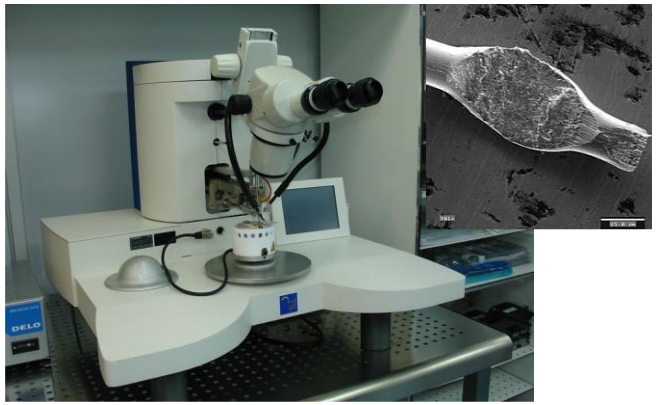


+ Laboratories of IMB-CNM research groups

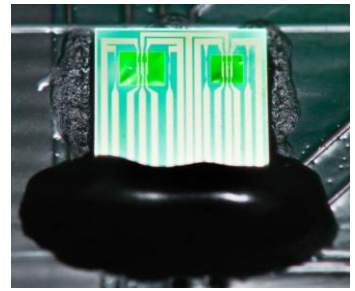
Packaging

From dicing, die attach, wire bonding, to final encapsulation

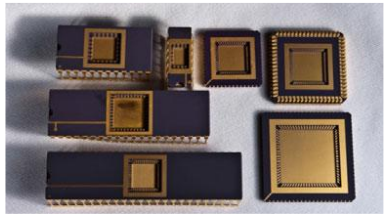
3 dicing saws & several ancillary tools

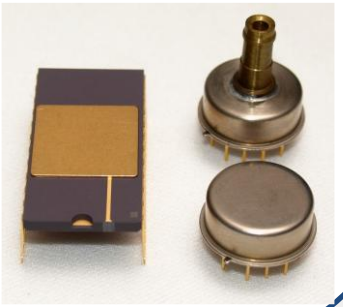


7 bonders & Test



Cleaving





Main Technologies

CMOS-compatible technologies	▪ CMOS
	▪ Radiation sensors
	▪ Power devices
	▪ ISFETs
	▪ Memristors
	▪ Integrated photonics
	▪ Semiconductor quantum devices
MEMS technologies	▪ Micro-fluidics
	▪ Gas sensors
	▪ Harvesters
	▪ Micro/nano mechanics
	▪ Graphene-based materials on thin films
2D functional materials	
Printed electronics	

ISO 9001

Organization: IMB-CNM, D+T & SBCNM

Scope: Design development and production of devices based on micro and nanoelectronics technologies

Validity: 28/04/2023 – 28/04/2026

IQNET

Building trust together.

Certificate

AENOR has issued an IQNET recognized certificate that the organization:

AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

INSTITUTO DE MICROELECTRÓNICA DE BARCELONA (IMB-CNM).
INSTITUTO DE MICROELECTRÓNICA DE BARCELONA (IMB-CNM). CL DELS TIL·LERS
CAMPUS UAB
08193 - BELLATERRA
(BARCELONA

has implemented and maintains a/an
Quality Management System

for the following scope:
Design development and production of devices based on micro and nanoelectronics technologies.

which fulfils the requirements of the following standard

ISO 9001:2015

Linked to the certificate ES-1026/2023

Registration Number: ES-1026/2023 - 001/00

First issued on: 2023-04-28 Validity date: 2026-04-28

Alex Stoichitoiu
President of IQNET

Rafael GARCIA MEIRO
CEO

AENOR

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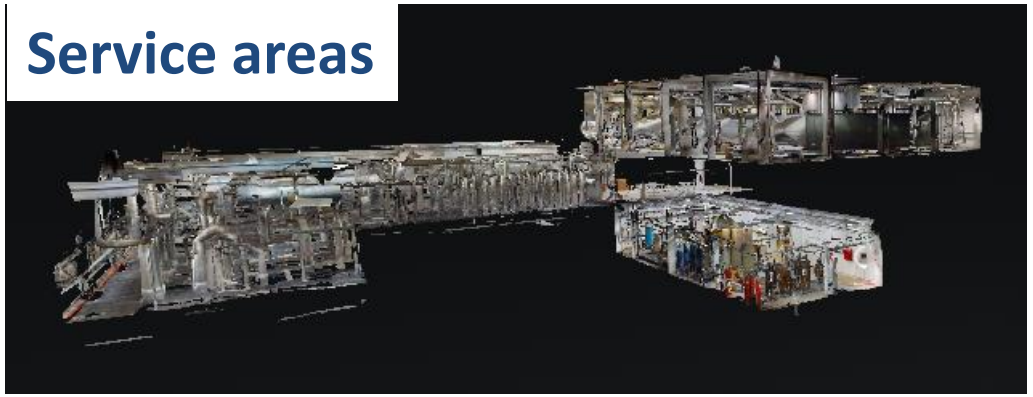
Virtual tour

Clean room

Service areas



Virtual tour of the clean room

Visit us!

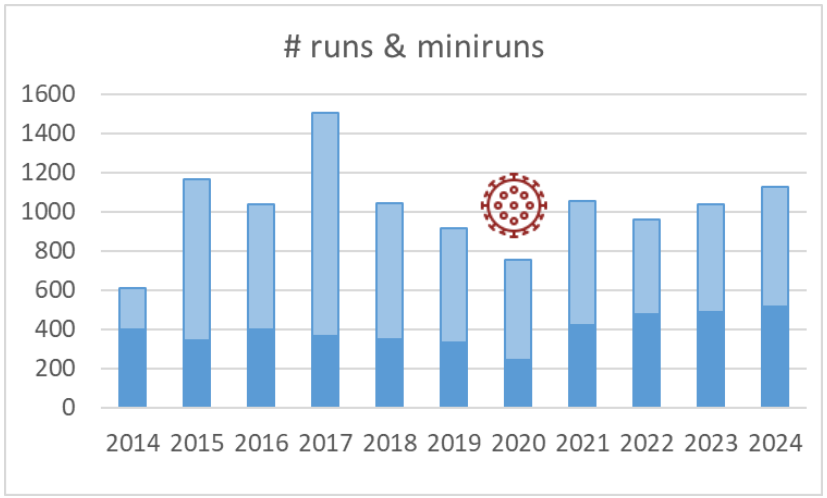
https://www.imb-cnm.csic.es/en/micro-and-nanofabrication-clean-room/clean-room-virtual-tour

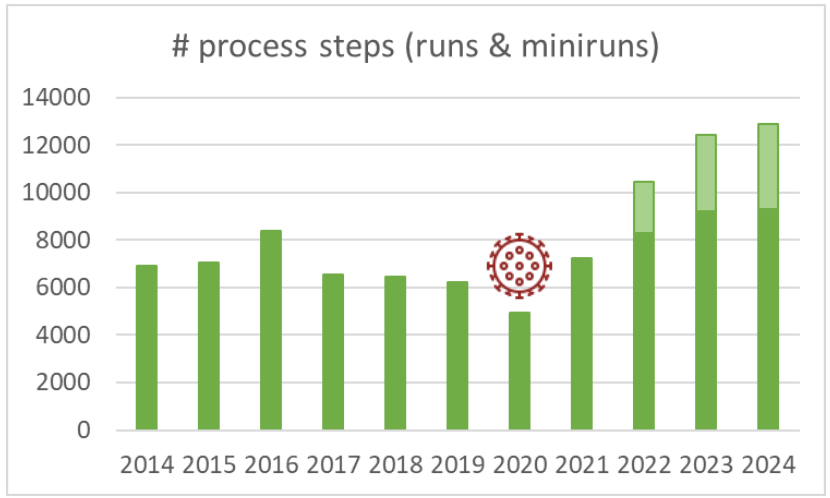
IMB-CNM cleanroom in numbers

KEY FIGURES

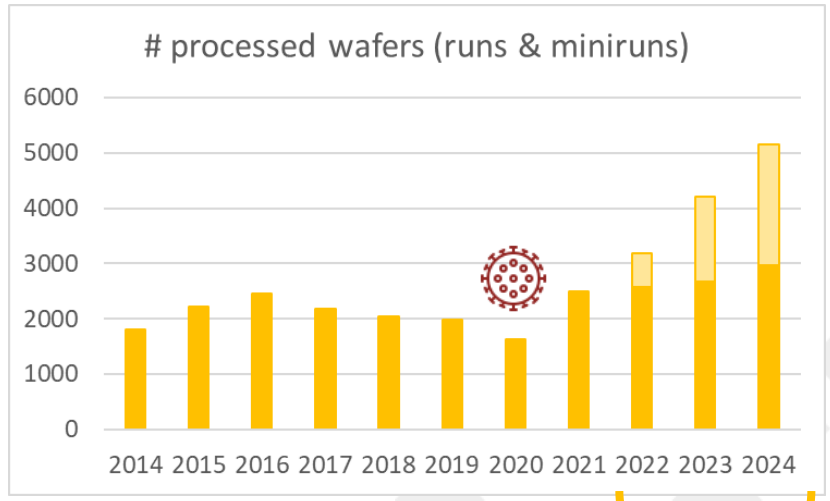
>150 Process tool	14 Process areas	44 Staff	1130 Runs & Mini-runs	315 For third parties (28%)	13117 Single steps	5289 Processed wafers	2342 External access	4582 Hours	101 Individual users

IN 2024





Runs & miniruns managed the same way



Runs & miniruns managed the same way

Runs in full colours – Miniruns in light colours

Investment plan in a nutshell

PERTE Chip. Microelectrónica y Semiconductores

ChipXXI
IMB-CNM, CSIC
19,5M€

General

Tools (~11M€)
Services (~7,5M€)
Staff (~1M€)

MICRONANOFABS
Strategic plan 2021-24
6,4M€

General

Tools (5,1M€)
Services (0,8M€)
Staff (0,5M€)

Deadline: 30/06/2026

QTEP - CSIC

QTEP
F. Perez-Murano
3,9M€

Quantum

EBL-HV
Nano area adaptation

Planned date of the works in Nano area: 08-12/2025

PIXEurope
C. Domínguez
~20M€

Photonics

DUV, track, CMP…

Advanced Packaging & Heterogeneous Integration
E. Ramon & M. Ullán
1,3M€ for project
1,0M€ for tools

PERTE: Proyectos Estratégicos para la Recuperación y Transformación Económica

Upcoming changes in the ICTS: Remodelling Nanolithography

Goals

- Setting up a high environmental control room for the **new EBL**
  - Stability in operating temperature: ±0.25ºC
  - Rate of change: <0.1ºC/h
- Upgrade of the nanolithography area (new wet benches…)
- Upgrade of the air conditioning system for Nano & Foto-MNC
  - Improvement in humidity control during summer
- Acquisition of new metrology EBL (40keV), new SEM

Dismantled tools

- Nanoimprint

Nanolithography area → **Quantum Nanofabrication Laboratory**

RAITH EBPG5150 Plus

- *Small chips up to 150mm wafer*
- *< 10nm overlay accuracy*
- *< 10nm stitching accuracy*
- *> 300nA max current (x 10 to 100 times faster)*
- *High level of automation*
- *Cassette loading solution for batch processing*

Upcoming changes in the ICTS: PERTE investment plan in a nutshell

PERTE Chip. Microelectrónica y Semiconductores

ChipXXI
IMB-CNM, CSIC
19,5M€

General

Tools (~11M€)
Services (~7,5M€)
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Advanced Packaging & Heterogeneous Integration (APECS)
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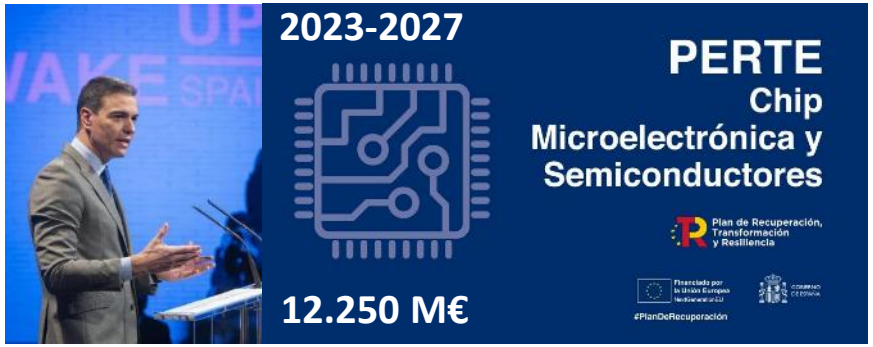
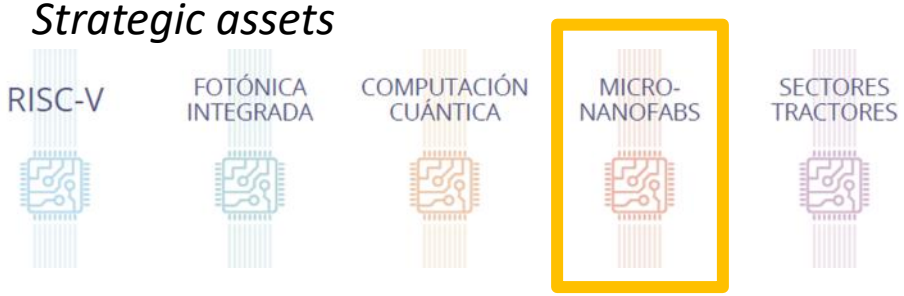
PERTE: Proyectos Estratégicos para la Recuperación y Transformación Económica

Upcoming changes in the ICTS: PERTE: a quick look backwards



Strategic assets



Abril 2022
PERTE Chip announcement
September 2022
First draft of ChipXXI project

October 2023
Revision of MICRONANOFABS Strategic Plan 2021-24 (100% funding by PERTE Chip)

December 2023
Approval of the revision of the MICRONANOFABS Strategic Plan and first investment part
Conceptual design of cleanroom extension

August 2024
Approval of the second investment part of MICRONANOFABS Strategic Plan
September 2024
ChipXXI scientific report

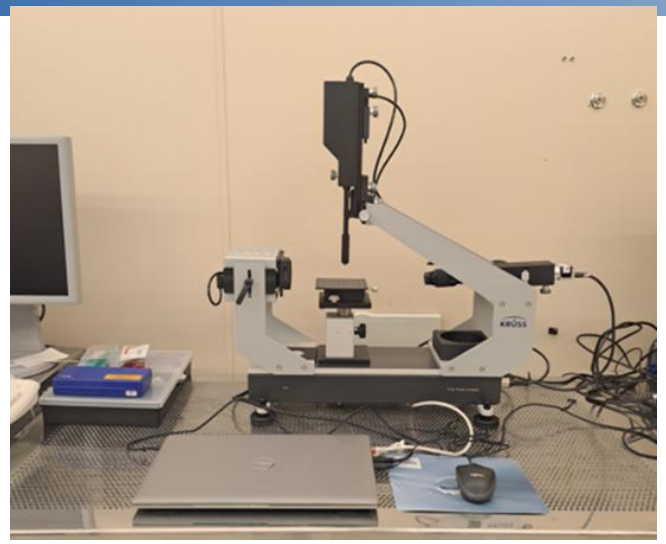
February 2025
Application to SINGULARS call (Generalitat) for the cleanroom extension
May 2025
Possibility to contract staff with ChipXXI

30/06/2026
All actions must be implemented

Upcoming changes in the ICTS: Process equipment

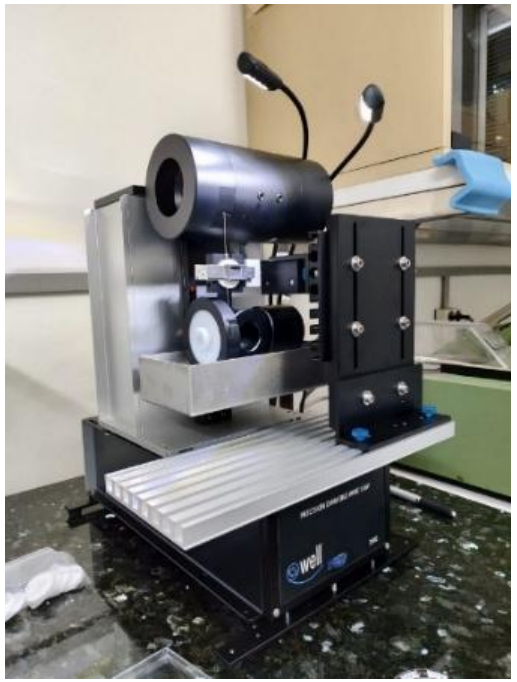
Investments implemented up to now

	Description
MICRONANOFABS Strategic Plan	Sentech RIE upgrade
	Oxford PECVD upgrade
	Corial PECVD upgrade
	Contact angle tool
	AS-Master RTA upgrade
ChipXXI	Auriga SEM upgrade
	SIAM upgrade
	Optical microscope
	Precision dicing machine
	Bonding tool



Contact angle tool

Bonding tool



Precision dicing machine

Upcoming changes in the ICTS

Actions:

- **Stepper Nikon g7** dismantled
- **Eaton implanter** and **Plasmos bonder** dismantled
- AFM and spinner for block copolymer installed during works in nano area
- Installation of **Ion-Milling Tool** in place of “contaminated” inspection area
- Move the **Not-CMOS inspection area** to the location of MRC sputtering
- New chemical benches for Microsystem and not-CMOS wet etching
- Dismantle the **Jipelec** furnace. Substitution by new **Zenit furnace.**
- New **laser annealing tool**
- Old tools removed (**CMP** and **scrubber**)
- Installation of **Electrospinning** and **Parylene** tools
- Upgrade of the **ultra-pure water plant**
- Upgrade **chillers** and Clean Room **Air Conditioning System**

Upcoming changes in the ICTS: Process equipment

Summary of process equipment to come…

MICRONANOFABS Strategic Plan

Description	Area
Sputter joker	Metallization
Sputtering tool for Al metallization	Metallization
CMOS contamination control	Inspection
BPTEOS PECVD tool	Thermal processes
Laser annealing system	Thermal processes
RTA tool for SiC annealing	Thermal processes
Multipurpose bonder	Packaging
Electrospinning tool	Research group
Ion-milling system	Dry etching

ChipXXI

Description	Area
Scanning electron microscope	Nano
Confocal microscope	Microsystems
E-beam lithography	Nano
Stepper tool	Photolithography
Wet benches	Microsystems
Critical point dryer	Microsystems
Laser micromachining system	Reverse engineering
Wafer dicing machine	Packaging

Upcoming changes in the ICTS: Infrastructure: photovoltaic plant

Installation of a photovoltaic plant on Clean Room and main building roof

Schedule still to be defined…

Upcoming changes in the ICTS: PERTE: a quick look forward

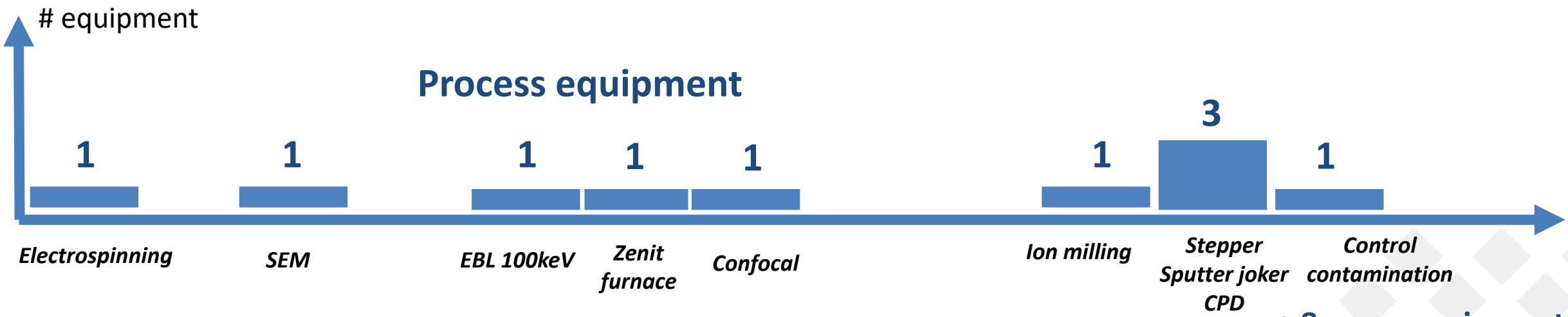
Best guess

Infrastructure

Works in Nanolithography area

Cleanroom shutdown for chiller replacement (4 months)

2025 **2026**

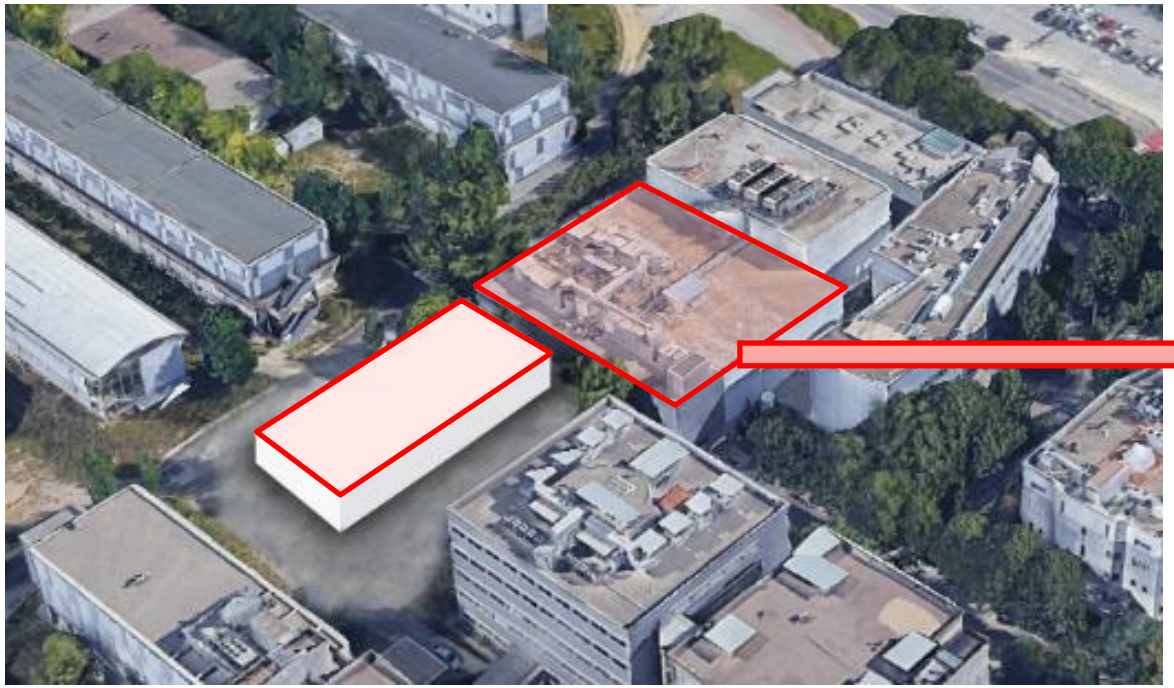


+ 8 more equipment…

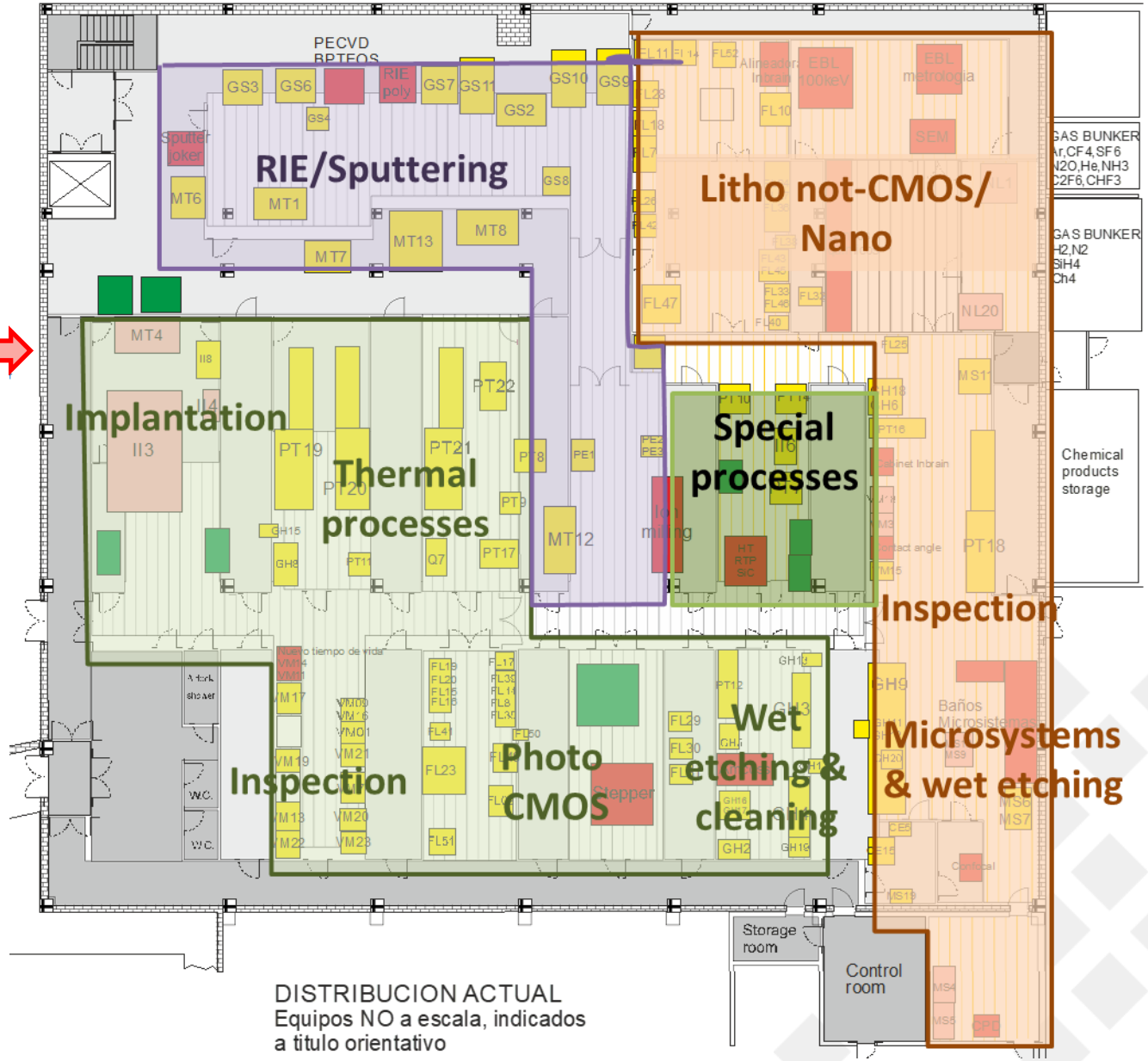
- **Improved capabilities**
- **New processes**
- **Better devices**

- **Service interruptions during >2 years**
- **New process parameters to develop**

Upcoming changes in the ICTS: Cleanroom extension



New building



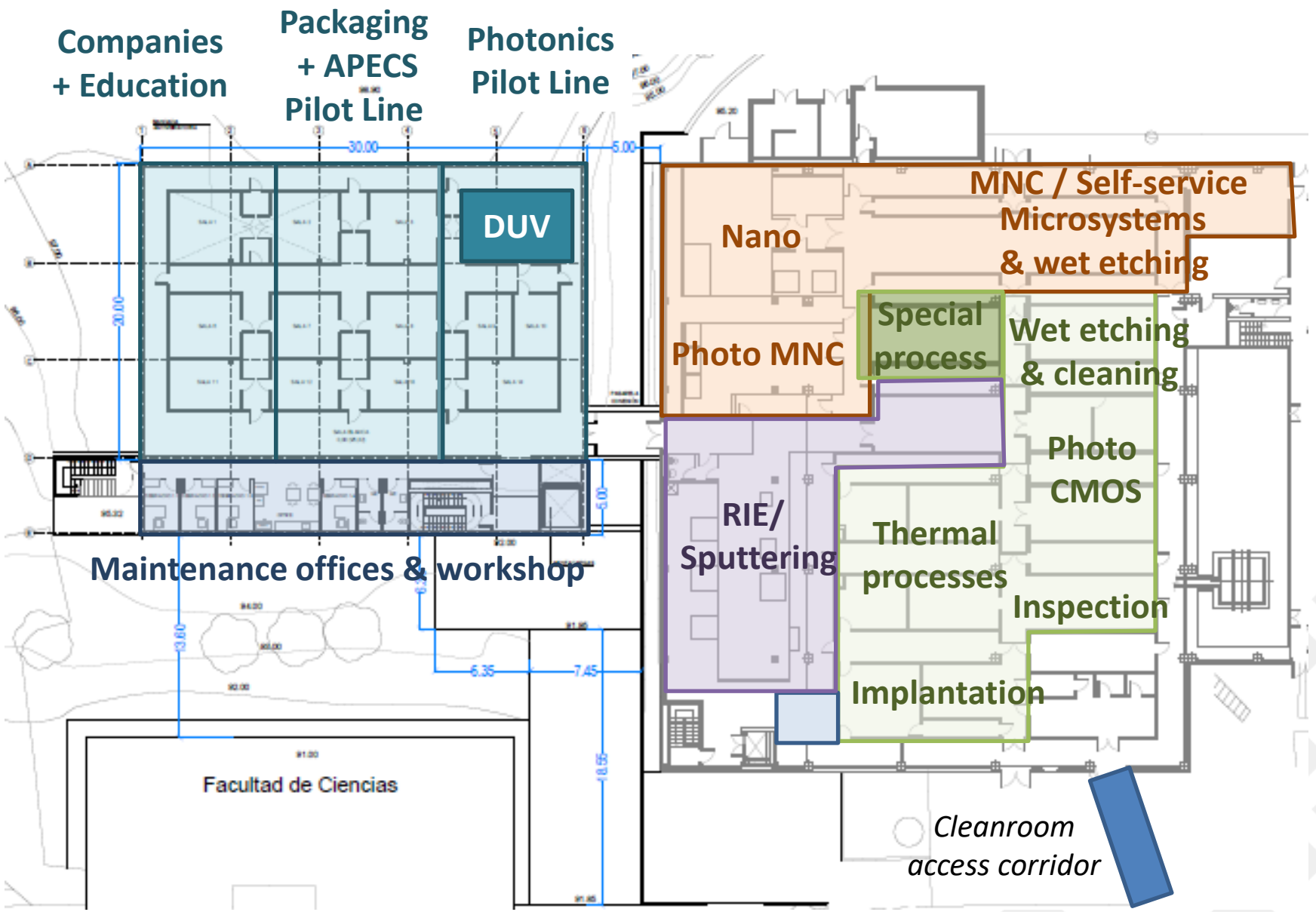
Upcoming changes in the ICTS: Cleanroom extension

Goals:

- Packaging
- Pilot lines
- Companies
- Training

Timeline:

- DUV expected for summer 2027
- Cleanroom extension?



MICRONANOFABS Strategic Plan 2025-2028

- **Submitted February 2025**

- **Main goals:**
  - Support new start-ups for ramping up in production
  - Collaboration with other ICTS and ESFRI
  - Agreement with national initiatives to strengthen the ecosystem
  - Benchmarking and contacts to our potential user community
  - Training to new labour forces
  - Actions towards more environment-sustainable cleanroom
  - Actions towards economic sustainability

MICRONANOFABS

ICTS Distribuida: Red de Salas Blancas Integradas de Micro y Nano Fabricación

Distributed ICTS: Network of Integrated Clean Rooms for Micro & Nano Fabrication

DOCUMENT 3

STRATEGIC PLAN 2025-2028

MICRO nano FABS

Project 1: Advanced Micro- & Nano-fabrication Systems

Investment/Tool	Description	Priority
MOCVD tool	Metalorganic Vapor Phase Epitaxy (MOCVD) for wide bandgap oxide semiconductors	High
RTP-CVD system	Rapid thermal deposition system by chemical vapor (RTP-CVD) for 2D-materials growth	High
RTA system	Rapid thermal annealing for wide bandgap technology	High
Sputtering tool	Renewal of sputtering tool for non-CMOS processes	High
Optical lithography system	Direct Laser Writer Lithography tool	Medium
Wet etching system	Upgrade of wet etching capacity for CMOS processes	Medium
High resolution mask printer	Printer for micrometric resolution lithography masks	Medium
Resist stripping upgrade	New chamber for resist ashing tool	Low
Dry etch tool	Renewal of dry etching capabilities for CMOS technology layers	Low
Evaporation tool	Evaporation tool for CMOS processes	Low

Project 2: Integration & Packaging Excellence

Investment/Tool	Description	Priority
Milling machine	PCB milling machine for electronic system integration	High
Dicing tool	Upgrade of dicing capabilities	Low
Pick and place tool	Pick and place tool for electronic system integration	Low
Die bonding tool	Semi-automatic equipment for die bonding and dispensing of adhesives in the die-attach process	Low

Project 3: Cutting-Edge Characterization Frontiers

Investment/Tool	Description	Priority
SEM	Renewal of Scanning electron microscope (SEM)	Medium
Probe station	Probe station for electrical characterization	Low

Project 4: Infrastructure for Tomorrow's Research

Investment/Tool	Description	Priority
Abatement system upgrade	Scrubber system for fluorine and chlorine-based gases	High
Services adaptation	Services supply and adaptation for new tools	High
Airlock	Airlock for introduction of new equipment in the clean room	Medium
Water plant upgrade	Upgrade of ultra-pure water plant for water recycling	Low

Innofab

New chip prototype factory in Catalonia

- Located next to Alba and UAB
- 2,000 m2 Clean Room
- 200 mm wafers
- Open to external companies
- Funded by Next Generation European Funds, Spanish Gov. & Generalitat
- Investment 392 M€. Approved 3.5 M€ for the engineering project.
- Coordinator: **ICN2**
- Participants: ALBA Synchrotron, IMB-CNM (CSIC), UAB, BSC, ICFO & Investment agency Barcelona&Partners
- Expected operation in 2028-2030

Objectives

- Clean room infrastructure of the latest generation and advanced characteristics
- Wide group of industrial members.
- New generation of microelectronics enabled by advanced materials.
- Solid education and training program
- Sustainable operations model

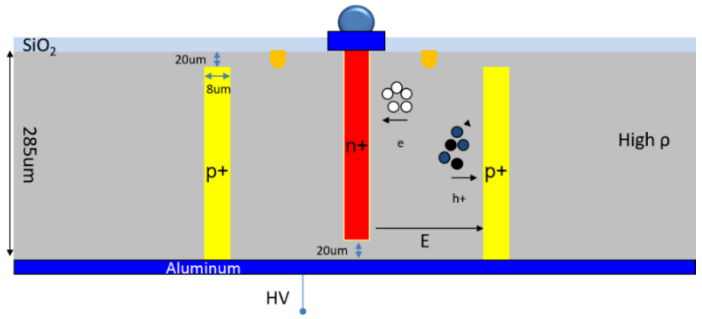
Actions

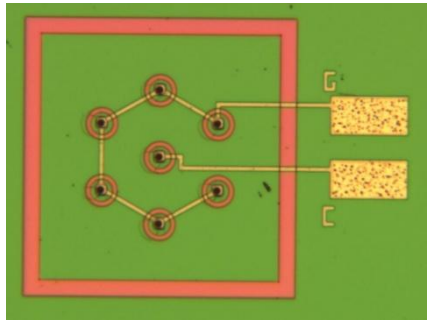
- Attract external companies to subcontract space and equipment
- Port IMB-CNM technologies to 200mm

Current Particle Detector development

3D timing for future tracking. Atlas and CMS timing layers :

- 3D Technology stabilization (100mm → 150mm)
- Devices for extremely harsh environments (>2×10^{15} n/cm^2) :
  - Silicon 3D timing devices
  - Future timing layers based on 3D technology



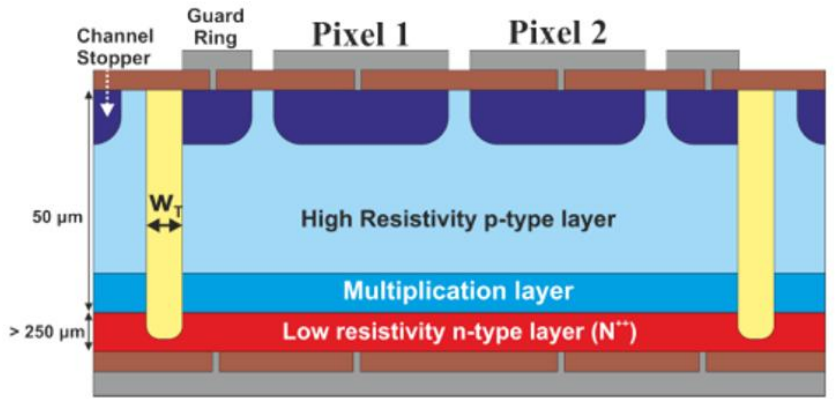


SiC detectors for Particle Physics and Nuclear Physics (IEM-CSIC):

- Devices for extremely harsh environments:
  - Silicon Carbide (SiC) based devices
- SiC diodes for X-ray detection and Beam monitoring

LGAD timing for timing and tracking applications :

- Inverse LGADs and Trenched iLGADs → 100% fill factor while maintaining precise tracking and timing information
- Deep Junction LGADs
  - More radiation hard (<2×1015 n/cm2)
- Technology Stabilization, increasing yield in 150mm wafers and large sensors
- N-type LGAD development for DUV and soft X-ray detection



imasenic

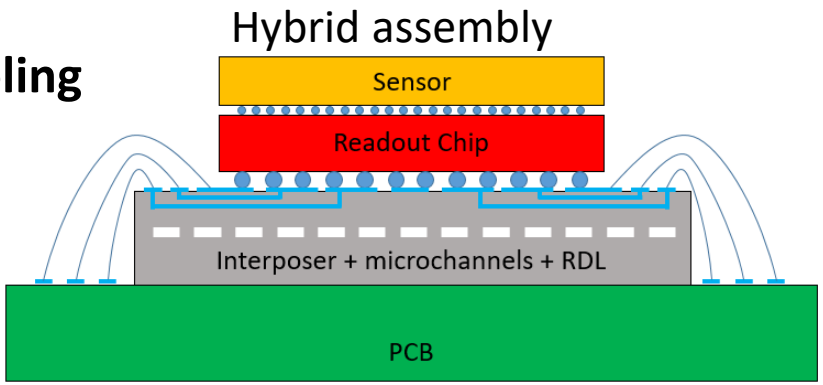
CMOS imaging sensor simulation (Imasenic and DRD3):

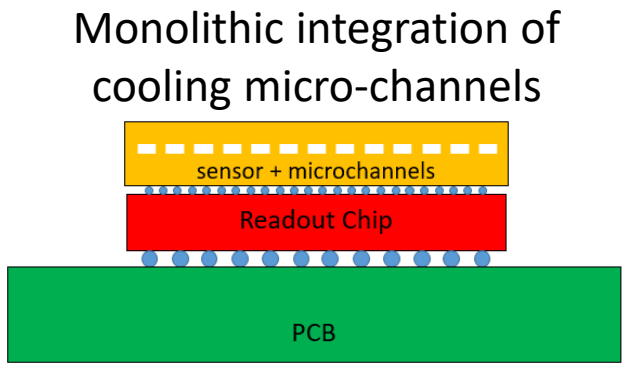
- Development of a simulation framework for the production of HV-CMOS detectors

Advanced Packaging and Heterogeneous Integration for Electronic Components and Systems

WP5 - Technology cooperation // T5.5 Collaborative projects with CSIC. Leader: CSIC. FMD-OFC, IZM

Task 5.5.1: Microchannel cooling





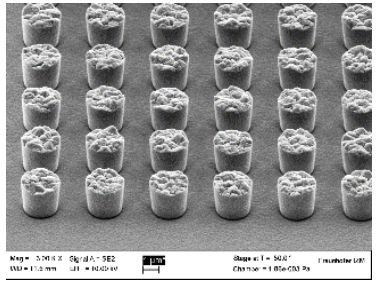
Miguel Ullán (IMB-CNM, CSIC)

- **Integration of embedded microchannels with RDL in silicon interposers**
- **Cooling microchannel fabrication in sensors or ASICs**
- **Qualification of cooling concept**

- **ASIC thermo-test chip fabrication**
- **IO pitch reduction for hybrid assemblies**
- **Heterogeneous integration**

Focus IZM: IO pitch reduction for hybrid assemblies

Sub-10µ-pitch



4µm pitch Au pillars

➡ **Services offered for (future) pilot-line customers:**

- Microchannel cooling for HPC and RF – Application
- Hybrid Assembly Technologies for HPC – Application

Centro Nacional de Microelectrónica IMB

CSIC
Consejo Superior de Investigaciones Científicas

Thanks for your attention

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