IMB-CNM R&D in the framework of InCAEM project

Presenter:
Dr. Gemma Rius - **On behalf of several groups of the IMB**

Institut de Microelectrònica de Barcelona
Campus UAB, Bellaterra

Centro Nacional de Microelectrónica IMB

IMB-CNM in a Nutshell

Centro Nacional de Microelectrónica IMB

The **Institute of Microelectronics of Barcelona (IMB-CNM)** is the largest institute in Spain dedicated to the research and development of Micro and Nano Technology (MNTs) and Microsystems, based on the unique capacities of silicon technology.
It belongs to the **Spanish National Research Council (CSIC)** since its foundation in 1985.

KEY FIGURES

- *184 people (35% women)*
- *Average of 8 patents per year*
- *100 scientific articles published in SCI journals per year*
- *14 spin-off companies created*
- *11,1 M Euros of budget (50% of competitive projects and contracts, 60% of them international)*

- **Our mission is to improve the knowledge in micro and nanosystems and to contribute to solve societal challenges through the implementation of solutions based in these technologies in new products.**

8 Research Groups

The research activities of the IMB-CNM are carried out by eight R&D groups, covering activities from ‘atoms to systems’.

- **MicroEnergy Sources and Sensor Integration Group (MESSI)**
- **Radiation Detectors Group (RDG)**
- **Power Devices and Systems Group (PDS)**
- Nanofabrication and Nanomechanical Systems Group (NANONEMS)
- Chemical Transducers Group (GTQ)
- Biomedical Applications Group (GAB)
- Micro and Nanotools Group (MNTL)
- Integrated Circuits and Systems Group (ICAS)

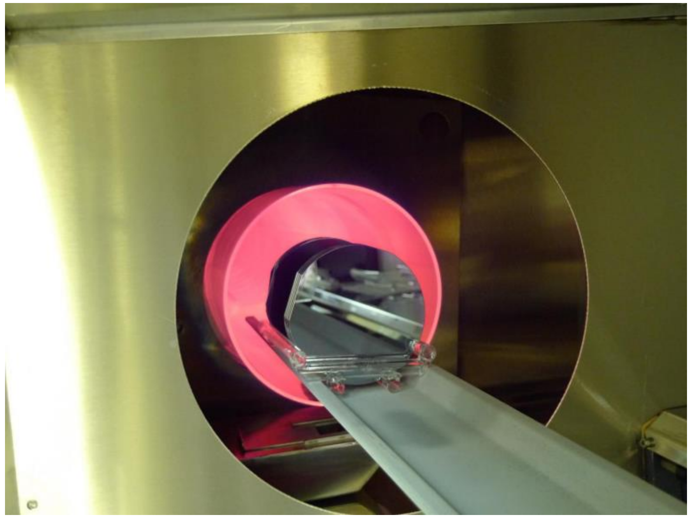
3 Thematic Axes

- Energy and Mobility
- Physics Frontiers and Civil Security
- Health and Environment

1 Transversal Unit

- Technologies and Advanced Processes for Micro and Nanosystems

ICTS – Integrated Micro and Nanofabrication Clean Room



KEY FIGURES

- *1500 m^2 facility*
- *190 processing equipment/instruments*
- *Average 2000 wafers/year*
- *5-7 ISO class (100-10,000)*
- *ICTS Staff - 40 pax*
- *External Access & Qualified Users*

In house Technologies Portfolio

CMOS-compatible technologies	▪ CMOS ▪ Radiation sensors ▪ Power devices ▪ ISFETs ▪ Memristors ▪ Photonics ▪ (Semiconductor) Quantum devices
MEMS technologies	▪ Micro-fluidics ▪ Gas sensors ▪ Harvesters ▪ Micro/nano mechanics
2D functional materials	
Paper / printed electronics	

EXAMPLE PROJECTS BRIEFINGS

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MESSI- NanoNEMS Collaboration

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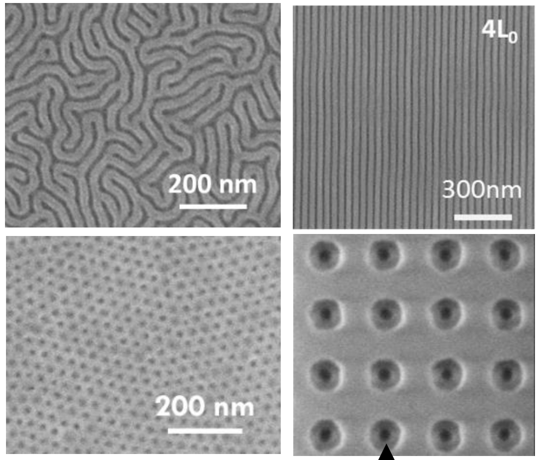
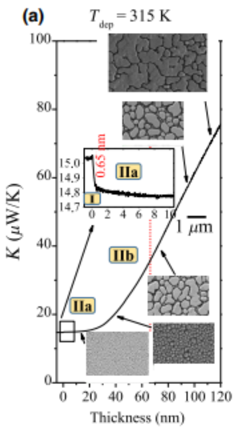
CSIC Consejo Superior de Investigaciones Científicas

Ultrathin films of crystalline Si periodic nanostructuring by BCP, thin films or decorated with metal nanostructures, as well as in operando studies of alternative methods for dopants diffusion in nano and thin film silicon or formation of silicides.

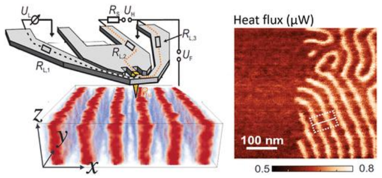
BCP - Nanofabrication



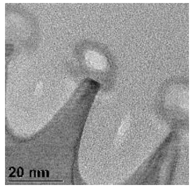
Metal decoration



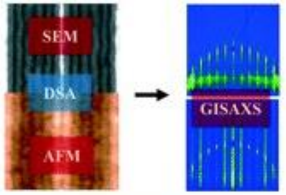
Advanced characterization



Scanning probe microscopy



TEM

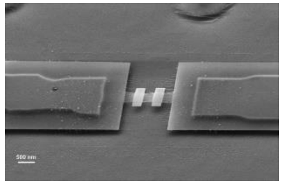


Synchrotron

Applications

Internet of things

Quantum computing



NEMS

Time line of the research line

2012 — ITRS: DSA alternative for advance fabrication nodes

2015

2018 — ASML: EUV high volumen manufacturing

2021

2023 — IRDS: DSA still for some applications

3 EU Projects
2 PhD Thesis
PLACYD

2 Nat projects, 1 MSC postdoc, 1 PhD Thesis
NANOINTEGRA STARSED

1 Nat and 1 EU Projects, 1 PhD thesis (ongoing)
NANODECOTEG QU-PILOT

Phys. Rev. Applied 12, 014007 (2019)
ACS Appl. Mater. Interfaces, 11, 3 (2019)
Mol. Syst. Des. Eng.,4, 175 (2019)
Nanomaterials 10 (1), 103 (2020)
J. Synchrotron Radiation 27 (5), 1278 (2020)
Polymers, 12, 2432 (2020)
ACS nano 15 (5), 9005 (2021)

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PI - Stella Vallejos (MESSI)

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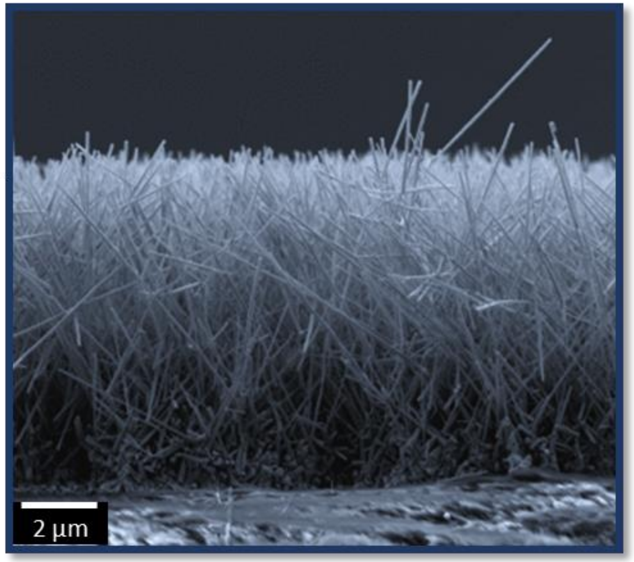
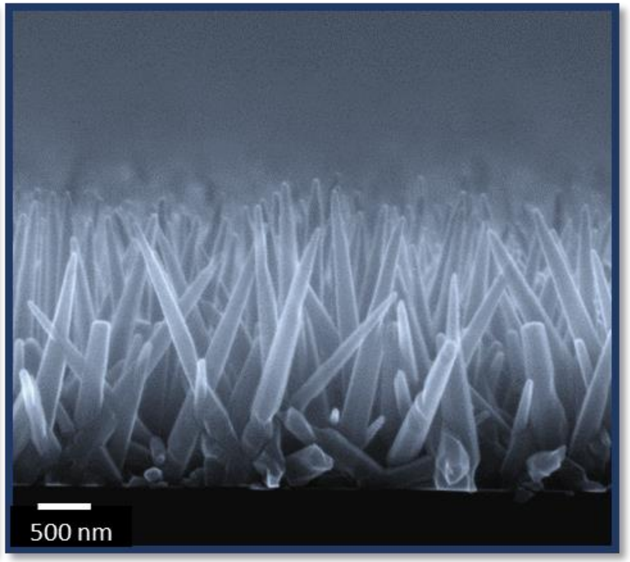
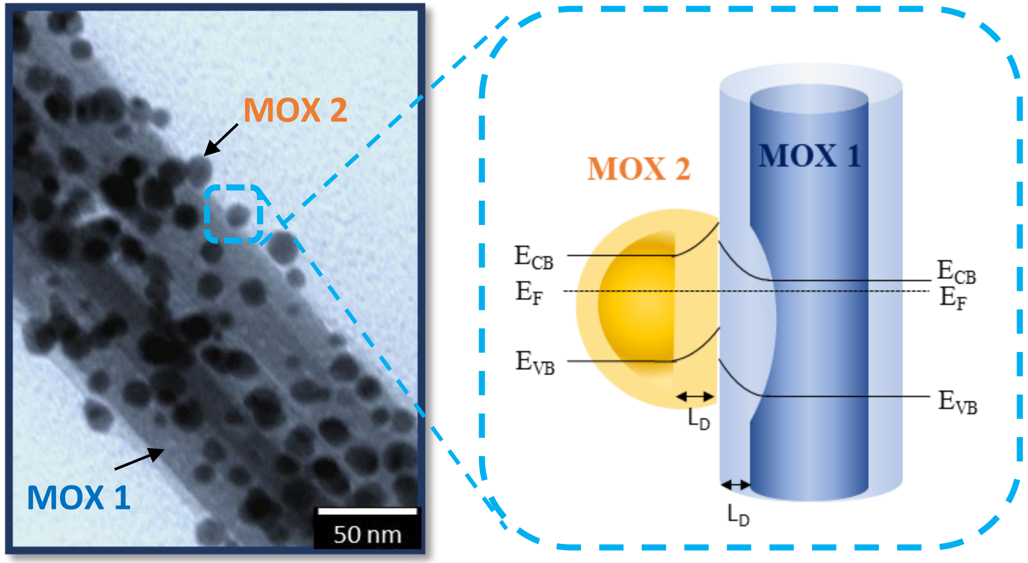
MOX structures (e.g., ZnO, WO_3, Fe_2O_3, SnO_2) grown via Aerosol Assisted CVD





Cross-sectional SEM imaging of columnar tungsten oxide (left) and zinc oxide (right) structures.

Surface modified MOX structures with metal (e.g., Au, Pt, Pd) or another MOX nanoparticles



HRTEM of a surface modified MOX structure (left) and schematic view of the nanoscale junctions formed at the surface (right).

<u>Needs that the InCAEM project could cover</u>

- In-situ and operando (structural, electronic) studies of the structures and nanoscale junctions in gas environment
- Studies of dopant diffusion in MOX structures
- Other complementary analysis in the ALBA beamlines for these type of materials

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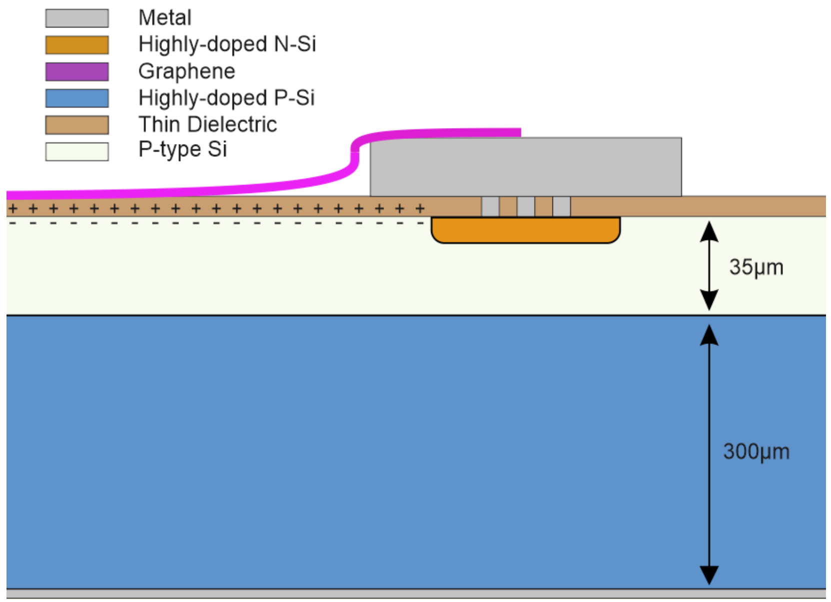
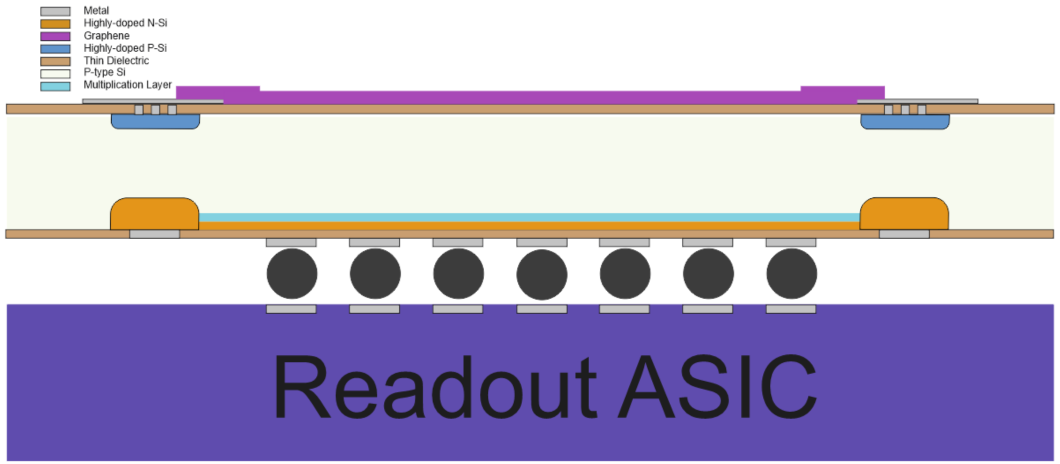
Graphene-on-Insulator (GIS) on a Silicon Radiation Detector



- Fabrication process to integrate GIS with a low gain avalanche detector (LGAD).
- Gain layer can increase signal by a factor of 10 – **sub-threshold** detection possible.
- Aim to detector X-rays with energy of **500eV**
- Uniform gain response as a function of position with AC coupled LGAD.

- Absorption layer (the 35um Si) and bulk Si (the 300um Si)
- **CVD Graphene isolated by etching and transferred on top of thin dielectric (3nm) in electrical contact with metal**
- An inversion layer is present at the interface of Oxide/Silicon
- **Dead region is defined by the HfO2 deposited by ALD**
- Process of ALD, wet etching, exfoliation and transfer
- High k allows for high quality thin dielectric
- Robust and scalable integration
- GIS design - https://pubs.acs.org/doi/10.1021/acsami.1c12050
- GIS design for DUV - 10.1109/NANO54668.2022.9928637



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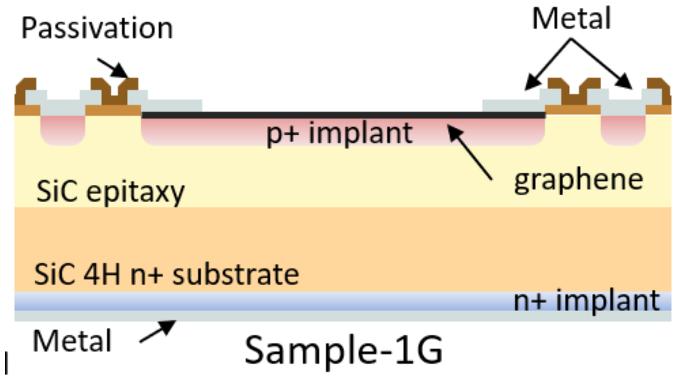
RDG - PDS Collaboration

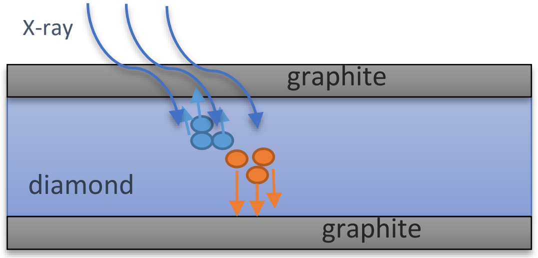
1. Epitaxial Graphene- SiC Radiation Detectors

- Graphene layer grown by epitaxy on Silicon Carbide diode, replacing metallic contact over active area, fabricated in the IMB-CNM clean room
  - More "transparent" to light, heavy ions, etc.

=> Ideal for radiation detection when metal is detrimental to signal



2. All-Carbon Diamond Dosimeters



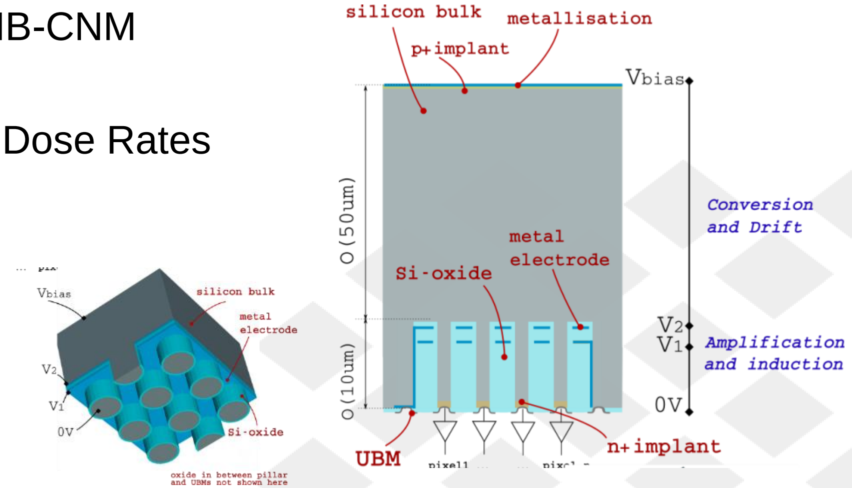
- Diamond is more radiation resistant than Silicon and other Wide Band Gap materials, and has a fast electron velocity in saturation, allowing for fast signals
- Graphite replacing metallic contacts enable a fully carbon-made detector, and thus more "tissue-equivalent"
- First prototypes fabricated with femto-second laser [2], at IMB-CNM we are trying to fabricate them using scalable processes

=> Ideal for radiotherapy dosimetry, in particular for Ultra High Dose Rates

3. Silicon Electron Multiplier

- Charge multiplication in silicon is typically achieved by a multiplication layer implantation, which degrades after radiation damage
  - Implement charge multiplication by high electric field in a pillar-like structure [3], being produced at IMB-CNM
- From simulations, good timing resolution (~20ps), multiplication holding after irradiation

=> Ideal for applications needing high time resolution



[1] Mat Science Forum, 1062, pp. 458-462 (2022)
[2] Diam and Rel Mat 133 109692 (2023)
[3] NIM A 1041 (2022), 167325

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Thank you for your attention

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