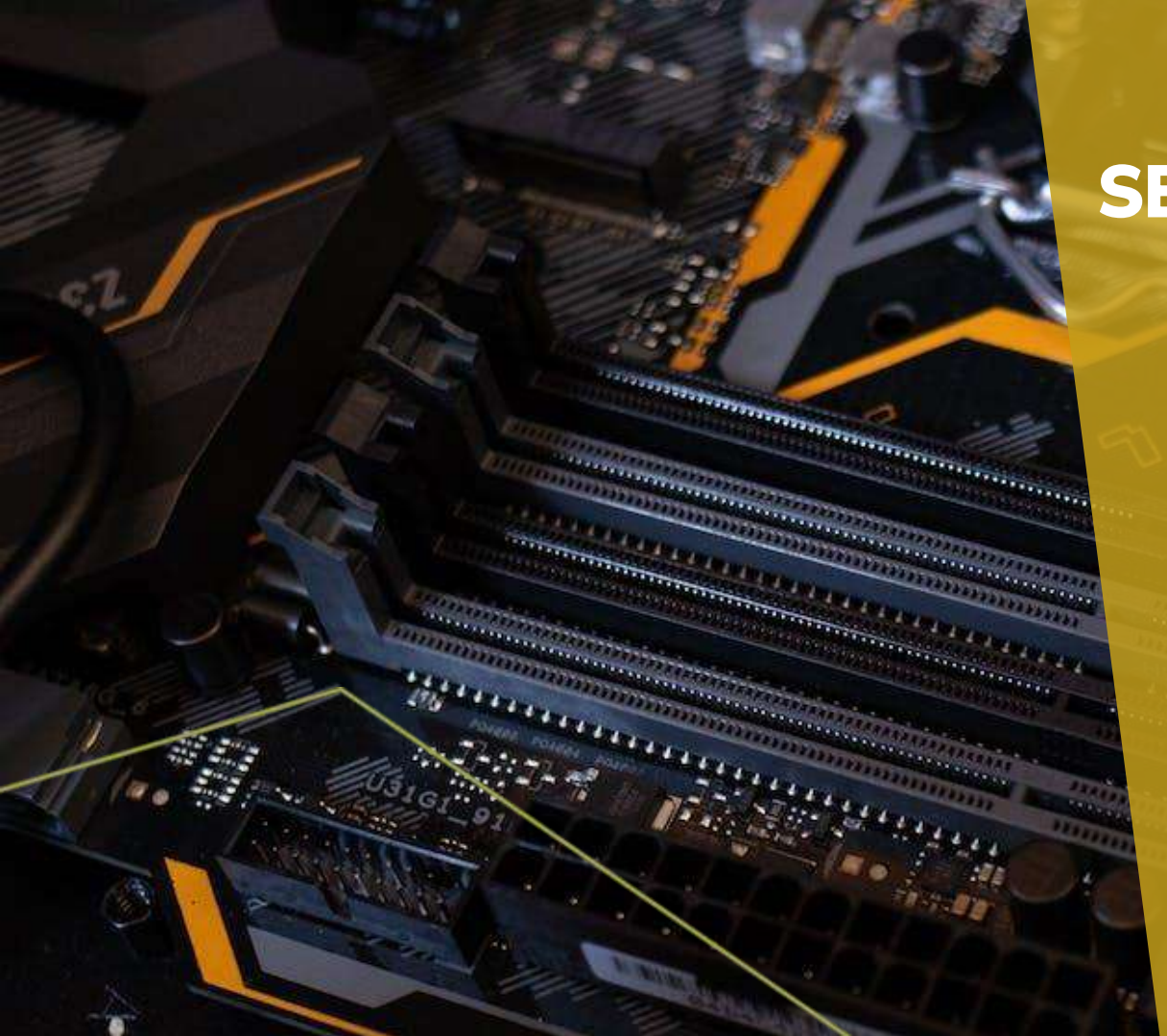


# R&D IN SEMICONDUCTORS AND CHIPS AT THE UPC

2023

Generalitat de Catalunya

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

CoFunded by the European Union

# CONTENT


01

## THE UPC

Get to know the Polytechnic University of Catalonia (UPC) and discover some of its indicators.

02

## SEMICONDUCTORS AND CHIPS

What is meant by semiconductors? And by chips?

03

## RESEARCH AND INNOVATION

Description of the research groups, centers and institutes that generate knowledge in the field of semiconductors and chips.

04

## UPC EXCELLENCE PROJECTS

Selection of R&D projects with the greatest impact on semiconductors and chips.

05

## EDUCATION

Degrees, masters, postgraduates and continuous training offered at the UPC and the UPC School in the field of semiconductors and chips.


UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# 01 THE UPC

The Universitat Politècnica de Catalunya (UPC) is a public institution of research and higher education in the fields of engineering, architecture, sciences and technology, and one of the leading technical universities in Europe.

The UPC participates in the innovation system of Catalonia with projects and contracts for research, development, valorization of knowledge and commercialization of technology.

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# RESEARCH, DEVELOPMENT AND INNOVATION ACTIVITY AT THE UPC IN 2022

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# 02

# SEMICONDUCTORS & CHIPS

Semiconductors are materials that have **electrical conductivity** between the **conductors** (such as metals) and **insulators** (such as plastics).

Semiconductors are formed mainly of materials such as silicon, germanium and gallium arsenide, which have a crystalline structure that allows the controlled movement of electrons.

By adding impurities to the material (which means, doping it), the electrical properties of the semiconductor can be controlled, allowing it to function as a conductor or an insulator as desired.

In electronics, a chip is composed of a semiconductor material cut from a larger wafer of material that is a few millimeters on a side.

Chips and conductors are essential components in electronic devices such as **transistors, diodes and integrated circuits**, and are used in a wide range of applications such as computing, telecommunications and power generation.

# AREAS OF APPLICATION OF SEMICONDUCTORS AND CHIPS

## COMPUTING AND INFORMATION TECHNOLOGIES

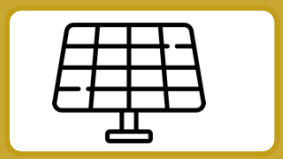
Semiconductors are used in microprocessors, memory chips, and other computer components.

They are critical components for the operation of computers, servers and other devices.

## TELECOMMUNICATION AND NETWORKS

They also have applications in communications systems, including wireless, fiber optic, and satellite communications.

These devices enable high-speed data transmission and efficient processing.



## ENERGY AND POWER

Integrated circuits are also key in power electronics, such as inverters and converters, critical for energy storage and conversion. They are also used in renewable energy systems such as solar panels and turbines.

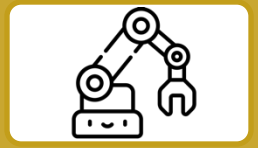
## TRANSPORT

They are essential for engine control units, anti-lock braking systems and safety systems. They are also used in avionics and aerospace systems.

# AREAS OF APPLICATION OF SEMICONDUCTORS AND CHIPS

## CONSUMER ELECTRONICS

We also find integrated circuits in consumer electronic products, including smartphones, televisions and video consoles. They are used to enable advanced features and to improve the performance of these devices.



## INDUSTRY

Chips and semiconductors are present in a wide range of industrial applications, such as process control, robotics and automation. They are also used in the manufacture of equipment and machinery.

## HEALTH TECH

The application of chips and semiconductors in medical devices, biomedical sensors, imaging devices, implants and electronic record systems has revolutionized the healthcare sector, enabling more accurate diagnoses, more effective treatments, as well as better management of medical information .

## Examples of activity I

**Design of specific domain architectures for computing systems energy efficient.**

**Energy management** in collaborative urban micro-grids.

Development **of low-dimensional chalcogenide-halide mixed compounds** by physical routes for applications in **tandem photovoltaic devices**.

**Study and development of ultra-fast optical sensors for three-dimensional metrology of surfaces.**

Design of **accelerators based on RISC technology** for the next generation of computers.

Creation of **autonomous devices for detection and release**: assembly of biomedical systems for diagnosis and therapy.

Development of algorithms for the numerical resolution of linear systems of equations in order to carry out **simulations specific to computational fluid dynamics (CFD) and heat transfer (HT).**

## Examples of activity II

**Development of devices assisted by automatic deep learning for high radio frequency efficiency.**

Integration of **advanced CMOS-MEMS** for new systems millimeter scale generation.

Development of **semi-transparent photovoltaic solutions** that can be integrated into buildings.

**2D/3D simulation of back contact silicon solar cells.**

Development of the next generation of instrumentation to characterize the surface-subsurface interface in **planetary exploration**: wind sensors for Mars and probes for regolith.

Development of materials and components for **photovoltaic thermionic hybrid devices.**

Manufacture of **photodiodes for avionics applications.**

# 03
# RESEARCH & INNOVATION

## R&D

Through the research groups distributed by its Schools and Faculties, the UPC has facilities and resources to provide its own services, in the areas of diagnosis, advice, development, demonstration, training, promotion and support to industry, the public sector and civil society in the promotion and deployment of semiconductors and chips.

# UPC RESEARCH GROUPS IN SEMICONDUCTORS AND CHIPS

- AcaPE → Advanced Control and Power Electronics Systems
- ARCO → Microarchitecture and Compilers
- CBA - Communications and Broadband Architectures Lab
- CIRCUIT → Communication Circuits and Systems Research Group
- CSC → Components and Systems for Communications Research Group
- EFRICS → Efficient and Robust Integrated Circuits and Systems
- EPIC → Energy Processing and Integrated Circuits
- GREP → Power Electronics Research Group
- HIPICS → High Performance Integrated Circuits and Systems
- IMEM-BRT → Innovation in Materials and Molecular Engineering – Biomaterials for Regenerative Therapies
- IS2 → Intelligent Sensors and Integrated Systems
- MNT → Group of Micro and Nano Technologies for Solar Energy
- QinE → Low Power Design, Test, Verification and Security Ics
- CRAAX → Advanced Network Architectures Lab

# SPECIFIC RESEARCH CENTERS
# UPC

## CD6

Centre for Sensors, Instruments and Systems Development

## IDEAI-UPC

Intelligent Data sciEnce and Artificial Intelligence Research Group

## PERC-UPC

Power Electronics Research Centre

## SSR-UPC

Smart Sustainable Resources

# COLLABORATION WITH COMPANIES

- Albora Technologies SL
- HiSilicon Technologies Co. Ltd, Advantest Corporation, Siemens AG, FormFactor Inc, Infineon Technologies AG, Synopsys Inc
- Huawei Technologies Co. Ltd
- ideaded SL
- Imagination Technologies Ltd
- Kerafrit SA
- Microsoft Corporation
- Nanusens SL
- Nec Labs GmbH
- Qorvo Inc:
- Semidynamics Technology Services SL
- Software Radio Systems Ltd
- Solar Mems Technologies SL
- Virtual Open Systems SAS
- Yocto Technologies SL

# 04

# UPC EXCELLENCE PROJECTS

In this document are considered excellence projects those in which:

- The scientific process is rigorous and complex with high quality standards.
- They are strategic and tractors.
- They acquire a commitment to both social aspects and to great scientific and socioeconomic impact.
- They have repercussions on the territory.
- They comprise the different entities participating in the quadruple helix, so that the projects remain multidisciplinary.

The UPC excellence projects are financed by various programs, such as the State Plan or Horizon Europe.

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# UPC EXCELLENCE PROJECTS

## WiPLASH - Architecting More Than Moore – Wireless Plasticity for Heterogeneous Massive Computer Architectures

The WiPLASH project aims to initiate an on-chip wireless communication plan that offers architectural plasticity, reconfigurability, and adaptability without sacrificing generality or efficiency. The project focuses on establishing solid experimental foundations for wireless on-chip communication, including functional integration at the unit level and technological aspects.

*UPC research group involved: CITCEA-UPC*

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# UPC EXCELLENCE PROJECTS

## SCRAMBLE - Turbulence-On-a-Chip: Supercritically Overcoming the Energy Frontier in Microfluidics.

The overall goal of the SCRAMBLE project is to overcome the microfluidic frontier by

I. discovering the fundamentals of turbulent flow induction in microchips using high-pressure supercritical fluids, the discovery of critical conditions to drastically improve and control mixing and transfer processes,

II. designing, manufacturing and testing of a first disruptive series of on-chip turbulence prototypes to transfer power with a hundredfold performance improvement over standard microsystems.

In the medium and long term future, the proposed technology could enable the efficient miniaturization of thermodynamic cycles for power generation, the reconceptualization of the next generation of computer processors based on very powerful microfluidic-based cooling, and the adoption of new microfluidic solutions in fuel cells for transport and propulsion.

*UPC research groups involved: Departament d'Enginyeria Electrònica*

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# UPC EXCELLENCE PROJECTS

## WINC - Wireless Networks within Next-Generation Computing Systems

The WINC project envisages a revolution in computer architecture made possible by the integration of wireless networks within computer systems and Artificial Intelligence. The main hypothesis is that terahertz wireless technology will lead to at least a tenfold improvement in the speed, efficiency and scalability of both quantum and non-quantum systems.

With a transversal approach, WINC aims to validate the hypothesis

I. revealing the fundamental limits of wireless communications within computing packages,
II. developing antennas and protocols that operate close to these limits while meeting the strict constraints of the scenario, and
III. developing radically new architectures that translate the unique benefits of wireless vision into order-of-magnitude system-level improvements.

*UPC research groups involved: Departament d'Arquitectura de Computadors*

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

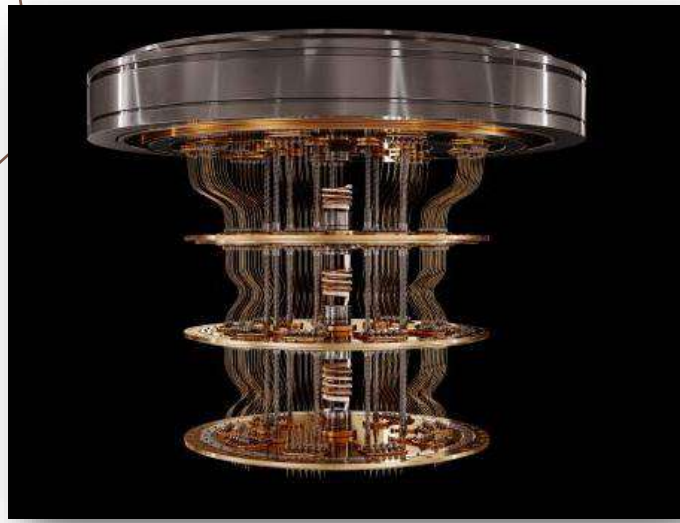
# UPC EXCELLENCE PROJECTS

## QUADRATURE - SCALABLE MULTI-CHIP QUANTUM ARCHITECTURES ENABLED BY CRYOGENIC WIRELESS / QUANTUM -COHERENT NETWORK-IN PACKAGE

The QUADRATURE project aims to develop scalable quantum computing architectures using distributed and interconnected quantum cores via quantum-coherent qubit state transfer links and an integrated wireless interconnect.

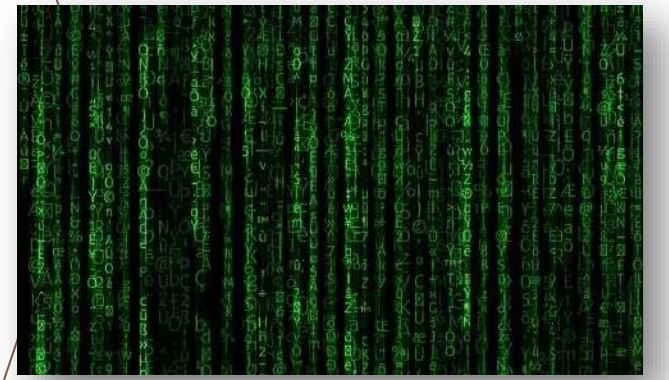
The goals include achieving microintegrated qubit state transfer of all RFs, classical wireless data transfer, developing protocols for a quantum coherent integrated network, implementing scalable architectural methods, and demonstrating improved performance.

*UPC research groups involved: Departament d'Enginyeria Electrònica*



UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# UPC EXCELLENCE PROJECTS



## ComplexData – Experiments and data analysis tools to characterize and forecast the output signals of complex systems

ComplexData was born with the purpose of overcoming the limitations of traditional industrial systems and further improving the performance of power converters. The aim of this project is to demonstrate:

1. the feasibility of implementing a new compact and high-performance device based on a series of switching cells formed by a single power transistor with anti-parallel diode, with a single nominal voltage, plus auxiliary circuits, and
2. that this new device can be used as a building block to implement any desired power conversion over a wide voltage and current range.

*UPC research groups involved: DONLL*

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# UPC EXCELLENCE PROJECTS

*UPC research groups involved : MCIA*

## RHODaS - Reinventing High-performance pOwer converters for heavy-Duty electric trAnSport

The RHODaS project aims to develop disruptive power converter topologies using new semiconductor materials as well as cutting-edge digital technologies to improve architecture efficiency, power density, reliability, cost and sustainability.

In addition, multidisciplinary approaches to integrated motor drive (IMD) modular power electronics and eco-design considerations are addressed to create compact solutions that can be integrated into a wide range and heavy-duty vehicles, allowing these electric vehicles to be more sustainable and autonomous throughout the life cycle of their components.

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# SOME ARTICLES (sorted by Journal Impact Factor)

Rodriguez, E. [et al.]. A survey of deep learning techniques forcybersecurity in mobile networks. IEEE communications surveys and tutorials, 7 Juny 2021, vol. 23, núm. 3, p. 1920-1955.
https://futur.upc.edu/32051926

---

Rodríguez, J. [et al.]. The diverse meteorology of Jezero crater over the first250 sols of Perseverance on Mars. Nature Geo science, 9 Gener 2023, vol. 16, p. 19-28.
https://futur.upc.edu/35067802

---

Abadal, S. [et al.]. Computing graph neural networks: A survey fromalgorithms to accelerators. ACM computing surveys, 1 Desembre 2022, vol.54, núm. 9, p. 191:1-191:38.
https://futur.upc.edu/32540435

---

Prades, I. [et al.]. Does Sb2Se3 admit nonstoichiometric conditions? Howmodifying the overall se content affects the structural, optical, andoptoelectronic properties of Sb2Se3 thin films. ACS applied materials andinterfaces, 9 Març 2022, vol. 14, núm. 9, p. 11222-11234.
https://futur.upc.edu/32870102

---

Lopez-Garcia, A. [et al.]. Ultrathin a-Si:H/Oxide transparent solar cellsexhibiting UV-Blue selective-like absorption.
Solar RRL,
15 Febrer 2023.
https://futur.upc.edu/35232310

# SOME DOCTORAL THESIS

Carrió, D. Juliol 2022. Simulació 2D/3D de cèl.lules solars de silici de contactesposteriors. Doctoral thesis. Department of Electronic Engineering, Universitat Politècnica de Catalunya.
http://hdl.handle.net/2117/371623

Aghazadeh, S. Maig 2022.Timed Array Antenna System: Application toWideband and Ultra-Wideband Beamforming Receivers. Doctoral thesis. Universitat Politècnica de Catalunya.
http://hdl.handle.net/2117/367766

Ntinas, V. Abril 2022. Harnessing Memristor circuits and device variability in Emergent Computing Applications. Doctoral thesis. Department of Electronic Engineering, Universitat Politècnica de Catalunya.
https://futur.upc.edu/33090393

Valle, J. Abril 2022. Design, fabrication and reliability of a CMOS-MEMS Lorentz-force magnetometer. Doctoral thesis. Department of Chemical Engineering, Universitat Politècnica de Catalunya.
http://hdl.handle.net/2117/367765

Salehi, N. Febrer 2022. Energy Management in Collaborative Power Electronics-Based Microgrid Integrated with Renewable Energies. Doctoral thesis. Department of Electronic Engineering, Universitat Politècnica de Catalunya.
https://futur.upc.edu/35152420

Rafiezadeh, R. 2022. Contributions to the Characterization and Design Optimization of Power Converters Based on Switching-Cell Arrays. Doctoral thesis. Department of Chemical Engineering, Universitat Politècnica de Catalunya.
https://futur.upc.edu/34922820

Ruano, G. Novembre 2021. Conducting polymers and hybrid materials for technological Applications . Doctoral thesis. Department of Chemical Engineering, Universitat Politècnica de Catalunya.
https://futur.upc.edu/32233774

Yoosefi, O. Juliol 2021. Simulation and Design of All-Optical Logic Gates Based on Photonic Crystals. Doctoral thesis. Department of Chemical Engineering, Universitat Politècnica de Catalunya.
http://hdl.handle.net/2117/351130

# 05

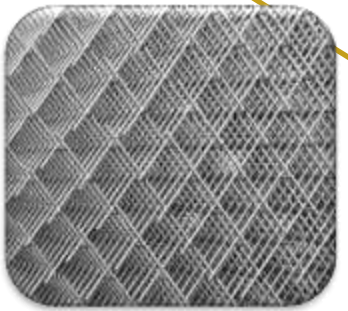
## EDUCATION

# EDUCATION – BACHELOR'S DEGREES

Bachelor's degree in Electrical Engineering
(EEBE, ESEIAAT, EPSEVG)

Bachelor's degree in Industrial Electronics and Automatic Control Engineering
(EEBE i EPSEM)

Bachelor's degree in Electronic Engineering and Telecommunications



Bachelor's degree in Materials Engineering

More information on UPC bachelor's degrees

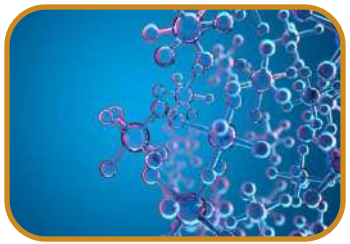
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# EDUCATION – MASTER'S DEGREES

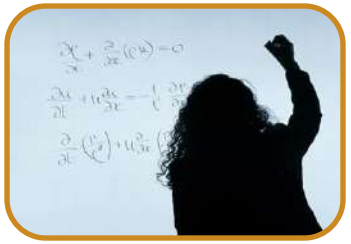
Master's degree in Energy Engineering (linked to the InnoEnergy programme)

Master's degree in Advanced Materials Science and Engineering

Master's degree in Telecommunications Engineering (MET)



Master's degree in Engineering Physics



Erasmus Mundus master's degree in Photonics Engineering, Nanophotonics and Biophotonics (Europhotonics)

Master's degree in Automatic Systems and Industrial Electronics Engineering

More information on UPC master's degrees

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# DOCTORAL PROGRAMMES

- Electrical Engineering
- Electric Energy Systems
- Automatic Control, Robotics and Vision
- Materials Science and Engineering
- Electronic Engineering
- Network Engineering

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

# RESEARCH AND INNOVATION SUPPORT SERVICE

https://rdi.upc.edu

@RDI_UPC

Research, Development and Innovation UPC

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Aquest document ha estat dissenyat amb imatges de Freepik.com, Pexels.com i Freeimages.com. Icones de Flaticon.com i el disseny de Slidesgo.com