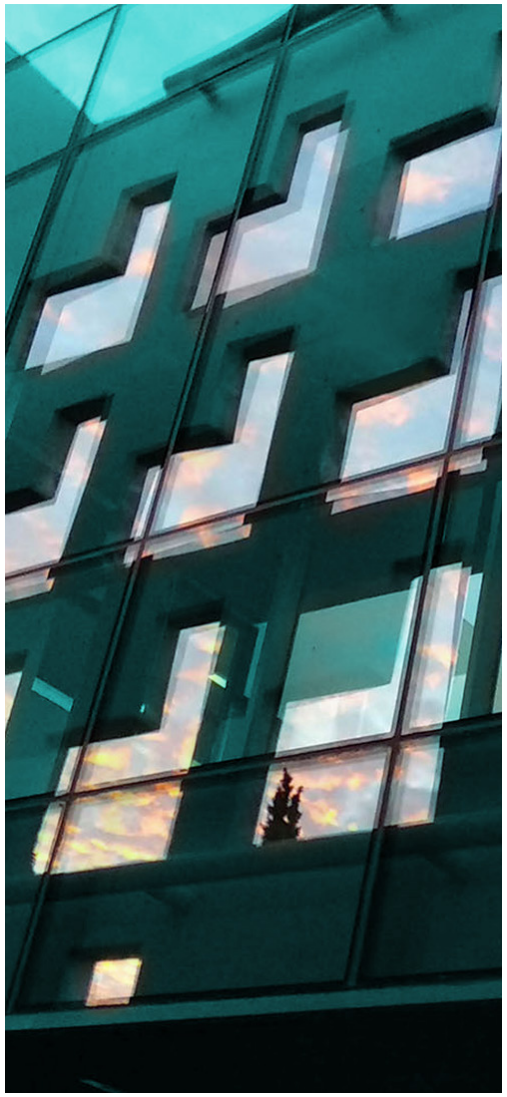
ANNUAL REPORT 2024

ICN2

Institut Català de Nanociència i Nanotecnologia

INDEX

LETTER FROM THE DIRECTOR



ICN2 continues to grow and consolidate its position as a leading centre for nanoscience and nanotechnology. In 2024, we have taken important steps to strengthen our research, broaden our impact, and deepen our connections with society, industry, and the global scientific community.

This has been a year marked by outstanding scientific achievements, institutional milestones, and a renewed sense of purpose. Our research community has demonstrated once again its creativity, resilience, and commitment to excellence. The first **ERC Synergy Grant awarded** to an ICN2 group is a major milestone in our journey, recognising the cutting-edge work of our Nanomedicine Lab in developing precision neurotechnology. The success of I**NBRAIN Neuroelectronics**—our flagship spin-off—continues to inspire, with a €50M Series B investment secured this year and the launch of human clinical trials for their graphene-based neurotechnology.

This year, we also welcomed **two new spin-off companies: Tirecat Health**, working on bioinspired membranes for tissue regeneration, and **LightNet Carbon Capture**, developing innovative nanomaterials for CO_2 sequestration. Our Business and Innovation team secured over **€2M in competitive innovation funding** and expanded our network of industrial collaborations, strengthening ICN2's role in translating science into technologies with real-world impact.

Beyond our scientific achievements, 2024 has been a year of reflection and celebration. We marked the **10th Anniversary of ICN2** with an event that brought together over 300 members of our community, celebrating a decade of scientific excellence, collaboration, and social impact. We also launched our first institutional **fundraising strategy** to explore new avenues of support for our mission, and joined the **My Green Lab global sustainability network**, becoming the first BIST centre to achieve this certification. These actions reflect our deep commitment to responsible research and our desire to engage with a broader range of stakeholders.

International collaboration remains at the heart of our work. This year, we established a **new partnership with the Waterloo Institute for Nanotechnology (WIN)** in Canada, opening the door to joint research, talent exchange, and strategic cooperation. Our participation in InnoFab, a large-scale semiconductor initiative supported by the Spanish and Catalan governments, positions ICN2 and the broader Catalan ecosystem at the forefront of European research and development in next-generation semiconductors.

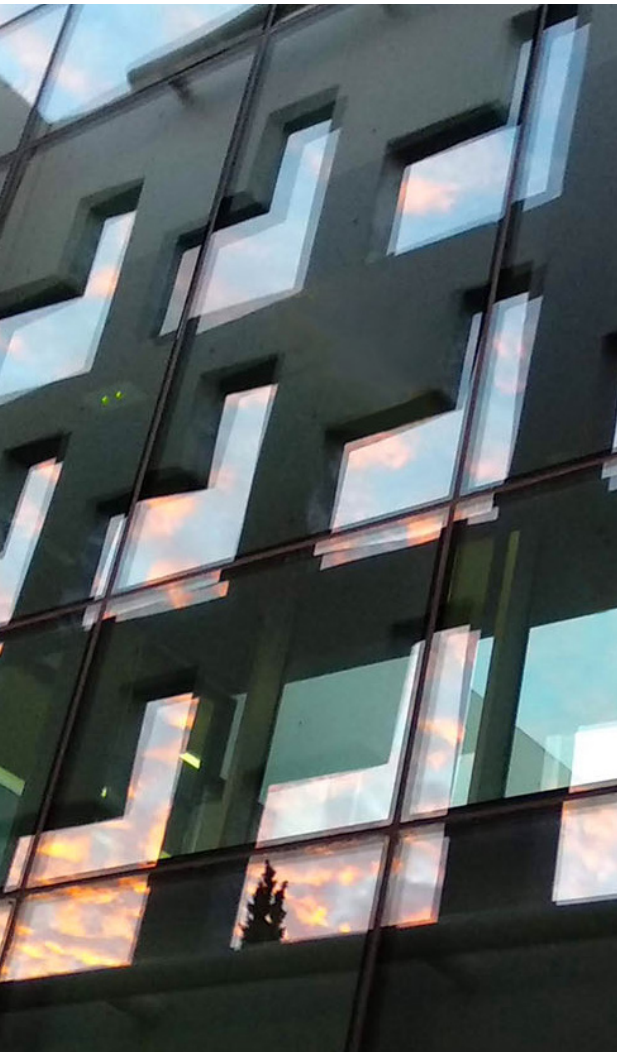
As part of our institutional evolution, we have also launched the recruitment process for a new **General Manager**, as **Mr. Lluís Bellafont** has announced his upcoming retirement in 2025 after many years of dedicated service.

All these achievements have been made possible thanks to the talent, enthusiasm, and commitment of our entire community—researchers, technicians, students, administrative staff, and collaborators. Their work is the driving force behind ICN2's success.

I invite you to explore the highlights of 2024 in this Annual Report, which stands as a testament to the collective effort and passion of everyone who forms part of ICN2. Together, we will continue to push the boundaries of nanoscience and nanotechnology, delivering solutions that address the pressing challenges of our time and contributing to a more sustainable and equitable future.

Sincerely,
Prof. Pablo Ordejón
Director, ICN2

INTRODUCTION



This document provides a summary of the activities undertaken by the Groups, Units and Facilities of the ICN2 during the year 2024. The complete information regarding their scientific production, projects, awards, and other impacts is available on the ICN2 website, where you can conveniently browse through all the science that we produce.

For in-depth details on each Group, Unit and Facility presented in this document, a specific link and QR code are provided for your reference. We encourage you to explore this comprehensive report at your leisure and delve into all the data and scientific achievements of our community.

WHAT IS THE ICN2?

The Institut Català de Nanociència I Nanotecnologia, also known as the Catalan Institute of Nanoscience and Nanotechnology (ICN2), is a nanoscience and nanotechnology research centre, located on the campus of the Universidad Autónoma de Barcelona, within a rich ecosystem of research and technological centres. Our mission is to open and explore new frontiers of knowledge at the nanoscale to bring value to society in the form of new discoveries, while inspiring and providing extensive training for the next generation of researchers. The trustees of ICN2 are the Generalitat de Catalunya (Catalan Government), the Spanish National Research Council (CSIC) and the Universitat Autònoma de Barcelona (UAB). ICN2 is a CERCA Centre and also one of the founding members of the Barcelona Institute of Science and Technology (BIST) and the Graphene Flagship.

The centre currently hosts 19 research groups that cover a broad spectrum of activities, yet share the common element of working at the nanometric scale. They operate at the intersection of classical disciplines such as physics, chemistry, biology, engineering, medicine and beyond. Basic science and applied research are equally valued and supported in our research and innovation strategy. This breadth of vision, from fundamental scientific knowledge to technological developments and the transfer of said new technologies, is a distinguishing feature of our centre.

ICN2 is a global leader in nanoresearch, a place where both fundamental and applied research, as well as efforts to bring technology innovations to market, receive strong support. It is a proud creator of opportunities for dialogue and collaboration between researchers, industry, policymakers and society and a research institute committed to equal opportunities, fair selection processes and guaranteeing a healthy work/life balance

Between 2014-2018, 2018-2022 and 2022-2026, ICN2 has been bestowed with the Severo Ochoa (SO) accreditation. SO´s current strategic plan aims to provide concrete nanoscience-based solutions for a more sustainable society. The SO accreditation is a seal of excellence, sponsored by the Spanish Ministry of Science, Innovation and Universities. It reflects the tremendous capability of the institute to continuously enhance its scientific and administrative processes to adapt to an increasingly diverse and complex society.

WHAT DO WE DO?

At ICN2, we firmly believe that nanoscience and nanotechnology will have a big impact in the years to come. We aspire to lead this impact by conducting excellent science, proposing innovative solutions to global challenges based on scientific knowledge, and engaging in dialogue with society about the benefits and potential risks of new technological advances. Our goal is to collaborate with, and provide expert advice to public and other institutions, and to facilitate the adoption of newly generated knowledge by the industry, the health sector, and society at large.

We are committed to achieving this with high standards of equality and diversity, attention to detail at every stage of the research career and providing the best possible work environment to ensure the safety and wellbeing of our community members. As you will discover in this report, our expertise in research and administration structures allows us to achieve these goals.

Nanoscience and nanotechnology offer a close examination of the world around us. Understanding and controlling the sometimes-unexpected behaviour of matter at this scale has implications for all other sciences. ICN2 brings together chemists, physicists, biologists, materials scientists, and engineers to explore the uncharted corners of the nanoworld and determine how to turn acquired knowledge into applications that improve life and the world. Our researchers tackle this challenge from every angle, with teams working on the discovery, simulation, visualization, and experimental exploration of the properties and behaviours of materials at the nanoscale, as well as the design and fabrication of devices that take advantage of their unique characteristics.

Research is at the heart of our mission, and therefore, we delve into it with detail in other sections of this document. In this introduction, we would like to focus on other aspects of our daily activities that enable us to achieve the desired levels of excellence.

CULTURE OF IMPACT

At ICN2, our research endeavours possess a dual focus: on one hand, we strive to push the boundaries of fundamental knowledge; on the other, we apply scientific insights to develop devices and solutions addressing major societal challenges.

The impact of ICN2 is exemplified through various products that have already reached the market in collaboration with spin-offs and both small and large multinational companies across diverse sectors. Our spinoff enterprises create job opportunities and mobilise resources to make a difference in medical, energy, and intelligent materials challenges. The ICN2 community is also deeply committed to science outreach and leads several educational initiatives that have a profound effect on society's understanding of the opportunities and challenges presented by nanotechnology.

ICN2 occupies a privileged position when measuring its influence in academic terms. However, our research has a far-reaching impact beyond academia, with the ultimate aim of constructing a more sustainable society deeply engaged with scientific advancement. By bridging the gap between the scientific community and society, we are shaping a world where innovation, collaboration, and knowledge dissemination drive progress to help address the pressing issues of our time.

EQUAL OPPORTUNITIES

ICN2 reaffirms its strong commitment to fostering equal treatment and opportunities, while managing diversity across all areas, preventing any direct or indirect discrimination based on any factors such as gender, religion, culture, or other potentially discriminatory conditions. The institute pursues measures to achieve genuine equality within our organisation by embedding equal opportunities as a strategic principle in our Corporate and Human Resources policies.

In 2024, the Equal Opportunities and Diversity Committee has been working diligently to implement the III Equal Opportunities and Diversity Plan, with a focus on promoting equality and diversity throughout the organisation.

Our Human Resources policies and practices uphold the principle of equal opportunities for individuals of all genders, cultures, nationalities, religions, or other distinguishing characteristics, covering areas such as selection, training, promotion, compensation, work-life balance, occupational risks, and occupational health. An example of this, done in 2024, was the implementation of menstrual points with hygienic material dispensers. We maintain a strong commitment to preventing harassment and promoting conducive working conditions, implementing procedures for prevention and addressing complaints or claims promptly. Specifically in this field, a new protocol was developed for the Prevention, Detection and Action Protocol for cases of harassment on the grounds of sexual orientation and gender identity and expression.

The Women Talent Programme specifically supports female researchers who aspire to achieve higher scientific goals, in 2024 it was incorporated the trajectory category award. This programme complements other initiatives supported by the ICN2 Equal Opportunities Committee, including training activities, awards recognising female talent, and funding for seed projects led by female researchers.

By embracing these principles and initiatives, ICN2 aims to create a more inclusive and diverse environment that nurtures talent and drives innovation.

FOSTERING TALENT

The ICN2 prides itself on its ability to attract skilled scientists, technicians, and support staff from all over the world. Once these individuals join the institute, they can take advantage of various training and professional development programs. Furthermore, ICN2 scientists actively participate in regional, national, and international research communities. A significant number of those who complete their PhD or postdoctoral research at the ICN2 continue their careers at renowned institutions worldwide. This enables the ICN2 to continue offering positions to future nanoscientists. In 2024, the institute had an average workforce of 366,38 members.

	Total no. of full-time equivalents	31/12/2024 Total no. of persons	31/12/2024 Women	
			Number	%
Total	366,38	377	148	39,26%
1. Academic staff	222,89	229	81	35,37%
Group leader senior	18,22	19	3	15.79%
Group leader junior	0	0	0	0.00%
Staff Scientists	24,77	27	11	40,74%
Postdoctoral	60,96	66	19	28,79%
Predoctoral	73,31	70	28	40,00%
Academic Others	45,63	47	20	42,55%
2. Non-academic staff	143,49	148	67	45,27%
Administration	58,85	58	42	72,41%
Core scientific platforms	17,76	19	3	15,79%
Laboratory support	23,33	22	8	36,36%
IT staff	3,73	4	0	0.00%
Others	39,82	45	14	31,11%
TOTAL	**366,38**	**377**	**148**	**39,26%**

PHD PROGRAMME

The ICN2 is firm in its commitment to fostering excellence in its PhD Programme designed to equip students with the expertise and resources of the institute as a whole, while benefiting from the guidance and challenges presented by individual research groups.

Each year, our internal committee offers advice to participants on essential formative experiences, including conference attendance, transferable skills, exposure, and publication records. Tailored to support students' development at every stage of their PhD journey, the comprehensive training calendar encompasses topics such as project planning, lab techniques, and scientific writing. In addition, our PhD students attend regular scientific seminars led by prominent industry members, participate in international conferences and workshops, and seize opportunities for academic and industry placements with local and global partner institutions.

In 2024, the ICN2 PhD Programme continues to build upon the success of the BIST Mentoring Programme launched in 2021 in collaboration with BIST. This enhanced Mentoring Programme, an evolution of the previous internal initiative, empowers PhD students to overcome potential obstacles inherent in the PhD experience, focusing on career development and transition. Moreover, the Career Week organized with the umbrella of BIST, allows also to see different career paths possibilities for the PhD Students who are at the moment of finishing their PhD.

The ultimate goal of the ICN2 PhD Programme is to ensure that students maximise their experience at the institute and are thoroughly prepared to excel in their professional paths.

POSTDOCTORAL TRAINING PROGRAMME

As part of the Severo Ochoa Programme and HRS4R budget, the ICN2 has crafted a Postdoctoral Training Plan dedicated to offering R2 and R3 Postdocs opportunities for professional and personal advancement. Conceived in 2020 and implemented in 2021, the plan encompasses a diverse array of activities included in the Annual Training Plan, all designed to empower Postdocs with cutting-edge tools and skills that elevate their proficiency, knowledge, and expertise in their respective fields.

The ICN2 remains committed to ensuring that Postdocs are primed for success in the next chapter of their careers, whether in academia or industry. By focusing on nurturing their talents and fostering their development, we are confident that our Postdocs will make substantial and lasting contributions to their chosen fields, driving innovation and shaping the future of research.

HUMAN RESOURCES STRATEGY FOR RESEARCHERS (HRS4R)

In May 2015, the ICN2 was awarded with the prestigious Human Resources Strategy for Researchers (HRS4R) badge, a testament to excellence in Human Resources practices within research centres and closely associated with the European Charter for Researchers. This esteemed recognition serves as a strategic framework guiding the institution's efforts in recruitment, training, development, and equal opportunities initiatives.

In 2024, the ICN2 successfully secured the renewal of the HRS4R badge, presenting the internal review for extending its acknowledgement of distinction until at least 2027The renewal process entailed updating the HR Action Plan and engaging with external experts. The devised actions for the current and previous periods can be accessed in the Careers section of the ICN2 website, showcasing our commitment to fostering a supportive and dynamic environment for our researchers and staff.

HR EXCELLENCE IN RESEARCH

THE YEAR AT A GLANCE

In this part of the Annual Report, we are excited to share the significant impacts of our institutional, research, and innovation efforts during 2024. In the sections that follow, you will find a selected collection of highlights and updates from the year, covering our achievements in important areas like sustainability, diversity, and scientific excellence.

INSTITUTIONAL HIGHLIGHTS

In the year 2024, the ICN2 led a number of institutional events and initiatives aimed at generating fresh scientific prospects through the ICN2 community. The subsequent paragraphs present a summary of some of the key accomplishments that have been featured on the news section of the ICN2 website.

ICN2 celebrates 10 years of impact and Scientific Excellence

In October 2024, ICN2 celebrated its 10th Anniversary with an event that brought together more than 300 members of the community. The programme reflected on a decade of scientific excellence, institutional milestones and societal impact. Throughout the year, a dedicated campaign highlighted the institute's evolution since 2013 and reaffirmed its strategic focus on nanoscience for a sustainable future.

Community Day opens ICN2 to society with record participation

On 25 April 2024, ICN2 celebrated its first Open Community Day, welcoming over 400 visitors, including families and friends of staff and researchers. Attendees enjoyed a rich programme of experiments, educational activities, and the opportunity to explore the Institute's offices and laboratories.

The event offered an engaging introduction to the world of nanoscience, strengthened internal community ties, and highlighted ICN2's dedication to science communication and outreach.

ICN2 joins the My Green Lab global sustainability network

In 2024, ICN2 became the first BIST centre to receive the My Green Lab Certification, an international standard for sustainable laboratory practices. As part of a pilot initiative, participating labs improved their workflows to reduce environmental impact. This certification reinforces ICN2's commitment to responsible research and marks a step forward in its broader sustainability strategy.

ICN2 launches a new fundraising strategy to boost philanthropic support

In mid-2024, ICN2 launched its first institutional fundraising initiative to attract philanthropic support aligned with its scientific mission and social value. Led by the Marketing, Communication and Fundraising Department, and developed in close collaboration with the Business and Innovation and Strategy teams, the initiative focuses on major gifts fundraising as the most suitable model at this stage. The initial phases identified over 90 potential donors and produced tailored value propositions to guide future engagement.

New partnership with Waterloo Institute for Nanotechnology (WIN)

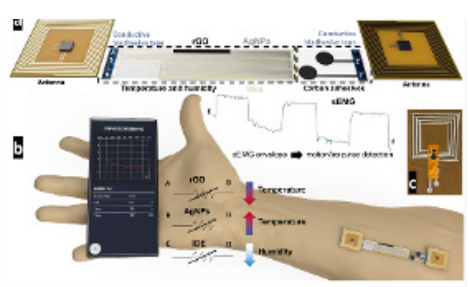
In April 2024, ICN2 and the Waterloo Institute for Nanotechnology (WIN) signed a Memorandum of Understanding to promote joint research, talent exchange, and strategic collaboration. This international partnership brings together two globally recognised institutes with complementary expertise and a shared vision for advancing nanoscience and nanotechnology to address major global challenges.

RESEARCH HIGHLIGHTS

This section showcases some of the published results and projects that illustrate the high quality of broad diversity of interests, fundamental approaches, and potential applications of the ICN2 research lines. Here, we also show some examples of the most notable awards, recognitions and grants of 2024.

Prof. Jordi Arbiol Achieves h-index of 100, a Milestone in Materials Science, Nanoscience and Nanotechnology

This accomplishment reflects his substantial contributions to scientific knowledge and underscores the impact of his work on advancing our understanding of materials and nanoscale phenomena.

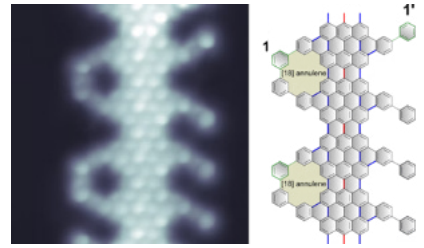


ICN2 Scientists Create New Wireless Technology to Prevent Heat Stroke

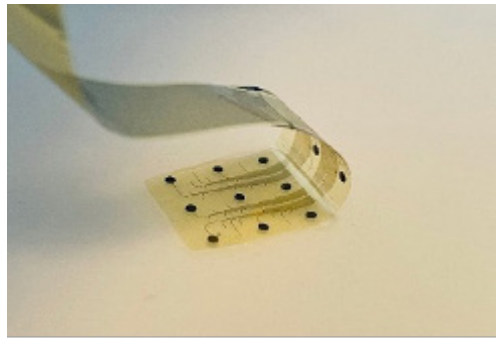
This innovative system, developed by researchers from the Nanobioelectronics and Biosensors Group, led by Prof. Arben Merkoçi, and the Nanostructured Functional Materials Group, led by Prof. Daniel Ruiz-Molina, can effectively measure biological parameters such as muscle contraction, temperature, and sweat. The technology, inspired by the adhesive properties of certain molecules found in mussels, can be easily attached to the skin.

ICN2 Researchers Develop Innovative Method for Creating Nanometric Pores in Graphene

This achievement by the Atomic Manipulation and Spectroscopy Group, led by Prof. Aitor Mugarza, is a significant advance in the synthesis of complex graphene-based nanostructures, with major implications for a wide range of technologies.



INBRAIN Neuroelectronics Achieves the World's First Application of a Graphene Brain-Computer Interface in a Human Patient



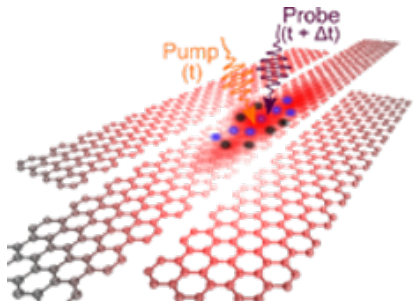
The revolutionary clinical procedure took place at the Salford Royal Hospital in Manchester. INBRAIN, co-founded by researchers from ICN2, confirms its position at the forefront of precision neurology.

Prof. Laura M. Lechuga Makes History as the First Woman to Receive an Honorary Doctorate (Honoris Causa) from the University of León

Her research focuses on developing nanobiosensor devices for clinical diagnostics, where she is recognised as a world leader.

First-ever ICN2 ERC Synergy Grant to Prof. Kostas Kostarelos and the Nanomedicine Lab

Prof. Kostas Kostarelos has been awarded one of the European Research Council's prestigious Synergy Grants 2024 to co-develop the SKIN2DTRONICS project, which aims to integrate conformable electronic devices based on 2D materials to monitor brain cancer recurrence.

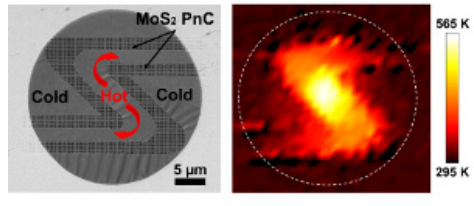


New Insights into Graphene Nanoribbon Properties Could Transform Next-gen Electronics

In a collaboration led by Prof. Klaas-Jan Tielrooj and Dr Aaron Cummings, researchers from ICN2 and the Max Planck Institute for Polymer Research analysed the electrical properties of graphene nanoribbons (GNRs) using spatiotemporal microscopy and numerical simulations. Their findings, published in Advanced Materials, establish GNRs as a promising material for developing new electronic devices requiring highly efficient electronic transport.

Prof. Victor F. Puntes Secures Funding from 'la Caixa' Foundation to Advance Treatment of Arteriovenous Malformations

He will collaborate on one of the new biomedical research projects selected for funding in the 2024 Caixa Research Health Research Call. This initiative will fund 29 projects with great potential for social impact from over 500 proposals. The projects will be carried out in hospitals, universities, and research centres in Spain and Portugal.



Nano-Patterned 2D Materials Pave the Way for Cooler Electronics and Greener Energy Solutions

Researchers from the Thermal Properties of Nanoscale Materials Group and the Atomic Manipulation and Spectroscopy Group have achieved a significant breakthrough in materials science, developing advanced phononic crystals and heat guides with far-reaching applications for electronics cooling, energy efficiency, medical devices, and environmental conservation.

Dr Elena del Corro Receives Her Medal as a Member of the Young Academy of Spain

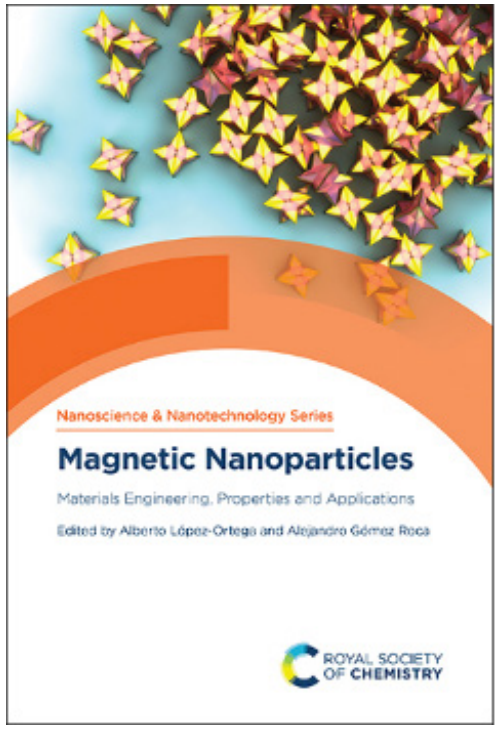
Dr Elena del Corro thus joins a select group of young researchers at the forefront of their fields, representing scientific excellence and commitment to the advancement of knowledge in Spain.

New Software Release: SIESTA 5.0

The Theory and Simulation Group, led by Prof. Pablo Ordejón, along with the Materials Simulation and Theory Group at ICMAB-CSIC, are pleased to announce the release of SIESTA 5.0. SIESTA is currently used in a wide range of fields (e.g., materials science, nanotechnology, biological sciences, geology, astrophysical and atmospheric systems).

Caixa Impulse Awards an ICN2 Project Based on Membranes for Skin Regeneration

The project, led by Dr Salvio Suárez, is focused on producing biomaterials with antimicrobial properties that can be used to treat lesions and skin regeneration. Caixa Impulse aims to promote the creation of new products, services and companies related to life sciences and health.



New ICN2 Book: Magnetic Nanoparticles - Materials Engineering, Properties and Applications

The publication, edited by Dr Alejandro Gómez (Magnetic Nanostructures Group) and Alberto López-Ortega (Public University of Navarra, UPNA), deals in depth with the wide range of applications of magnetic nanoparticles.

Prof. María Escudero Receives the "María Teresa Toral" National Research Award for Chemical Sciences and Technologies

The ICN2 Group Leader is recognised by the Spanish Ministry of Science, Innovation and Universities for her outstanding work on electrochemical processes and advanced materials for clean and sustainable energy conversion.

OUTREACH AND EDUCATIONAL HIGHLIGHTS

ICN2's involvement in educational and outreach activities is a significant investment in raising the profile of nanoscience and ICN2's role within society. Its efforts are having an increasingly significant impact, with established programmes and new initiatives opening up new channels of communication with a wide range of audiences.

Bojos per la Física (Crazy about Physics) 2024 programme

This educational initiative, co-organised by Fundació Catalunya La Pedrera, ICN2 and IFAE, is aimed at high school students with a special interest and talent for physics. Throughout the 2024 course, the students had the opportunity to attend different sessions at leading research centres and facilities.

Great Success of ICN2 Open Community Day

ICN2 opened its doors to families and friends for a day filled with experiments, educational activities and the chance to visit the Institute's offices and laboratories.

New BIST outreach initiative: Investiga'm

Investiga'm is an activity that aims to bring science and scientists closer to general audiences, including secondary school students. It showcases the impact of cutting-edge scientific research on society. As part of this BIST initiative, ICN2 organised several sessions.

The LeaderSHE Programme 2024 Brings New Talks by Women Who Have Reached Leadership Positions

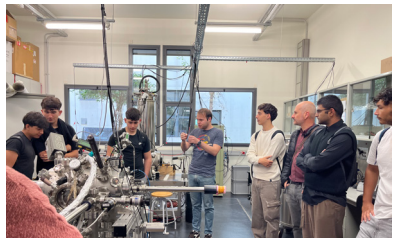
This initiative is organised by the ICN2 Equal Opportunities Committee in the framework of the institutional ICN2 2023-2026 Equality and Diversity Plan.

NanoEduca 2023-2024 Concludes with Event Gathering 12 Catalan High Schools

The final session of this educational programme for secondary school teachers and students in Catalonia featured scientific talks and a roundtable discussion with young scientists. It also included an awards ceremony for the best nanoscience videos created by students.

10alamenos9 Nanoscience and Nanotechnology Festival 2024 at the UAB

On April 2024, a special day of activities for high school students was organised at UAB, in the framework of the 10alamenos9 Nanoscience and Nanotechnology Festival. The programme included visits to a few research centres on the campus (ICN2, ICMAB, IMB-CNM) and a roundtable with young scientists.



JPhD2024 at UAB: a New Successful Edition of this Benchmark Event for PhD Candidates

The conference brought together many young researchers from the Barcelona Nanocluster-Bellaterra, including several from ICN2, to promote scientific communication, collaboration and the exchange of innovative ideas.

B&I HIGHLIGHTS

In line with the entrepreneurial spirit of the institute and its researchers, ICN2 continues to strive for excellence in Innovation and Impact. In this section, we highlight some of the major technology transfer and value creation actions that took place in 2024.

ICN2 captured the extraordinary opportunities in funding for Innovation

The year 2024 offered an extraordinary number of calls for applications in Innovation. ICN2 was able to secure an annualised grant income of more than €2M euro. These competitive public grants include collaborations with companies, providing not only robust funding to ICN2, but also a network of strategic partnerships.

INBRAIN Neuroelectronics closed a Series B Capital Raise of 50M€

ICN2 spinoff INBRAIN Neuroelectronics develops graphene- based applications for neurological diseases founded by researchers from IMB-CNM-CSIC, ICN2 and ICREA. The injected capital will allow the company to begin clinical trials, following the successful first-in-human study done in 2024.

ICN2 founded two new spinoff companies.

ICN2 and CSIC partnered through 2024 to found 2 new spinoff companies, in the field of clinical of tissue regeneration and carbon dioxide capture. Tirecat Health, stemming from Daniel Ruiz´s laboratory, will develop catechol-based membranes for tissue scaffolding. LightNet Carbon Capture will advance solutions in nano-material based sequestration of carbon dioxide.

ADVANCING SCIENTIFIC FRONTIERS WITH THE THIRD SEVERO OCHOA CENTRE OF EXCELLENCE ACCREDITATION (2023-2026)

This year has seen the kick-off of ICN2's third consecutive Severo Ochoa award. In alignment with our current strategic plan, this Severo Ochoa project seeks to help ICN2 take major steps towards consolidating its international leadership and influence, as well as its impact. The scientific programme "Nanosolutions for a Sustainable Society" is being developed through three Application Domains (ADs) and four Enabling Research Areas (ERAs). ADs spearhead the delivery of transformative nanoscale solutions for concrete societal needs, being representative of ICN2 capabilities, resources, and strategic direction: Medicine, Energy-Efficient Information Processing and Sustainable Energy Technologies. Work in ADs is complemented and catalysed by the ERAs: ICN2's hubs of scientific expertise and knowhow, pivotal to excellent science: Nanomaterials and Nanofabrication, Nanocharacterization, Modelling and Simulation and the Artificial Intelligence Computational Platform (AI@ICN2). Main highlights for 2024 have been:

Governance

Setting up the project's governance, including the establishment of working groups (WGs) for each of the ADs and ERAs. These WGs are the heart of the Severo Ochoa (SO) project, proposing and deploying activities aligned with the project objectives. WGs operate autonomously, but their decisions require approval from the SO Scientific Committee members, who serve as chairs.

Human resources

During this first year, the ten SO predoctoral students assigned to the project were selected and incorporated to ICN2. So was the SO project manager. The selection processes for other profiles were launched, though incorporations happened early in 2024.

Infrastructure

275K€ were allocated for equipment to the Investment Committee, which launched two calls (one at the start of the year and another one at the end of 2023.) By the end of the year, over 100K€ had already been spent or committed. Furthermore, an investment of 100K€ was committed for a new computational cluster.

Internal calls

The first edition of all the SO competitive calls were launched in 2023, and many were resolved. The Internationalisation Committee allocated almost 15K€ for a total of 9 grants for the Outbound Mobility and the International Visitors Programmes. The Business and Innovation Office delivered a total of 2 grants and 45K€ through the Technology Valorisation and Venturing Programmes. Furthermore, they offered, as well, five places in the From Science to Business course organised by BIST.

The 2023 Seed funding call was launched in October, to be resolved in 2024.

AI@ICN2 Platform

The Artificial Intelligence Computational Platform is one of the high impact activities of the SO programme. It is aimed at providing internal operational guidance and tools to the ICN2 community. This year, we have set the bases for the platform by defining profiles and launching processes that have been concluded early 2024; exploring new strategic partnerships and designing specific trainings to be delivered inhouse. We have also mapped ICN2 research lines using or aiming to use AI/ML in the near future. Other many actions, both cross-cutting and from the working groups were kicked-of this year and will see the light during 2024 and beyond. The journey towards developing nanosolutions for a sustainable society has started.

ORGANISATION

At ICN2, we take immense pride in recognising that our people are the driving force behind our success. Our dynamic team of scientists, hailing from a wide array of backgrounds, is bolstered by the invaluable expertise of our technicians and administration professionals, all working in unison towards the Institute's ambitious objectives. We are truly privileged to have the guidance and insights of our esteemed Board of Trustees and Scientific Advisory Board, composed of distinguished international peers, paving the way towards a bright future for the ICN2 community.

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DIRECTOR

The ICN2 is led by Director Prof. Pablo Ordejón, who also leads an ICN2 Group. He reports directly to the Board of Trustees and is advised by the Scientific Advisory Board. The Director works closely with the ICN2 Vice-Director, ICREA Prof. Jose A. Garrido, also Group Leader, the General Manager, Mr. Lluís Bellafont and the Executive Assistant, Ms. Cristina Granadero.

STRATEGY DEVELOPMENT OFFICE

Led by Dr Margarita Navia, this office works to provide a response to the different challenges faced by the institute on the short and long term, addressing issues at the national and international level, to improve the institute's responsiveness to an ever-changing global context. It oversees the development of the strategic plan, coordinates institutional projects like the Severo Ochoa Programme and provides advanced research development support to the ICN2 research community.

It works in close collaboration with both the research community and the administration departments, as well as the external collaboration network of the institute, and aims to bring insight and strategic manpower to research activities, hot topics like research data management, and ongoing initiatives to support the ICN2 in becoming a world-leading research institute.

MAIN ACTIVITIES

- Design and management of the ICN2 Strategic Plan, supporting its translation into actionable goals and yearly plans, and monitoring overall progress towards bigger-picture objectives.
- Delivering institutional strategic projects and initiatives.
- Coordination of institutional projects and initiatives of strategic importance.
- Supporting the direction in drawing new strategies and policies.
- Co-identification of funding opportunities for research groups and researchers, plus dedicated pre-award information and support for calls considered strategic for the centre.
- Cultivation of mutually beneficial relationships with key stakeholders.

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BUSINESS AND INNOVATION OFFICE

The Office of Business and Innovation is dedicated to protecting and commercializing ICN2's groundbreaking research results, establishing R&D and licensing contracts with industry partners and fostering new collaborations within both private and public sectors. Our innovation instruments connect scientific discoveries to the market, expand our scientists' collaborative networks, and ensure that public science generates resources that fuel further scientific advancement. The Severo Ochoa Programme has facilitated a range of pioneering innovation activities, produced tangible outcomes and reinforced ICN2's status as a center of excellence. The Business and Innovation Office team aims to achieve excellence in innovation by providing robust support and empowerment to our researchers.

Initiated in 2019, the Business and Innovation Office has been on a mission to become a true incubator for ICN2 technologies, making significant strides towards integrating public science with the production of goods and services. Severo Ochoa funding has enabled internal support programs for Proof of Concept and Venturing. In the coming years, the Business and Innovation Office will deploy additional tools and mechanisms to ensure ICN2's continued leadership in innovation. In 2024, the Business and Innovation Office focused on extending and strengthening our network through strategic communication efforts. In 2024, ICN2's Business and Innovation (B&I) team successfully accelerated the transition from scientific discoveries to market applications, emphasizing its dedication to fostering knowledge transfer and innovation.

The B&I team deposited 10 new patents, managed 52 active patent families, and negotiated 3 new Licenses, initiated 11 new R&D projects. The B&I team reaffirms our unwavering commitment to bridging the gap between scientific research and real-world applications.

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RESEARCH GROUPS

Research activities at the ICN2 are directed by senior scientists of international repute who lead teams of PhD students, postdocs and other senior scientists in the development of their respective areas of expertise. In 2024 the ICN2 gathered 19 research groups that together cover much of the breadth of nanoresearch:

ADVANCED ELECTRON NANOSCOPY
ICREA Prof. **Jordi Arbiol**

ADVANCED ELECTRONIC MATERIALS AND DEVICES
ICREA Prof. **Jose A. Garrido**

ATOMIC MANIPULATION AND SPECTROSCOPY
ICREA Prof. **Aitor Mugarza**

INORGANIC NANOPARTICLES
ICREA Prof. **Víctor F. Puntes**

MAGNETIC NANOSTRUCTURES
ICREA Prof. **Josep Nogués**

NANOBIOELECTRONICS AND BIOSENSORS
ICREA Prof. **Arben Merkoçi**

NANOBIOSENSORS AND BIOANALYTICAL APPLICATIONS
CSIC Prof. **Laura M. Lechuga**

NANOELECTROCATALYSIS AND SUSTAINABLE CHEMISTRY
ICREA Prof. **María Escudero Escribano**

NANOMEDICINE LAB
ICREA Prof. **Kostas Kostarelos**

NANOSTRUCTURED FUNCTIONAL MATERIALS
CSIC **Daniel Ruiz-Molina**

NANOSTRUCTURED MATERIALS FOR PHOTOVOLTAIC ENERGY
CSIC Prof. **Mónica Lira-Cantú**

NOVEL ENERGY-ORIENTED MATERIALS
CSIC Prof. **Pedro Gómez-Romero**

OXIDE NANOPHYSICS
ICREA Prof. **Gustau Catalán**

PHYSICS AND ENGINEERING OF NANODEVICES
ICREA Prof. **Sergio O. Valenzuela**

SUPRAMOLECULAR NANOCHEMISTRY AND MATERIALS
ICREA Prof. **Daniel Maspoch**

THEORETICAL AND COMPUTATIONAL NANOSCIENCE
ICREA Prof. **Stephan Roche**

THEORY AND SIMULATION
CSIC Prof. **Pablo Ordejón**

THERMAL PROPERTIES OF NANOSCALE MATERIALS
UAB Prof. **Javier Rodríguez-Viejo**

ULTRAFAST DYNAMICS IN NANOSCALE SYSTEMS
Prof. **Klaas-Jan Tielrooij**

ADVANCED ELECTRON NANOSCOPY GROUP

JORDI ARBIOL
ICREA Research Professor and Group Leader

38	ARTICLES	14,39	MEAN IMPACT FACTOR
13	FUNDED PROJECTS	35	CONTRIBUTIONS
8	AWARDS	10	OUTREACH IMPACT
5	CONGRESSES ORGANISATION	13	COURSES
1	THESIS		

MAIN RESEARCH LINES

- **Exploration by means of electron microscopy and related spectroscopies of the structure-properties relationships in nanomaterials for physical applications (photonics/plasmonics/ phononics/electronics/quantum technologies)**
- **Understanding of the behaviour and mechanisms of nanomaterials for energy and environmental applications down to the atomic scale**
- **Developing AI-based methodologies for advanced automated data analysis and 3D atomic modelling (deep and machine learning) searching the design of digital twins from devices and heterostructures with atomic accuracy**
- **Developing in-situ/operando, correlative and multimodal methodologies combining electron microscopy and synchrotron light experiments, with the help of AI-automated characterization tools**

NEW PROJECTS & MILESTONES

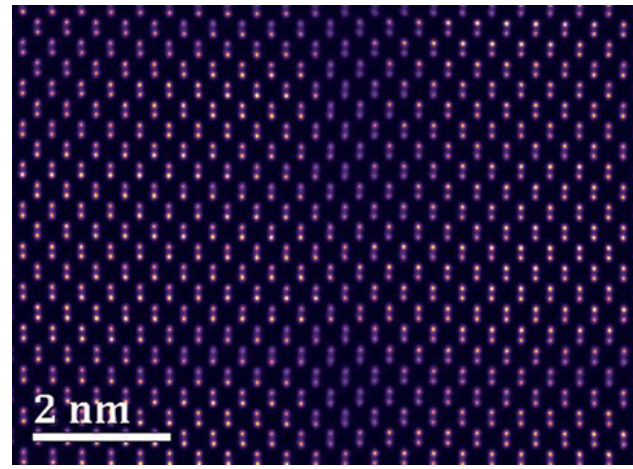
JEMCA has fulfilled the primary objective of the group, that of creating and leading a state-of-the-art research infrastructure in electron microscopy in Catalonia with strong international projection (thanks to e-DREAM). The new infrastructure and funded projects (In-CAEM, SOLARUP, IMPRESS, Re-Made@ARI, RIANA and PeCATHS) will allow expanding the group's capabilities in the in-situ correlative electron / synchrotron microscopy / spectroscopy on energy, environmental and quantum nanomaterials and will allow to open new research lines (see below). In parallel, we plan to continue working within e-DREAM as part of the Analytical Research Infrastructures in Europe (ARIE). One of our main objectives in ARIE and e-DREAM is the development of novel and disruptive correlative synergies and methodologies between different characterization technologies, as it can be between EM and Synchrotron light sources.

New projects started in 2024: RIANA (HORIZON EU), EDISON (AGAUR), DeQD (Danmarks Innovationsfond), ARQuDS (Novo Nordisk Quantum Computing Programme (NQCP)), AMADE (PID from AEI/MICIN), PeCATHS (HORIZON EU) and NEXPECH2 (M-ERA.Net).

Two of the research topics we will explore further, in addition to the research lines on which the group already works, are:

A) Development of AI-based methodologies for advanced automated data analysis

Our research line devoted to the direct correlation between atomic scale structure/ composition and sub-nanometer scale physical properties will benefit from the funds from the collaborative projects with Microsoft, Novo Nordisk, the EU HORIZON



EIC Pathfinder SOLARUP that Prof. Arbiol is coordinating and the IMPRESS project.

The new analysis capacities offered by JEMCA will allow for the study of newly designed hybrid semiconductor/ superconductor heterostructures for their application in quantum computing (NQCP and Quantum Foundry Copenhagen) as well as the photovoltaic (PV) cells developed within SOLARUP, and a better understanding of the physical phenomena involved in the related devices. In addition, as the new industry developments for quantum materials

or novel nanostructured photovoltaic devices have as a priority objective the scalability of their systems (e.g.: scalable topological quantum networks or patterned PV nanostructures), it will be mandatory to combine detailed structural and compositional analyses at the atomic scale with a precise 3D modelling. Current such methodologies based on STEM imaging and related spectroscopies like EELS are limited by scale: conversion of the vast number of data points in a nanostructured system into the models needed for properties simulation is a mammoth task. In the next years, one of our main objectives will be to develop new methodologies for the automated processing of atomic-scale STEM-EELS data in order to obtain their direct conversion into the required nanoscale finite-element simulations input models. In order to do this, we will explore the application of AI methods based on machine/deep learning- enhanced pattern recognition. The computing infrastructure necessary to develop such an ambitious AI-based project has been included in In-CAEM, which is providing the large data storage, data analysis and data treatment computing resources in collaboration with ALBA and PIC-IFAE.

B) In-situ/operando, multimodal and correlative study of energy nanomaterials

The next steps, moving forward in the energy nanomaterials research line, will be related to the development of in-situ / operando experiments in the electron microscopy to understand the physical and chemical phenomena promoting the different energy mechanisms (e.g.: (photo) electrochemical) with unprecedented resolution. Taking advantage of the synergy with ALBA, within In-CAEM and IMPRESS projects, we will work on developing correlative in-situ electron microscopy and Synchrotron experiments, in correlation to the developed theoretical models. In-CAEM provides not only the equipment but also the necessary synergies. Together with ALBA engineers and beam line scientists, we have already started to design the modifications required to adapt some of the ALBA beam lines (e.g.: CIRCE, CLAESS, MSPD, MIRAS and NCD-SWEET) to allow the necessary in-situ correlative experiments with the new (S)TEMs. In-CAEM will also provide the computing resources for the in-situ data analysis and the availability of a large data storage capability.

In the following years, we will continue working hard to strengthen even more the JEMCA national and international alliances and synergies and apply for more funding to develop the future research ideas (several new proposals are right now being drafted and will be submitted in the coming 2024 HORIZON EU Calls).

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ADVANCED ELECTRONIC MATERIALS AND DEVICES GROUP

JOSE ANTONIO GARRIDO
ICREA Research Professor, Group Leader and Vice Director

MAIN RESEARCH LINES

- **Chemical vapour deposition (CVD) of graphene and metal-organic CVD of transition metal dichalcogenide (e.g. MoS2) films**
- **Technology and micro/nanofabrication for advanced electronic devices and systems based on 2D materials**
- **Fundamental electronic, electrochemical, and interfacial phenomena of 2D materials**
- **Neurotechnology and biomedical technologies: neural interfaces, neuroprosthetics**
- **Self-powered bioelectronics and neuroelectronics**

NEW PROJECTS & MILESTONES

The AEMD group explores fundamental electronic and electrochemical phenomena of novel materials, with a current particular emphasis on graphene and other 2D materials (e.g. MoS2), and develops micro and nanotechnologies necessary to prepare advanced electronic devices and systems based on these materials. A major focus of our work are applications related to neural interfaces and neuroelectronics.

2024 has been a year of tremendous progress and great news for the group. At individual level, Dr. Elena del Corro was

14 ARTICLES	11,02 MEAN IMPACT FACTOR
14 FUNDED PROJECTS	34 CONTRIBUTIONS
3 AWARDS	6 OUTREACH IMPACT
1 CONGRESSES ORGANISATION	1 COURSES
1 THESIS	1 AWARDS

awarded with an ERC Consolidator Grant (GA: 101125401) to work on triboelectric energy generators for self-powered medical implants to improve the life of patients suffering from diseases linked to the activity of the vagus nerve. This project has started in September 2024. Since then, the team has work on the laboratory set up and we have carried out first preliminary experiments for the development of miniaturized triboelectric devices based on biocompatible materials.

In the same research direction, the project TriBioNics lead by Dr. Elena del Corro in collaboration with Samuel Sanchez from IBEC was selected in the BIST Ignite programme. This project combines for the first time three innovative technologies: 3D skeletal muscle printing, graphene bioelectronics and triboelectronics. The aim is to mould skeletal muscle and, among other things, develop new therapies for rehabilitation. We have demonstrated the superior capabilities of graphene microelectrodes to stimulate muscular contraction for healing and rehabilitation. The project was awarded for a second stage in which we will explore the direct coupling of the triboelectric devices with the graphene electrodes to provide stimulation pulses of interest.

January marked the launch of the NEURO2FAB project (PDC2023-145866-I00), a proof-of- concept initiative aimed at pushing forward the MoS2 technology, upscaling the preparation of materials and devices, with the ultimate goal of developing a novel flexible hybrid technology integrating graphene and MoS2 devices in one single neural probe. This project has been funded by MICIU/AEI (10.13039/501100011033) and the European Union through NextGenerationEU/PRTR."

The GAIA project (GA: 101158723) started on March 2024, an EIC Transition project, in collaboration with AZALEA, an IMEC spinoff, to work on the integration of graphene on smart contact lenses. In this project, the AEMD team will develop new microfabrication strategies for integrating CVD graphene electrodes onto flexible and transparent substrates for application in incorporation in optical lens for medical purposes.

In MINIGRAPH (GA: 101070865), a EIC Pathfinder project coordinated by AEMD, we have advanced in the development of surface and depth bidirectional neural probes targeting neuromodulation in large animal models, a step closer to human translation. Importantly, our team reached a key milestone: the demonstration of a thin-film encapsulation technology that enables the long-term operation of the neural interfaces. In the frame of this project and expanding previous work within the Graphene Flagship EU project, N. Ria (PhD) used AEMD's rGO technology for deep brain stimulation (DBS), implanting flexible high-density arrays of rGO microelectrodes in the subthalamic nucleus (STN) of hemi-parkinsonian rats. This collaboration with Rob Wykes (University of Manchester) and Kostas Kostarelos (University of Manchester and ICN2) enabled us to demonstrate that these microelectrodes record action potentials with a high signal-to-noise ratio, allowing the precise localization of the STN and the tracking of multiunit - based Parkinsonian biomarkers, while being able to deliver high-density focal stimulation, confirming the potential of bidirectional high-resolution neural interfaces in closed-loop DBS.

We have been working in the RESCUEGRAPH project (PCI2021-122095-2A), focused on a functional stimulation system for rehabilitation after spinal cord injury using graphene-based nerve electrodes (under the FLAG ERA programme, led by Prof. Xavier Navarro from the UAB). We have demonstrated the capabilities of small graphene microelectrodes to stimulate selectively and with low current thresholds different fascicles within the sciatic nerve in acute and chronic animal experiments. This project has been funded under the call "Proyectos colaboración internacional" funded by MCIU/AEI and by the European Union NextGenerationEU/PRTR, and has resulted in two published manuscripts (B. Rodriguez-Meana et al., and D. Viana et al.).

Our team is also working on the i-VISION project (funded by La Caixa Foundation; HR18-00313 Code: LCF/PR/HR19/52160003), focused on the development of retinal implants for vision restoration, an endeavour carried out in collaboration with IFAE, ICFO, Barraquer Foundation and Paris Vision Institute. We conducted chronic in vivo experiments to assess the efficacy of retinal stimulation to evoked cortical activity, as evidenced by functional ultrasound monitoring. We have also worked in the integration of rGO electrodes with an application specific integrated circuit (ASIC) designed by IFAE for visual restoration.

We continue advancing our research as a Consolidated Research Group thanks to the support of the Catalan Government (2021 SGR 01534) and as part of a project founded by the Spanish Ministry (PID2020-113663RB-I00), focused on technologies based in 2D materials for biomedical applications, of which Dr. Elena del Corro is co-PI. We have notably advance in the development of 2D materials of higher quality and reproducibility, also working towards an automatic transfer of these materials. The upgraded 2D materials

are currently being integrated in the technologies developed by the group.

Additionally, the group has contributed to the project "BrainGraph, led by Antón Guimerà from CNM-IMB and in collaboration with INBRAIN Neuroelectronics, focused on graphene based neurotechnology for advanced clinical brain monitoring. This project (PLEC2022-009232) has been funded under the call "Proyectos en líneas estratégicas" funded by MCIU/AEI and by the European Union NextGenerationEU/PRTR.

As part of 2024, we have continued maturing the CVD graphene transistor technology for its integration in brain-computer interfaces within "GphT-BCI", an EIC Transition project led by INBRAIN electronics (funded by the EU under grant 101136541) aiming to accelerate the clinical translation of graphene-transistor arrays for brain-computer interfaces. Within this collaborative project, the AEMD team has mainly contributed to the upscaling of graphene transistor fabrication to 6-inch wafers and to the development of new strategies for graphene protection during fabrication.

Finally, it is worth highlighting that the group started the project GRAPHYZ in January 2025 (2024 INNOVADORS 0046) to assess the possibility of commercialization of graphene-based neural interfaces tailored for pre-clinical research. The project focuses on translating the EGNITE technology into an accessible platform for scientists. This includes developing user-friendly toolkits that integrate advanced graphene-based probes with embedded electronics (ASICs), aiming to address current limitations in flexibility, resolution, and bidirectional interfacing in neurotechnology. F. Taygun Duvan assumes the role of the entrepreneurial lead, driving efforts to evaluate market viability and formulate the business strategy.

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ATOMIC MANIPULATION AND SPECTROSCOPY GROUP

AITOR MUGARZA EZPELETA
ICREA Research Professor and Group Leader

MAIN RESEARCH LINES

- **Synthesis and advanced characterization, and device applications of carbon-based 1D and 2D nanomaterials**
- **Tailoring the quantum properties of 2D materials with atomically precise superlattices**

NEW PROJECTS & MILESTONES

The scientific research carried out by the Atomic Manipulation and Spectroscopy Group in 2024 was centred on two main topics: i) the synthesis of atomically precise graphene-based 2D nanostructures, the characterization of their chemical and physical properties, and exploring their potential application in different type of devices; ii) the engineering of the electronic properties of 2D quantum materials with tunable superlattices.

As an ongoing study of the on-surface synthesis of graphene nanostructures, we focused our efforts on exploring the flexibility of our method to produce atomically precise nanoporous graphene (NPG) for varying pore geometry and shape, as well as chemical composition. We have demonstrated the integration of flexible

phenylene bridges for tuning he quantum electronic coupling and anisotropy of NPG, with prospects on similar tunability of their nanosieving and thermoelectric properties. This research has been carried out within the PORMOLSYS project, funded by the State Research Agency. In parallel we are exploring different types of application of these graphene nanoarchitectures, such as the capability of imprinting superlattice potentials to trap excitons in 2D materials –in

6 ARTICLES	**7.15** MEAN IMPACT FACTOR
5 FUNDED PROJECTS	**17** CONTRIBUTIONS
4 CONGRESS ORGANISATION	**3** COURSES
5 OUTREACH IMPACT	

collaboration with ICFO partners within a BIST-IGNITE grant project– and their application as chemical sensors, which is done within PORESENSE and SENSATION, both funded by the State Research Agency. The former is devoted to the development of a proof-of-concept field-effect transistor chemical sensor based on nanoporous graphene, whereas the latter is more focused on developing the next generation of NPG materials with improved functional properties for sensing. In this context, and inspired by our recent achievement where the interdigitation of two type of graphene nanoribbons led to lateral heterostructure superlattices, we have explored the synthesis of hybrid heterostructures by including non-graphenoid components. We have also been carrying out an atomistic study of the interaction of NPG and derivatives with gaseous analytes by combining scanning probe microscopy with synchrotron-based spectroscopies.

As a parallel activity, we have continued previously established collaborations in the search for stabilizing and controlling magnetism in single molecular and atomic units. In particular, we have demonstrated that single rare earth atoms deposited on the surface of a topological insulator can induce a gap at the topological surface bands, a crucial prerequisite for the realization of the Quantum Anomalous Hall Effect and other topological phenomena.

Finally, Prof. Aitor Mugarza is coordinating the development of a scanning probe microscopy (SPM) platform at ALBA synchrotron. The SPM platform, to be opened to users by the end of 2025, will consist of four different instruments that, together with several synchrotron beamlines, will be capable of carrying out

correlative in-situ characterization of advanced materials. This initiative is part of InCAEM, the Catalan project within the "Advanced Materials" programme of the Spanish Recovery, Transformation and Resilience Plan.

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INORGANIC NANOPARTICLES GROUP

VÍCTOR F. PUNTES
ICREA Research Professor and Group Leader

MAIN RESEARCH LINES

- **Designing and development of synthetic strategies for the production of complex nanoparticles**
- **Functionalizing nanoparticle surfaces with specific and relevant biomolecules**
- **Studying of their physicochemical and fundamental properties and reactivity**
- **Exploring the diverse applications of inorganic nanoparticles in biomedicine, spanning nanooncology, immunology, and antimicrobial fields, as well as their potential uses in energy harvesting and catalysis**
- **Ensuring nanosafety through the development of toxicity and ecotoxicity testing models for nanoparticles, aimed at minimizing associated risks while maintaining desired properties**

NEW PROJECTS & MILESTONES

In 2024, the Inorganic Nanoparticles Group advanced projects focused on the design and synthesis of inorganic nanoparticles for biomedical applications and energy technologies.

A central focus has been the TRANSCERIA project, part of the Proyectos de Generación de Conocimiento, which aims to precisely engineer oxygen vacancies in cerium oxide nanoparticles to modulate reactive oxygen species (ROS). This work bridges fundamental materials science with biomedical applications, positioning the group at the forefront of precision nanomaterial design.

Complementing this, the INCERIA project, funded by AGAUR Indústria del Coneixement (Producte), focuses on developing cerium

8 ARTICLES	9.05 MEAN IMPACT FACTOR
4 FUNDED PROJECTS	2 CONTRIBUTIONS
2 OUTREACH IMPACT	1 THESIS
1 BOOK	

oxide-based formulations as adjuvants for therapies targeting retinal diseases characterized by pathological angiogenesis.

The group also plays an active role in the ENDONANO project, funded by the European Commission through the Marie Skłodowska-Curie Initial Training Network (ITN) program. This project develops innovative nanotechnology-based methods for the quantitative detection of bacterial endotoxins, advancing diagnostic capabilities.

In the catalytic domain, the SAPHNa project, supported through the Women Talent Postdoc program, pioneers the design and fabrication of Pt-based hollow nanocrystals engineered for superior catalytic performance.

The CEOTOM project, supported by SO3 Seed Funding, explores gold–ceria hybrid nanoparticles as advanced theragnostic agents, combining enhanced CT imaging with mitigation of radiation-induced oxidative stress—integrating diagnostics with protective therapeutic action.

In the food safety sector, the project "Nuevos sistemas de inmunoanálisis automatizados para la detección de alérgenos en alimentos", supported by the Consejo de Administración del Centro para el Desarrollo Tecnológico y la Innovación (CDTI), focuses on developing and optimizing automated immunoanalysis systems. It centers on the preparation and functionalization of amorphous silica for turbidimetric detection, offering a competitive alternative to current polystyrene nanoparticle-based technologies.

Finally, the group contributes to the international NANOBIOREAL project, funded by the Research Council of Norway, which aims to establish robust methodologies for assessing nanomaterial safety using advanced in vitro biological models—strengthening international collaboration on nanosafety assessment.

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MAGNETIC NANOSTRUCTURES GROUP

JOSEP NOGUÉS
ICREA Research Professor and Group Leader

MAIN RESEARCH LINES

- **Exchange coupling in bi-magnetic core/shell nanoparticles and nanostructures**
- **Magneto-optic-mechanic nanostructures for biomedical applications**
- **Nano/micro-structures for environmental remediation**
- **(Photo)electrochemical nanostructures with self-motility and magnetic coupling**
- **Novel magnetic and structural characterisation tools for nanostructures**
- **Innovative fabrication approaches**

NEW PROJECTS & MILESTONES

The group finished the research in the Spanish Proof-of-Concept STERILAIR (led jointly by Prof. Josep Nogués and Dr Borja Sepúlveda), where a fully functional air filter system based on steel porous structures heated by magnetic induction has been developed and demonstrated to eliminate 99.99% of SARS-COVID virus.

The Proof-of-Concept MAPSCALE (led jointly by Prof. Josep Nogués and Dr Borja Sepúlveda) deals with the upscaling of the fabrication of magneto-plasmonic nanoparticles for biomedical application. A new sputtering system incorporating a roll-to-roll set up is being built in collaboration with the Instrumentation Division.

10 ARTICLES	11.35 MEAN IMPACT FACTOR
5 FUNDED PROJECTS	13 CONTRIBUTIONS
1 THESES	1 CONGRESSES ORGANISATION
1 BOOK	5 OUTREACH IMPACT
3 COURSES	

The MOTYCAT project has been running under the leadership of Dr Esplandiu. This project aims at the development of multicomponent and anisotropic micro/nanoreactors with motile capabilities for water remediation through photocatalytic degradation of pollutants under visible light or through pollutant capture via ion-exchange. The project also pursues the in-situ and direct synthesis of highly valuable compounds.

The group been working in the MOMTHER project (led jointly by Dr Alejandro Gómez and Prof. Josep Nogués). The project is based on the development of wireless controlled anisotropic nanostructures with magnetic-optic-electric and mechanical actuation and detection. These nanostructures will be used to design amplified therapies for cancer and neurological diseases .

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NANOBIOELECTRONICS AND BIOSENSORS GROUP

ARBEN MERKOÇI
ICREA Research Professor and Group Leader

15 ARTICLES	8.07 MEAN IMPACT FACTOR
12 FUNDED PROJECTS	35 CONTRIBUTIONS
5 THESES	15 CONGRESSES ORGANISATION
4 AWARDS	8 OUTREACH IMPACTS
7 COURSES	

NEW PROJECTS & MILESTONES

In 2024 the group has continued working on the following European projects, in addition to national projects. The first one, MICROBPREDICT (Microbiome-based biomarkers to predict decompensation of liver cirrhosis and treatment response) aims to develop personalised strategies to prevent and treat decompensated cirrhosis and acute-on-chronic liver failure by investigating the human gut microbiome. The second EU project is EMERGE (Emerging Printed Electronics Research Infrastructure). And finally, SUSNANO project, a Horizon Europe Twinning project together with UP /CATRIN (Czech Republic) as high-quality Twinning partner. The idea of this project is to boost the scientific excellence and innovation capacity in sustainable

MAIN RESEARCH LINES

- Innovative nanocomposites with improved electronic/catalytic properties, spatially-oriented anchoring substrates and highly sensitive electro/colorimetric readouts for sensing applications
- Paper-based biosensors modified with laser patterned rGO to enable electrochemical sensing on paper substrates without altering the paper microfluidic properties, thanks to our proprietary stamping method
- Novel signal enhancement strategies that can be applied on colorimetric and electrochemical sensors based on the optimization of bioreceptors proportion on nanomaterials surface
- Plug & play printing platforms for the ubiquitous fabrication of low-cost, wearable and environmental-friendly nanomaterial biosensors with nanofunctional inks, using commercially available office printers
- Multilayered graphene and magnetic nanoparticle sensors printed on flexible polymers for the development of sensitive biosensors with impedimetric readout
- The development of cleanroom-free nanoband electrodes for ultrasensitive detection applications
- Integration of these clean-room free nanoband electrodes into Lateral Flow Assays to create nano-eLFAs
- Fabrication of nanoelectrode based micropores for the sizing and counting of blood cells for anaemia diagnosis

nanosensors for water pollution detection of Universiteti I Tiranes (UT). This is an important project which will contribute to strengthen the new NANOBALKAN center in Albania.

Another international project is GLEBIOASSAY in collaboration with the Hospital Sant Joan de Déu (Spain) and Palacký University Olomouc (UP)/CATRIN (Czech Republic). This project, funded through the EuroNanoMed-III call, aims to develop a multiplexed point-of-care nanobiosensing platform to monitor the efficacy of the naxitamab-based immunotherapy in neuroblastoma. Also, we

MAIN RESEARCH LINES

- Investigation of next generation lateral flow assay technologies that improve sensor performance, including the development of eLFAs and novel signal transduction methods
- The optimisation of aptameric lateral flow assays for phenylalanine detection for PoC phenylketonuria and acute-on-chronic liver failure (ACLF) diagnosis. Including the set-up of an in-house SELEX workflow for aptamer discovery. Particularly focussed on small molecule biomarkers for ACLF
- Development of nanoscale electroactive molecularly imprinted polymers (non-eMIPs) for the detection of small molecule biomarkers for ACLF

have a Horizon Europe project 2D-BioPAD (Supple Graphene Bio-Platform for point of- care early detection and monitoring of Alzheimer's Disease).

We have started a new EU funded Twinning Project, Know4Nano, a collaboration between ICN2, CNR (National Research Council, Italy) and the University of Chemistry and Technology (Czech Republic) to boost the excellence in research and technology transfer of the Biosense Institute (Serbia).

We also continued working on our four national projects: NANOANAEMIA (Multiplexed nanobiosensor for the instantaneous diagnosis and classification of anaemia at the point of care), PAPYRUs (Polymerase Amplification combined into a Paper-based electrochemical lateral flow arraY for antimicrobial Resistance qUantification) and FULLPOC (Fully Integrated nanomaterial-based point-of-care devices for health-care applications). In 2024 we started the ScreenEC project (Development of a non-invasive IVD for endometrial cancer screening on high-risk populations), a collaboration with a Vall d'Hebrón spin-off company, MIMARK.

During 2024 our group was the main contributor in the organisation of NanoBalkan International Conference (NB2024) with interest also for the NANBALKAN research center.

During 2024 four PhD students of the group defended their PhD thesis: Liming Hu, Gabriel Maroli, José Alfonso Marrugo and Celia Fuentes.

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NANOBIOSENSORS AND BIOANALYTICAL APPLICATIONS GROUP

LAURA M. LECHUGA
CSIC Research Professor and Group Leader

9 ARTICLES	7.99 MEAN IMPACT FACTOR
9 FUNDED PROJECTS	24 CONTRIBUTIONS
2 AWARDS	8 OUTREACH IMPACTS
2 COURSES	2 THESIS

MAIN RESEARCH LINES

- Plasmonics (SPR) and nanoplasmonics (LSPR) biosensor technologies
- Photonics-integrated biosensor nanotechnologies
- Lab-on-a-chip integration and prototyping as point-of-care (POC) biosensor devices
- Robust and innovative surface biofunctionalization strategies and biochip packaging
- Application and validation for clinical diagnostics, biomedical studies, and environmental control

NEW PROJECTS & MILESTONES

The primary goal of the NanoB2A group is to develop, fully validate, and transfer innovative optical biosensor technologies for precision diagnostics, biomedical analysis, and environmental monitoring. Our work focuses on two main platforms: nanoplasmonics, including SPR and LSPR biosensors, and silicon photonics, particularly our pioneering bimodal waveguide (BiMW) interferometric biosensor.

We have accomplished significant milestones, such as the full integration and clinical validation of a compact, multiplexed nanoplasmonic biosensor device and the set-up and optimization of a novel BiMW prototype for ultrasensitive, multiplexed analysis (patent application in process). In parallel with the technological developments, we have demonstrated the potential of our biosensors for a range of medically relevant applications. These include the rapid identification of respiratory viruses (PROXIM project, 2021-PROD-00191), monitoring of COVID-19 circulation in humans and animals (MUSECOV project, PCI2020-120687-2), early detection of neurodegenerative diseases and sepsis (POINTED project, PDC2021-121325-IOO). Besides, as part of the collaborative PHITBAC project (PLEC2021-121325-I00), the group has made significant progress in the rapid diagnosis of antimicrobial resistance (AMR), specifically addressing the clinical workflow of bacterial infections. This includes pathogen identification, antibiotic resistance profiling, and therapeutic drug monitoring (TDM), enabling an efficient and highly personalized management of the patient.

A unique strength of our group is the investigation and development of innovative sensor biofunctionalization strategies. In this regard, we have advanced in the development of biomimetic sensors based on artificial cell membranes for the evaluation of immunotherapies targeting cancer and infectious diseases (ICN2-SO-WTP). Also, through a long-term collaboration with the ICN2 Supramolecular Nanochemistry and Materials group led by Prof. Daniel Maspoch, we have incorporated novel metal-organic polyhedral (MOP) to our sensors for the sensitive detection of pollutants in water. Based on these results, we have obtained an ICN2-SO funded project (SAMOA) to explore further the capabilities of these new MOP-integrated nanophotonic sensors.

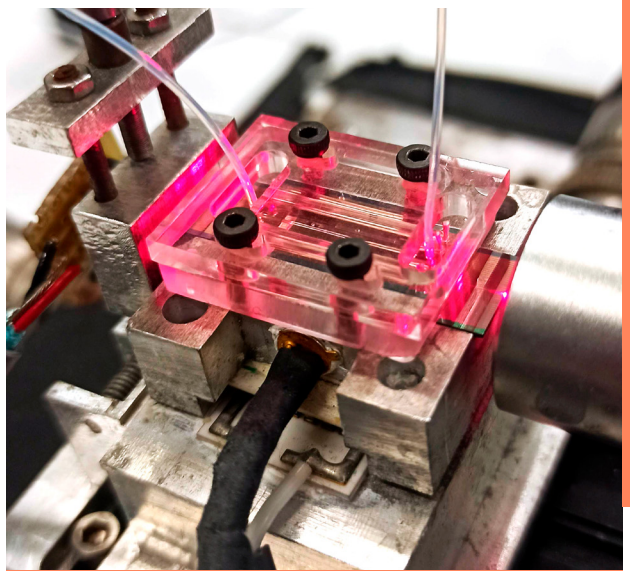
In 2024, we started a national Proof-of-Concept project (TYPLEX, PDC2023-145891-I00) that focuses on the prototyping and full validation of a nanophotonic microchip-based biosensor for precision diagnostics of Sexually Transmitted Infections (STIs). In this area, we have coordinated the DIGITS project, funded by the Barcelona City Council and La Caixa

Foundation, that addresses the point-of-care (POC) detection of chlamydia and gonorrhoeae, especially directed to facilitate routine screening in young and vulnerable population.

Additionally, the group is actively participating in two large HORIZON Europe projects. AMBROSIA (HORIZON-CL4-2022-DIGITAL-EMERGING-01-03) aims at developing an innovative biosensor system for fast, accurate diagnosis of sepsis based on plasmo-photonic technology and artificial intelligence (AI)-assisted data reading. It involves 12 partners, including academic institutions, industry, and hospitals. On the other hand, the NIAGARA project (HORIZON-CL6-2022-ZEROPOLLUTION-01) aims at developing strategies to solve the widespread issue of water pollution, involving academic researchers, companies, and policy makers. Our work focuses on the integration and validation of a multianalyte biosensor based on nanophotonic technology for monitoring of industrial, pharmaceutical, and microbiological contaminants in drinking water.

Finally, in the last year, we launched to new national projects from the Generación de Conocimiento call, funded by the Spanish Research Agency (AEI), both led by senior researchers of the group. The PRIME project (PID2023-1515240B-I00), led by Dr. Maria Soler (RyC Senior Researcher), will develop novel biomimetic nanophotonic technologies to facilitate the design and implementation of personalized cell immunotherapies for cancer. The SENTINEL project (PID2023-1489250B-I00), led by Dr. M. Carmen Estévez (CSIC Tenure Scientist), aims at developing a point-of-care biosensor for rapid and sensitive detection of fungal pathogens, a key diagnostic need in immunocompromised patients.

Through these projects, we have established crucial collaborations with prestigious hospitals, research institutions, and leading industry both nationally and internationally. We have secured public funding as well as research fellowships and contracts for the next years. Importantly, we have made a substantial progress in technology prototyping and validation that will consolidate and boost the technology transfer process toward the commercialization and implementation of our nanophotonic biosensors as medical devices.



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NANOELECTROCATALYSIS AND SUSTAINABLE CHEMISTRY GROUP

MARÍA ESCUDERO ESCRIBANO
ICREA Research Professor and Group Leader

MAIN RESEARCH LINES

- **Functional nanomaterials for green hydrogen production and utilisation**
- **Electrochemical reduction of carbon dioxide into renewable fuels and chemicals**
- **Electrochemical methane activation and conversion into green methanol**
- **Sustainable electrosynthesis of value-added chemicals**
- **Surface nanostructuring and atomic ensemble control**
- **Mechanistic investigations of electrocatalytic reactions with in-situ/ operando vibrational spectroscopy and scanning probe microscopy**

7 ARTICLES	**6.86** MEAN IMPACT FACTOR
4 FUNDED PROJECTS	**5** CONTRIBUTIONS
1 AWARDS	**3** CONGRESSES ORGANISATION
1 OUTREACH IMPACTS	

NEW PROJECTS & MILESTONES

Research at the NanoElectrocatalysis and Sustainable Chemistry (NanoESC) Lab (nanoesclab.com) aims to elucidate the design principles for the discovery of new materials and interfaces for renewable energy conversion and production of sustainable fuels and chemicals. In 2024, the group has developed highly innovative research lines in electrochemistry, atomic-scale materials engineering, in-situ/operando vibrational spectroscopy, and scanning probe microscopy methods at ICN2. Key new and ongoing projects are summarized below.

The NanoESC Lab uses a multidisciplinary approach to engineer new nanomaterials, elucidate the reaction mechanisms and gain atomic-scale insight into the active sites. In 2024, the team installed a unique combination of electrochemical and in-situ methods to achieve these goals, including:

- In-situ/operando Raman spectroscopy, to carry out surface-enhanced and shell-isolated nanoparticle-enhanced Raman spectroscopy (SERS and SHINERS, respectively), key to elucidating the molecular mechanisms of electrocatalytic reactions.
- Electrochemical scanning tunnelling microscopy (EC-STM) with atomic resolution and scanning electrochemical microscopy (SECM) to visualize the active sites at the atomic level gain a deeper understanding of the reaction mechanisms.

Atomic-scale tailored materials for electrochemical methane activation and conversion

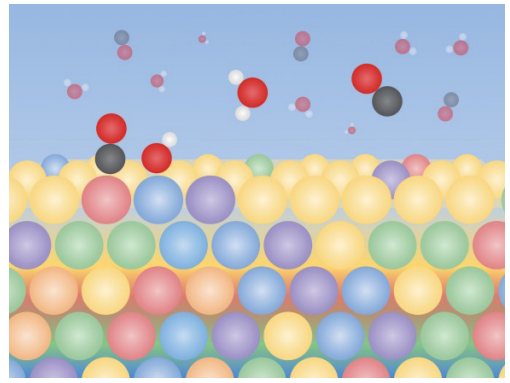
The electrochemical methane to methanol conversion is a dream reaction that would convert a greenhouse gas into a green, liquid fuel, powered by renewable electricity. However, sustainable C-H activation and methane to methanol conversion at ambient conditions remain as great fundamental challenges. Within the ERC Consolidator Grant ATOMISTIC (2023-2028), funded by the European Research Council, the NanoESC Lab is carrying out pioneering research on electrochemical methane activation and conversion. The group is investigating structure sensitivity and electrolyte effects and combining electrochemical methods with in-situ characterisation to understand C-H activation and design active and selective catalyst materials.

Active site engineering of functional electrocatalysts for renewable fuels production

In 2024, the NanoESC Lab started two new projects: ELECTROFUEL (2024-2027) and HYDROCAT (2024-2026). ELECTROFUEL, funded by the Spanish Ministry of Science, Innovation and Universities, aims to engineer the structure of the active site on functional materials to optimize selectivity toward key reactions to produce green fuels and chemicals. These reactions include: i) Electrochemical water oxidation for green hydrogen production; ii) carbon dioxide conversion into renewable fuels; iii) nitrate conversion into green ammonia. The first reaction is also the focus of HYDROCAT, funded by the Government of Catalonia (AGAUR). Within this project, the group is investigating new hybrid electrocatalysts for green hydrogen production.

Emerging materials and reactions for the synthesis of sustainable chemicals

The NanoESC Lab is investigating new reactions and materials for the sustainable synthesis of commodity chemicals. Relevant projects include EIC Pathfinder Grant ICONIC (2023-2026) funded by the European Innovation Council and the Pioneer Center for Accelerating Power-to-X Materials Discovery CAPeX (2023-2036). The group is studying electrochemical C-N coupling to produce sustainable fertilisers such as urea, combining catalyst-electrolyte engineering and in-situ spectroscopy to understand the reaction mechanisms and design more efficient catalysts. Moreover, the team is investigating new materials for selective oxidation reactions to synthesize commodity chemicals.



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NANOMEDICINE LAB

KOSTAS KOSTARELOS
ICREA Research Professor, Severo Ochoa Distinguished Professor and Group Leader

8 ARTICLES	**27.96** MEAN IMPACT FACTOR
1 FUNDED PROJECTS	**10** CONTRIBUTIONS
13 OUTREACH IMPACTS	**1** AWARD
3 COURSES	

MAIN RESEARCH LINES

- **Nanomaterials as transport systems for therapeutic and diagnostic applications against cancer and neurodegenerative disease**
- **Clinical translation of advanced nanomaterials (including graphene and 2D materials)**
- **Discovery of novel liposome and vesicle systems to be used as components of therapeutics in oncology and neurologyDiscovery of novel biomarkers and therapeutic targets in oncology**
- **Neurotechnology based on flexible, thin-film technologies for therapeutic applications in oncology and neurology**
- **Contribute to the framework for ethical use of nanotechnology and neurotechnology**

Our mission is to pioneer the cutting-edge and emerging discipline of nanomedicine by bringing advanced materials and nanoscale platforms to the clinic.

The Nanomedicine Lab aim is the development of novel, safe and effective therapeutics based on nanoscale components and their combinations, used as either the 'drug' or the 'transport system'. Such components have included small molecules, DNA, RNA, viruses, stem cells, radionuclides, liposomes, graphene, 2D-heterostructures, carbon nanotubes and other nanomaterials (quantum dots, fullerenes, carbon nanohorns).

The research efforts taking place within the Nanomedicine Lab have been cross-cutting disciplines, bridging the gap between fundamental nanomaterial engineering and medicines development towards the realisation of advanced therapeutic modalities.

The Nanomedicine Lab has strong links with the Center for Nanotechnology in Medicine at the Faculty of Biology, Medicine and Health of The University of Manchester.

NEW PROJECTS & MILESTONES

Two recent first-in-human clinical trials championed by the Nanomedicine Lab using our materials and technologies developed for medical use, include: pulmonary safety with the Royal Infirmary of Edinburgh (completed), and precision-enhancing surgical removal of aggressive brain cancer with Salford Royal Hospital (ongoing). This clinical trial is sponsored by the University of Manchester and supported by INBRAIN Neuroelectronics (a start-up we co-founded with Prof. Jose A. Garrido) as the legal manufacturer of the devices, and executed by our long-term collaborator Dr David Coope, neurosurgeon in the Manchester Centre for Clinical Neuroscience as the Chief Clinical Investigator of the trial.

In 2024 the Nanomedicine Lab was awarded one of the ERC Synergy Grants to co-develop the SKIN2DTRONICS project, which aims to integrate ultra-conformable electronics based on 2D materials to monitor brain cancer recurrence. This is the first time an ERC Synergy Grant has been awarded to an ICN2 research group and was major milestone in the recruitment strategy of the Nanomedicine Lab. The work programme will start in May 2025.

Lastly, at the individual level, Prof. Kostarelos was awarded the BRIDGE Fellowship by the Japanese Society for the Promotion of Science (JSPS) hosted by the University of Tokyo in September 2024.

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NANOSTRUCTURED FUNCTIONAL MATERIALS GROUP

DANIEL RUIZ-MOLINA
CSIC Professor and Group Leader

14	ARTICLES	8.59	MEAN IMPACT FACTOR
11	FUNDED PROJECTS	21	CONTRIBUTIONS
2	BOOK CHAPTERS	3	COURSES
1	CONGRESS ORGANISATION	8	AWARDS
18	OUTREACH IMPACT		

MAIN RESEARCH LINES

- **Synthesis, characterization and application of nanomaterials for biomedical applications mainly nanoparticles, nanocapsules or thin films using biocompatible and bioinspired materials, aiming to improve drug delivery, tunable release profiles, enhance the crossing of biological barriers, increase the in-vitro and in-vivo optical imaging properties or favor tissue regeneration**
- **Synthesis, characterization and application of novel energy-efficient devices based on chromogenic and emissive materials. Light, pH and temperature-responsive films, cellulose papers, paints and inks are used to obtain organic light-emitting devices, dynamic light filters (for their use in smart windows, ophthalmic glasses, etc.), rewritable devices, and anticounterfeiting technologies**
- **Another area where the group has been very active in the development of functional coatings for environmental applications and sustainability. We have developed coatings with antimicrobial properties for clinical textiles or CO2 capture, taking advantage of recycled paper, fabrics, etc**

NEW PROJECTS & MILESTONES

Biomedical applications. Our primary objective is the continuous developing of advanced therapies for neurodegenerative diseases, infections and tissue regeneration, as described next:

» Neurodegenerative diseases and brain cancer: improve intranasal administration for the targeted delivery of therapeutics, aiming to improve brain penetration and treatment efficacy. For this, materials such as polyphenol-based hydrogels will be developed. Additionally, we aim to optimize bioadhesive membranes for localized drug delivery to optimize its therapeutic potential in glioblastoma and other neurodegenerative conditions, always including in vivo experiments.

» Infection and antimicrobial resistance: validate polyphenol-inspired antimicrobial materials in medical devices, coatings, and wound healing, especially for multidrug-resistant bacteria and fungi. We also plan to explore novel ways of incorporating bioactive compounds into coatings and devices combing synergistic effects such as photothermal effect

» Tissue regeneration: further validate our bioadhesive scaffolds and regenerative platforms, by improving the delivery of growth factors, stem cells, and other regenerative molecules. We also aim to optimize their application in tissues like cartilage, skin, bone or on emerging properties, such as conductivity, for neuronal modulation and/or nerve regeneration.

» Clinical and industry collaborations: We will deepen our existing partnerships with hospitals such as Hospital Universitari Vall d'Hebron, Hospital del Mar and Hospital de Bellvitge to ensure that our research can be translated into clinical settings.

» Navigating the regulatory landscape for the approval of new medical devices and therapies, ensuring that our materials meet the required biocompatibility and safety standards required for translating our research into clinical applications.

» Precision medicine: by leveraging bioadhesive membranes and targeted drug delivery systems, we aim to improve the treatment of neurodegenerative diseases and cancer, offering tailored solutions to patients. We will also focus on tissue regeneration to offer enhanced healing process.

Recently, a patented technology has been licensed to a new biotech-based Spin-Off: Tirecat Health S.L. This new Spin-Off is devoted to the development of bioinspired membranes for tissue regeneration, which belongs to the European Patent "Catecholamine-based membrane, process for its preparation and uses thereof" (WO2022258780 A1).

Environmental remediation (collaboration with private sector), especially aiming to expand the development of eco-friendly and sustainable materials for pollutant removal:

» Water remediation: improve our selective capture and elimination technologies for water contaminants, particularly heavy metals, organic pollutants, and emerging contaminants (e.g., pharmaceuticals). We aim to create more efficient and reusable coatings for water filtration, potentially applying these materials in large-scale water treatment systems, ensuring both sustainability and high performance.

» Air remediation: develop high-performance materials capable of removing airborne pollutants (using nanoparticles and membranes), easily integrated into existing infrastructure for air purification and carbon capture, as well as enhancing their efficiency and longevity.

» Sustainable materials: establish a new avenue for creating bio-based, recyclable materials that can replace petroleum-based products, as an eco-friendly alternative to potentially reduce the environmental impact of waste. This could significantly contribute to solving global environmental challenges and establishing our group as a leader in the field of sustainable nanotechnology.

» Industrial collaborations in water purification and sustainable materials. These collaborations will provide vital real-world testing environments for our innovations and help guide their commercialization. One of the primary challenges will be scaling up our lab-based prototypes using good laboratory and manufacturing practices (GLP and GMP).

» Building energy efficiency: we will work on new technologies for smart windows.

» Bring to the market the most advanced technologies, through the collaboration with the spinoff and glass companies.

» Merge and look for synergies between current technologies, as for example (smart windows with luminescent solar concentrators, to obtain smart LSCs that not only modulate the light transmittance but also generate current when absorbing incident light.

» Moving transmittance modulation towards near infrared region, which accounts for the 55% of the solar energy

» Start exploring radiative cooling modulation in the middle infrared

To achieve these goals, we will apply for national and EU grants (e.g. EIC Pathfinders), as well as collaboration with private companies, which will guide us on the main requirements for commercialization.

Safer society. In this respect we aim to continue developing stable, reproducible and high-contrast colorimetric sensors, sensitive to temperature and oxygen, of relevance for food packaging. On the other hand, these stimuli-responsive materials could be exploited for further anticounterfeiting markers which will be co-developed with our spinoff Distinkt.

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NANOSTRUCTURED MATERIALS FOR PHOTOVOLTAIC ENERGY GROUP

MÓNICA LIRA-CANTÚ
CSIC Research Professor and Group Leader

MAIN RESEARCH LINES

- **Novel sustainable and green materials for Photovoltaics (Next-generation thin film, organic, hybrid, dye-sensitised, halide perovskite and all-oxide solar cells) and Poto(electro)catalysis**
- **Green synthesis of nanomaterials by low-cost, low temperature and green solution processing methods**
- **Solution processing methods for the fabrication of solar cells and printed electronics**
- **Degradation studies of the stability of solar cells following ISOS protocols**
- **Semiconductor oxides for energy, ICT applications, printed electronics**
- **Self-powered, transparent, flexible electronic and optoelectronic devices**
- **In-situ characterization techniques**
- **Electrochemical Impedance Spectroscopy**

NEW PROJECTS & MILESTONES

The NMPE group research objectives are focused on the synthesis of novel nanomaterials and the control of their optoelectronic properties through their manipulation at molecular level, with the aim of developing very stable and highly efficient perovskite solar cells. We search for novel Pb-free halide perovskites (both hybrid and inorganic).

Specifically, our contribution is in the area of solution processable metal oxides (classical and complex), halide perovskites (Pb-free, 2D and 3D) and 2D materials and MXenes. We aim at the development of highly stable solar cells for industrial applications (e.g. building integration PV) and novel self-powered photovoltaic-based devices for Internet of things (IoT) applications (e.g. sensors, wearables, printed electronics). The group,

6 ARTICLES	**10.18** MEAN IMPACT FACTOR
8 FUNDED PROJECTS	**37** CONTRIBUTIONS
1 THESIS	**2** CONGRESSES ORGANISATION
2 COURSES	

with more than 15 years of experience in the field, is internationally recognised for its involvement in the enhancement of the operational stability of emerging photovoltaics and the development of ISOS protocols.

Fundamental Research Lines

Various of our lines of study are related to highly innovative and fundamental research within technology readiness levels (TRLs) below 3. We aim at the synthesis of materials as absorbers, transport layers and interfaces in solar cells. This line includes the synthesis of novel materials such as Pb-free halide perovskites, 2D materials and halide perovskites, novel anti-perovskites.

We work on the development of novel heterojunctions of MXenes (and 2D materials) with perovskites for their application in photovoltaics,photo(electro) catalysts and memristors. One of the objectives of this research is the manipulation of materials properties to enhance solar cells stability and the understanding of the mechanisms that permit their stability. We focus on the study and passivation of point defects of materials and interfaces.

We have also developed our own in-situ characterization methodology to study the materials and solar cell degradation under operando conditions. For this, we employ in-situ X-Ray diffraction analysis, Rama spectroscopy, Photoluminescence and Electrochemical Impedance Spectroscopy, among others. We employ indoor and outdoor stability procedures following ISOS protocols.

Another major goal of the group is the synthesis of nanostructured materials, especially those involving transition metal oxides (TMOs), via the application of low cost and solution processing methods.

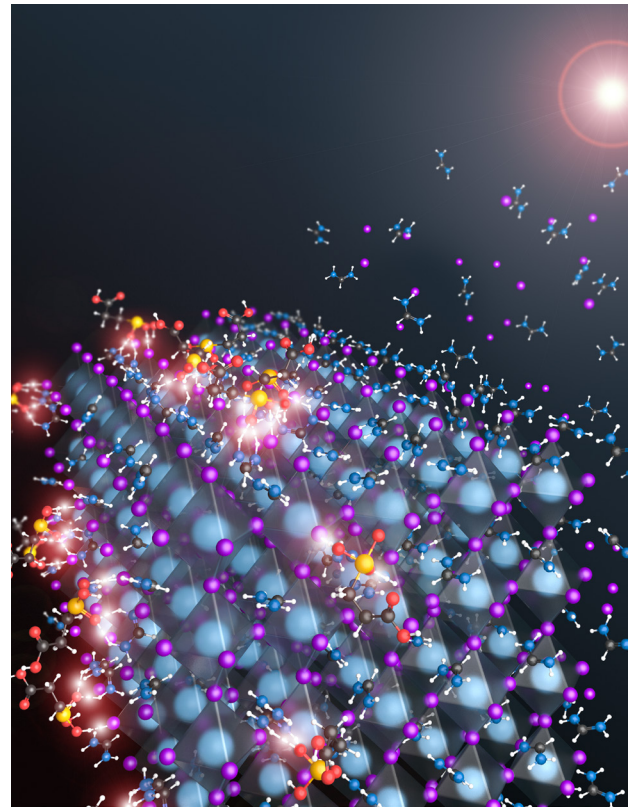
They have many possible applications as main active materials or barrier layers, but also as materials for external light management. The use of low-temperature synthesis methods (sol gel, hydrothermal, SILAR, among many others) permits tuning and controlling the properties of the final device. These oxides are being applied in our group as nanostructured materials (nanorods, nanowires, nanotrees, core-shell, etc.) and dense thin films in the various next-generation solar cells, offering excellent performance in term of efficiency and lifetime. We are now functionalising these oxide surfaces by anchoring self-assembled anchoring groups to interact simultaneously with the oxide and the active light harvesting material.

Applied Research Lines

Our applied research lines are dedicated to the development of novel and innovative devices whose technology readiness levels (TRLs) can be up to 7. We are working on high-efficiency perovskite solar cells and novel printed electronic devices, which can allow the group to collaborate with industry and to obtain intellectual property rights. We are also collaborating with top laboratories for the development of protocols and standards, with the aim to make the perovskite solar cell technology reach the market.

The group also works on the development of self-powered electronic and optoelectronic devices, as well as flexible and transparent devices for ICT and electronic applications.

We are employing machine learning for the elucidation of degradation mechanisms in Perovskite solar cells and the finding of a correlation between indoor and outdoor stability and accelerator factors for device degradation. Our aim is to employ machine learning also for the study of novel nanomaterials and data treatment.



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NOVEL ENERGY-ORIENTED MATERIALS GROUP

PEDRO GÓMEZ-ROMERO
CSIC Research Professor and Group Leader

8 ARTICLES	5.03 MEAN IMPACT FACTOR
4 FUNDED PROJECTS	18 CONTRIBUTIONS
1 THESIS	6 OUTREACH IMPACT
1 COURSE	1 AWARD

MAIN RESEARCH LINES

- Hybrid electrode materials for supercapacitors, batteries and hybrid energy storage devices
- Nanocarbons (graphenes, nanopipes, porous nanocarbons) for batteries and supercapacitors
- Nanomaterials for Zn-ion and Zn-Air batteries. Polyoxometalates
- Nanopastes / Nanogels for energy applications
- Harvestorage (triboelectric/supercapacitors) materials and devices

NEW PROJECTS & MILESTONES

The NEO-Energy group has reached a healthy equilibrium in 2024. Scientifically, we have continued our work on materials and devices for ground-breaking energy storage. Dr. Rosa M. González Gil is now a consolidated post-doc managing new projects and contributing to a more robust group structure. And Dr. Leandro Bengoa has continued his innovative input in the group with new emphasis on Zn-Air batteries. Finally, Napptilus Battery Labs, our startup company keeps maturing our fast-charging low-cost battery technology.

We still believe that the emphasis of our work should change from the writing of highly-cited articles to the production of materials and energy storage technologies with direct impact on our society. This is particularly true for our energy-related applications and in the critical times we are living. In this respect, I totally despise and disregard the figures of "Mean Impact Factor" of the Journals in which our publications appear, because they say nothing about the real impact of our work and go against the DORA declaration both ICN2 and CSIC have signed.

We don't forget about the fundamentals and the broad view of our field. In this respect, I have had the privilege to contribute a unique review (a metareview I dubbed it) on the very broad field of hybrid materials ("Hybrid Materials. A Metareview." Pedro Gomez-Romero,*, Anukriti Pokhriyal, Daniel Rueda-Garcia, Leandro N. Bengoa and Rosa M. González-Gil. Chemistry of Materials (ACS) 2024, 36 (1), (8-27).

But in our group the fundamentals are put to work to contribute to solve grand challenges in the world of applications and in particular energy storage.

These applied targets have been fostered by the development of our projects, all focused on energy storage and at the same time quite complementary in their specific objectives:

Thus, NANOPEISTORAGE is a "Proyecto de Generación de Conocimiento (Investigación Orientada)" addressing fundamental aspects of the electrode- electrolyte interface in energy storage devices based on nanopastes. The project REVOLT, on the other hand, deals with nanopastes as well but it is decidedly focused on the design of devices and their final application. REVOLT is funded within the programme of "Lineas Estratégicas" and is developed between ICN2 and the startup company "Napptilus Battery Labs" (NBL), originated as a spinoff rooted in the materials and technologies developed by our group. Our collaboration with NBL includes publicly funded projects like REVOLT but also privately funded contracts to optimize, advance the TRL and scale-up our technology. NBL results are very positive. The great dedication of Dr. Daniel Rueda and Veronica Fabian have a lot to do with this success. I strongly believe that the public-private collaboration of our group and center with Napptilus Battery Labs is exemplary.

Concerning other projects, we should highlight the very good results of our TED project to develop a new type of Zn-Air battery, based on polyoxometalates (POMs) as bifunctional electro-catalysts under near-neutral pH conditions. This is a project developed in collaboration with the group of prof. Nieves Casañ-Pastor at ICMAB. In this topic of Zn-Air batteries, the work in the group of Dr Leandro N. Bengoa supported with a Marie S. Curie Fellowship has been crucial to success. This line has also been reinforced with the contract of Dr. Riccardo Argurio and with the incorporation of Andrea Inclán as a new PhD student.

In our group, presential congresses were reduced to a minimum, with online participation gaining weight during this 2024 year. Maybe we should keep using these more sustainable alternatives in the future. Shouldn't we?

Besides our enhanced technology transfer efforts, our group has continued working on the fundamentals of our NEO-Energy brand research, namely, hybrid electrode materials for hybrid energy storage. We focused not only on materials, but also on energy storage devices, which we strived to further develop, with emphasis on supercapacitors, batteries, and their hybrids.

We give more details about each research line in the following paragraphs.

From hybrid materials to hybrid devices for improved energy storage

The boundaries between batteries and capacitors are quickly blurring. Control over nanostructures is of great importance in the design of high-performance energy storage devices. We are developing materials with high specific surfaces, as well as ultra-dispersed molecular materials like polyoxometalates (POMs) for application in electrochemical energy storage devices featuring the best properties of batteries (high energy density) and supercapacitors (high specific power, fast charging, long cyclability). Two PhD thesis works have been tackling this topic (Anukriti Pokhriyal's Thesis, defended 14/11/2024 and Lipeng Wang, ongoing) from different points of view. We have published a review article on the use of polyoxometalates in energy applications, a topic in which our group was a pioneer.

To flow or not to flow? Meet Nanopastes

Our previous works on conventional LIBs batteries and on Flow Batteries made us converge in a middle point in the form of batteries formed by pastes, more specifically, nanopastes, in which solid electrode materials (preferably hybrid) are nanodispersed in liquid electrolytes (which could also be "hybrid". This leads to a complex but fascinating materials landscape from which final improved performance in energy storage is taking place.

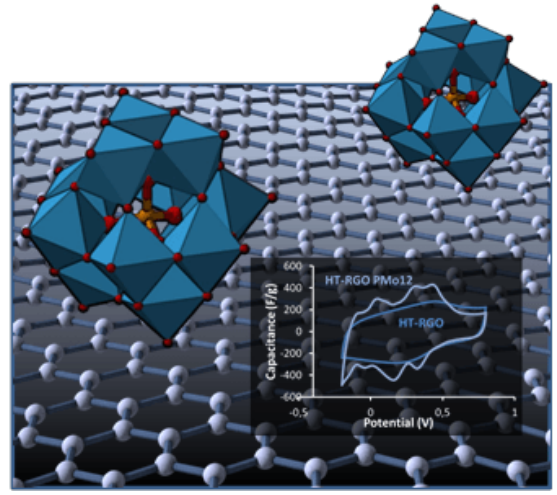
From Zn-Ion Capacitors to Zn-Ion batteries

Zinc is one of the most promising post-lithium technologies. We are presently working on an integrated scaled approach to advance in this technology: integrated because we pursue the simultaneous development of compatible and integrated components (anode, electrolyte cathode); scaled because we work stepwise on devices of increasing complexity, from Zn-Ion capacitors to Zn-Ion batteries to Zn-Air batteries. The ultimate goal is to develop Zn-Air batteries working at near neutral pH thanks to the bifunctional activity of Polyoxometalates.

Harvestorage materials

The coupling of our energy storage devices with harvesting devices was proposed in our strategic plan (as well as in the Severo Ochoa Programme 2018-2022). In 2024 Ms. Sharin M. Thomas keeps working on her PhD thesis on this topic.

Collaboration with various European groups working on triboelectric nanogenerators is being initiated, as well as an internal collaboration with Dr Elena del Corro.



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OXIDE NANOPHYSICS GROUP

GUSTAU CATALÁN
ICREA Research Professor and Group Leader

12 ARTICLES	10.96 MEAN IMPACT FACTOR
7 FUNDED PROJECTS	10 CONTRIBUTIONS
1 AWARD	2 OUTREACH IMPACT
1 THESIS	

MAIN RESEARCH LINES

- Flexoelectricity and piezoelectricity: fundamentals and devices
- Ferroelectrics, antiferroelectrics, multiferroics, metal-insulator transitions
- Electronic, electromechanical and photovoltaic properties of oxide thin films
- Domain wall nanoelectronics

NEW PROJECTS & MILESTONES

This year our research is steering into two new directions: free-standing (membrane) oxide films, and light-matter interactions in polar materials.

Among the former, we have produced the first free-standing antiferroelectric thin film capacitors of PbZrO3 (the reference antiferroelectric material), and shown that they have better (faster) switching efficiency than normal, substrate-clamped thin films [Saeed et al., Adv. Electron. Mater. 10, 2400102 (2024)]. We have also made photostrictive actuators based on ferroelectric membranes that, upon illumination, change their size. The lack of clamping allows such actuators to display much larger mechanical deformations than their epitaxial counterparts so, again, we find that substrate-free is not just fancy but useful [Ganguly et al. Advanced Materials 36, 2310198 (2024)].

Photostriction (light-induced deformation) is only one of the interesting light-induced functionalities of polar materials. Another that we are also interested in is the so-called bulk photovoltaic effect, whereby polar (or, as we showed, flexoelectrically polarized materials) can display large photovoltages, even bigger than their bandgap -a response that is not possible in conventional, junction-based photovoltaic cells. We have shown this year that halide perovskites, when subject to bending, can indeed display photovoltages bigger than the bandgap, thanks to the coupling between flexoelectric polarization and photovoltage, the so-called “flexophotovoltaic effect”. This article [Z. Wang et al., Phys. Rev. Let. 132, 086902 (2024)] was an “Editor’s Choice” in Physical Review Letters, and was also highlighted by the Physics Magazine of the APS [https://physics.aps.org/articles/v17/27].

The aforementioned result also illustrates our unabated activity in flexoelectricity, where we continue to be a worldwide reference, highlighted also by other works: [Catalan, Nature Physics 20, 358-359 (2024); S. Cho et al., Nat. Coms. 15, 387 (2024)].

Moving forward, we plan to continue working along these lines, and this year we have gained a national grant (PID2023-148673NB-I00, 220k€ + PhD student) to investigate gradient-induced photovoltaic and photostrictive phenomena. Stay tuned.

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PHYSICS AND ENGINEERING OF NANODEVICES GROUP

SERGIO VALENZUELA
ICREA Research Professor and Group Leader

MAIN RESEARCH LINES

- **Development of novel nanodevice structures and nanofabrication methods to investigate the physical properties of materials at the nanoscale and their technological relevance**
- **Investigation of topological properties and low energy propagation of information in quantum anomalous edge states**
- **Spin and thermal transport in two-dimensional systems, including topological insulators, graphene and transition metal dichalcogenides**
- **Control of the magnetic state of ferromagnetic systems by means of the spin-orbit interaction and, particularly, the spin Hall and spin galvanic effects**
- **Coupling in hybrid magnon-phonon-photon systems**
- **Quantum circuitry and quantum transduction**

4 ARTICLES	**5.5** MEAN IMPACT FACTOR
7 FUNDED PROJECTS	**18** CONTRIBUTIONS
2 OUTREACH IMPACTS	**7** CONGRESSES ORGANISATION
1 COURSE	**1** THESIS
1 BOOK CHAPTER	

NEW PROJECTS & MILESTONES

In 2024, the Physics and Engineering of Nanodevices (PEN) Group continued advancing spintronic applications based on graphene and related two-dimensional (2D) materials. The group investigated the thermal properties of transition metal dichalcogenides (TMDC) and studied proximity-induced spin–orbit fields and magnetic exchange effects using spin transport techniques. It also made significant progress in examining the spin properties of materials with strong spin–orbit coupling—particularly (magnetic) topological insulators grown using a dual-chamber molecular beam epitaxy (MBE) system. Furthermore, PEN developed multilayer, all-2D spin torque devices and demonstrated magnetization switching in structures just a few monolayers thick. This latter line of research will be further supported by the FLAG-ERA JTC 2021 project MNEMOSYN ("2D Magnetic Memories: Scalable Growth and Hybrid Electrical Operation").

Work has also been conducted as part of the national project "Van der Waals Heterostructures for Digital Technologies and Opto-Spintronics (HEDOS)", supported by the Spanish Ministry of Economy, Industry and Competitiveness (MINECO). The HEDOS initiative focuses on advancing the understanding of the spin Hall effect, as well as the charge and spin transport properties of graphene. It also explores the electrical injection and detection of hot carriers, and the efficiency of spin-to-charge conversion in graphene/TMDC hybrids. Additionally, the project aims to expand the group's research into optoelectronic and opto-spintronic phenomena in van der Waals heterostructures.

The group has coordinated two European projects—TOCHA and 2DSPINMEM (described below)—and participates in the quantum initiative led by ICFO, which focuses on the development of quantum transduction approaches Additionally, the group is a partner in the EIC Pathfinder project PALANTIRI ("Phase-sensitive Alteration of Light Coloration in Quadripartite Garnet Cavity"), coordinated by Spintec (France), which aims to develop quantum-coherent frequency upconversion technologies. It is also an active member of the SpinTronicFactory network, established to coordinate spintronics research across the EU, and represents the Bellaterra node of the Spanish Spintronics Network.

The TOCHA project ("Dissipationless Topological Channels for Information Transfer and Quantum Metrology", FETPROACTIVE), funded under the Horizon 2020 EU Research and Innovation Programme and concluded in June 2024, explored the use of topological concepts to enable next-generation devices and architectures capable of transmitting information with minimal losses. While conceptually straightforward, achieving these goals poses significant technological and fundamental challenges. Overcoming dissipation is critical for advancing technologies in fields such as information processing, quantum communication, and metrology—where information loss often results in excessive thermal loads or unacceptably high error rates. It also investigated the use of magnetic topological insulators in quantum resistance standards.

The 2DSPINMEM project ("Functional 2D Materials and Heterostructures for Hybrid Spintronic-Memristive Devices", M-ERA) investigated group-IV monochalcogenide (IV-MC) materials and conducted the first-ever evaluation of their potential as memristive elements. The project also developed graphene-based heterostructures to modulate the spin properties of graphene via proximity effects.

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SUPRAMOLECULAR NANOCHEMISTRY AND MATERIALS GROUP

DANIEL MASPOCH
ICREA Research Professor and Group Leader

MAIN RESEARCH LINES

- **Metal-organic frameworks (MOFs), covalent-organic frameworks (COFs) and metal-organic cages or polyhedra (MOPs)**
- **Functional delivery systems**

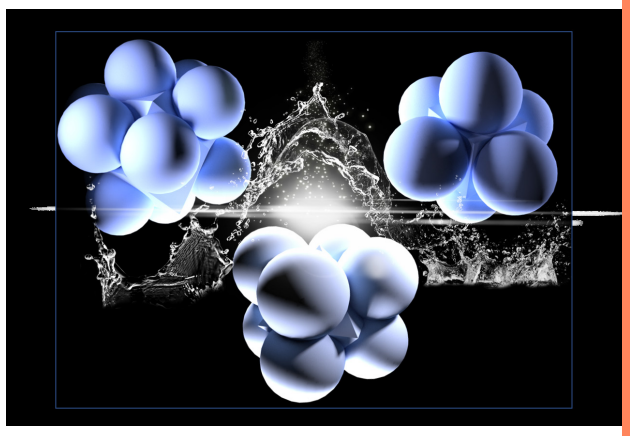
NEW PROJECTS & MILESTONES

In 2024, the group has also continued working on CLIPOFF-CHEM, which is supported by ERC under its Advanced Grant. This project aims to develop a highly innovative top-down synthetic method, based on controlling bond breaking in reticular materials to synthesize new molecules and materials. Also, the group has actively worked on DISASSEMBLE and MOFTONIC, both funded by the Spanish Ministry of Science and Innovation – AEI. These projects are focused on the full disassembly of reticular materials to obtain clusters and cages and on the self-assembly of colloidal MOF particles. The main objective of the fourth project, called ReMOVeAs and supported by the Spanish Ministry of Science and Innovation – AEI as well, is to develop new porous composites for the removal of arsenic in water. The fifth project is SGR 2021 (AGAUR), supported by the Catalan Government. And finally, the group has also actively worked on CHITINMETICS and FUNCYCLING, both funded by the Spanish Ministry of Science and Innovation – AEI. They are focused on the valorization of chitosan for the production of sustainable plastics for the cosmetics industry, and on the development and application of functional materials in sports clothing for cycling. The group has also continued to collaborate with companies to bring customised micro- and nano-encapsulation

12 ARTICLES	13.43 MEAN IMPACT FACTOR
8 FUNDED PROJECTS	15 CONTRIBUTIONS
3 AWARDS	2 THESES
3 OUTREACH IMPACT	5 COURSES

technologies to the market, working in parallel with different entities. Also, the group has continued to support the spin-off Ahead Therapeutics S.L.

On the other hand, during 2024, the group has started one new project: "Role of HDL miRNA in coronary heart disease incidence; Customised miR-sHDL as strategy for atherosclerosis treatment" founded by Fundació La Marató TV3. This project aims to determine a high-density lipoprotein (HDL)-linked miRNA association with coronary heart disease (CHD) in a case-cohort from a general population-based study, and further validation in a matched case-control study in high cardiovascular-risk subjects. After establishing a robust association between miRNA and CHD, miRNArich customized synthesized HDL (sHDL) will be addressed as a therapeutic strategy.



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THEORETICAL AND COMPUTATIONAL NANOSCIENCE GROUP

STEPHAN ROCHE
ICREA Research Professor and Group Leader

MAIN RESEARCH LINES

- Theoretical research on quantum transport phenomena in topological quantum matter (topological insulators, Weyl semimetals) in equilibrium and non-equilibrium regimes
- Spin dynamics and entanglement properties in Dirac matter (graphene, two-dimensional materials) and van der Waals heterostructures, with the search for new paradigm of quantum information manipulation and quantum transduction mechanisms
- Artificial Intelligence and machine learning techniques to accelerate the building of realistic and adaptative structural and electronic models of disordered and amorphous materials and heterostructures
- Predictive modelling and multiscale numerical simulation of complex nanomaterials and quantum nanodevices
- Molecular dynamics, thermal transport properties and thermoelectricity in nanomaterials of interest for microelectronics (amorphous graphene and boron nitride)

16 ARTICLES	7.11 MEAN IMPACT FACTOR
10 FUNDED PROJECTS	5 CONTRIBUTIONS
3 OUTREACH IMPACT	3 CONGRESSES ORGANISATION
1 COURSE	

NEW PROJECTS & MILESTONES

In 2024 the group published the following relevant works:

Field-Free Spin–Orbit Torque Switching in Janus Chromium Dichalcogenides

This work brings the prediction of a very large spin–orbit torque (SOT) capability of magnetic chromium-based transition-metal dichalcogenide (TMD) monolayers in their Janus forms CrXTe, with X = S, Se. The structural inversion symmetry breaking, inherent to Janus structures is responsible for a large SOT response generated by giant Rashba splitting, equivalent to that obtained by applying a transverse electric field of ~ 100 V nm–1 in non-Janus CrTe2, completely out of experimental reach. By performing transport simulations on carefully derived Wannier tight-binding models, Janus systems are found to exhibit an SOT performance comparable to the most efficient two-dimensional materials, while additionally allowing for field-free perpendicular magnetization switching, due to their reduced in-plane symmetry. Altogether, our findings evidence that magnetic Janus TMDs stand as suitable candidates for ultimate SOT-MRAM devices in an ultracompact self-induced SOT scheme.

Emerging spin-orbit torques in low-dimensional Dirac materials

This contribution is a theoretical description unravelling novel spin-orbit torque components emerging in two-dimensional Dirac materials with broken inversion symmetry. In contrast to usual metallic interfaces where field-like and damping-like torque components are competing, we find that an intrinsic damping-like torque which derives from all Fermi-sea electrons can be simultaneously enhanced along with the field-like component. Additionally, hitherto overlooked torque components unique to Dirac materials emerge from the coupling between spin and pseudospin angular momenta, leading to spin-pseudospin entanglement. These torques are found to be resilient to disorder and could enhance the magnetic switching performance of nearby magnets.

Exploring dielectric properties in atomistic models of amorphous boron nitride

This contribution provides the first theoretical study of dielectric properties of models of amorphous Boron Nitride, using interatomic potentials generated by machine learning. We first perform first-principles simulations on small (about 100 atoms in the periodic cell) sample sizes to explore the emergence of mid-gap states and its correlation with structural features. Next, by using a simplified tight-binding electronic model, we analyse the dielectric functions for complex three-dimensional models (containing about 10.000 atoms) embedding varying concentrations of sp1, sp2 and sp3 bonds between B and N atoms. Within the limits of these methodologies, the resulting value of the zero-frequency dielectric constant is shown to be influenced by the population density of such mid-gap states and their localization characteristics. We observe nontrivial correlations between the structure-induced electronic fluctuations and the resulting dielectric constant values. Our findings are however just a first step in the quest of accessing fully accurate dielectric properties of as-grown amorphous BN of relevance for interconnect technologies and beyond.

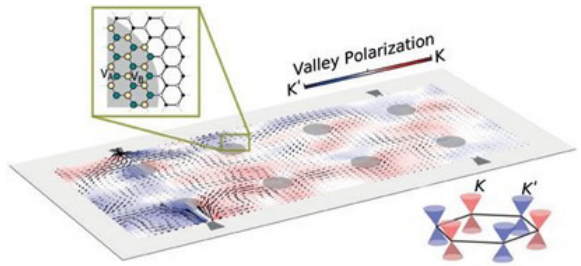
Resilient intraparticle entanglement and its manifestation in spin dynamics of disordered Dirac materials

Topological quantum matter exhibits transport phenomena driven by entanglement between internal degrees of freedom, as, for instance, generated by spin-orbit coupling effects. This report evidences a direct connection between the mechanism driving spin relaxation and the intertwined dynamics between spin and sublattice degrees of freedom in disordered graphene. Beyond having a direct observable consequence, such intraparticle entanglement is shown to be resilient to disorder, pointing towards a unique resource for quantum information processing using novel quantum materials with intrinsic multiple quantum degrees of freedom.

Tailoring giant quantum transport anisotropy in nanoporous graphenes under electrostatic disorder

During the last 15 years bottom-up on-surface synthesis has been demonstrated as an efficient way to synthesize carbon nanostructures with atomic precision, opening the door to unprecedented electronic control at the nanoscale. Nanoporous graphenes (NPGs) fabricated as two-dimensional arrays of graphene nanoribbons (GNRs) represent one of the key recent breakthroughs in the field. NPGs interestingly display in-plane transport

anisotropy of charge carriers, and such anisotropy was shown to be tunable by modulating quantum interference. By using large-scale quantum transport simulations, we have shown that electrical anisotropy in NPGs is not only resilient to disorder but can further be massively enhanced by its presence. This outcome paves the way to systematic engineering of quantum transport in NPGs as a novel concept for efficient quantum devices and architectures.



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THEORY AND SIMULATION GROUP

PABLO ORDEJÓN
CSIC Research Professor, Group Leader and ICN2 Director

MAIN RESEARCH LINES

- Development of theoretical methods, numerical algorithms and simulation tools for atomic scale simulations towards massive HPC facilities
- First-principles simulations at the nanoscale
- Physical properties and chemical processes in materials

PROJECTS

In 2024, the Theory and Simulation group (T&S) continued the execution of relevant projects for the group:

MaX "Materials design at the eXascale", one of the fifteen European Centres of Excellence in high-performance computing (HPC) Applications supported by The European High-Performance Computing Joint Undertaking (EuroHPC JU) and The Spanish State Research Agency (AEI).

MaX supports developers and end users of advanced applications for materials simulations, design and discovery, and works at the frontiers of current and future HPC technologies. It brings together leading developers and users of materials applications, together with top experts in HPC. After two periods of three years (2015-2018 and 2018-2021), the grant was renewed for the 2023-2026 term, with an increased budget and the inclusion of new groups and codes to the team.

During this year, part of the work has focused on adapting SIESTA for its execution in GPU-accelerated architectures. These are crucial building blocks of some of the current European pre-Exascale supercomputers (located at BSC in Spain, CINECA in Italy, CSC in Finland and IZUM in Slovenia), and the future exascale ones (Jupiter at Jülich Supercomputing Centre).

ALCOAT – "Recycled aluminium alloy coatings with chemically tailored electrochemical potential for safe

8 ARTICLES	5.81 MEAN IMPACT FACTOR
9 FUNDED PROJECTS	8 CONTRIBUTIONS
2 THESES	6 CONGRESSES ORGANISATION
9 OUTREACH IMPACTS	1 AWARD
18 COURSES	

protection of steel structures" is a European project funded under the Research Fund for Coal and Steel call. Its runs between 2023 and 2027 and is a highly industry-oriented project, with the participation of several industries in the steel area, and with target TLRs as high as 5, its goal is to develop new, efficient, sustainable and "green" coatings for the inhibition of the corrosion of steel, based on aluminium scrap (aluminium from waste and parts rejected or discarded). T&S is focusing on Work Package 4, which is related to advanced material modelling.

"SIESTA ecosystem of materials simulation techniques". Our base funding for the development of methods for the simulation of materials, revolving around SIESTA, was renewed for the period 2023-2026 (PID2022-139776NB-C62), and funded by The Spanish State Research Agency (AEI). This is the continuation of a series of collaborative, coordinated projects starting in 1996, by the core group of developers of SIESTA, which provide the main base funding for the development of the code and its associated methodologies.

The project aims to develop an ecosystem of revolutionary methods, algorithms, and computer codes for simulating atomic-level condensed matter systems.

NFFAEurope, a project funded under the H2020-INFRAIA-2018-2020 call "Integrating and opening existing national and regional research infrastructures of European interest". The Nanoscience Foundries and Fine Analysis (NFFA) is a platform for interdisciplinary research at the nanoscale, in which our group participates as an "installation" offering computational support for experimental users' projects.

During 2024, the T&S Group has worked on several projects within NFFAEurope: "Molecular Modeling of electron transfer reaction in self-assembled monolayers" and "Theoretical and experimental study of the adsorption of MBI on Cu oxides". Due to the successful approval of the theoretical proposals, the execution of seven projects is expected for the upcoming year, which has led to an increase in the initially estimated budget."

MAGNIFIC – "Materials for a next-generation (nano-) opto-electro-mechanical systems": a Horizon Europe-funded project which will continue until the end of 2026. T&S group is responsible for the theoretical modeling of the electrons and phonons dynamics in nanocrystalline silicon samples. This year, work was focused on developments on phonon dynamics and interactions in silicon grain boundaries.

This year, the group continued advancing on the "Proof of Concept" project supported by the AEI (PDC2022- 133467-I00), entitled **THERMOS – "Industry-grade software for the simulation of- thermal properties of materials"**. The project explores the commercialization of the software developed by the group for the calculation of the thermal properties of materials. Work during this year has finalized mapping the functionalities and interfaces of the different layers of the workflow structure to the required technologies and modes of operation, and on defining the intellectual property strategy and the transfer of IP for commercial exploitation.

In 2024 we started the project **HANAMI-"Hpc AlliaNce for Applications and supercoMputing Innovation: the Europe-Japan collaboration"** funded by European High-Performance Computing Joint Undertaking. Our group works with the group of Prof. Otani at the University of Tsukuba to define the new, general and version-agnostic interface between SIESTA and the code Effective Screening Medium (ESM).

A MSCA Cofund Postdoctoral programme has also been granted, the **"Australia-Spain Network for Innovation and Research Excellence" (AuSpire)**, through which a postdoctoral researcher will join the team in the coming years.

SCIENTIFIC MILESTONES

Several significant results were obtained by T&S group. An example is the advance in producing DFT and QM/ MM simulations of electrified interfaces using Non-Equillibrium Green's Functions, which offers a viable solution to the computational challenges of investigating the dynamics of liquid electrolytes interacting with electrified surfaces, providing a good balance between accuracy and computational cost.

The group also participated in the development of a method to describe superconducting states in materials, and its implementation in SIESTA. The approach allows to describe non-conventional superconductors, cases where the interplay between superconductivity and magnetism is relevant (as in materials with strong spin-orbit coupling), and inhomogeneous superconductors or interfaces between superconducting and non-superconducting materials.

We also started some activities related to Artificial Intelligence techniques applied to materials science. We have developed a method for the prediction of the electronic density based on machine learning, which accelerates the self consistency cycle in DFT calculations, and exploring the use of these Machine Learned potentials to study several problems that require length and time scales unfeasible to achieve with first-principles methods.

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THERMAL PROPERTIES OF NANOSCALE MATERIALS GROUP

JAVIER RODRÍGUEZ-VIEJO
UAB Professor and Group Leader

11	ARTICLES	6.95	MEAN IMPACT FACTOR
4	FUNDED PROJECTS	23	CONTRIBUTIONS
7	OUTREACH IMPACTS	21	COURSES
4	CONGRESS ORGANISATION	2	AWARDS
1	THESIS		

MAIN RESEARCH LINES

- Heat capacity of low-dimensional materials
- Phase transitions with emphasis on size effects; influence of external fields on heat capacity and phase transitions
- Cross-plane and in-plane thermal transport in thin films and low dimensional materials, including crystalline and amorphous membranes, 2D materials & single nanowires, characterised by electrothermal and optothermal methods (DC and frequency-domain)
- Design, development and characterization of microthermoelectric devices for energy harvesting and sensing applications
- Growth and characterization of ultrastable organic thin film glasses with applications in organic electronics

NEW PROJECTS & MILESTONES

Prof. Rodríguez-Viejo joined ICN2 in 2021, where he established the new Thermal Properties of Nanoscale Materials group, while continuing to lead his research team at UAB. By 2022, two laboratories, focused on AFM and nanocalorimetry, became fully operational. These facilities include a high-vacuum nanocalorimetric setup for measuring phase transitions in ultrathin layers, and a high-vacuum evaporation chamber that enables co-evaporation of small organic molecules with simultaneous in-situ nanocalorimetry characterization. Additionally, the labs are equipped with several topographic AFM systems featuring temperature-controlled stages, allowing real-time monitoring of phase transition kinetics. The group also welcomed a new permanent member, Marianna Sledzinska, who has brought her expertise in optothermal methods, such as Raman spectroscopy and frequency-domain thermoreflectance, along with specialized equipment to measure thermal transport in 2D and 1D materials; projects PETITE, EIG Concert Japan & EU 3D-BRICKS.

We continue our activities in the frame of the project PYROMETHER (TED2021) in collaboration with the Oxyde Nanophysics group to investigate pyroelectric and electrocaloric effects of single-crystal freestanding (anti)ferroelectric oxide membranes using the nanocalorimetric chips as suitable platforms for direct measurements.

Within Project ELEMENTAL (PID2023), we are developing characterization techniques for high-sensitivity analysis of the thermal properties of low-dimensional materials, with a particular focus on transition metal dichalcogenides (TMDs) at sub-nanometric thicknesses. The project seeks to deepen our understanding of thermal transport and energy conversion in 2D systems by investigating interfacial thermal resistance in twisted TMD bilayers, examining the effects of mechanical strain on the optical and thermal properties of 2D materials, and exploring photothermoelectric phenomena in ultrathin semiconductors and related systems.

The group continues its research on ultrastable glasses, employing nanocalorimetry and Atomic Force Microscopy (AFM) to monitor temperature-dependent phase transitions in real time. In vapor-deposited glasses, molecular anisotropy can lead to spontaneous surface polarization and the development of surface potential. To investigate this phenomenon, we are utilizing Electrostatic Force Microscopy (EFM) and Kelvin Probe Force Microscopy (KPFM) to map the presence of isotropic domains, characterized by randomly oriented molecules with isotropically distributed permanent dipole moments, and anisotropic regions, where vertically aligned dipoles generate significant surface potential.

Within the EU NFFA-PILOT project, thin silicon nitride membranes have been fabricated, in collaboration with IMB-CNM-CSIC, and assembled in UHV-compatible liquid cells for HAXPES (Hard X-rays Photoelectron Spectroscopy) experiments using synchrotron radiation at the GALAXIES beamline in SOLEIL (France). 20 nm thick membranes have been successfully tested in electrochemistry experiments.

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ULTRAFAST DYNAMICS IN NANOSCALE SYSTEMS GROUP

KLAAS-JAN TIELROOIJ
Group Leader

MAIN RESEARCH LINES

- Quantum materials
- Ultrafast transport and dynamics of heat and charge
- Terahertz technologies
- Photodetection

6 ARTICLES	10.3 MEAN IMPACT FACTOR
3 FUNDED PROJECTS	11 CONTRIBUTIONS
2 OUTREACH IMPACT	1 COURSE
1 THESIS	3 CONGRESSES ORGANISATION

NEW PROJECTS & MILESTONES

The UDNS group experienced several highlights related to its team members:

- Sebin Varghese obtained his doctorate degree on October 28th 2024 with a thesis entitled “Heat Transport in Layered Semiconductors” – the first one of the group!
- Bachelor project student Wiktor Kwapinski from Eindhoven University of Technology (TU/e), who performed part of his project at ICN2, was awarded two (!) prizes for his project: the Best BSc thesis of TU/e and the Best BSc thesis of the Netherlands by SPIN – Students of Physics in the Netherlands
- Klaas-Jan Tielrooij obtained the University Teaching Qualification from Eindhoven University of technology
- Postdoctoral researcher Anand Nivedan joined the group in April 2024
- Roshan Krishna Kumar joined the UDNS group as an Independent Team Leader, supported by a prestigious Ramón y Cajal fellowship, in September 2024

There were also several scientific highlights:

- We discovered a novel electron-phonon Umklapp scattering mechanism that governs the cooling dynamics of hot electrons in twisted bilayer graphene near the magic angle, which we published in Sci. Adv. and which involved a collaboration with LMU (Germany) and MIT (USA)
- Together with the TCN group at ICN2, we studied charge diffusion in graphene nanoribbons, which we published in Adv. Mater.
- Together with the T&S group at ICN2, we studied heat diffusion in layered semiconductors of the transition metal dichalcogenide type, which we published in Phys. Rev. B
- We published a review paper on spatiotemporal microscopy in Adv. Electron. Mater. together with collaborators from ICFO
- We published a review paper on charge and energy flow in graphene-semiconductor heterostructures, published in The Innovation, which was led by our long-term collaborators from the Max Planck Institute for Polymer Research (Germany)

Besides these highlights, we continued to develop the ICN2 Quantum Synergy Lab (QSL). The goal of the QSL is to be a research-focused platform that facilitates the access to state-of-the-art equipment, and serves as a nexus that boosts synergy among groups, both internal and external to ICN2, and a space for performing and developing basic research in a specific field, in particular quantum materials and quantum communications. The UDNS group is responsible for its operation, and Francesc Alzina from the UDNS group is the QSL manager. Besides the UDNS group, the QSL involves the PEN group of Prof. Sergio Valenzuela and the TCN group of Prof. Stephan Roche.

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Research at the ICN2 is supported by a centralised support infrastructure that provides shared access to specialised equipment, services and expertise. It is made up of three research support units, and a set of technical facilities run by specialised technicians.

RESEARCH SUPPORT UNITS

ELECTRON MICROSCOPY UNIT
Dr **Belén Ballesteros**

INSTRUMENTATION UNIT
Dr **Gustavo Ceballos**

NANOMATERIALS GROWTH UNIT
Dr **José Santiso**

CORE RESEARCH FACILITIES

- **Biolab Facility**
- **Mechanical Workshop**
- **Molecular Spectroscopy Facility**
- **Nanofabrication Facility**
- **Photoemission Spectroscopy (XPS&UPS) Facility**
- **X-Ray Diffraction Facility**

ELECTRON MICROSCOPY UNIT

BELÉN BALLESTEROS
CSIC Scientific Researcher and Unit Leader

MAIN RESEARCH LINES

- Use of advanced electron microscopy techniques for nanoscience and nanotechnology research and applications
- Scientific-technical support for both internal ICN2 research groups and external scientists and companies
- Study of the structure and chemistry of functional carbon nanostructures
- Exploration of 2D layered inorganic nanotube systems
- Investigation of the evolution of nanomaterials under in-situ conditions

NEW PROJECTS & MILESTONES

The electron microscopy unit focuses on the use of advanced electron microscopy techniques for nanoscience and nanotechnology research and applications. The Unit's main objective is to provide scientific-technical support to the ICN2 research groups and to other research centres and companies, as well as to develop and implement novel techniques.

During 2024 the Unit experienced a leap forward in its capabilities. The Spectra 300 new Double Aberration-Corrected STEM with monochromator and Helios 5UX FIB installed in the JEMCA and ICN2 respectively started their activity with users, providing state-of-the-art and groundbreaking experiments on samples, such as atomic-scale spectroscopy, detection of individual atoms, imaging

3 ARTICLES	**7.53** MEAN IMPACT FACTOR
1 FUNDED PROJECTS	**1** CONTRIBUTIONS
5 OUTREACH IMPACTS	**1** COURSE

light elements like oxygen or carbon, and studying sensitive materials using low doses.

Besides, the members of the Unit actively participated in the electron microscopy activities of the inCAEM project leaded by ALBA, contributing significantly to various stages, including the acquisition, installation, and commissioning of the systems. Within this project, a new state-of-the-art double aberration corrected microscope focussed on in-situ experiments will be installed in ALBA. During 2024 the three TEM sample holders to work under different working environments (gas, liquid, biasing, temperature) started being commissioned in JEMCA, as well as an electrochemical stage for the environmental SEM at ICN2.

In 2024 the Unit hosted visiting researchers from other institutions, namely Chiara Puccinnelli from University of Vienna and Judith Medina from CENIM (Madrid).

Aside from their daily fundamental activities, during 2024 the members of the Unit were involved in the organization of the third edition of the ICN2 ArtMeetsNano Image Contest. As in previous years, the team actively participated in the BIST Winter School on Microscopy and Imaging Sciences, which is part of the BIST-UPF Master of Multidisciplinary Research in Experimental Sciences. Moreover, the Unit participated in the outreach activities organised at the ICN2, such as the Bojos per la Física (Crazy for Physics) programme, or 100tifiques, from FCRI and BIST.

Besides, the Unit devoted efforts to the NFFA- Europe and the ReMADE@ARI infrastructure projects, providing access to the ICN2 electron microscopy facilities to a number of researchers from international institutions.

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INSTRUMENTATION UNIT

GUSTAVO CEBALLOS
Head of Research Support Division - Instrumentation Unit

MAIN ACTIVITIES

The Instrumentation Unit at ICN2 is involved in various activities aimed at providing scientific and technical support in applied physics, precision instrumentation, microengineering, nanotechnology, scientific computing, and 3D design of precision devices. The main activities of the unit include:

- **Designing, developing, and improving advanced precision instrumentation**
- **Modifying commercial instrumentation to meet specific experimental requirements**
- **Scientific computing for data analysis and modelling**
- **Data acquisition for experimental measurements**
- **3D computer-aided design (CAD) of precision devices**
- **3D Printing for prototyping and functional parts**
- **Expertise in vacuum technology, including high vacuum (HV) and ultrahigh vacuum (UHV) systems**
- **Cryogenics for experiments requiring low-temperature environments**

Additionally, the Instrumentation Unit collaborates with several institute Spin-offs, participating in the prototyping and final development of devices.

3 ARTICLES

3.93 MEAN IMPACT FACTOR

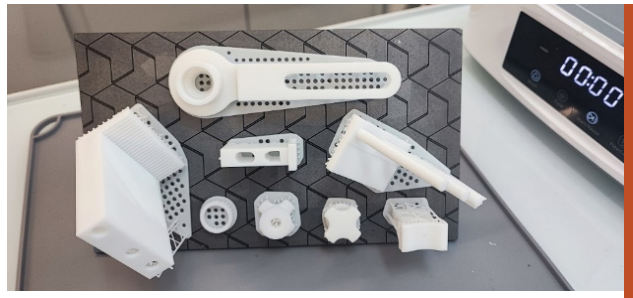
1 FUNDED PROJECTS

NANOMATERIALS GROWTH UNIT

JOSÉ SANTISO
CSIC Tenured Scientist and Unit Leader

NEW PROJECTS & MILESTONES

In 2024, the Instrumentation Unit achieved several milestones and contributed to new projects. The unit developed innovative setups to facilitate experiments in various fields such as magnetometry, spectroscopy, nanomaterial synthesis, photovoltaics, and bio-sensing. Additive manufacturing capabilities, as 3D printing, have been successfully introduced. Being now routinely used for prototyping and testing designs as well as for final functional parts. Furthermore, the unit actively participated in dissemination activities, utilizing their expertise to design and construct prototypes and technology demonstrations.



MAIN ACTIVITIES

- Pulsed laser deposition of epitaxial thin films and free-standing membranes of different materials (mainly oxides), looking at strain and relaxation mechanisms, and the microstructural and functional properties (metal-insulating transitions, ferroelectric, ferromagnetic, oxide ionic conducting, thermoelectric, transparent conducting, resistive switching, etc.)
- MOCVD growth of 2D layers of transition metal dichalcogenides
- Structural characterisation by RHEED and advanced XRD and electronic transport properties
- Fundamental aspects of interfacial phenomena in layered oxide materials and multilayers for their use as components in ionic and protonic solid oxide fuel cells (SOFCs), as well as in resistive switching devices
- Accurate structural characterization of epitaxial thin films making use of advanced X-ray diffraction techniques (reciprocal space mapping under non-ambient conditions and external stimuli: gas change, voltage, illumination)

Visit our website for extended information

7 ARTICLES	**10.26** MEAN IMPACT FACTOR
1 FUNDED PROJECTS	**2** COURSES
2 CONTRIBUTIONS	

NEW PROJECTS & MILESTONES

Our unit produces films by means of pulsed laser deposition and metal organic chemical vapour deposition (MOCVD) techniques and works in close collaboration with many ICN2 research groups, as well as with external teams. A recently developed two-laser PLD setup allows coablation of two targets for deposition of films with composition gradient new mixed composition materials. Our unit carries out advanced structural characterisation of thin films, primarily by X-ray diffraction (XRD), and work on developing advanced methods for the characterisation by XRD of epitaxial thin films. These include in-plane diffraction, Grazing Incidence XRD (GIXRD) analysis, as well as 3D reciprocal space mapping. This microstructure research is complemented with High-Resolution Transmission Electron Microscopy (HRTEM) characterisation.

We are particularly interested in surface and interfacial phenomena, such as oxygen exchange kinetics. For this purpose we have developed a time-resolved XRD technique that monitors the subtle chemical expansion produced in transition metal oxide thin films when changing their oxygen stoichiometry.

We aim to perform in-situ and operando characterisation by XRD in different solid state electrochemical devices. These studies have also been extended to in- situ structural analysis of ferroelectric materials, and materials showing resistive switching.

We have also continued working on the development of a thin film MOCVD process for the growth of high-quality ultrathin transition metal dichalcogenides, starting with MoS2, in collaboration with the ICN2 group led by Prof. José A. Garrido.

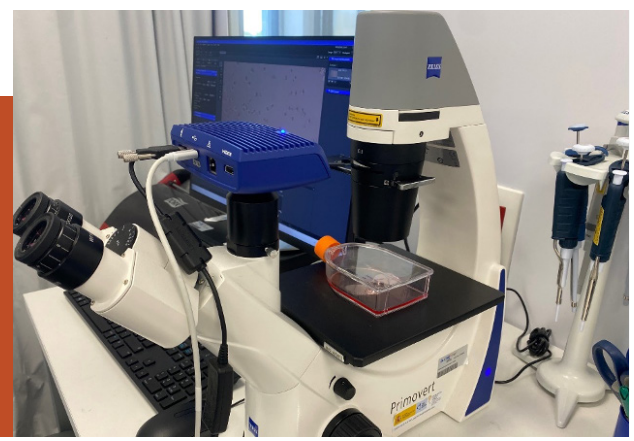
In 2020, we started working in collaboration of Prof. Gustau Catalan's group on the fabrication of single-crystal free-standing membranes of perovskite oxides by using water-soluble sacrificial epitaxial layers in an attempt to implement functional oxides in a new generation of electronic devices. Currently, we are engaged in the fabrication of free-standing membranes of different ferroic oxide materials to analyse the intrinsic characteristics of strain-free ultrathin films.

Visit our website for extended information

BIOLAB FACILITY

AVAILABLE TECHNIQUES

- Biological Safety Cabinets (class II)
- CO_2 Incubators
- Cryopreservation of cells in cryogenic tank
- Microbiological incubator
- Bench-top microcentrifuges
- Refrigerated centrifuge
- Autoclaves
- Inverted optical microscopy
- Orbital shakers
- Cell density meter
- Portable vacuum aspiration system
- Water bath, vortex, pipettes
- Refrigerators, freezer and ultra-freezers



NEW PROJECTS & MILESTONES

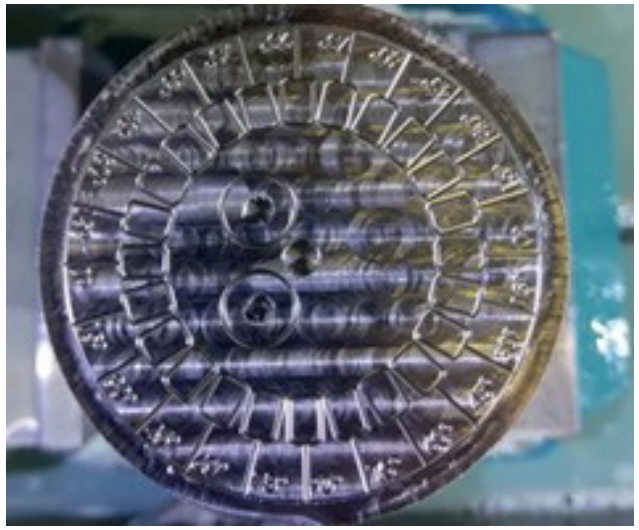
In 2024, the Biolab Facility has continued to offer its service to scientists of ICN2 and other research centres and companies on the UAB campus. In particular, scientists from the neighbouring *Institute of Materials Science of Barcelona* (ICMAB) made use of the service provided by the Biolab Facility. The central cell strain collection of animal and bacterial cells that the Biolab had started to establish in 2021 was expanded with further cell lines. This institutional strain collection offers the users of the Biolab Facility the possibility to acquire rapidly and cost-efficiently a variety of cells for their studies. New equipment has been acquired and installed, amongst them a PC and a compact inverted microscope with camera for easier cell observation. 2024 was also the year of a thorough revision of the Institutional Biosafety Programme and the Biolab Facility and its safety procedures by the Biosafety Committee of the UAB. The Biosafety Committee of the UAB accredited the Biolab a very high standard for a BSL-2 facility in all aspects.

Visit our website for extended information

MECHANICAL WORKSHOP

AVAILABLE TECHNIQUES

- Precision milling, turning and grinding
- Close tolerance machining
- Mechanical assembly
- Computer-aided design (CAD)
- Computer-aided machining (CAM)
- Computer numerical control (CNC)
- Tungsten inert gas (TIG) welding
- Bending and cutting machine
- 3D Printing of thermoplastics
- Sand Blast Cabinet



Visit our website for extended information

MOLECULAR SPECTROSCOPY FACILITY

AVAILABLE TECHNIQUES

FT-IR spectroscopy

- Detectors available for MIR, NIR and FIR measurements
- Powders, films and surfaces
- Variable temperature (73 K - 500 K)
- Polarization modulation-infrared reflection-absorption spectroscopy (PM-IRRAS)
- Vibrational circular dichroism (VCD)

UV-Vis spectroscopy

- Two ranges available: 175 - 900 nm/ 190 - 1100 nm (only for liquid samples)
- Liquids, films, surfaces and powders
- Integrating sphere
- Variable temperature (r.t. - 372 K)

Microspectroscopy

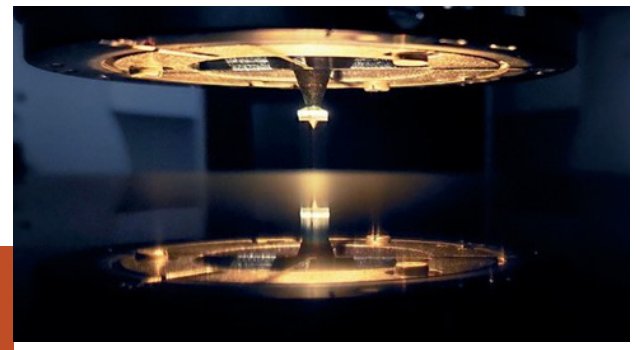
- FTIR and Vis-NIR measurements
- Solids, films and surfaces
- Objectives:
  - 15x reflection/transmission
  - 36x (only reflection)
  - Grazing angle
  - ATR
- Vis and IR polarizers available

Dynamic light scattering and zeta potential

- Particle size and colloidal stability
- Surface zeta potential
- Dip cell for measurements of zeta potential in organic solvents available

Drop shape analysis

- Static and dynamic contact angle
- Surface and interfacial tension
- Advancing and receding contact angles and evaluation of a roll off angle by tilting table method



Visit our website for extended information

NANOFABRICATION FACILITY

AVAILABLE TECHNIQUES

- Electron-beam lithography (EBL)
- Direct write laser UV lithography (DWL)
- UV mask aligner
- E-beam evaporation
- ICP-RIE plasma dry etching
- Plasma cleaning
- Wedge wire bonding
- Spin coating
- Optical microscopy
- 3D optical profiler
- Stylus profilometer

Visit our website for extended information

NEW PROJECTS & MILESTONES

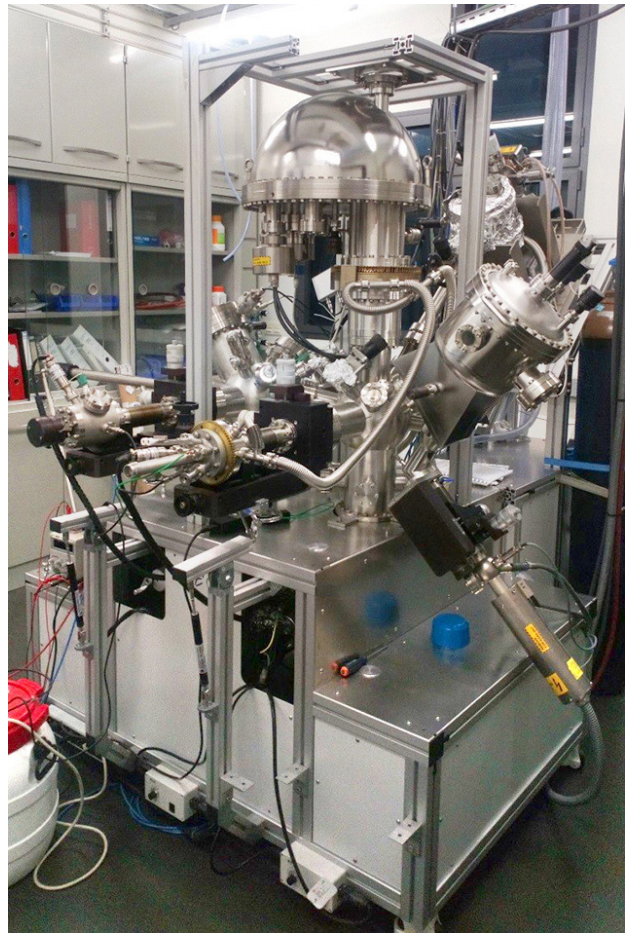
In 2024, the Nanofabrication Facility activities focused on the improvement of standard protocols and procedures for micro- and nano-fabrication techniques linked to key equipment and to the most common processes involved in the facility users' work. A new ebeam evaporation system was installed to allow 6" processing and upgrade the options with a sputter target and an ion gun for assisted ion deposition. The facility has kept growing in the number of active users and processes developed, some of them from ICN2 spin-off companies that are making intensive use of the facility. New processes have been developed that enhance the existing nanofabrication services and improve users experience regarding these techniques. With a focus on dry etching and ebeam lithography processes (combined with the existing thin film evaporation systems), the new processing protocols will allow the development and fabrication of fully functional micro- and nano-devices.

In addition to providing essential micro- and nano-fabrication capabilities for research in electronics, optoelectronics, and 2D materials and devices, this facility is intended to contribute to the pursuit of research in other emerging, interdisciplinary, and rapidly growing areas of study, such as biomedical and biochemical lab-on-a-chip devices, heterogeneous integrated circuits, and photonic and phononic devices.

PHOTOEMISSION SPECTROSCOPY (XPS&UPS) FACILITY

AVAILABLE TECHNIQUES

- Elemental composition
- Detection of contaminants
- Quantitative analysis
- Determination of chemical or electronic state of each element on the surface
- Layer ordering in the first 8-10 nm (relative depth plot)
- Work function, ionization energy and valence band measurement using UPS
- Direct band mapping using ARUPS
- Temperature-dependent XPS measurements
- In-situ preparation of materials by thermal evaporation for later analysis
- » Accessory to transfer samples from a glove box to the load lock without contact with the atmosphere

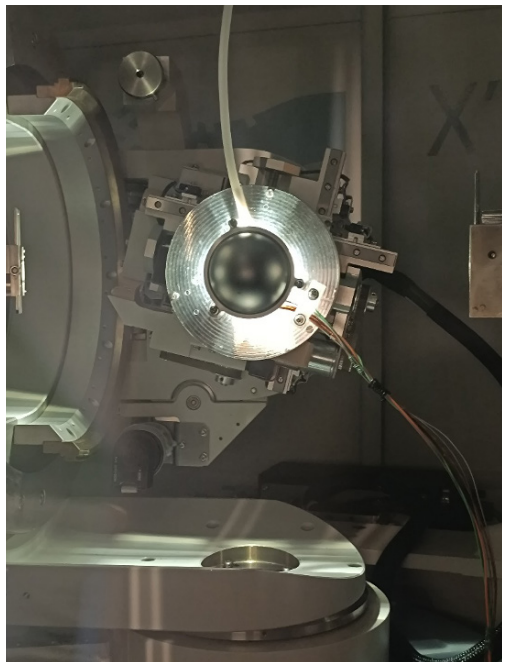


Visit our website for extended information

X-RAY DIFFRACTION FACILITY

AVAILABLE TECHNIQUES

- XRD of powder materials for the structural analysis of phases in both reflection and transmission geometries
- Capillary measurements in transmission mode for liquid specimens or air sensitive powder materials
- Small-angle X-ray scattering (SAXS) for flat nanopowder samples in transmission geometry
- In-situ powder characterization of the crystal structure in organic and inorganic materials, and pharmaceutical materials. Studies of structural phase transitions as a function of temperature, oxidation states and cell parameters evolution.
- XRD of thin films to identify phases and determine cell parameters, domain orientation and stress on epitaxy and polycrystalline films (at normal and high resolution)
- In-situ thin films characterization applying:
  - Gas exchanges at elevated temperatures (redox kinetics, oxide ionic materials)
  - Applied voltage bias (piezoelectric, ferroelectric, electrostriction, resistive switching)
  - Exchange between wet and dry atmosphere (water uptake, protonic conducting materials)
  - Simultaneous atmosphere exchange and electrical conductivity
  - LED illumination at RT and applying low temperature (up to 100 °C) with controlled atmosphere (photoactivated phase transitions, photostriction, etc.)



Visit our website for extended information

MANAGEMENT AND SERVICES

Research is also underpinned, protected and promoted by a comprehensive set of management and support services. Overall responsibility for ICN2 administration lies with the ICN2 General Manager Mr. Lluís Bellafont, with each department and area having its own head.

COMPETITIVE FUNDING
Mireia Martí Barroso

FINANCE
Judit Vela

HEALTH AND SAFETY AREA
Jose Antonio Pérez

HUMAN RESOURCES
Julio Gómez

INFORMATION TECHNOLOGIES
Javier Gonzálvez

MAINTENANCE AND SERVICES
Xavier Ros

MARKETING, COMMUNICATION AND FUNDRAISING
Anna Rovira

TECHNICAL MANAGEMENT SUPPORT AREA
Estefanía Latorre

DEVELOPMENT AND STRATEGIC ENHANCEMENTS

Throughout 2024, the ICN2 Management and Services Department experienced a period of significant growth and strategic transformation, aimed at enhancing the operational efficiency and overall support provided to the institute's scientific community. These improvements reflect ICN2's unwavering commitment to excellence in research and innovation, ensuring that the services and resources available to researchers and staff are of the highest standard.

One of the most notable milestones of the year was the launch of the recruitment process for a new ICN2 General Manager, following the announcement of the upcoming retirement of Luis Bellafont, who will conclude his tenure in 2025. This transition marks a pivotal moment for the institute, as it ensures continuity in leadership and aligns with our long-term vision of sustained growth and institutional development.

The year also saw a continued focus on process optimization and team expansion within the Management and Services Department, with new roles and resources dedicated to improving support for research activities and fostering a collaborative and responsive working environment. These enhancements are part of a broader strategy to anticipate and meet the evolving needs of ICN2's researchers and administrative teams, reinforcing the institute's position as a leading hub for cutting-edge research in nanoscience and nanotechnology.

Our ongoing efforts reflect ICN2's dedication to providing a dynamic, efficient, and supportive environment for all members of our community, enabling them to focus on their scientific pursuits and contribute to groundbreaking discoveries that address global challenges.

For more information about the ICN2 services and activities, please visit our website: icn2.cat.

Visit our website for extended information

ICN2 IN NUMBERS

FINANCE

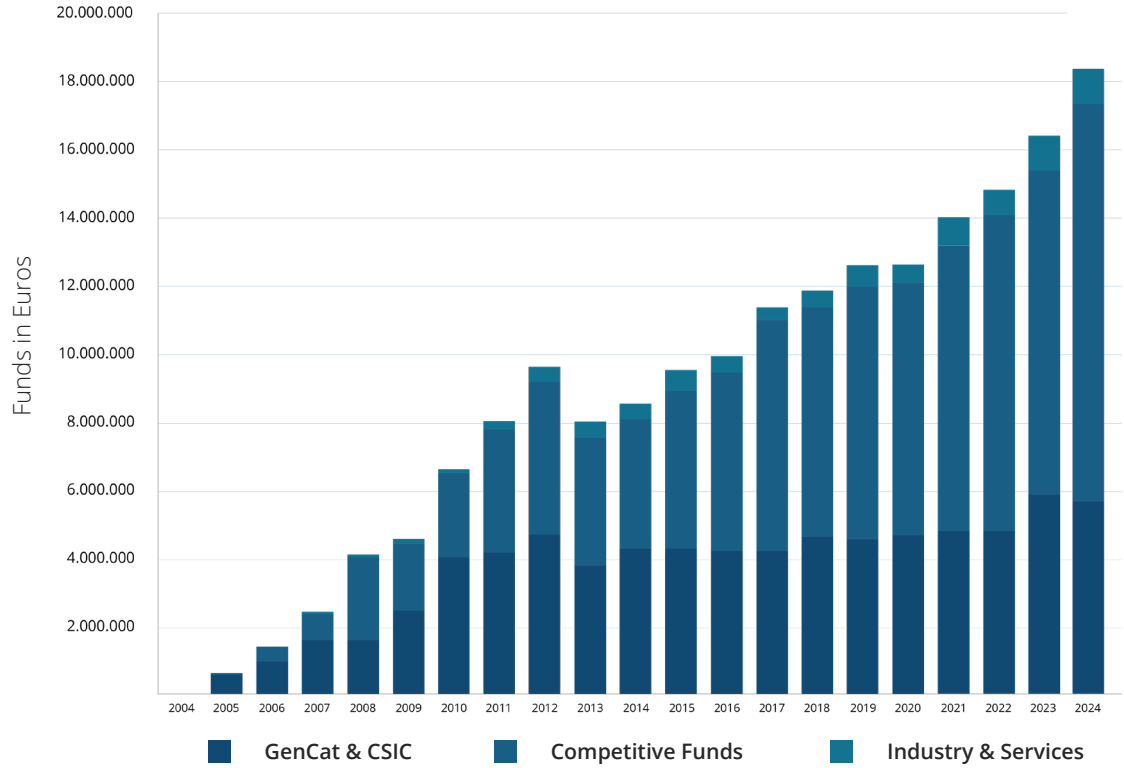
FINANCIAL ACCOUNTS 2024

In 2024 due to the continuous growth of the Institute, the ICN2 Finance Department, has focus on:

- Consolidate the digitalization processes, making the web solutions more steady
- Improve different reports of the department (to internal departments and external agents)
- Integrate some registration processes with the accounting programme, to improve the budget control

Finally, we have tried to anticipate itself to the needs of the coming years, seeking alternatives to existing processes for its improvement and quickly adaptation, that help keep us on the path of excellence.

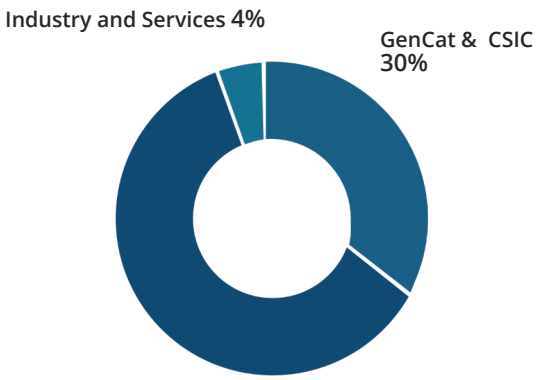
Evolution of ICN2 Operational Funds



INCOME

The ICN2's total operating funds in 2024 stood at € 18.453.216 of which 30% were obtained from the Generalitat de Catalunya and the Spanish National Research Council (CSIC), 66% from competitive funding calls, and 4% from industry and services.

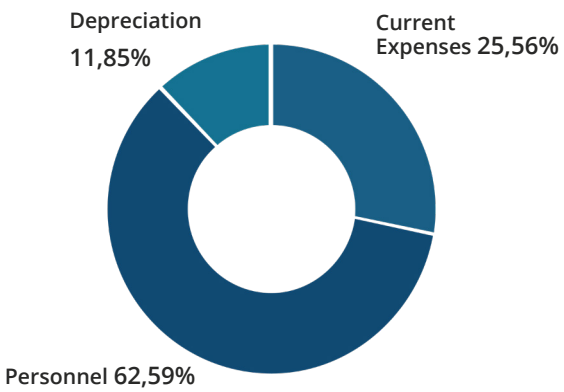
Funds Distribution 2024



EXPENSES

Total expenditure in 2024 reached €17.985.416 including current expenses, personnel costs and depreciation.

Expenditure in 2024



FACILITIES AND EQUIPMENT

Total accumulated investment by the ICN2 in scientific equipment, common services and general infrastructure as of year-end 204 stood at € 35.228.298

During 2024 investment reached a total of € 2.644.869 being the most important investments:

- ESPECTOMETRO RAMAN
- EC-STM
- SCANNING ELECTROCHEMICAL MICROSCOPE
- 2D CMOS DETECTOR
- ESPECTOMETRO RAMAN
- MICROSCOPIO DE BARRIDO DE SONDA Y ESPECTROSCOPIA OPTICA EN CONDICIONES DE ATMOSFERA CONTROLADA
- UHV PHOTON-LTSTM
- NANOIMPRINT
- PVD EVAPORATION SYSTEM

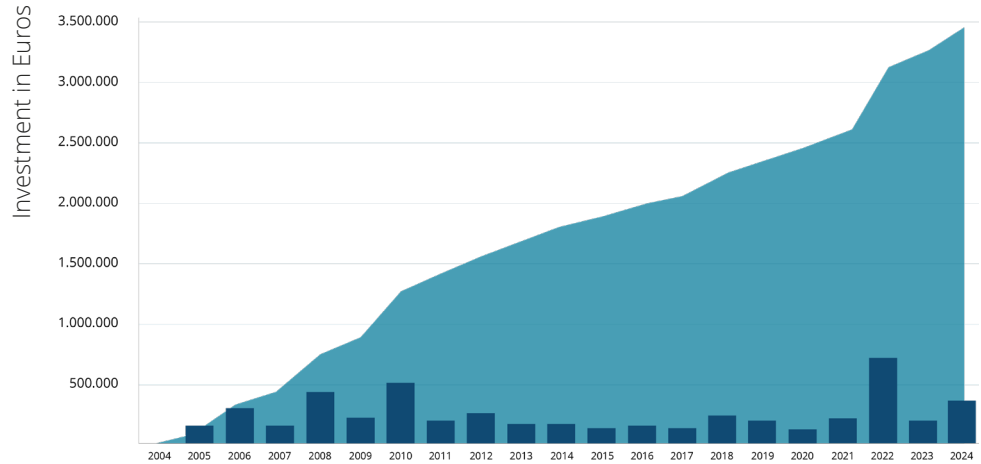
Equipment funded using Spanish ERDF ("FEDER") funds:

- OPTICAL DELAY LINE
- DIODE LASER 808 NM
- OPTICAL MICROSCOPE
- FUENTE DE ALIMENTACION 320W
- SCAN HEAD OF A SCANNING TUNNELING MICROSCOPE
- IPCE - QUANTUM EFFICIENCY MEASUREMENT SYSTEM
- VACUUM LAMINATOR
- LINKAM TEMPERATURE CONTROLLER
- ATMOSBAGS
- PC
- CHILLER PUMP
- MONITOR
- ACER KA272EBI 27" LED IPS FULLHD 100HZ FREESYNC
- ACCUMET AB250 PH/ISE KIT AND ELECTRODES
- INTEGRATING SPHERE
- CHEMISTRY VACUUM SYSTEM
- CENTRIFUGA
- AGITADOR ROTATIVO
- BAÑO ULTRASONIDOS
- FILTRO OZONIZADOR
- ROTOR PARA CENTRIFUGA
- CENTRIFUGA
- OPTICAL CHOPPER SYSTEM
- ANALYSIS COMPUTER MEDION ERAZER RECON P25

Unió Europea
Fons Europeu de Desenvolupament Regional

Generalitat de Catalunya
Departament de Recerca i Universitats

Evolution of Investments between 2004 and 2024



JUDIT VELA
Head of Finance

The ICN2 Finance Department is split into two areas: administration and accounting.

The administration team oversees all of the institute's administrative functions. Each research group, unit, facility and department has a contact person responsible for all administrative tasks in order to ensure a fluent communication and adaptation of the service to their specific needs. Sales and billing management is also carried out by this team.

Meanwhile, the accounting team is responsible for the overall financial reporting and control. Reporting is carried out both internally and externally, in fulfilment of the institute's legal obligations as set out by the Spanish tax office and other public bodies, trustees, dashboards and internal economic reports. Its responsibilities include financial analysis, budget monitoring, treasury and public tenders.

RESEARCH OUTPUTS

PUBLICATIONS

200

JOURNAL ARTICLES 2024 (Indexed)

78% Q1 → **41,5%** D1 (JCR - WOS) 156 Q1 / 83 D1

92% Q1 → **68,5%** D1 (SJR -SCOPUS) 184 Q1 / 137 D1

95,2% OPEN ACCESS (198 art.)

81,25% INCLUDED IN DDD (169 art.)

10.15
AVERAGE IMPACT FACTOR (JCR - WoS)

136
ICN2 DOCUMENTS H-INDEX (JCR - WoS)

14
VERY HIGH IMPACT ARTICLES (IF > 20)

74
HIGH IMPACT ARTICLES (IF > 10)

3
JOURNAL COVERS

8
NON-INDEXED JOURNAL ARTICLES

INSTITUTIONAL ICN2 EVENTS

61

TOTAL

21 THESES

23 SEMINARS

1 HEALTH & SAFETY SEMINARS

14 NANOSEMINARS

1 INNOVATORS TALK

1 OPEN KNOWLEDGE PROGRAMME

PARTICIPATED EVENTS

115
ORAL CONTRIBUTIONS

168
INVITED

55
ORGANISING COMMITTEES

61
POSTERS

MEDIA IMPACT

609
ONLINE

99
OFFLINE (PRINT, RADIO, TV)

* The 2024 data is consistent with the media impact trends seen in previous years.

SOCIAL NETWORKS

LinkedIn

22,384
FOLLOWERS

+54,89% vs 2023

YouTube

1,690
SUBSCRIBERS

+16,31% vs 2023

8,434
FOLLOWERS

+3,94% vs 2023

Bluesky

248
FOLLOWERS

* On 21 November 2024, we opened a new account on Bluesky after seeing a significant decline in overall users and followers on X (formerly Twitter).

BUSINESS AND INNOVATION

2
SPINOFF COMPANIES CREATED

46
NDAS SIGNED

52
ACTIVE PATENT FAMILES

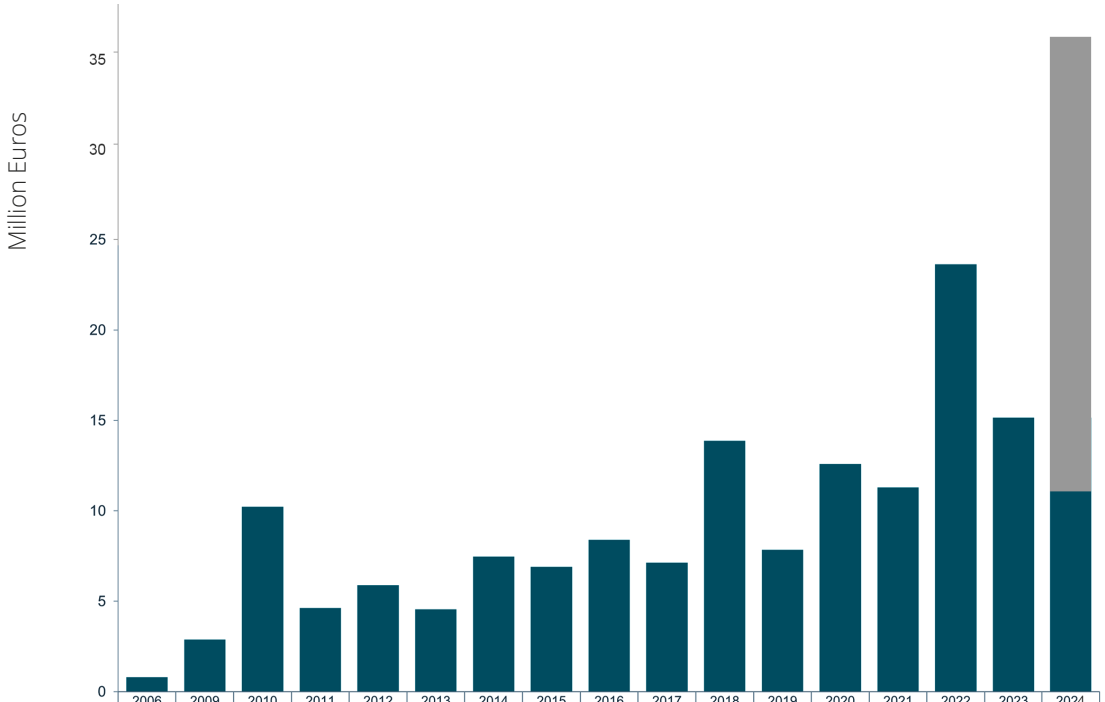
10
NEW PATENTS

3
NEW LICENSES

11
R&D CONTRACTS

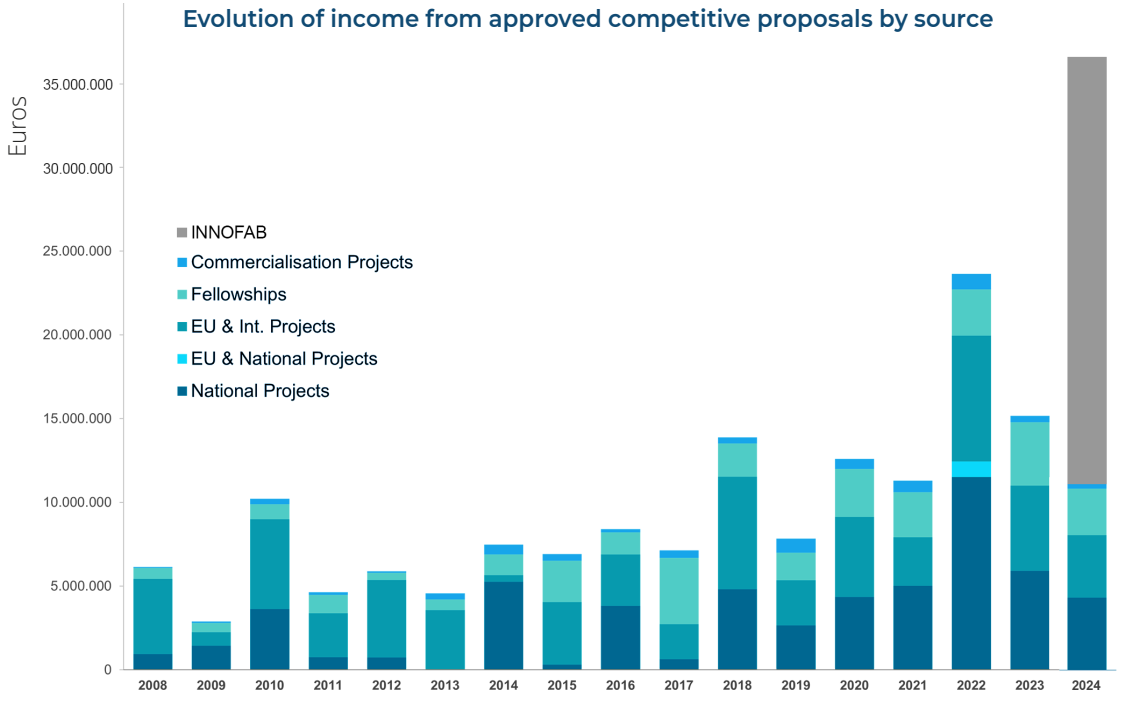
124
COMPANIES ENGAGED

Evolution of Competitive Funding Approvals 2008-2024



	2006	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
INNOFAB																	24.866.800
Approved	790.189	2.872.724	10.216.119	4.630.420	5.877.353	4.557.138	7.474.975	6.896.030	8.386.862	7.127.086	13.864.781	7.834.981	12.592.643	11.282.989	23.638.042	15.158.152	11.687.005

Evolution of income from approved competitive proposals by source



Annual Report 2024

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Marketing, Communication and Fundraising Department

May 2025