

# ANNUAL REPORT 2022



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# LETTER FROM THE DIRECTOR

Welcome to the ICN2 Annual Report, a comprehensive overview of our institute's activities throughout 2022: the results of a collective effort of a talented team of researchers, technicians, students, administration personnel and collaborators. Together, **we advance the frontiers of nanoscience, bring value to society in the form of new understanding, capabilities and innovation, and inspire and train the next generations of researchers.**

The Catalan Institute of Nanoscience and Nanotechnology (ICN2) is a foundation of the public sector. Our trustees are the Government of Catalonia (*Generalitat de Catalunya*), the *Consejo Superior de Investigaciones Científicas* (CSIC), and the *Universitat Autònoma de Barcelona* (UAB). As a part of CERCA (the network of research centres launched by the Catalan Government) ICN2 is a cornerstone in the strategy to develop a knowledge-based economy.

ICN2 has the honour of having been recognised as a Severo Ochoa Centre of Excellence by the Spanish Government for three consecutive times (in the 2014-2018, 2018-2022, and 2023-2026 periods) – an accomplishment few research centres can boast. This status has allowed ICN2 to focus its mission around **international scientific leadership, ground-breaking research, driving the impact of nanotechnologies and nanomaterials, and translating their applications into tangible benefits.** The last awarded Severo Ochoa project focuses on developing nanotechnologies for three application areas: energy efficient

information processing, sustainable energy technologies, and nanosolutions for medicine. Prof. Jose A. Garrido, vicedirector of ICN2, is the Scientific Director of the proposal.

ICN2 incorporated a new Group Leader in 2022: Prof. María Escudero Escribano, who joined us in September with an ICREA Professorship, to create a group on NanoElectrocatalysis and Sustainable Chemistry.

2022 was an exceptional year in terms of consecution of competitive projects, with a total of over 23 M€, a quantity that duplicates the average of the past five years. Besides the Severo Ochoa award, we highlight two ERC (European Research Council) projects: a Consolidator Grant won by Prof. María Escudero Escribano, and a Starting Grant by Dr. Jose Hugo García, from the Theoretical and Computational Nanoscience group led by Prof. Stephan Roche. We have also been successful in the consecution of EIC (European Innovation Council) grants, with a success rate of 13.6% (considerably higher than the EU and Spanish averages, of 8.58% and 7.92% respectively). ICN2 is currently coordinating a Pathfinder Challenges and a Pathfinder Open project, and participating in three more (one Challenges and two Open).

Our institute's excellent performance in technology transfer is exemplified by the success of INBRAIN Neuroelectronics, one of the most prosperous spin-offs created by the ICN2, in collaboration with CERCA and IBM-CNM-CSIC. This company has successfully raised over 35 M€ in private and competitive funds (including a EIC Acceledator Award) to develop graphene-

based neurotechnology with potential applications in epilepsy, Parkinson's disease, and depression.

We anticipate the exciting prospects offered by projects involving **new facilities and research spaces**, like the Joint Electron Microscopy Centre at the ALBA Synchrotron, which hosts the new ICN2 High Resolution, Aberration Corrected Transmission Electron Microscope acquired by ICN2 in collaboration with ALBA, ICMAB and UAB, and with EU-ERDF funds and contributions from Microsoft and the Barcelona Institute of Science and Technology (BIST). It will also host several new microscopy equipment which will be obtained with the funding from the "Planes Complementarios en Materiales Avanzados", granted to a collaboration between several institutions including ICN2, which is the scientific coordinator of the InCAEM project. We are also progressing in the plans for the ICN2 activities at the BIST hub on interdisciplinary which will be hosted at a new building at the *Mercat del Peix*, within the Parc de la Ciutadella in downtown Barcelona.

I invite you to review our 2022 activities through this Annual report, and to join us in the fascinating voyage towards solving grand challenges from the very small.

Sincerely,

Prof. **Pablo Ordejón**  
Director of ICN2



# INTRODUCTION

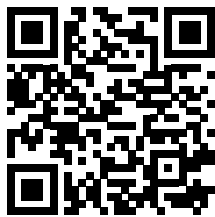


## We extend a warm welcome to the ICN2 2022 Annual Scientific Report.

This document provides a summary of the activities undertaken by the Groups, Units and Facilities of the ICN2 during the year 2022. The **complete information** about their scientific production, projects, awards, and other impacts will be made **available on the ICN2 website**, where you can conveniently browse through all the science that we have produced.

For in-depth details about 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.

For a quick overview of the ICN2's activities in 2022, we recommend that you refer to the ICN2 2022 Executive Summary, which is available here:



<https://icn2.cat/annual-reports/2022/>

Visit our website for  
extended information

## WHAT IS THE ICN2?

The **Institut Català de Nanociència i Nanotecnologia**, also known as the Catalan Institute of Nanoscience and Nanotechnology (**ICN2**), is a non-profit international research institute located near Barcelona in Catalonia, Spain. It is committed to advancing knowledge, materials and devices in the fields of Information and Communication Technology (ICT), health, energy and the environment.

ICN2's expertise lies in the nanoscale, where it uncovers new properties, interactions and ways to exploit them in everyday life. The institute's objectives include bringing together scientists from diverse backgrounds to pursue better science, providing improved training for future generations of nanoscientists, and enhancing outreach to society, while also exploring new ways to engage with local and global industry.

ICN2 was accredited as a Severo Ochoa Centre of Excellence in 2014, a recognition that was renewed in 2018 for another 4-year period. The Severo Ochoa Programme, which is sponsored by the Spanish Ministry of Science, Innovation and Universities, aims to identify and support Spanish research centres that are among the world's best in their specialty. In 2022, it was announced that the ICN2's accreditation would be renewed for the third time in a row, effective from 1 January 2023. This reflects the tremendous capability of the institute to continuously enhance its scientific and administrative processes to adapt to an increasingly diverse and complex society.



The trustees of ICN2 are the **Generalitat de Catalunya (Catalan Government)**, the **Spanish National Research Council (CSIC)** and the **Universitat Autònoma de Barcelona (UAB)**, where it is based. 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.

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 work/life balance.



## WHAT DO WE DO?

At ICN2, we firmly believe that nanoscience and **nanotechnology will have an even more significant 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 private institutions**, and to facilitate the adoption of newly generated knowledge by **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 multinational companies across diverse sectors. Our spin-off 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 and address the pressing issues of our time.

## EQUAL OPPORTUNITIES

ICN2 reaffirms its steadfast **commitment to fostering equal treatment and opportunities**, while managing diversity across all areas, preventing any direct or indirect discrimination based on factors such as gender, religion, culture, or other potentially discriminatory conditions. The institute diligently 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 2022, a renewed Equal Opportunities and Diversity Committee has been working diligently to develop an ambitious **III Equal Opportunities and Diversity Plan**. This updated plan encompasses various aspects of the institute's institutional development, 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. We maintain a strong commitment to preventing harassment and promoting conducive working conditions, implementing procedures for prevention and addressing complaints or claims promptly.

The **Women Talent Programme** specifically supports female researchers who aspire to achieve higher scientific goals. 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 such as Harvard University, Yale University, the Max Planck Institutes, the French National Centre for Scientific Research (CNRS), and the French Alternative Energies and Atomic Energy Commission (CEA). This enables the ICN2 to continue offering positions to future nanoscientists. In 2022, the institute had an **average workforce of 303.51 members**.



	Total no. of full-time equivalents	31/12/2022 Total no. of persons	31/12/2022 Women	
			Number	%
<b>Total</b>	<b>303,51</b>	<b>326</b>	<b>143</b>	<b>43,87%</b>
<b>1. Academic staff</b>	<b>182,28</b>	<b>196</b>	<b>82</b>	<b>41,84%</b>
Group leader senior	17,93	20	4	20,00%
Group leader junior	0	0	0	0,00%
Staff Scientists	18,48	21	12	57,14%
Postdoctoral	49,23	57	19	33,33%
Predocctoral	59,72	63	27	42,86%
Others	36,92	35	20	57,14%
<b>2. Non-academic staff</b>	<b>121,23</b>	<b>130</b>	<b>61</b>	<b>46,92%</b>
Administration	44,73	47	33	70,21%
Core scientific platforms	14	14	3	21,43%
Laboratory support	20,86	24	11	45,83%
IT staff	4,9	5	0	0,00%
Others	36,71	40	14	35,00%
<b>TOTAL</b>	<b>303,51</b>	<b>326</b>	<b>143</b>	<b>43,87%</b>

## PHD PROGRAMME

The ICN2 is unwavering in its **commitment to fostering excellence** in its PhD Programme, designed to equip students with the unparalleled 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 **invaluable 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 industry pioneers, participate in international conferences and workshops, and seize opportunities for academic and industry placements with local and global partner institutions.

In 2022, 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.

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 chosen professional paths.**

## POSTDOCTORAL TRAINING PROGRAMME

As part of the Severo Ochoa Programme and HRS4R budget, the ICN2 has meticulously crafted a Postdoctoral Training Plan dedicated to offering R2 and R3 Postdocs **exceptional 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 steadfast in its commitment 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 bestowed 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 2021, the ICN2 successfully secured the renewal of the HRS4R badge, extending its acknowledgement of distinction until at least 2024. The renewal process entailed updating the HR Action Plan and engaging with external experts. The meticulously devised actions for the current and previous periods can be accessed in the Careers section of the ICN2 website, showcasing our unwavering **commitment to fostering a supportive and dynamic environment for our researchers and staff.**

# THE YEAR AT A GLANCE

In this part of the Annual Report, we're excited to share the significant impacts of our institutional, research, and innovation efforts during 2022. In the sections that follow, you'll find a carefully selected collection of highlights and updates from the year, covering our achievements in important areas like sustainability, diversity, and scientific excellence. We're proud to share these accomplishments with our stakeholders and look forward to continuing our mission to make a real difference.



<https://icn2.cat/annual-reports/2022/introduction/the-year-at-a-glance/>

Visit our website for extended information



## INSTITUTIONAL HIGHLIGHTS

In the year 2022, the ICN2 spearheaded 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.

### Excellence in Research recognition to ICN2 Human Resources renewed

The ICN2 has renewed its Human Resources Strategy for Researchers (HRS4R) badge for its continued excellence in recruitment, training, development, and equal opportunities policies and projects.



This recognition is linked to the European Charter for Researchers and is valid until 2024. The renewal process included updating the HR Action Plan and external expert evaluation.



### The ICN2 joins the International Network for Sustainable Nanotechnology

This consortium promotes nanotechnology's advancement for sustainability, aligned with the United Nations Sustainable Development Goals, to collaborate and share best practices with leading organizations in the field.

### #100tífiques: Women researchers come together to promote scientific vocation in young students

The #100tífiques initiative was a huge success gathering almost 500 women researchers and technologists. Organised by the FCRI and BIST, with support from the Catalan Government's Department of Education, it aimed at bringing science closer to schools and highlighting women's contributions. #100tífiques creates female role models to inspire both girls and boys. An opening event focused on women in science, addressing gender stereotypes and barriers gathering almost a half of the participants.

### #100tífiques



Organitzen:



Barcelona Institute of Science and Technology

Hi col·labora:



Departament d'Educació



**UPF and UB sign an agreement to collaborate in the BIST’s “Ciutadella del Coneixement” project**

The two universities will collaborate for concrete actions, among which is the participation in the boards of trustees of three of the BIST centres that will be located in the future BIST building. The ICN2 will increase its research power with new facilities in the building.

**Women Talent Programme 2021 Event**

On International Women’s Day, the ICN2 hosted the Women Talent Programme Final Event to give visibility and financial support to female researchers. The event, organised by the ICN2 Equal Opportunities and Diversity Committee, included presentations by previous awardees, a panel discussion, and the 2021 awards ceremony. Awards were given for the best PhD theses, articles published in peer-reviewed journals, and project grants received by women from the ICN2. A round table discussed the effectiveness of these tools for promoting women in scientific careers and the ICN2 Women Talent Programme.



**Investiture of Prof. Laura Lechuga as Doctor Honoris Causa at the University of Cádiz**

On March 2022, Prof. Laura Lechuga, CSIC research professor and ICN2 group leader, was officially awarded the title of Doctor Honoris Causa in a ceremony held in the Auditorium of the Faculty of Science at the University of Cadiz.



## The White Paper on Nanotechnologies: an ethical and social vision of the advances in nanoscience and nanotechnology

The most relevant aspects of nanoscience and nanotechnologies and their impact on society, the environment and human health are discussed in this book, the writing and editing of which was coordinated by researchers from the University of Barcelona and the Catalan Society of Nanoscience and Nanotechnology.

## NanoEduca 2022: final event and video contest award ceremony

The 2022 edition of the NanoEduca Programme ended with a special event for the teachers and students of the high schools that participated in the project. The winners of the NanoEduca 2022 Video Contest were awarded in a joyful ceremony.



## CATRIN and ICN2 lay the foundations for future scientific collaborations

A Memorandum of Understanding was signed on May 2022 by the Directors of the Czech Advanced Technology and Research Institute (CATRIN) and the ICN2. The agreement established a programme of scientific cooperation, interchange of ideas, knowledge, and researchers.





### Severo Ochoa Workshop on the present and future of Nanomedicine

The event, which was organised by group leader Prof. **Laura Lechuga** and counted on the participations of many members of the ICN2 community, aimed at bringing together researchers in the field on nanomedicine, clinicians from relevant hospitals, and healthcare industry experts to share results and views both on recent advances in the field and on effective procedures to transfer new technologies into clinical practice.

### Severo Ochoa Workshop on Ultrafast Physics

Organised and chaired by Dr **Klaas-Jan Tielrooij**, the event's purpose was not only to present some of the latest trends in ultrafast physics but also to discuss the usefulness of ultrafast measurements in other research fields.



### ICREA Prof. María Escudero Escribano joins the ICN2 bringing a new Research Group and an ERC Grant

Prof. **María Escudero Escribano** joined ICN2 in September 2022 as an ICREA Research Professor. Her arrival at the ICN2 strengthened the institution's involvement in renewable energy research. She was awarded an ERC Consolidator Grant for a project aiming at developing novel techniques for the conversion of methane into renewable fuels, which she will carry out at the ICN2.

### III Event on Gender Equality by SOMMa: new visions and actions for increased diversity in the research environment

Various members of the centres that are part of the the Severo Ochoa - María de Maeztu alliance (SOMMa) participated in this meeting held at ICN2. Current challenges and results of previous equal opportunities programmes were discussed, and proposals for new actions launched.





### Quantum Matter Conference: a very successful second edition in Barcelona

After the enthusiastic reception of the first edition (Bilbao, 2021), this second appointment of the Quantum Matter Conference renewed its success with great participation by representatives of academia, research and industry. The ICN2 is among the organisers of the event.

### A large ICN2 representation at the Graphene 2022 Conference in Aachen

The ICN2 is one of the organisers of the Graphene Conference series and in 2022 participated with many talks, posters and a stand in the exhibition, sharing results of the many research lines on graphene and 2D materials –both theoretical and application-oriented— pursued at our institute.



### Fundació Èpica - Fura dels Baus presents the 'Survival vs. Resilience' project with ICN2, BIST and ICFO

On July 2022 a group of creators gathered by the Fundació Èpica – Fura dels Baus presented the result of two weeks of intensive cocreation. The “Survival vs Resilience” workshop started with experts from ICN2, ICFO, BIST, UOC, HLRS and UB who shared some scientific knowledge with the creators. Two weeks later, a complex and exciting performance surprised the attendees who were able to discuss the contents of the event with scientists and creators. Graphene was one of the main topics thanks to previous contacts with GraphCAT, a project led by ICN2, ICFO and BIST.



## ICN2 among the founding members of e-DREAM: the European Distributed Research Infrastructure for Advanced Electron Microscopy

An article on “Microscopy and Microanalysis” introduces the motivations and objectives of this new platform for advanced electron microscopy, which will allow many European research centres to optimise resources, strengthen collaborations and guarantee translational access to advanced equipment.

## Prof. Laura Lechuga participates in a WHO scientific meeting on strategies to prevent and face possible future pandemics

The WHO R&D Blueprint organised this consultation with experts in the field to apply scientific lessons learned during the SARS-CoV-2 global pandemic and draw an outline list of scientific gaps and priority research questions to prepare for pathogens with epidemic and pandemic potential.



## Graphene Week 2022: celebrations kick off for 10 years of Graphene Flagship

The 2022 Graphene Week (September, Munich) not only presented new developments in research and applications of graphene and related materials, but also had a note of celebration, as the Graphene Flagship has just turned 10.

## STEAMConf Barcelona 2022: a new agreement between BIST and STEAM SokoTech

This education and learning-focused event reached its eighth edition with the participation of STEAM SokoTech from the Fundació Ciència en Societat. The ICN2 presented brand new educational materials together with other BIST centers.





### Trends in Nanotechnology 2022: a lively and activity-packed event in Albania

On October 2022, representatives of research centres, companies and other institutions met in Tirana (Albania) to share their scientific activities and results, to discuss progress in current projects, as well as to shape future policies and initiatives. A huge delegation of the ICN2, which is one of the organisers, participated in the conference and satellite events.

### Angeleta Ferrer secondary school inaugurates its permanent premises in Barcelona's Eixample neighbourhood

The Angeleta Ferrer secondary school opened its doors for the in 2021 in a temporary location. In September 2022, 142 students started school at the institute in a brand-new building located in Barcelona's Eixample neighbourhood. To mark the occasion, an official inauguration took place with the Catalan Minister of Education Josep González-Cambray, the Mayor of Barcelona Ada Colau, BIST President Andreu Mas-Colell, and members of the school managing team, the education community, and students.



### The ICN2 celebrates the MBADay with Barcelona Global

Barcelona Global returned with a day to share the entrepreneurial, industrial and scientific Barcelona with more than 600 MBA students from five prestigious business schools: IESE, ESADE, EADA, UPF Barcelona School of Management and IQS. The visitors interacted with the Groups led by Prof. **Laura Lechuga** and Prof. **Daniel Ruiz** and discussed the interaction between science and industry with the ICN2 Business and Innovation team and the Marketing and Communication Department.



### CATRIN-ICN2 Workshop in Olomouc

The Czech Advanced Technology and Research Institute (CATRIN) of Palacký University Olomouc hosted a 'CATRIN-ICN2 Workshop' on October 2022, where representatives of the two institutes discussed ideas and opportunities for future R&D collaborations in strategic areas related to nanoscience and nanotechnology. In May 2022 CATRIN and ICN2 signed a Memorandum of Understanding for collaborations.

### ICN2 awarded for the third time with the Severo Ochoa Centre of Excellence recognition

The renewed award boosts the institutional efforts to develop excellent research and management, to consolidate new lines of work and to reinforce technology transfer strategies. With the overarching theme of "Nanosolutions for a Sustainable Society", the new ICN2 Severo Ochoa programme focuses on a series of Enabling Research Areas and three Applications Domains: Medicine, Energy-Efficient Information Processing, and Sustainable Energy Technologies.



### ERC Starting Grant awarded to Dr José Hugo García, senior researcher at the ICN2

Dr **José Hugo García**, senior postdoctoral researcher in the ICN2 Theoretical and Computational Nanoscience Group, received one of the 408 grants assigned in the ERC Starting Grants 2022 call. Thanks to this funding, Dr García will be able to enhance his research career at the ICN2 and develop artificial intelligence-driven materials for spintronic applications over the next years.





## 2022 BIST Conference: latest developments in precision medicine and much more

The 6th edition of the BIST Conference took place in November 2022, with its main day dedicated to the topic of precision medicine, and satellite sessions focusing on current issues within art and science, and diversity in STEM careers. A third satellite session, which took place in the framework of the 2022 Setmana de la Ciència, was devoted to sharing precision medicine research projects from the BIST Community with high school students.

## The closing ceremony of the 7th Edition of Crazy for Physics engaged the young participants and their families

ICREA Prof. **Stephan Roche** delighted the attendees with some history about the first quantum revolution and inspiration to face the third one that will be tackled by the students who are now finishing their high-school studies. **Àlex Argemí**, **Ana de la Osa** and Sebastian Grischpun, from the coordinating institutions ICN2 and IFAE, conducted the event of this programme promoted by Fundació La Pedrera.



## RESEARCH HIGHLIGHTS

In this section, we showcase some of the published results that have been highlighted in the news section of the ICN2 website. These results illustrate the broad diversity of interests, fundamental approaches, and potential applications of the ICN2 research lines. To learn more about the exceptional results obtained in terms of the number of publications and their excellence indicators, please refer to “The ICN2 in Numbers” section of this document.

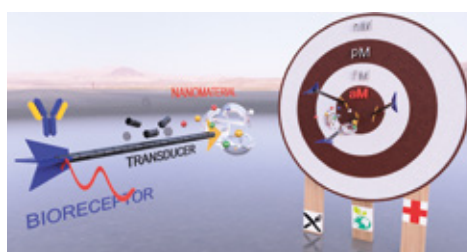


### New graphene-based neural probes improve detection of epileptic brain signals

Scientists have developed a flexible neural probe made of graphene-based transistors that can record the full range of brain signals, including infraslow signals associated with epilepsy. The probe offers high spatial fidelity and can detect electrographic signatures of the epileptic brain. The technology may lead to better surgical outcomes by more precisely identifying the zones of the brain responsible for seizure onset before surgery. The research, led by ICREA Prof. **Jose A Garrido**, was published in *Nature Nanotechnology*.

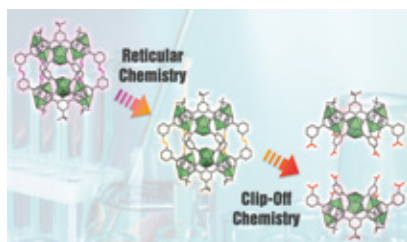
### State of the art and prospects in AttoSens, techniques for detecting ultra-low concentrations of analytes

A paper published in *Chemical Society Reviews* presents a comprehensive overview of the progress made in Attomolar Analyte Sensing Techniques (AttoSens) over the last decade. Researchers discuss the key elements of bio-chem-sensing platforms and provide examples of sensing platforms for attomolar detection of analytes in medical, environmental, and agro-food fields.



The review concludes by discussing future prospects for research in this field. This work was coordinated by ICN2 group leader ICREA Prof. **Arben Merkoçi** and Prof. V.V.R. Sai.

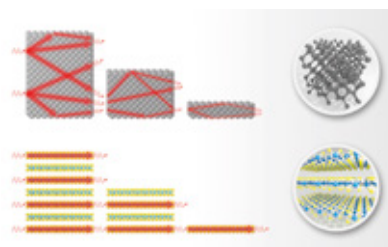
## Clip-off Chemistry: a powerful novel strategy for synthesising new materials



Scientists from various research institutions in Spain, led by Prof. **Daniel Maspoch** and Dr. **Inhar Imaz**, have developed a novel synthetic strategy called “Clip-Off Chemistry” to design new materials and molecules. The technique published in *Angewandte Chemie* involves selectively breaking bonds in existing reticular materials, such as metal-organic frameworks and metal-organic polyhedra, to generate new structures with unique topologies and properties. This powerful tool has the potential to engineer a wide range of new molecular blocks and structures for various applications. The research was funded by the European Research Council under the European Union’s Horizon 2020 programme.

## Researchers unveil the excellent heat dissipation properties of layered semiconductors down to the monolayer

A study in *Advanced Materials* shows that molybdenum diselenide (MoSe<sub>2</sub>), a transition metal dichalcogenide (TMD), maintains thermal conductivity at sub-nanometer thicknesses, unlike silicon. This makes TMDs promising for miniaturized devices, such as wearable electronics. The research, coordinated by Dr. **Klaas-Jan Tielrooij** of ICN2, involved ICN2 Group Leaders Prof. **Clivia Sotomayor Torres**, Prof. **Pablo Ordejón**, and Prof. **Sergio Valenzuela**.



## Analysis and containment of defect formation in Zn<sub>3</sub>P<sub>2</sub> crystals: a nanoscale approach

A study published in *Nanoscale* demonstrates a nanostructure fabrication strategy that produces high-quality zinc phosphide (Zn<sub>3</sub>P<sub>2</sub>) nanowires with fewer defects, making the material more attractive for use in solar cells. Coordinated by ICREA Prof. **Jordi Arbiol** and Prof. Anna

Fontcuberta, the research utilised selective area epitaxy to grow Zn<sub>3</sub>P<sub>2</sub> nanowires on an indium phosphide substrate. This method resulted in fewer interface-related defects. Advanced microscopy and 3D atomic modelling techniques were employed to understand defect formation and its impact on the material, contributing to the development of higher-quality Zn<sub>3</sub>P<sub>2</sub> crystals for solar cell applications.





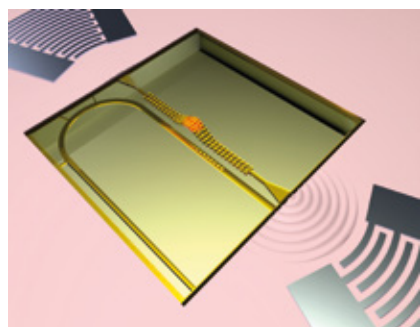
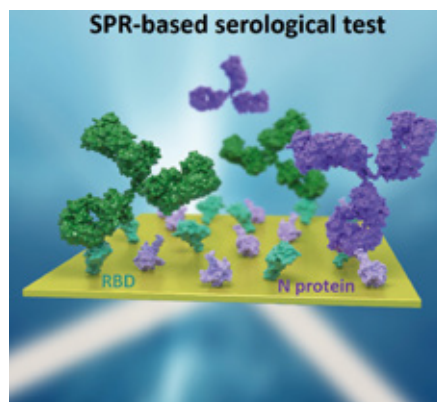
### A novel free software allows improved calculation of transport properties in materials with potential for green technologies

Researchers led by Prof. **Pablo Ordejón's** Group and the Department of Physics of Boston College developed elphbolt, a groundbreaking software that simulates the

reciprocal effect of electron and phonon interactions on the transport properties of materials. This fully self-consistent solution addresses a long-standing challenge in understanding the transport properties of solid materials. The software, based on ab initio computational methods, is freely available and well-documented. It paves the way for in-depth investigations of transport physics in solid materials and could prove valuable in the search for materials for green technologies.

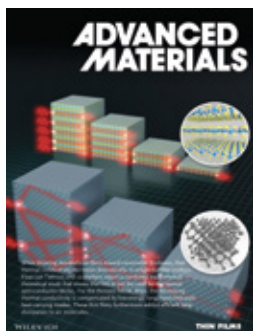
### A novel and clinically validated optical biosensor enables rapid and quantitative serological testing of COVID-19

Researchers led by CSIC Prof. **Laura M. Lechuga** have developed a novel serological nano-biosensor that quickly identifies and quantifies SARS-CoV-2 antibodies in blood serum. The plasmonic biosensor technology, published in *Analytical Chemistry*, provides results in less than 15 minutes, with 99% sensitivity and 100% specificity. Its compact design and automation potential make it suitable for point-of-care applications in doctors' practices and pharmacies.



### New vibes in information technology: a ground-breaking platform for advanced multi-signal systems

The PHENOMEN project, led by ICREA Prof. Dr. **Clivia Sotomayor-Torres**, has developed a proof-of-concept technology platform for integrating phononic, photonic, and radio-frequency (RF) electronic signals. Published in *ACS Photonics*, the research demonstrates a system that operates at ambient conditions and is fully compatible with CMOS technology. The system uses nanocrystalline silicon (nc-Si) to maximize opto-mechanical interaction and aluminum nitride (AlN) for converting electrical signals into mechanical waves. This platform has the potential to revolutionize information transmission and processing in both classical and quantum domains.

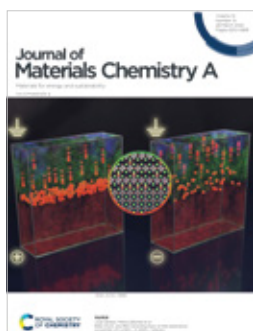
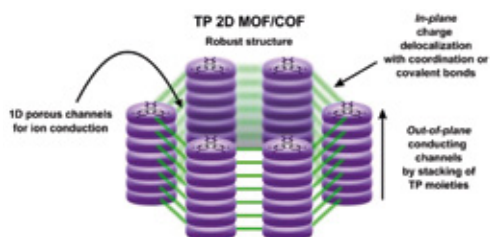


## A study on heat dissipation properties of layered semiconductors led by ICN2 on the frontispiece of “Advanced Materials”

A research on the heat dissipation properties of layered semiconductors led by the ICN2 and published in “Advanced Materials” was featured on the frontispiece of the journal. The study revealed the thermal transport properties of ultrathin crystals of molybdenum diselenide, a two-dimensional material of the transition metal dichalcogenide (TMD) family, showing that it is able to dissipate heat very efficiently to surrounding air molecules.

## Conductive properties of metal-organic and covalent organic frameworks based on triphenylene

A publication in “Coordination Chemistry Reviews” by members of the ICN2 Nanostructured Functional Materials Group discussed synthesis approaches, properties and applications of MOFs and COFs based on triphenylene molecules.

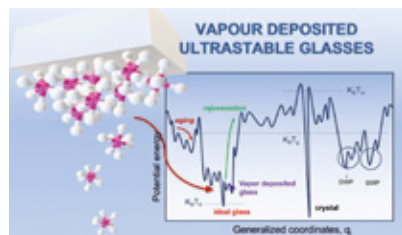


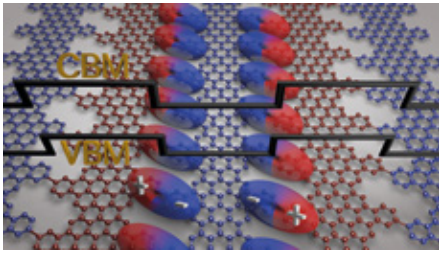
## A study on the memristive properties of lanthanum nickel oxide bilayers featured on the front cover of “Journal of Materials Chemistry A”

This research revealed the optimal film growth conditions to obtain memristive behaviour at the interface between oxygen ion conducting  $\text{La}_2\text{NiO}_4$  and electron conducting  $\text{LaNiO}_3$  epitaxial layers. Dr **José Santiso**, leader of the ICN2 Nanomaterials Growth Unit, was one of the coordinators of the study.

## Extraordinary properties and applications of ultrastable glasses: a review

Vapour deposition allows producing glassy materials that show high density and excellent properties, in particular high thermodynamic and kinetic stability. Due to these advantages over liquid-cooled glasses, new applications are now within reach, particularly in the field of organic optoelectronic devices. This work was coordinated by Prof. **Javier Rodríguez-Viejo**.



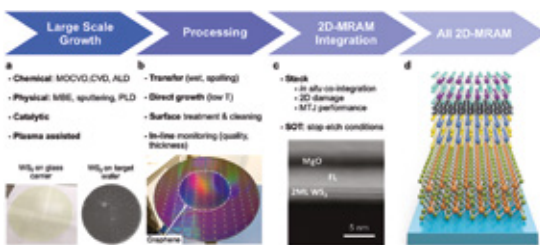
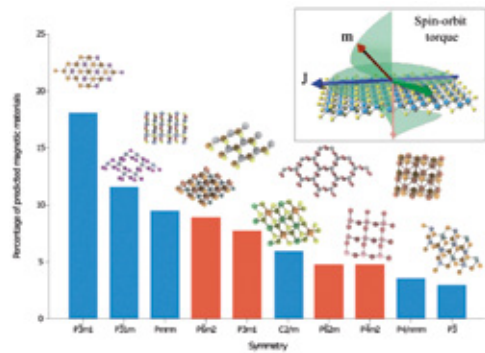


## Stitching nanostrips together to create new 2D heterogeneous materials: a novel synthesis technique

A research team led by ICREA Prof. **Aitor Mugarza**, group leader at the ICN2, devised a novel bottom-up method to assemble 2D lateral superlattice heterostructures composed of interdigitated pristine and nitrogen-doped graphene nanoribbons. Designed with unprecedented precision, this nanomaterial exhibits properties relevant for application in photodetection, excitonic solar cells, water splitting, or selective nanofiltration.

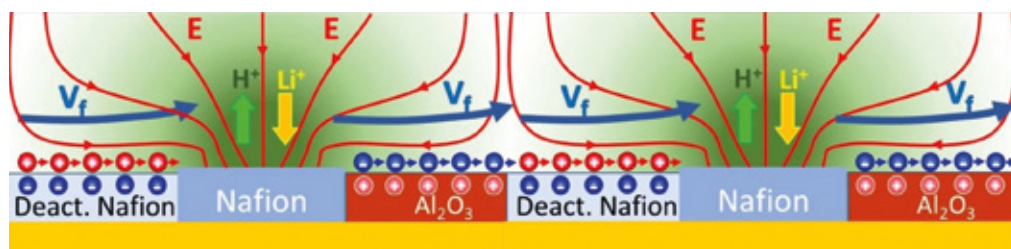
## Novel theoretical and computational tools for the design of future memory devices based on spin-orbit interactions

A theoretical analysis of magnetism, symmetry characteristics and spin transport in van der Waals materials provides guiding rules for benchmarking new tailor-made structures built by stacking different layers of atomic thickness. This work, published in 'Nature Reviews Physics', was carried out by researchers from the ICN2, the University College of London and the Johannes Gutenberg University of Mainz.



## 2D materials for a major leap forward in non-volatile memory technologies

A review published last week in "Nature" highlights the extraordinary opportunities provided by two-dimensional (2D) materials for the development of next-generation non-volatile memories, based on spintronic mechanisms. This work was coordinated by ICN2 group leaders and ICREA professors **Stephan Roche** and **Sergio O. Valenzuela**, and by Prof. Hyunsoo Yang from the National University of Singapore.

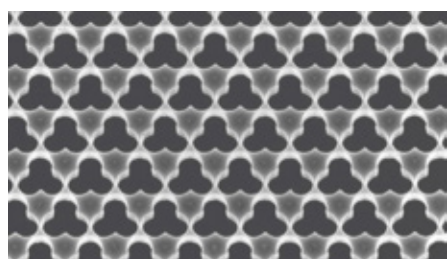
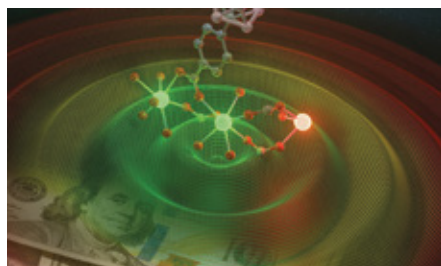


### Self-driven micropumps propelled by salts show high efficiency in water decontamination

A study published in “Nature Communications” and led by ICN2 researcher Dr **María José Esplandiú** introduced micropatterned pumps that use salts as fuel and that can selectively remove cadmium ions from water samples. Reusable, operable in high salt concentrations and able to drive unidirectional fluid flows, these devices look promising for various environmental and biomedicine applications.

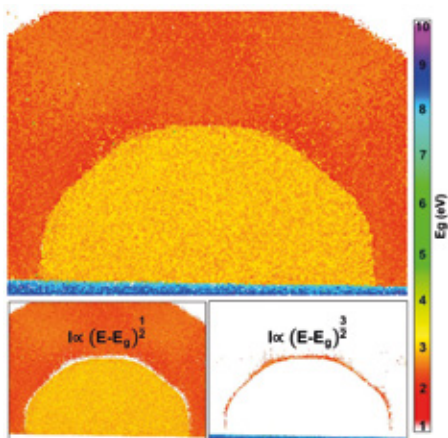
### New MOF materials for advanced anticounterfeiting techniques

A study led by researchers from the ICN2 and the ICMAB and published in “Chemistry of Materials” demonstrated the remarkable and tunable optical properties of a set of new materials –made of metal-organic frameworks combined with lanthanide and carbon-boron clusters. By suspending these materials in water, luminescent watermarks and bar-codes that change in the microsecond scale can be printed on papers for anticounterfeiting purposes.



### A novel nanostructured geometry to control and suppress unwanted GHz mechanical vibrations in materials

As reported in an article in ‘Nature Nanotechnology’, a team of researchers led by scientists at the ICN2 achieved the suppression of mechanical vibrations in a silicon nanostructured membrane by shaping it into a cloverleaf-like pattern. Unwanted vibrations compromise the performance of materials for micro- and nano-electromechanical systems. These results open the way to applications in nanotechnology, optical communications and quantum computing, among others.

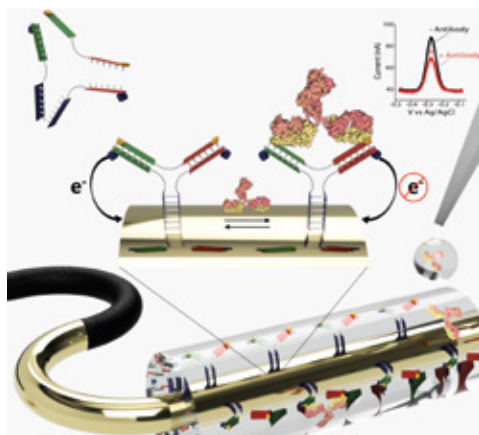


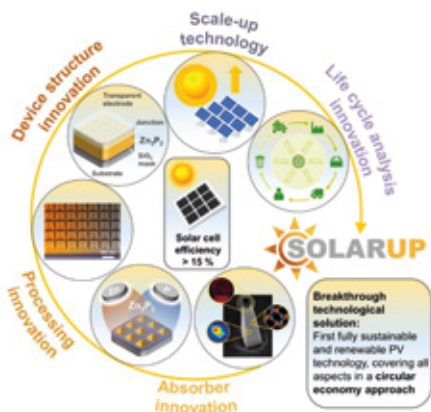
## Novel electron-microscopy methodology enables sub-nanometer characterization of the electronic properties of semiconductor nanowires

In a study coordinated by ICREA Prof. **Jordi Arbiol** and his Advanced Electron Nanoscopy Group at the ICN2, and published in "Nature Communications", arrays of core-shell nanowires made of two different semiconductors and grown horizontally on a planar surface were thoroughly analysed by means of scanning transmission electron microscopy. This atomic-scale study is key to understanding how morphological characteristics affect opto-electronic, plasmonic, and quantum properties and how to control them for application in next-generation devices.

## A DNA-based nanostructure inspired by antibodies as the core of a programmable sensing platform for rapid, single-step diagnostics

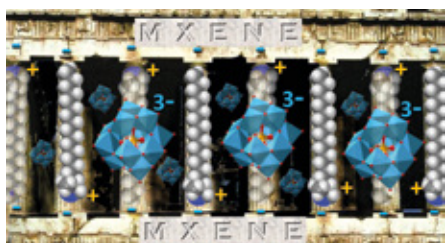
A team consisting of current and former members of the ICN2 Nanobioelectronics and Biosensors Group developed an electrochemical sensor based on a modified DNA scaffold nanostructure able to detect antibodies and proteins in unprocessed biological fluids. It has a Y-shaped architecture that mimics the one of natural Immunoglobulin antibodies. According to the results published in an article in 'Advanced Functional Materials', it is selective, specific, and adaptable to the detection of different biomarkers.





## The SOLARUP project led by Prof. Jordi Arbiol receives an EIC Pathfinder Open grant

Aimed at the development of an innovative and scalable technology for solar energy conversion, SOLARUP will be coordinated by the ICN2, with ICREA Prof. Jordi Arbiol at the leadership.

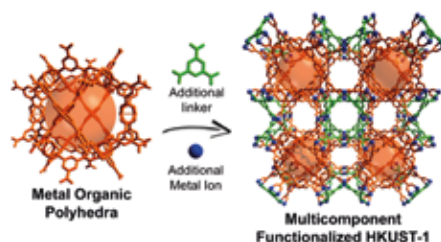


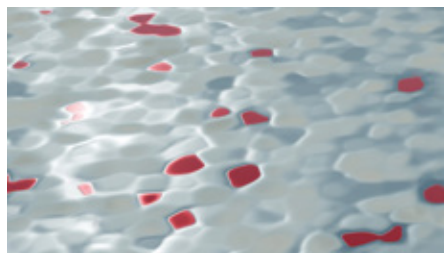
## New hybrid materials to enhance performance of supercapacitors

Two studies led by members of the ICN2 Novel Energy-Oriented Materials Group, recently published in specialised journals, explore two parallel strategies for the development of a hybrid material –based on MXene and polyoxometalates— for the electrodes of supercapacitors, which results in improved energy storage performance.

## A new strategy for custom design of multicomponent materials based on metal-organic frameworks

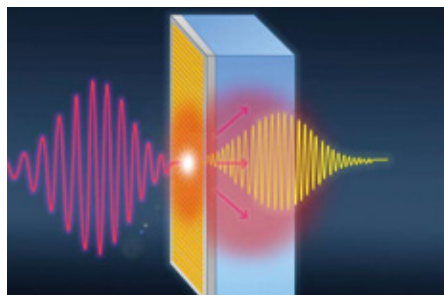
In a paper published in 'JACS', an alternative method to synthesize complex metal-organic framework (MOFs), by assembling prefabricated “pores”, was proposed. The approach envisioned by a team of researchers from the ICN2 Supramolecular NanoChemistry and Materials Group provides greater control over the materials produced and their specific properties.





### Physicists shed new light on unanswered questions about glass-liquid transition

A study published in 'Nature Physics' provided new insights into the glass to supercooled-liquid transition, a complex phenomenon that still holds many secrets. A new mechanism that drives the transition under specific conditions is introduced. These results will spark off further research and enable novel and improved applications, in particular in the field of organic electronics.



### Quantum materials enable next-generation photonics for mobile networks in the terahertz regime

A paper published in 'Light: Science & Applications' demonstrates that quantum materials of the topological insulator family can efficiently upconvert electromagnetic radiation in the terahertz (THz) regime. These results open new avenues for THz photonics technology and its application in sensing, homeland security and sixth-generation mobile communications. The study was conducted by a team of researchers coordinated by ICN2 group leader Dr **Klaas-Jan Tielrooij**.

### The next generation lateral flow assays and the integration of nanomaterials, a review

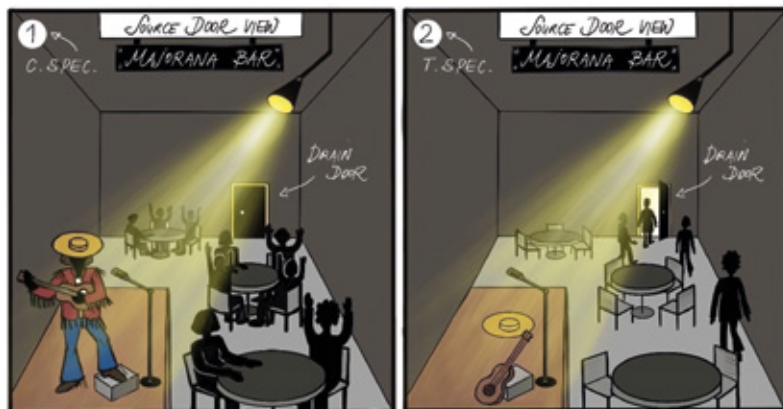
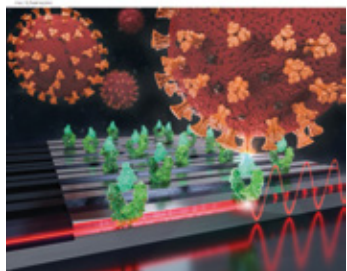
In an article published in 'Chemical Reviews', members of the ICN2 Nanobioelectronic and Biosensors Group discussed the developments carried out over the latest ten years in the field of lateral flow assay technology for diagnostics and other sensing applications. The different strategies used to overcome some of the limitations of currently used LFAs are analysed, with special focus on the contribution of nanomaterials and nanotechnologies.





## A sensitive photonic nanodevice provides rapid and quantitative diagnostic of COVID-19

A team of researchers led by members of the ICN2 NanoBiosensors and Bioanalytical Applications Group presented on the pages of 'Sensors & Diagnostics' an innovative photonic biosensor that can detect the presence of the SARS-COV-2 virus at very low concentrations in a sample. It can also provide a quantitative measure of the viral load in less than 20 minutes, which is crucial to prevent the spread of the infection and to intervene quickly with the appropriate treatment.



## A two-technique cross measurement allows identifying impostor Majorana particles

Majorana anyons, theoretically predicted particles which are expected to show exotic properties with great potential for quantum computing applications, are both very elusive and difficult to distinguish from other quantum states. Researchers from ISTA, ICN2 and ICMM-CSIC combined two different measurement techniques to unmask an impostor Majorana particle, as described in a study published in 'Nature'.



## BUSINESS AND INNOVATION HIGHLIGHTS

In line with the entrepreneurial spirit of the institute and its researchers, many research lines developed at the ICN2 have an applied objective. In this section, we highlight some of the major technology transfer and applied innovation actions that took place in 2022.



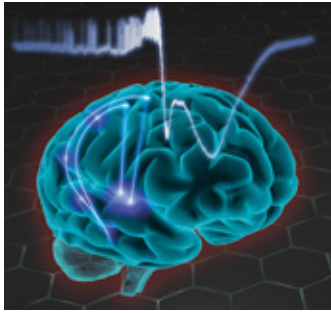
### **ICN2 presents the future of neurotechnology and batteries at 4YFN – Mobile World Congress**

4 Years From Now (4YFN) is the part of the Mobile World Congress focused on pioneers, founders and ground breakers. The ICN2 was present in this startup ecosystem to share in a round table the results and vision of INBRAIN Neurotechnologies, a spin-off company led by CEO Carolina Aguilar, and to present the achievements of Napptilus Battery Labs, an ICN2 spin off from the ICN2 Novel Energy-Oriented Materials Group.

### **INBRAIN Neuroelectronics signs an agreement to develop neurotechnology patented by six public research institutions**

INBRAIN Neuroelectronics is a technology company developing graphene-based applications for neurological diseases founded by researchers from IMB-CNM-CSIC, ICN2 and ICREA who lead some of the research areas of the Graphene Flagship. The agreement paved the way for further development and industrialization of patented technology from CSIC, ICN2, ICREA, CIBERBBN, UAB and IDIBAPS.





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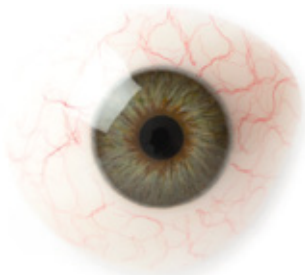
### **ICN2 leads an EIC Pathfinder Challenges grant to develop breakthrough neurotechnology for brain interfaces**

Granted a total of 5.2M euros, the project will be carried out by a consortium coordinated by the ICN2 and that includes INBRAIN Neuroelectronics, a spin-off company founded by researchers from ICN2, IMB-CNM-CSIC and ICREA developing graphene-based implants to treat neurological diseases.

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### **From Publish or Perish to Profit or Perish: the professional journey of a scientist turned into deeptech entrepreneur**

Dr Gerardo Marchesini opened a new series of seminars launched by the ICN2 Department of Business and Innovation. He shared his experience with deeptech technology and startup companies.



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### **Nanotechnology for improved natural-look ocular prostheses**

The ICN2 and CSIC are partnering with Art-lens to develop better ocular prosthetic solutions for patients that have lost an eye. From the ICN2 side, the project will be led by Dr Claudio Roscini from the Nanosfun group.

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### **PUZZLE X puts on stage frontier technologies and audacious ideas for the future of humanity**

This lively and exiting event, which reached its second edition in 2022, was held in Barcelona in November 2022. The ICN2 participated with a booth and brought along some of its spin-off companies.





### The spinoff INBRAIN Neuroelectronics receives new funding by the EC via the EIC Accelerator

A highly competitive process led to successful recommendation by the European Commission to provide up to 15M€ investment in INBRAIN Neuroelectronics. Funding will be used to support the development of the world's first graphene intelligent brain network platform towards commercialization.

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### A new spin-off of ICN2, UAB and CSIC will commercialise a nanotechnology-based smart ink

Distinkt sprang from years of research by Dr **Àlex Julià-López**, Dr **Claudio Roscini** and CSIC Prof. **Daniel Ruiz-Molina**, from the Nanosfun group at the ICN2, and Prof. Jordi Hernando, from the Universitat Autònoma de Barcelona. They have developed an invisible ink for anti-counterfeiting applications in official documents, banknotes, luxury goods, and more.



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

At the core of ICN2's ethos lies an unwavering commitment to scientific excellence, societal impact, and addressing major global challenges. This dedication has manifested itself in the Institute's relentless pursuit of groundbreaking research, the development of cutting-edge nanotechnologies and nanomaterials, and their translation into practical applications. As we celebrate the third consecutive Severo Ochoa Centre of Excellence accreditation (2023-2026), ICN2 is poised to further strengthen its international leadership, expand its influence, and maximise its impact on the world.

The Scientific & Strategic Plan for the Severo Ochoa Programme 2023-2026 is meticulously designed, encompassing three Application Domains, four Enabling Research Areas, and an array of Cross-Cutting Initiatives (both Scientific and Institutional). This innovative framework not only paves the way for ICN2's future endeavours but also builds upon our previous successes as a Severo Ochoa Centre of Excellence.

First recognised in 2014, ICN2's journey as a Severo Ochoa Centre of Excellence has been marked by remarkable achievements. Our initial accreditation placed us among the most prestigious research centres in Spain, inspiring our research groups, support division, and administration to collaborate in converting our vast knowledge into tangible devices and solutions for society's pressing challenges. This period also saw ICN2's international reputation soar, solidifying our institute as a magnet for talented professionals seeking to advance their careers within and beyond research.

Following our initial success, ICN2 was once again honoured with the Severo Ochoa distinction in 2018, as one of the five national research centres recognised by the Spanish Research Agency (AEI). Our reaccreditation further validated our position as a leading force in national and international research, building on the scientific leadership established during our first Severo Ochoa tenure.

As we embark on the next chapter of our journey with the third iteration of the Severo Ochoa Award, announced in 2022, we remain steadfast in our commitment to making a meaningful difference in the world. Through our innovative research, unwavering dedication to societal impact, and global leadership, ICN2 is poised to continue breaking boundaries and shaping the future for the better.



## APPLICATION DOMAINS

Our **Application Domains**, focused on delivering transformative nanoscale solutions to address pressing societal needs, include:

- **Nanosolutions for Medicine:** ICN2 aims to become a driving force within the health ecosystem, consolidating research efforts directed towards health applications, such as Oncology, Neurology, and Infectious Diseases. Our focus lies in developing novel technologies for prevention, diagnosis, and treatment, boosting translational academic research, fostering collaboration with clinicians, and facilitating the transfer of knowledge and results to clinical settings and health-related industries.
- **Nanosolutions for Energy-Efficient Information Processing:** The program concentrates on tailoring artificial materials for specific applications, exploring topological materials and structures for future communication technologies (beyond 5G), and developing Multivariable Quantum & Neuromorphic technologies. Artificial Intelligence (AI) will also be employed to accelerate the design of nanoengineered materials for optimal device performance.
- **Nanosolutions for Sustainable Energy Technologies:** ICN2 will focus on developing efficient systems and advanced technologies for Energy Harvesting, Conversion and Storage, as well as Thermal Management. Our innovative approach will utilize AI@ICN2 and advanced infrastructure, enabling the discovery of new practical energy materials and minimizing the environmental footprint of our technologies.

## ENABLING RESEARCH AREAS

Our four **Enabling Research Areas** serve as the foundation for the Application Domains:

- **Artificial Intelligence Computational Platform (AI@ICN2):** AI@ICN2 aims to offer internal operational guidance and tools while advancing machine learning (ML) methods in existing in-house molecular dynamics and quantum transport formalisms. This platform aspires to become a central and transformative driving force for sustainability and impact.
- **Nanomaterials and Nanofabrication:** ICN2 boasts considerable expertise in nanomaterials and nanofabrication, providing the synthesis of novel nanostructures and nanomaterials using bottom-up or top-down approaches. New procedures for accelerating the industrial and clinical translation of nanotechnologies and nanomaterials will be developed, and nanofabrication protocols and processes will be adapted to green chemistry principles for more sustainable material usage and reduced waste and toxic agents.
- **Nanocharacterisation:** ICN2 has access to in-house advanced equipment and large-scale facilities for nanocharacterisation, as well as leading scientific expertise and technical competencies in imaging, spectroscopy, and nanoscale manipulation. The In-CAEM project, supported by €15 million from the EU Next Generation Programme, will provide access to a beyond-state-of-the-art nanocharacterisation platform for in-situ/in operando materials analysis.
- **Modelling and Simulation:** ICN2 is an international benchmark in methodologies, computational tools, and codes for modelling and simulation.

These techniques are applied in collaboration with Research Groups to various topics, including neuromorphic computing, spintronics, and electrochemical environments for energy storage/conversion and bioelectronic devices. AI and Machine Learning methods will also be developed and leveraged within local and international high-performance computing infrastructures.

## CROSS-CUTTING INITIATIVES

The **Cross-Cutting Initiatives** encompass several scientific and institutional actions that aim to enhance our research capabilities, support innovation, and promote a diverse and inclusive environment:

### Scientific Actions:

- **Seed Funding Program:** Fund proposals to develop new ideas or concepts and promote collaborations.
- **Research Personnel:** Severo Ochoa co-funded PhDs & Postdocs.
- **Equipment & Infrastructure:** Acquisition of equipment and infrastructure for new groups, AI@ICN2, and other initiatives.
- **International Scientific Workshops**

### Institutional Actions:

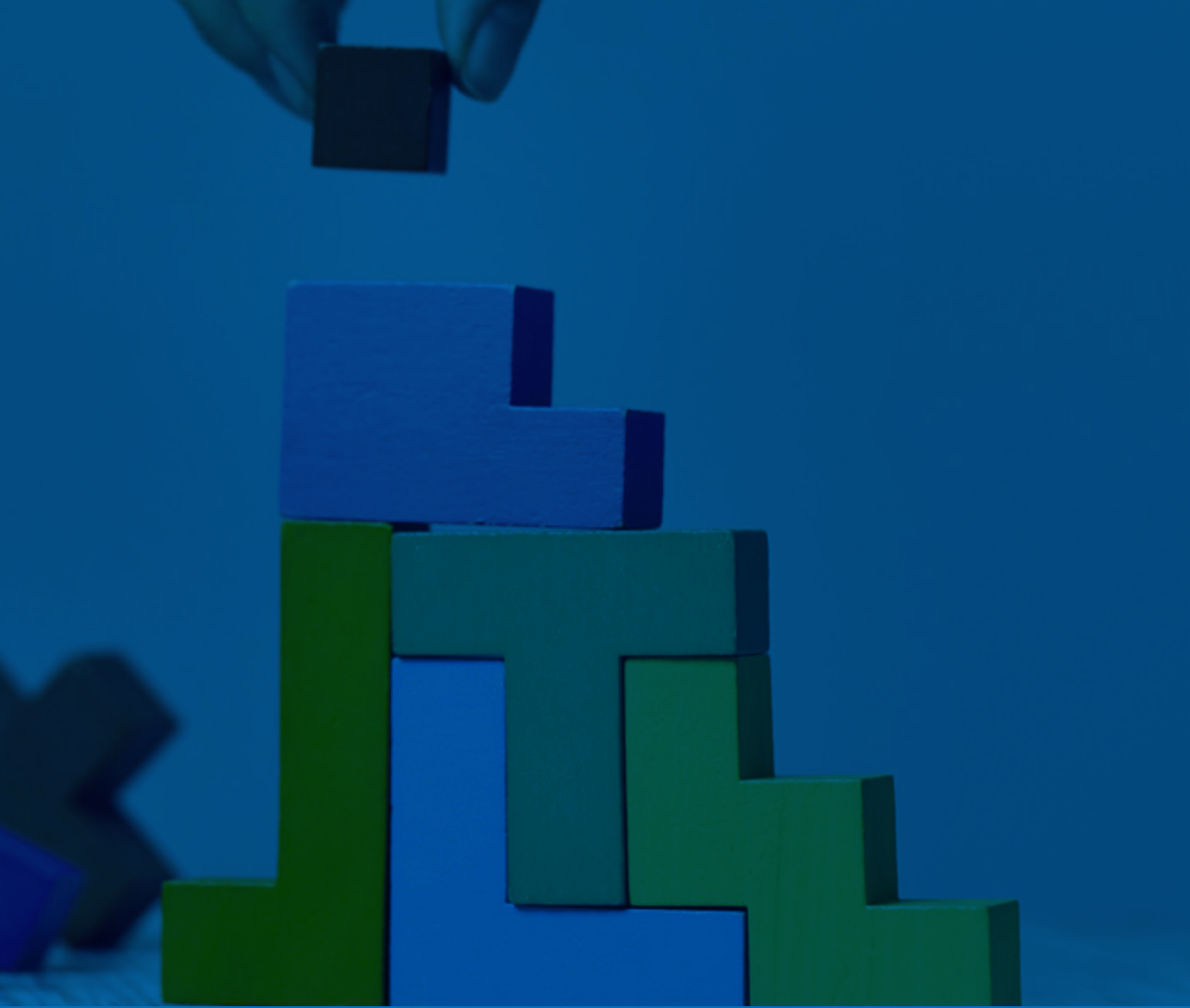
- **Fundraising:** Diversify our income sources to reduce dependence on core funding & competitive projects.
- **Internationalisation actions** to maximise excellence and influence.
- **Talent Attraction and Retention**
- **Equity, Diversity and Inclusion:** Actions tackling structural gender imbalances

and providing tools to promote integration and belonging.

- **Business and Innovation:** Strengthening activities for ICN2 to become a self-sustained tech incubator integrated into the EU and global science and innovation systems.
- **Outreach and Dissemination:** Activities to further engage with the community at large in a two-way dialogue on benefits/risks of nanotechnology.
- **Open Science and Open Data**
- **Ethics And Integrity**

As we continue our journey with the third iteration of the Severo Ochoa Award, ICN2 remains steadfast in our **commitment to making a meaningful difference in the world**. Through our innovative research, unwavering dedication to societal impact, and global leadership, ICN2 is poised to continue breaking boundaries and shaping the future for the better.





# ORGANISATION



# ORGANISATION

At ICN2, we take immense pride in recognizing 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.

## BOARD OF TRUSTEES

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\* The roles of president and vice-president alternate every two years.

## SCIENTIFIC ADVISORY BOARD

### PRESIDENT

Prof. **Miquel Salmerón**, Lawrence Berkeley National Laboratory and UC Berkeley, USA

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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, and the General Manager, Mr **Lluís Bellafont**.

## 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 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.

## BUSINESS AND INNOVATION OFFICE

In 2022, 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 team evaluated 14 new technologies, filed multiple patents, and signed various agreements to strengthen collaboration with industry partners. Furthermore, the B&I team managed 40 active patent families, initiated 16 new R&D projects, and supported the creation of one spin-off company, Distinkt, S.L.. These achievements, combined with private contracts and licenses, resulted in an annual income of €838,953 for ICN2, highlighting the team's unwavering commitment to bridging the gap between scientific research and real-world applications.

## RESEARCH GROUPS

At the ICN2, senior scientists of global recognition spearhead research endeavours, guiding teams of PhD students, postdoctoral researchers, and fellow senior scientists in advancing their respective areas of specialisation. In 2022, the ICN2 proudly hosted 20 distinguished research groups, collectively encapsulating a comprehensive spectrum of nanoscience research.

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. Puentes**

Magnetic Nanostructures  
ICREA Prof. **Josep Nogués**

Nanobioelectronics and Biosensors  
ICREA Prof. **Arben Merkoçi**

Nanobiosensors and Bioanalytical  
Applications  
Prof. **Laura M. Lechuga**

Nanoelectrocatalysis and Sustainable  
Chemistry  
ICREA Prof. **María Escudero Escribano**

Nanomedicine  
Prof. **Kostas Kostarelos**

Nanostructured Functional Materials  
Dr **Daniel Ruiz-Molina**

Nanostructured Materials for Photovoltaic  
Energy  
Dr **Mónica Lira-Cantú**

Novel Energy-Oriented Materials  
Prof. **Pedro Gómez-Romero**

Oxide Nanophysics  
ICREA Prof. **Gustau Catalán**

Phononic and Photonic Nanostructures  
ICREA Prof. Dr **Clivia M. Sotomayor-Torres**

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  
Prof. **Pablo Ordejón**

Thermal Properties of Nanoscale Materials  
Prof. **Javier Rodríguez-Viejo**

Ultrafast Dynamics in Nanoscale Systems  
Dr **Klaas-Jan Tielrooij**

## RESEARCH SUPPORT DIVISION

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

Instrumentation Unit  
Dr **Gustavo Ceballos**

Electron Microscopy Unit  
Dr **Belén Ballesteros**

Nanomaterials Growth Unit  
Dr **José Santiso**

### CORE RESEARCH FACILITIES

Biolab Facility

Mechanical Workshop

Molecular Spectroscopy and Optical  
Microscopy

Nanofabrication Facility

Photoemission Spectroscopy (XPS&UPS)  
Facility

X-Ray Diffraction Facility



## MANAGEMENT AND SERVICES

Research at ICN2 is not only driven by our scientists, but it's also supported and enhanced by a wide range of management and support services. The ICN2 General Manager, Mr Lluís Bellafont, holds overall responsibility for the administration of the institute, with each department and area led by its own Head. These dedicated teams work together to ensure a strong foundation for our groundbreaking research.

Competitive Funding  
**Mireia Martí Barroso**

Finance  
**Judit Vela**

Health and Safety Area  
**Jose Antonio Pérez**

Human Resources  
**Julio Pérez**

Information Technologies  
**Javier González**

Maintenance and Services  
**Xavier Ros**

Marketing and Communication  
**Àlex Argemí**

Technical Management Support Area  
**Estefanía Latorre**



# ICN2 IN NUMBERS

## FINANCE

### FINANCIAL ACCOUNTS 2022

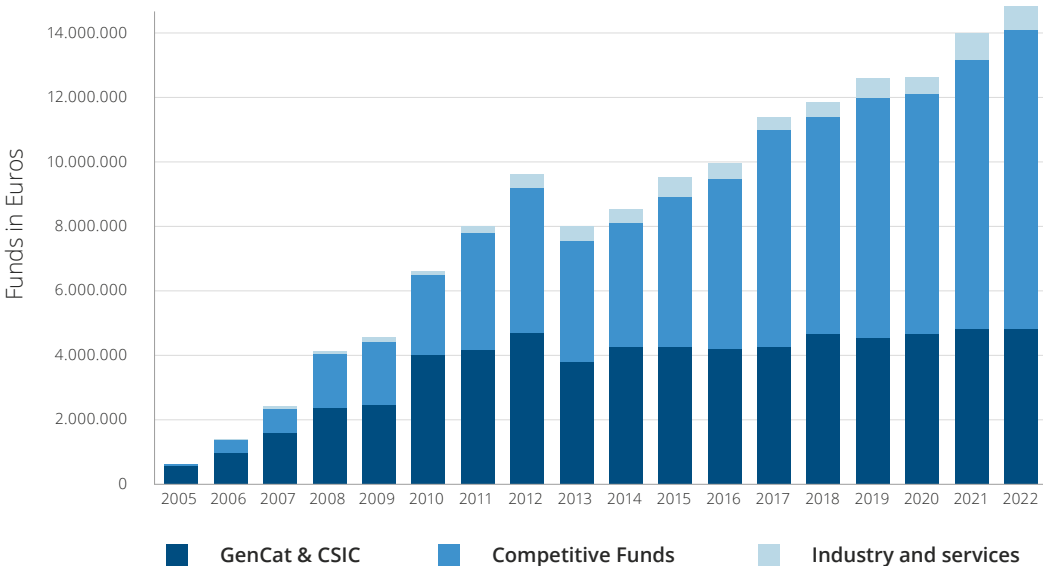
Throughout 2022, the ICN2 Finance Department has sustained its commitment to digitise its operations, thereby augmenting departmental efficiency. This endeavour has resulted in the creation of an online platform for procurement and travel management.

This year, our efforts have been concentrated on the consolidation of two primary objectives. The first is to enhance communication and adapt our services to align with the varying requirements of distinct groups and departments. The second is to commence provision of financial information to all users.

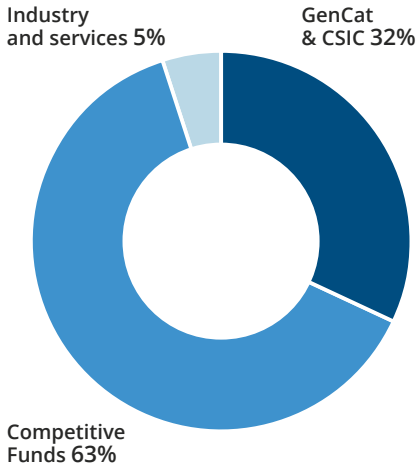
### INCOME

In 2022, the **total operational funds for ICN2 were recorded at €14,813,266**. Of this sum, **32%** was procured from the **Generalitat de Catalunya and the Spanish National Research Council (CSIC)**, **63%** was drawn from **competitive funding** opportunities, and the remaining **5%** was sourced from **industry and services**.

### Evolution of ICN2 Operational Funds



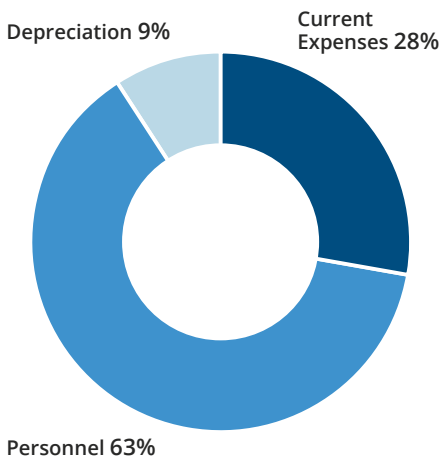
## Funds Distribution 2022



## EXPENSES

Total expenditure in 2022 reached **€14,213,866** including current expenses, personnel costs and depreciation.

## Expenditure in 2022



## FACILITIES AND EQUIPMENT

The **aggregate investment** committed by ICN2 towards scientific equipment, communal services, and general infrastructure, as of the close of the year 2022, amounted to **€31,148,685**. The **year 2022** witnessed a significant investment allocation totalling **€5,268,476**, with the following being the most substantial contributions:

- 2-Laser Raman Spectroscopy
- Fluotime 300
- Laser Spectroscopy Microscope (Raman)
- Picosecond Supercontinuum Laser With Tunable Wavelength
- Raman And PI Spectrometer
- Nanoindenter KLA Tencor
- Verdi Laser from Coherent
- Fluxim Litos Lite
- Cryo-Free Cryostat
- UHV Process Chamber
- THR64000 Spectrometer
- Ivium Potentiostat
- Exp. 2017-03 ICN2 "Works For The Conditioning of Controlled Environment Laboratories for Nanofabrication"
- Scanning Tunneling Microscope and Atomic Force Microscope (STM/AFM)
- Ultrarapid Mechanical Mapping Module
- Craker Effusion Cell Type CRC-40-SBTE
- Circulation Thermostat
- Probes and Positioner Manipulators

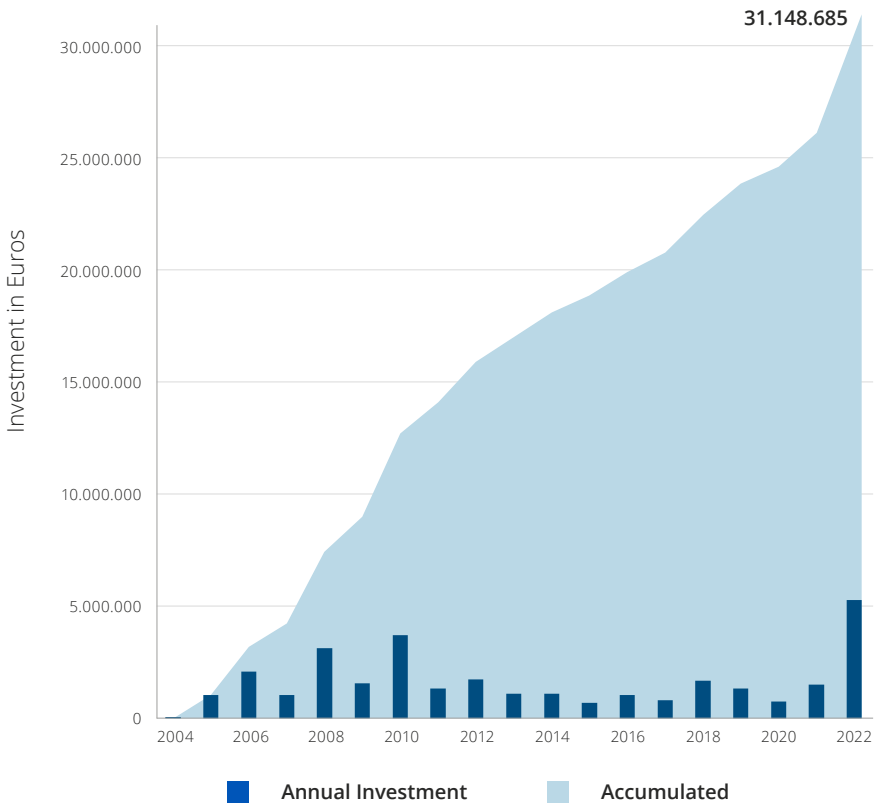


## EQUIPMENT FUNDED USING SPANISH ERDF (“FEDER”) FUNDS:

- nXDS6i Dry Pump
- Capacitive Guage
- Chemistry Diaphragm Pump
- Activeline Control Software
- RV3 Vacuum Pump
- Laser 808 Nm
- Micro-Heater MPN:CMH-7019
- Valve Gate Cf 35 Manual Operated
- CNI-MGL-III-532-300-2%-Led
- Pfeiffer Duo 6 Vacuum Pump  
Ref: Pk 195 488-T
- Dewar Refrigeration
- Thr64000 Spectrometer
- Rotavapor Bath
- Oil Vacuum Pump with Sensor



## Evolution of Investments between 2004 and 2022



# RESEARCH OUTPUTS

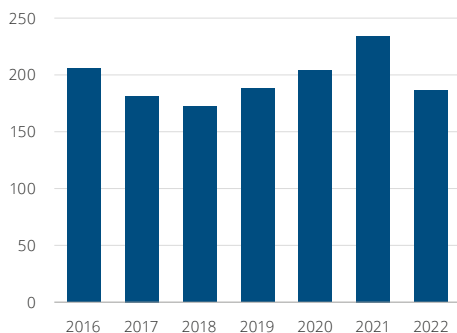
## PUBLICATIONS

In 2022, ICN2 excelled in terms of scientific publications, producing **186 original papers** published in the most prestigious journals in the field. The average institutional impact factor (IF) witnessed further growth, rising from 11.11 in 2021 to **13.451** (JCR - WoS) in 2022. Additionally, 9 articles were published in non-indexed journals.

According to the Journal Citation Reports (JCR) from Web of Science, **76%** of these articles were accepted for publication in first-quartile journals, while **47%** were featured in first-decile journals. In 2022, papers authored by ICN2 researchers were cited **15,699 times**, as recorded by Web of Science databases.

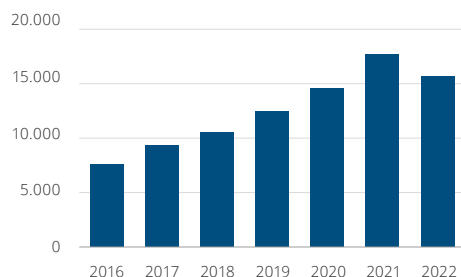
While we acknowledge that bibliometric data is still a significant indicator for some of our funders, it is worth mentioning that ICN2 has signed the **Coalition for Advancing Research Assessment Agreement**. This agreement establishes a shared direction for changes in assessment practices for research, researchers, and research performing organisations, ultimately aiming to maximise the quality and impact of research.

### Number of indexed articles per year



Source: iMarina

### Number of citations per year



Source: Web of Science

## TOP 10 JOURNALS by IF

The table lists the higher impact factor journals where the ICN2 researchers have authored at least one article in 2022.

Journal	JCR IF	No. articles
<i>Chemical Reviews</i>	72.087	1
<i>Nature</i>	69.504	2
<i>Nature Reviews Clinical Oncology</i>	65.011	1
<i>Nature Materials</i>	47.656	2
<i>Nature Catalysis</i>	40.706	1
<i>Nature Nanotechnology</i>	40.523	4
<i>Energy &amp; Environmental Science</i>	39.714	1
<i>Nature Reviews Physics</i>	36.273	1
<i>Advanced Materials</i>	32.086	6
<i>Advanced Energy Materials</i>	29.698	2

## BUSINESS AND INNOVATION

The Office of Business and Innovation is dedicated to **protecting and commercialising ICN2's groundbreaking research results**, forging 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, producing tangible outcomes and reinforcing ICN2's status as a centre of excellence. The Business and Innovation Office strives 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 and accelerator for ICN2 technologies**, making significant strides towards integrating public science with the production of goods and services. Severo Ochoa funding has enabled internal support programmes 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.

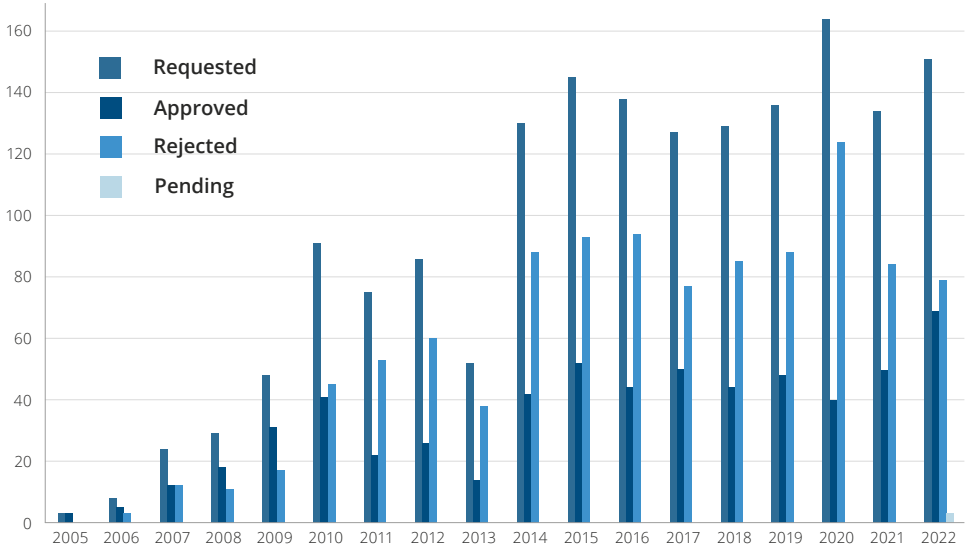
In 2022, the Business and Innovation Office focused on **extending and strengthening our network** through strategic communication efforts, engaging with **112 companies** and generating an annual income of **€838,953** from private contracts and licenses.

## PROJECTS

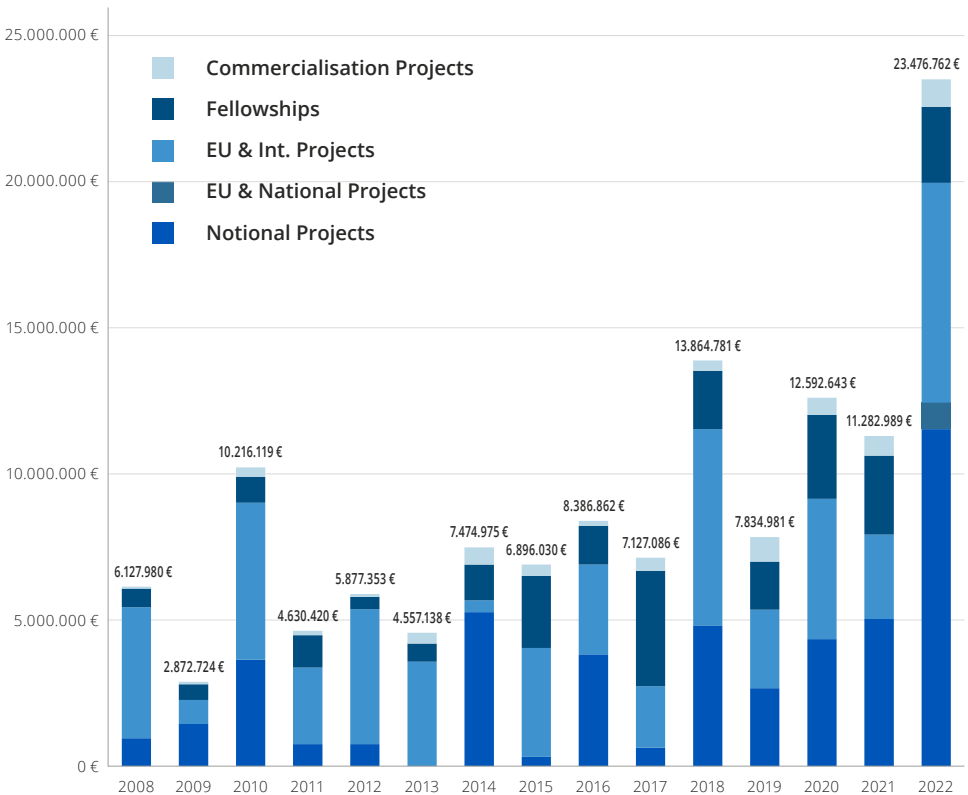
In 2022, the number of proposals submitted has remained consistent with the average of previous years. However, there has been a significant increase in the number of projects awarded. The income generated has experienced exponential growth, doubling the average of previous years and reaching an exceptional milestone.

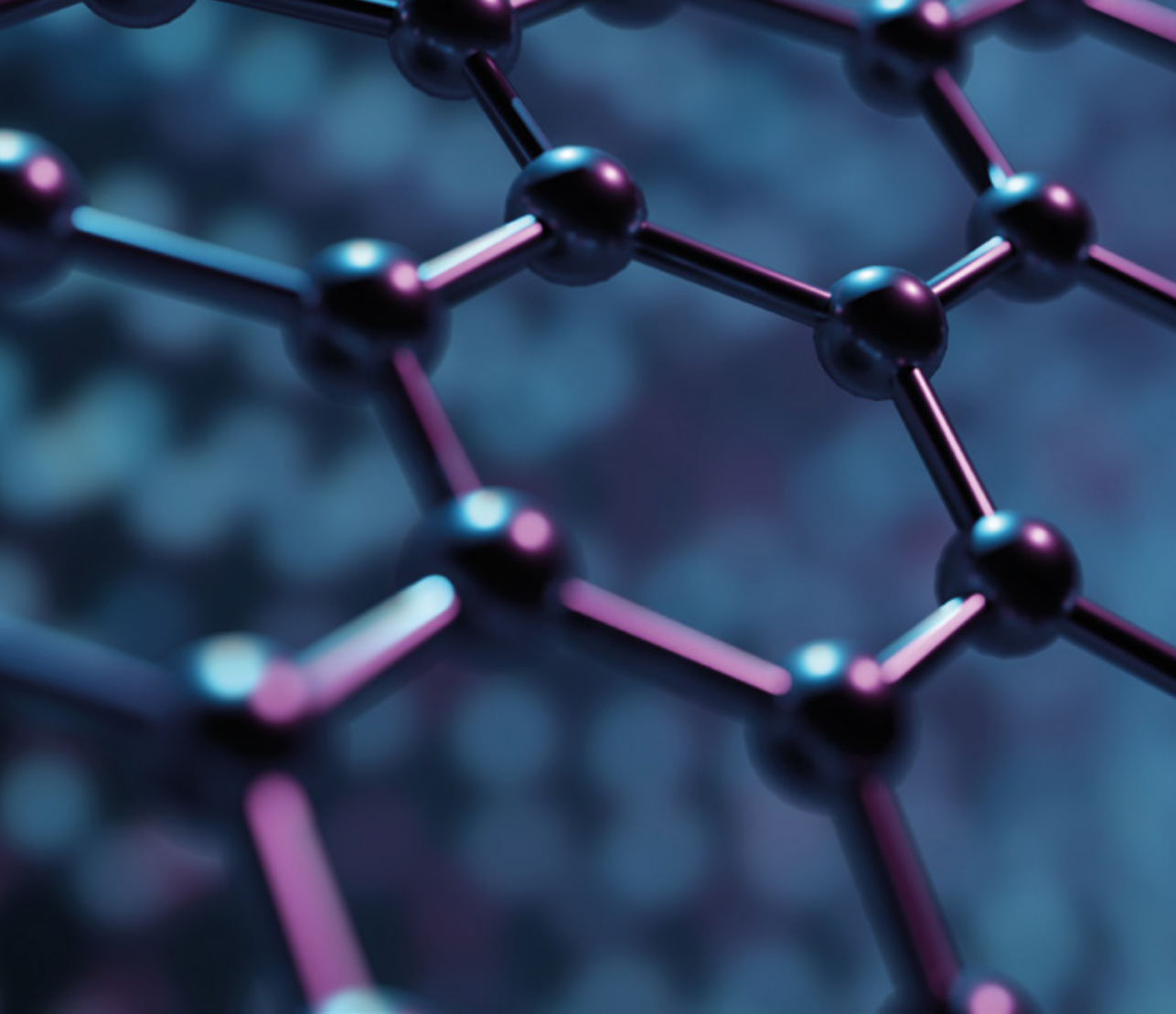
### Outcome of proposals submitted on each year

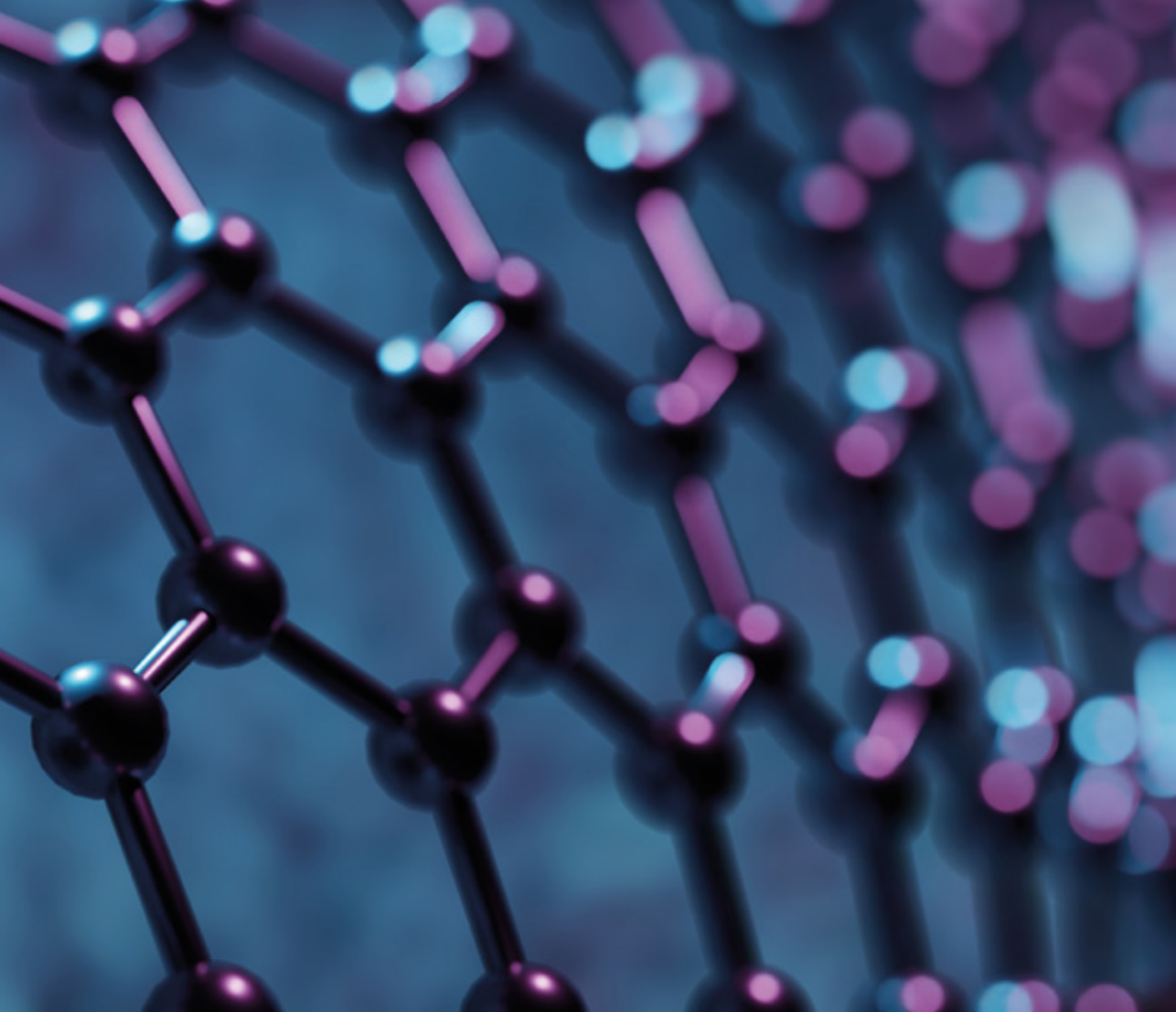
(2022: between Jan.1 and Dec.31; solved by Apr.17, 2023)



### Proposals approved on each year (regardless the year of application)







# OUR RESEARCH

# RESEARCH GROUPS

The ICN2 currently has 20 research groups which together cover much of the breadth of nanoresearch. Each group pursues its own clear lines, while also working towards joint research objectives.

- Advanced Electron Nanoscopy **p.56**
- Advanced Electronic Materials and Devices **p.62**
- Atomic Manipulation and Spectroscopy **p.68**
- Inorganic Nanoparticles **p.72**
- Magnetic Nanostructures **p.76**
- NanoBioelectronics and Biosensors **p.80**
- NanoBiosensors and Bioanalytical Applications **p.86**
- Nanoelectrocatalysis and Sustainable Chemistry **p.92**
- Nanomedicine **p.96**
- Nanostructured Functional Materials **p.100**
- Nanostructured Materials for Photovoltaic Energy **p.106**
- Novel Energy-Oriented Materials **p.112**
- Oxide Nanophysics **p.118**
- Phononic and Photonic Nanostructures **p.122**
- Physics and Engineering of Nanodevices **p.128**
- Supramolecular NanoChemistry and Materials **p.132**
- Theoretical and Computational Nanoscience **p.138**
- Theory and Simulation **p.144**
- Thermal Properties of Nanoscale Materials **p.150**
- Ultrafast Dynamics in Nanoscale Systems **p.156**



# ADVANCED ELECTRON NANOSCOPY GROUP

## 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), adding AI-based methodologies for advanced automated data analysis and 3D atomic modelling (deep and machine learning).
- Understanding of the behaviour of nanomaterials for energy and environmental applications down to the atomic scale and creation of in-situ and correlative methodologies combining electron microscopy, synchrotron and AI.

## GROUP MEMBERS

### **Arbiol Cobos, Jordi**

ICREA Research Professor and Group Leader

### **Arias Cano, Noèlia**

Project Manager

### **Botifoll Moral, Marc**

Doctoral Student

### **Garzón Manjón, Alba**

Senior Researcher

### **Han, Xu**

Postdoctoral Researcher

### **Kienhoefer, Richard Julian**

Visiting Master Student

### **Llorens Rauret, David**

Visiting Doctoral Student

### **Luo, Shunrui**

Postdoctoral Researcher

## GROUP LEADER

### JORDI ARBIOL

ICREA Research Professor



ICREA Prof. Jordi Arbiol was born in Molins de Rei (Catalonia) in 1975. Having graduated in physics from the *Universitat de Barcelona* (UB) in 1997, he went on to obtain his PhD in transmission electron microscopy applied to nanostructured materials from this same university in 2001. He earned the “*European Doctorate*” label in recognition of the European dimension of his thesis project, as well as an extraordinary doctorate award from UB. He then held the position of assistant professor at the UB, before becoming a group leader at the *Institut de Ciència de Materials de Barcelona* (ICMAB) in 2009, as well as the scientific supervisor of the institute’s electron microscopy facility. There he began his personal and professional mission to improve Barcelona’s baseline electron microscopy infrastructure, an endeavour he has continued to pursue at the ICN2, which he joined in 2015 as the leader of the Advanced Electron Nanoscopy Group.

#### **Martí Sánchez, Sara**

Research Engineer

#### **Naranjo Bejarano, Enrique**

Fellowship Master Student

#### **Pinto Huguet, Iván**

Doctoral Student

#### **Quiñones Acuña, Judith**

Visiting Degree Student

#### **Salutari, Francesco**

Doctoral Student

#### **Spadaro, Maria Chiara**

Postdoctoral Researcher

#### **Xifra Montesinos, Claudia**

Visiting Degree Student

#### **Yu, Jing**

Fellowship Doctoral Student

#### **Zhang, Ting**

Postdoctoral Researcher

#### **Zhifu, Liang**

Postdoctoral Researcher

He has been President of the *Spanish Microscopy Society* (SME) (2017-2021), Vice-president (2013-2017) and member of its Executive Board (2009-2021). In 2019 he became a Member of the Executive Board of the *International Federation of Societies for Microscopy* (IFSM) (2019-2027). He is member of the Research Committee at the *Barcelona Institute of Science and Technology* (BIST) and Scientific Coordinator of the Joint Electron Microscopy Center at ALBA Synchrotron (JEMCA).

Other recognitions include the *FWO Commemorative Medal* in 2021, the *BIST Ignite Award* in 2018, the 2014 EU40 Materials Prize (E-MRS), the 2014 *EMS Outstanding Paper Award*, as well as being listed in the Top 40 under 40 Power List (2014) by *The Analytical Scientist*. He currently has more than 446 peer-reviewed publications, h-index 94 GoS (81 WoS), with more than 28,000 GoS citations.



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**34**  
ARTICLES



**6**  
FUNDED PROJECTS

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**15**  
CONTRIBUTIONS

## 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 and ReMade@ARI) 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. In this way, two of the research topics we will explore, 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, 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 1D and 2D nanomaterials for their application in quantum computing (Microsoft) as well as the photovoltaic (PV) cells developed within SOLARUP, and a better understanding of the physical

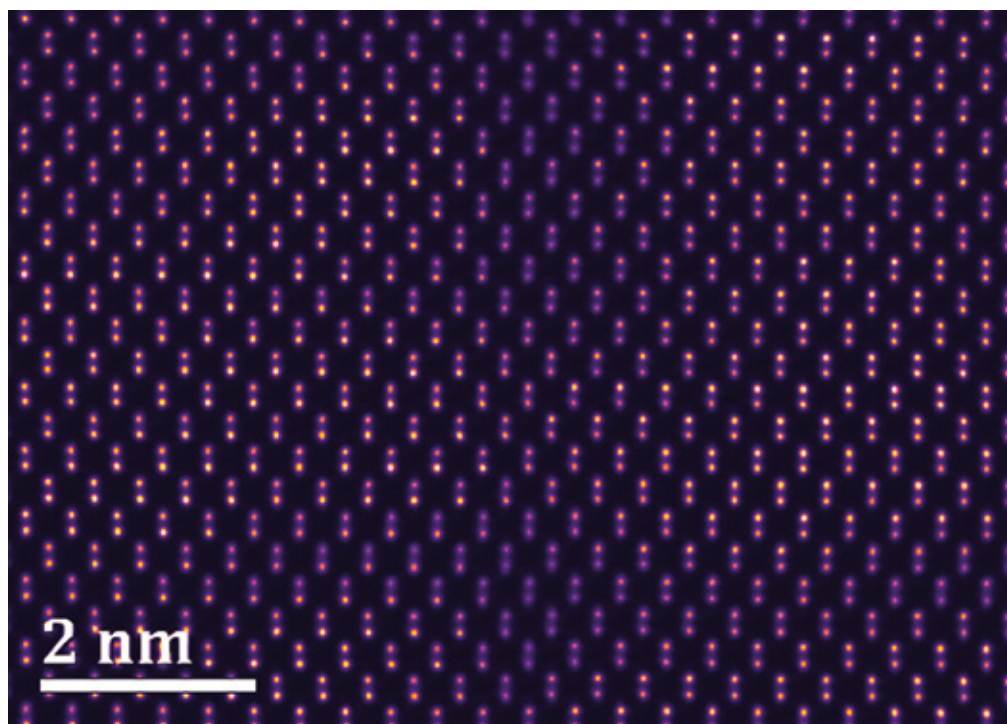
phenomena involved in the related devices. We will continue the search for Majorana-based or related quantum devices supported by our recent highlight in Nature 2022. In addition, as the new industry developments for quantum materials or novel nanostructured photovoltaic devices have as a priority objective 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 (Nanoscale Horiz. 2022). The computing infrastructure necessary to develop such an ambitious AI-based project has been included in In-CAEM, which will provide the large data storage, data analysis and data treatment computing resources in collaboration with ALBA and PIC-IFAE.

## B) In-situ 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 2023 HORIZON EU Calls).





**5**

AWARDS

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**2**

THESES

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**3**

CONGRESSES  
ORGANISATION

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**4**

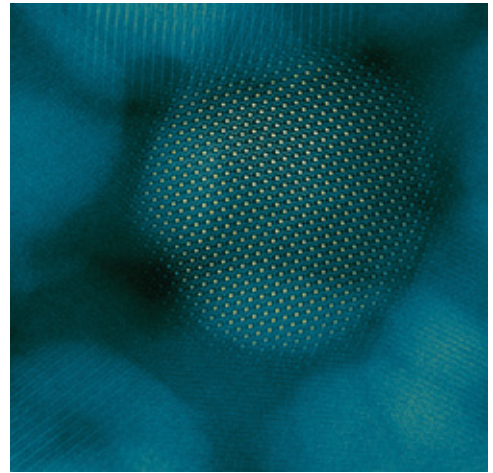
OUTREACH IMPACTS

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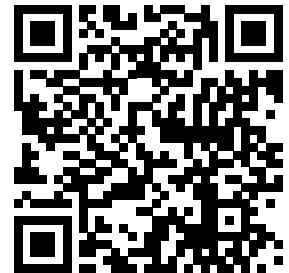


**1**

COURSE



Visit our website for  
extended information



# ADVANCED ELECTRONIC MATERIALS AND DEVICES GROUP

## MAIN RESEARCH LINES

- Technology and micro/nanofabrication for advanced electronic devices and systems based on 2D materials
- Chemical vapour deposition (CVD) of graphene and metal-organic CVD of transition metal dichalcogenide (e.g. MoS<sub>2</sub>) films
- Fundamental electronic and electrochemical phenomena of 2D materials
- Bioelectronics and biomedical technologies: neural interfaces, neuroprosthetics, cell bioelectronics
- Electronic and electrochemical biosensors

## GROUP MEMBERS

### **Garrido Ariza, Jose Antonio**

ICREA Research Professor and Group Leader and Vice Director

### **Bernícola García, María del Pilar**

Doctoral Student

### **Bujaldon Velasco, Marina**

Research Support Technician

### **Clares Rodriguez, Ana Sofia**

Visiting Degree Student

### **De Antonio Garcia, Isabel**

Visiting Master Student

### **De la Cruz Sánchez, José Manuel**

Doctoral Student

### **Del Corro García, Elena**

Senior Researcher

### **Delgà Fernández, Marta**

Doctoral Student

### **Duvan, Fikret Taygun**

Doctoral Student

## GROUP LEADER

### JOSE ANTONIO GARRIDO

ICREA Research Professor and Vice Director



Jose A. Garrido is an ICREA Research Professor and leader of the ICN2 Advanced Electronic Materials and Devices Group, which explores novel electronic materials, such as graphene and other 2D materials, and their potential in electronic and bioelectronic applications.

He received his Master's and PhD degrees in Telecommunication Engineering from the *Universidad Politécnica de Madrid* in 1996 and 2000, respectively. From 2001 to 2004 he worked as a postdoc at the *Walter Schottky Institute, Technische Universität München* (Germany). He obtained his habilitation in experimental physics at this university in 2010 and from 2011 to 2015 held a lecturer (privatdozent) position at its department of physics.

#### **Ferreira Morais, João Pedro**

Research Support Technician

#### **Galceran Sabatés, Aina**

Visiting Degree Student

#### **García Barceló, Carmen**

Visiting Degree Student

#### **Gener, Thomas Adrien**

Senior Postdoctoral Researcher

#### **Graf, Anna Weronika**

Doctoral Student

#### **Hidalgo Nieves, Sara**

Visiting Degree Student

#### **Jiménez Terrones, Víctor**

Visiting Master Student

#### **Katirtsidis, Georgios Alexandros**

Doctoral Student

#### **Llamas Llamas, Nicolás**

Visiting Master Student

#### **López Cabezón, Cristina**

Visiting Degree Student





In 2015 Jose A. Garrido joined the ICN2 where, in addition to his role as Group Leader, he is Vice-Director. He was the coordinator of the European project *BrainCom* (finished in April 2022), in which 10 institutions from 6 countries participated in the development of a brain implant that allows verbal communication in patients with aphasia. He was also the leader of the *GraphCAT* project (finished in June 2022), which is part of a large initiative of the Catalan government aiming at supporting emerging communities with large innovation potential. The project involves over 20 institutions including industry and academia.

In addition, he is also the coordinator of the *i-VISION* project funded by *La Caixa Foundation*, where 5 institutions join forces in the development of a retinal implant to restore vision. Since October 2022, he is coordinating the *MINIGRAPH* project, in which 7 institutions from 5 countries work together develop and validate a new generation of brain implants with closed-loop neuromodulation capabilities enabled by high-density arrays of graphene microelectrodes.

Jose A Garrido is also founder, Chief Scientific Officer, and member of Board of Directors of *INBRAIN Neuroelectronics*, an ICN2 spin-off that aims at the commercialization of graphene-based neural devices for medical applications. During 2022, *INBRAIN* has raised €17.5M from the European Commission via the EIC Accelerator, and won the most innovative company of 2022 prize by “*El Periodico*”.

### **Madrid Gimeno, Miquel**

Research Support Technician

### **Masvidal Codina, Eduard**

Postdoctoral Researcher

### **Navarro García, Adrián**

Visiting Degree Student

### **Pérez Marín, Antonio Pablo**

Specialist Technician

### **Pérez Tomás, Amador**

Senior Postdoctoral Researcher

### **Pérez Torres, Iván**

Visiting Master Student

### **Prokop, Michal**

Doctoral Student

### **Puig Velasco, Maria Victoria**

Senior Researcher

### **Remacha Gelabertó, Laura**

Visiting Master Student

### **Ria, Nicola**

Doctoral Student

### **Ruiz Nicolás, Patricia**

Scientific Project Manager

### **Ruiz Puerta, Jon Ander**

Visiting TFG Student

### **Schäfer, Christian Martin**

Research Assistant

### **Walston, Steven**

Senior Postdoctoral Researcher

## NEW PROJECTS & MILESTONES

The AEMD group aims to explore fundamental electronic and electrochemical phenomena of novel materials, with a current particular emphasis on graphene and other 2D materials (e.g. MoS<sub>2</sub>), and to develop the fabrication and processing technologies necessary to prepare advanced electronic devices and systems based on them. A major focus of our work are applications related to neural interfaces and neuroelectronics.

2022 has been a year of great progress for the group. Our team has continued working on the BrainCom, the EU FET Proactive project coordinated by us and which finished in April 2022, which is oriented at developing a new generation of neural prostheses for restoring communication in patients with severely impaired language processing abilities. As a highlight, we have validated the use of graphene field effect transistors for mapping of brain activity in acute and chronic in vivo settings as well as the development of an ASIC for controlling the graphene-based neural arrays operation.

Within the EU Graphene Flagship, our group has continued participating in the Core 3 phase. During 2022, we have advanced with the development of graphene-transistor based neural recording technology and showing its usefulness for detecting epilepsy-related biomarkers, a study that was published in Nature Nanotechnology<sup>1</sup>.

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<sup>1</sup> Full-bandwidth electrophysiology of seizures and epileptiform activity enabled by flexible graphene microtransistor depth neural probes | Nature Nanotechnology



6

ARTICLES

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14

FUNDED PROJECTS

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4

TECHNOLOGY TRANSFER  
MILESTONES

We have started the RESCUEGRAPH<sup>2</sup> project, focused on the functional stimulation system for rehabilitation of gait and driving neural plasticity after spinal cord injury using graphene-based nerve electrodes (under the FLAG ERA programme, led by Prof. Xavier Navarro from the UAB). As an important outcome of this project, we have demonstrated the capabilities of small graphene microelectrodes to stimulate selectively and with low current thresholds different fascicles within the rat sciatic nerve. These results confirm that rGO microelectrodes are excellent candidates for peripheral nerve interfaces such as those intended for motor recovery. Our team is also working on the i-VISION project (funded by La Caixa Foundation), 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. During this year stimulating electrode arrays for implantation in the subretinal space have been developed and tested in vivo demonstrating its usefulness to elicit visually evoked sensations as recorded by electrocorticography and functional ultrasound.

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 funded by the Spanish Ministry, focused on technologies based in 2D materials for biomedical applications, of which Dr Elena del Corro is co-PI.

The EU project WASP, devoted to the development of wearable electronics for biomedical applications, finished in June 2022. During the last stage of the project, we have explored different enzyme immobilization approaches towards the dotation of our devices with glucose sensing capabilities.

Together with the ICN2 Phononic and Photonic Nanostructures Group, our group also take part in the NANOSMART project for the development of wireless technology based on carbon and 2D materials.

At individual level, Dr. Eduard Masvidal Codina was awarded with a Juan de la Cierva grant<sup>2</sup> and Anna Graf was awarded with the predoctoral grant “INPHINIT INCOMING” funded by La Caixa Foundation.

Since October 2022, the AEMD group is working and coordinating the MINIGRAPH, and EIC Pathfinder project funded by the European Commission. The Kick off meeting was held in October 2022, where representatives of the consortium met in Barcelona to discuss the short-term objectives and the project timeline.

In December 2022 our group started the new project “BrainGraph”, led by Antón Guimerà from CNM-IMB and collaborating with INBRAIN Neuroelectronics, focused on graphene based neurotechnology for advanced clinical brain monitoring. This project has been funded under the call “Proyectos en líneas estratégicas” funded by MCIN/AEI and by the European Union NextGenerationEU/ PRTR.

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<sup>2</sup> Funded by MCIN/AEI /10.13039/501100011033 and by the European Union NextGenerationEU/PRTR



**22**

CONTRIBUTIONS

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**5**

AWARDS

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**1**

THESIS

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**2**

CONGRESSES  
ORGANISATION



**9**

OUTREACH IMPACTS

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**1**

COURSE

Visit our website for  
extended information



# ATOMIC MANIPULATION AND SPECTROSCOPY GROUP

## MAIN RESEARCH LINES

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

## GROUP MEMBERS

### **Mugarza Ezpeleta, Aitor**

ICREA Research Professor and Group Leader

### **Chávez Angel, Emigdio**

Senior Researcher

### **Diego Lisboa Amaral Lopes, Bárbara**

Research Support Technician

### **Durán Retamal, José Ramón**

Postdoctoral Researcher

### **García Diez, Kevin**

Doctoral Student

### **Merino Mateo, Pablo**

Senior Researcher

### **Paradinas Aranjuelo, Marcos**

Laboratory Engineer

### **Ribas Saurí, Esteve**

Doctoral Student

### **Simon De Febrer, Roger**

Visiting Degree Student

### **Tenorio Tuñas, María**

Postdoctoral Researcher

### **Toda Cosi, Serni**

Visiting Master Student

## GROUP LEADER

### AITOR MUGARZA EZPELETA

ICREA Research Professor and Group Leader



Prof. Aitor Mugarza graduated in physics in 1997 and completed his PhD in the same field in 2002, both at the *Euskal Herriko Unibertsitatea* (University of the Basque Country). He was awarded a Marie Curie Fellowship to work as a postdoctoral scientist at the *Lawrence Berkeley National Laboratory* (USA) and the *Institut de Ciència de Materials de Barcelona* (ICMAB). He joined the former *Catalan Institute of Nanotechnology* in 2007 with a Ramón y Cajal Fellowship. In 2013 he became group leader of the Atomic Manipulation and Spectroscopy Group at ICN2. He has been an ICREA Research Professor since 2015.

His research activity revolves around the study of quantum electronic and magnetic phenomena at the nanoscale and the development of strategies for their manipulation with atomic precision. By combining scanning tunnelling microscopy techniques with spectroscopy using synchrotron radiation, he correlates microscopic phenomena to macroscopic observables for the characterisation and design of new materials and devices. He is currently focused on novel materials including molecular and graphene nanostructures, and 2D quantum materials.

## NEW PROJECTS & MILESTONES

The scientific research carried out by the Atomic Manipulation and Spectroscopy Group in 2022 was centred on the synthesis of atomically precise graphene-based 2D nanostructures, the characterization of their chemical and physical properties, and on exploring their potential application in different devices.

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 the quantum electronic coupling and anisotropy of NPG, with prospects on similar tunability of their nanosieving and thermoelectric properties. By developing a new synthetic method, we have also been able to fabricate the narrowest lateral superlattice heterojunctions featuring band discontinuities at the single-bond limit. 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 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.

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 can behave as single atom magnets even in the presence of a two-dimensional electron gas, which can be used to manipulate the magnetic properties of the individual atoms.



4

ARTICLES

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8

FUNDED PROJECTS

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14

CONTRIBUTIONS

In the line of 2D quantum materials, we have been able to fabricate an atomically precise step superlattice of a single atom thick BiAg<sub>2</sub> layer, a 2D material with record high Rashba-type spin-orbit interaction. The profound transformation of the spin-orbital texture of the Rashba electron gas under such potential superlattice constitutes the proof of concept of the use of step superlattices to tailor the quantum properties of 2D materials.

Finally, Prof. Aitor Mugarza is coordinating the development of a scanning probe microscopy (SPM) platform at ALBA synchrotron. The SPM platform 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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**2**

**AWARDS**

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**1**

**CONGRESS  
ORGANISATION**

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**1**

**THESIS**

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**6**

**COURSES**



# INORGANIC NANOPARTICLES GROUP

## MAIN RESEARCH LINES

- Design and development of synthetic strategies for the production of complex nanoparticles
- Surface functionalisation of nanoparticles with specific relevant (bio) molecules
- Study of their physicochemical and fundamental properties and reactivity
- Applicability of inorganic nanoparticles in biomedicine, energy harvesting and catalysis

## GROUP MEMBERS

### **Franco Puentes, Víctor**

ICREA Research Professor and Group Leader

### **Ahenda, Stephen Ouma**

Doctoral Student

### **Álvarez García, Alba**

Visiting Degree Student

### **Barberà Ferrando, Laura**

Visiting Technician

### **Demakova, Elizaveta**

Doctoral Student

### **Espada Santacreu, Aleix**

Visiting Degree Student

## GROUP LEADER

### VÍCTOR F. PUNTES

ICREA Research Professor



ICREA Research Prof. Víctor F. Puentes' work spans the full breadth of research on nanoparticles: synthesis, conjugation, and characterisation of inorganic nanoparticles; study of their physicochemical properties; nanotoxicology and nanosafety; and a wide range of applications in different fields, including energy harvesting, catalysis, medicine and environment.

Prof. Puentes completed his undergraduate studies in chemical engineering and materials science at the *Université Louis Pasteur Strasbourg* (France) and the *Universitat Autònoma de Barcelona* (UAB). In 1998, he earned his PhD in physics from the *Universitat de Barcelona* (UB), working with Prof. Xavier Batlle and Prof. Amílcar Labarta on giant magnetoresistance in granular alloys. He then spent over three years at the *University of California, Berkeley* (USA) and the *Lawrence Berkeley National Laboratory* (LBNL, USA) in the groups led by Prof. Paul Alivisatos and Prof. Kannan Krishnan, working on the synthesis and control of nanostructures. In 2003 he returned to Catalonia with a Ramon y Cajal research grant at the UB. In 2005 he obtained an ICREA professorship at the then ICN (now ICN2) to create the Inorganic Nanoparticles Group, which he currently leads.

#### Freixanet Gusta, Muriel

Research Support Technician

#### Gómez Bastus, Neus

CSIC Tenured Scientist

#### González Rioja, Ramón

Research Assistant

#### Hervés Carrete, Carmen

Doctoral Student

#### Martincic, Markus

Postdoctoral Researcher

#### Mejía Carmona, Karen Stefanie

Doctoral Student





**14**  
ARTICLES



**3**  
FUNDED PROJECTS



**4**  
CONTRIBUTIONS

## NEW PROJECTS & MILESTONES

In 2022, the Inorganic Nanoparticles Group continued working on several ongoing projects devoted to designing and synthesising inorganic nanoparticles for interaction with biological systems and energy harvesting.

The CONCORD project, funded by the European Commission through the EuroNanoMed programme, aims to develop a new type of transfection nanovectors to improve current CAR-T cell therapy technology by using gold nanoparticles. The project is coordinated by our team and can count on the expertise of the *Hospital Clínic de Barcelona*, the *Istituto di Ricerche Farmacologiche "Mario Negri"* in Milan (Italy) and the Tel Aviv University in Tel Aviv (Israel).

### **Michelini, Sara**

Fellowship Doctoral Student

### **Mira Vidal, Guillem**

Visiting Degree Student

### **Mondragón Martínez, Laura**

Visiting Technician

### **Montaña Ernst, Lena Nerea**

Visiting Doctoral Student

### **Moriones Botero, Oscar Hernando**

Doctoral Student

The ECLIPSE project, funded by the Spanish Ministry of Economy, Industry and Competitiveness, focuses on developing novel functional nanoparticles for diverse energy applications. This project aims to develop bottom-up colloidal strategies to produce tailor-making novel catalytic materials based on atomically defined colloidal NCs, for their efficient transformation of solar energy to solar fuels and the low-cost transformation of solar fuels to electrical energy.

Finally, the ENDONANO project, a Marie Skłodowska-Curie Initial Training Network (ITN) project funded by the European Commission, is devoted to quantitatively detecting bacterial endotoxins using novel nanotechnological approaches.



2

THESES



2

OUTREACH IMPACTS



1

BOOK CHAPTER

**Olivé Morales, Júlia**

Visiting Degree Student

**Oliveras Solà, Jana**

Doctoral Student

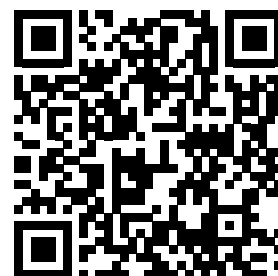
**Ramis García, Joana**

Visiting Doctoral Student

**Salazar Montoya, Vivian Angelica**

Postdoctoral Researcher

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# MAGNETIC NANOSTRUCTURES GROUP

## MAIN RESEARCH LINES

- Exchange coupling in bi-magnetic core/shell nanoparticles and nanostructures
- Magneto-optic 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 nanoparticles
- Innovative fabrication approaches

## GROUP MEMBERS

### **Nogués Sanmiquel, Josep**

ICREA Research Professor and Group Leader

### **Al Bast, Nour al Hoda**

Doctoral Student

### **Blasi Alsina, Rita**

Visiting Degree Student

### **Esplandiu Egido, María José**

CSIC Scientific Researcher

### **Fons Cervera, Arnau**

Visiting Master Student

### **Gómez Roca, Alejandro**

Senior Researcher

### **González Romero, Carlos**

Visiting Master Student

### **Lafuente López de Arbina, Aritz**

Doctoral Student

## GROUP LEADER

### JOSEP NOGUÉS

ICREA Research Professor



ICREA Research Professor Josep Nogués earned his degree from the *Universitat Autònoma de Barcelona* (UAB) in 1986. After obtaining his PhD at the *Kungliga Tekniska Högskolan* (*Royal Institute of Technology*) in Stockholm (Sweden) in 1993, he moved to the *University of California San Diego* (USA) to complete his postdoctoral studies. Four years later he returned to the UAB as an associate researcher, becoming an ICREA research professor in 2001 and a founding member of the former *Catalan Institute of Nanotechnology* (ICN) shortly thereafter. His Magnetic Nanostructures group was formally integrated into the ICN structure in 2006.

Prof. Nogués has published 259 articles (including eight reviews), with over 20,000 citations and an H-index of 61. He is the author of three patents and his work has given rise to over 250 invited talks at international conferences and workshops.

**López-Barberá Martín, José Francisco**

Postdoctoral Researcher

**Martín Sánchez, Ylenia**

Research Support Technician

**Perdikos, Filippos Giannis**

Research Assistant

**Ramírez De La Torre, Jessica Casandra**

Doctoral Student

**Shahnazarova, Gubakhanim**

Doctoral Student

**Tajada Herraiz, José Luís**

Research Support Technician

## NEW PROJECTS & MILESTONES

The group has continued to work on the PANTHER project (led jointly by Prof. Nogués and Dr Borja Sepúlveda) funded by the Spanish Ministry of Science and Innovation. It is devoted to the development of novel nanomaterials and actuation devices to enable highly efficient wireless nanotherapeutic actuation and detection of the actuation strength. The group is also leading the Spanish Proof of Concept project STERILAIR, which is devoted to the development of an efficient air disinfection system.

In December 2022, the group started working on two new projects, MAPSCALE and GREENCHEMSUN. The former (led jointly by Prof. Nogués and Dr Borja Sepúlveda) deals with the upscaling of the fabrication of magneto-plasmonic nanoparticles for biomedical application. The latter (led jointly by Dr Borja Sepúlveda, Dr María José Esplandiu and Dr Albert Serra) is devoted to the synthesis of high value chemicals from biomass.

During 2022, two research projects led by Dr Alejandro Gómez Roca, MAGPLADRUG (funded by the Ramon Areces Foundation) and PHOTOPHEOX (funded by the Ministry of Science and Innovation), were completed after three years of work. The MAGPLADRUG project successfully designed a photothermal-based therapy for eradicating cancer in vivo using magnetoplasmonic nanostructures. In PHOTOPHEOX, the critical parameters for exploiting the photothermal properties of iron oxide nanoparticles were identified.

Activities for the COLMO project, led by Dr María José Esplandiu and Prof. Jordi Fraxedas and funded by the Spanish Ministry of Science and Innovation, were completed in 2022. This project has allowed the development and fundamental understanding of (photo)



5

ARTICLES



7

FUNDED PROJECTS



8

CONTRIBUTIONS

chemically self-propelled motors, triggered by innocuous fuels, which can also act collectively to steer motion and to promote a more cooperative and efficient motor functionality. In 2022 another research project, MOTYCAT has been started (funded by the Ministry of Science and Innovation) 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.

Finally, the group has continued to work in BeMAGIC, an EU Marie Curie-Skłodowska ITN project, which deals with the fabrication and characterization of magneto-electric nanostructures for wireless neural and muscle stimulation.



**5**

**OUTREACH IMPACTS**

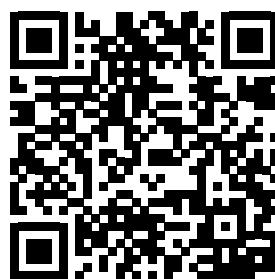
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**1**

**BOOK CHAPTER**

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# NANOBIOELECTRONICS AND BIOSENSORS GROUP

## 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 (e.g. lateral flow) modified with laser patterned rGO to enable electrochemical sensing on paper substrates without altering the paper microfluidic properties, thanks to the stamping method
- Plug & play printing platforms for the ubiquitous fabrication of low-cost and environmental-friendly nanomaterial biosensors with nanofunctional inks, using commercially available office printers
- Multilayered graphene and metal nanoparticle sensors printed on flexible polymers for the development of sensitive biosensors with impedimetric readout

## GROUP MEMBERS

### **Merkoçi, Arben**

ICREA Research Professor and Group Leader

### **Abarintos Rentino, Vernalyn**

Visiting Doctoral Student

### **Álvarez Diduk, Ruslan Raulevich**

Senior Postdoctoral Researcher

### **Ates, Hatice Ceren**

Visiting Doctoral Student

### **Batista Deroco, Patricia**

Fellowship Postdoctoral Researcher

### **Beltrán Chamorro, Laura**

Visiting Degree Student

### **Bukhari, Qurat-ul-ain**

Fellowship Doctoral Student

## GROUP LEADER

### ARBEN MERKOÇI

ICREA Research Professor and Group Leader



ICREA Research Professor and leader of the ICN2 Nanobioelectronics and Biosensors Group, Arben Merkoçi obtained his PhD at the *University of Tirana* (Albania) in ion selective electrodes. Since 1992 he has carried out research as postdoctoral fellow and research professor at the *Polytechnic University of Budapest* (Hungary), *University of Ioannina* (Greece), *Università degli Studi di Padova* (Italy), *Universitat Politècnica de Catalunya*, *Universitat Autònoma de Barcelona* and *New Mexico State University* (USA). His research is focused on the integration of biological molecules and other species with micro- and nanostructures to design novel (bio)sensors. He is member of the *Academy of Sciences of Albania* and director and coordinator of NANOALB ([www.nanoalb.al](http://www.nanoalb.al)), the regional network of nanoscience and nanotechnology.

Prof. Merkoçi is Co-Editor in Chief of *Biosensors and Bioelectronics*, the principal international journal devoted to research, design development and application of biosensors and bioelectronics, member of editorial board of *Electroanalysis*, *Microchimica Acta* and other journals.

#### **Calucho Palma, Enric**

Doctoral Student

#### **Capolungo, Chiara**

Fellowship Doctoral Student

#### **De Mariscal Molina, Nerea**

Doctoral Student

#### **Echeverri Hincapié, Danilo**

Fellowship Doctoral Student

#### **Fuentes Chust, Celia**

Doctoral Student

#### **Giliberti, Chiara**

Fellowship Doctoral Student

#### **Gonçalves Dalkiranis Pereira, Gustavo**

Fellowship Postdoctoral Researcher



Prof. Merkoçi has published 338 articles (H-index / citations: Google Scholar 89 / 29520; WOS 76 / 21533) and supervised 39 PhD theses. He is also involved in teaching PhD courses in the field of nanomaterial-based biosensors in several Spanish and international centres. He has been a member of the commission for establishing the new Nanoscience and Nanotechnology undergraduate academic curriculum at the UAB, the first one in Spain, which started during the academic year 2010-2011. He is a member of the Academics Working Group of BIST and coordinator of the Nanodiagnostics module of the Nanotechnology Master at the UAB.

He has got several national and international grants related to nanomaterials application in biosensors and his group is collaborating with several worldwide leading labs in the field of nanobiosensors. Prof. Merkoçi serves also as scientific evaluator and member of panels of experts of various international governmental and nongovernmental agencies (EU-FP and EU-ERC panels and other panels in Europe, USA and other countries), as a scientific committee member of many international congresses, director of several workshops and other scientific events and have been invited to give plenary lectures, keynote and invited speeches in more than 200 occasions in various countries. Prof. Merkoçi is the co-founder of two spin-off companies: *GraphenicaLab*, devoted to graphene patterning, and *Paperdrop*, dedicated to paper-based (i.e. lateral flow) clinical diagnostics.

### **Hu, Liming**

Doctoral Student

### **Kobrin, Robert**

Fellowship Degree Student

### **Kose, Kazim**

Fellowship Postdoctoral Researcher

### **Krishnakumar, Manasi**

Fellowship Degree Student

### **Maroli, Gabriel**

Research Assistant

### **Marrugo Ramírez, José Alfonso**

Doctoral Student

### **Metitiero, Mayla**

Visiting Master Student

### **Ngamdee, Tatchanun**

Fellowship Doctoral Student

### **Panáček, David**

Visiting Doctoral Student

### **Piper, Andrew**

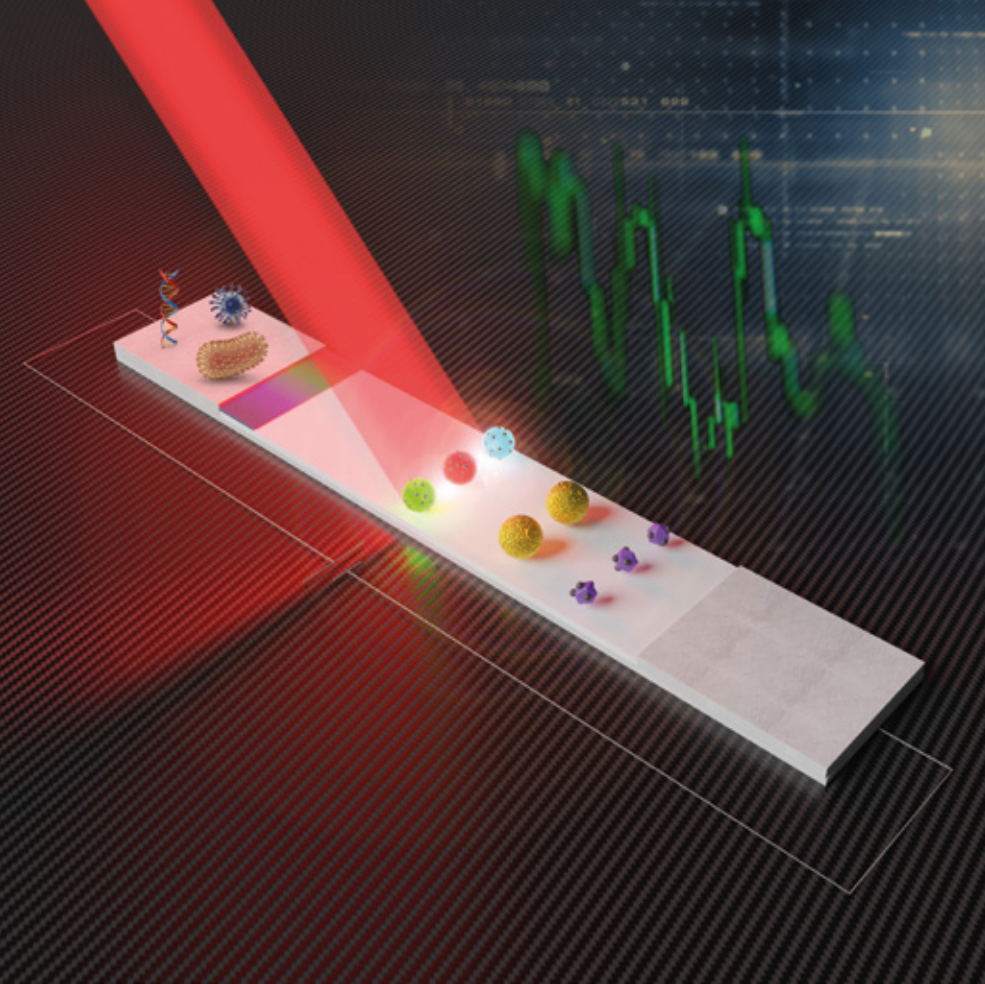
Postdoctoral Researcher

### **Puig Font, Anna**

Scientific Group Administrator

### **Quesada González, Daniel**

Postdoctoral Researcher



**Renzi, Emilia**

Fellowship Doctoral Student

**Rosati, Giulio**

Postdoctoral Researcher

**Rossetti, Marianna**

Senior Postdoctoral Researcher

**Srisomwat, Chawin**

Fellowship Doctoral Student

**Tornador Antolin, Cristian**

Visiting Doctoral Student

**Urban, Massimo**

Doctoral Student

**Uzunçar, Sinan**

Fellowship Postdoctoral  
Researcher

**Yaman Akbay, Hatice Gözde**

Visiting Master Student

**Yang, Qiuyue**

Fellowship Doctoral Student

**Zayeni, Rihem**

Visiting Doctoral Student

**Zhao, Lei**

Fellowship Doctoral Student



**14**  
ARTICLES



**10**  
FUNDED PROJECTS



**25**  
CONTRIBUTIONS



**4**  
CONGRESSES  
ORGANISATION

## NEW PROJECTS & MILESTONES

In 2022 the group has continued working on the following European projects, in addition to national projects. The first one, *MICROB-PREDICT* (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 one, *CORE 3*, is part of the Graphene Flagship project and focuses on the development of graphene-based sensors. The third EU project is *EMERGE* (Emerging Printed Electronics Research Infrastructure).

The fourth 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.

We also continued working on our two national projects: *NANOANAEMIA* (Multiplexed nanobiosensor for the instantaneous diagnosis and classification of anaemia at the point of care) and *PAPYRUS* (Polymerase Amplification combined into a Paper-based electrochemical lateral flow array for antimicrobial Resistance qUantification).



**5**

**BOOK CHAPTERS**

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**1**

**THESIS**

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**2**

**AWARDS**

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**8**

**OUTREACH IMPACTS**

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**2**

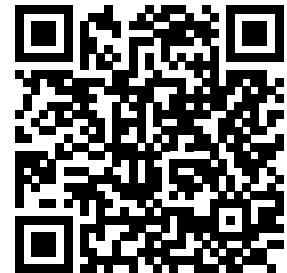
**COURSES**

A new granted project on which our group is involved started in 2022: *SUSNANO*, 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 nanosensors for water pollution detection of *Universiteti i Tiranës* (UT). This is an important project which will contribute to strengthen the new *NANOALB* centre in Albania.

During 2022 our group was one of the main contributors in the organisation of TNT2022, the 22nd edition of the *Trends in Nanotechnology International Conference* (TNT2022) with interest also for the NANOALB.

During 2022 Miguel Angel Aroca Cervantes, visiting student from Universidad de Los Andes in Colombia, defended his thesis partially developed within the group and co-directed by Prof. Merkoçi. A PhD student of the group, Qiuyue Yang, also defended her PhD thesis directed by Prof. Merkoçi.

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# NANOBIOSENSORS AND BIOANALYTICAL APPLICATIONS GROUP

## MAIN RESEARCH LINES

- Plasmonics (SPR) and nanoplasmonics (LSPR) biosensors
- Nanophotonic biosensors based on Silicon Photonics technology
- Customised polymer microfluidic devices and flow delivery systems
- Full integration in point-of-care biosensor analytical platforms
- Universal biofunctionalisation techniques and biochip packaging
- Bioanalytical applications in clinical, environmental and molecular biology, providing application-specific functionalities

## GROUP MEMBERS

### **Lechuga Gómez, Laura**

CSIC Research Professor and Group  
Leader

### **Alonso Fernández, Andrés**

Research Support Technician

### **Astúa Rosales, Alejandro**

Doctoral Student

### **Batool, Razia**

Doctoral Student

### **Beliaev, Leonid**

Fellowship Doctoral Student

### **Calvo Lozano, Olalla**

Postdoctoral Researcher

### **Cardeñosa Rubio, María de la Cruz**

Postdoctoral Researcher

### **Corbat Usandizaga, Bárbara**

Scientific Group Administrator

## GROUP LEADER

### LAURA M. LECHUGA

CSIC Full Professor



Prof. Laura M. Lechuga received her PhD in Chemistry from the *Universidad Complutense de Madrid* (Spain) in 1992. She is Full Professor of the *Spanish National Research Council* (CSIC) and Head of the Nanobiosensors and Bioanalytical Applications Group at the Catalan Institute of Nanoscience and Nanotechnology (ICN2) in Barcelona (Spain) and at the *Networking Biomedical Research Center* (CIBER-BBN).

The principal focus of her research is the development of novel nanobiosensor devices based on Nanoplasmonics and Silicon photonics principles for point-of-care diagnostics. Prof. Lechuga is a world reference in the Photonic Biosensor area, making key contributions and opening new horizons in this field. Her research activities cover from fundamental research to the technological operation of complete sensing platforms, including the technological transfer into products of social applicability. Her Group is considered as a world reference in this field.

#### **Crocifero, Luca**

Fellowship Master Student

#### **Dominguez Pazos, Marta Lucia**

Visiting Technician

#### **Estévez Alberola, Maria Carmen**

Senior Researcher

#### **Fernandez Sánchez, Cristina**

Specialist Technician

#### **García Aparicio, Pablo**

Doctoral Student

#### **Garcia Ferrer, Raquel**

Visiting Master Student

#### **Giarola, Juliana de Fátima**

Visiting PostDoctoral Researcher

#### **González Morote, Víctor**

Research Support Technician





She has published over 300 publications (articles, book chapters and proceedings), has 8 families of patents and 4 trade secrets, and has presented her work worldwide in more than 490 invited talks. She has co-founded two spin-off companies. She is Associate Editor for international journals in the field of engineering, chemistry, and optics, belongs to the Scientific Advisory Committees of highly prestigious national and international institutions and has participated regularly in high-level international scientific evaluation panels (such as Panel Chair for ERC Adv. grants).

The quality of her research has been recognised with prestigious prizes and awards, such as the *Spanish National Research Prize* in 2020, the *King Jaume I Award* in New Technologies in 2020, the *Ada Byron 2020 Prize*, the *Physics, Innovation and Technology Prize* from the *Spanish Royal Physics Society* (RSEF) and *BBVA*

*Foundation* in 2016, the *XVIII Burdinola Research Award* in 2021, the *2021 Medal of the International Foundation Olof Palme*, the *Doctorate Honoris Causa* awarded by the *University of Cádiz*, the *Lung Ambition Alliance Prize* from AstraZeneca, and the *National Prize in Nanotechnology* (2023), among others.

In addition, she has been carrying out a significant science dissemination activity for more than 25 years, being one of the national pioneers in this field, with more than 250 TV, radio, podcast, social media, press interviews, as well as conferences and articles for scientific popularization at national and international level.

From April 2020 to September 2021, she belonged to the Expert Scientific Panel advising the Ministry of Science and Innovation and the Spanish Government in the management of the COVID-19 pandemic.

### **Llop Castelbou, Jessica**

Scientific Project Manager

### **Mendia Azkoaga, Irati**

Visiting Doctoral Student

### **Pérez Chicharro, Llara**

Specialist Technician

### **Quintano Ramos, Vanesa Maria**

Senior Postdoctoral Researcher

### **Ramírez Priego, Patricia**

Postdoctoral Researcher

### **Serrano do Couto, Beatriz**

Research Assistant

### **Singh, Rukmani**

Postdoctoral Researcher

### **Soler Aznar, Maria**

Senior Researcher

### **Tarasova, Anna**

Fellowship Master Student

### **Torabi Goodarzi, Mehdi**

Postdoctoral Researcher

## NEW PROJECTS & MILESTONES

In 2022 the group has made significant progress in the development of integrated and multiplexed devices with interferometric nanophotonic and (nano) plasmonic biosensors, with the end goal of achieving sensitive, affordable, handheld and portable point-of-care devices. New multiplexed nanoplasmonic sensor devices have been implemented based on flexible substrates for further integration in portable platforms. Novel designs of the multiplexed version of the nanointerferometric sensors together with a multiplexed microfluidics have further expanded the capabilities of this ultrasensitive technology.

In parallel to the technological developments, we have demonstrated the feasibility of the nanophotonic biosensor technology in several fields of application. We have maintained our focus on applications of clinical interest, including the detection of infectious diseases via a direct biosensor test in plasma. In our research line about dysregulation of cellular pathways evaluation, we have used our nanobiosensor technologies as alternative analytical techniques for the evaluation of different gene regulating pathways, with the aim of obtaining more informative and accurate cancer diagnoses and follow-up therapies. These technologies also allow for a fast, direct and highly sensitive analysis of such regulating routes without the need for labelling or amplification. We have demonstrated a new and unique methodology for the direct detection of epigenetic marks (as methylation) in double strands of DNA and applied it to lung and ovarian cancer, two types of cancer which are difficult to detect in the early stages.

Within a granted Euronanomed project (ABISENS), coordinated by the Group, we are using our nanophotonic biosensing



9

ARTICLES



11

FUNDED PROJECTS



23

CONTRIBUTIONS



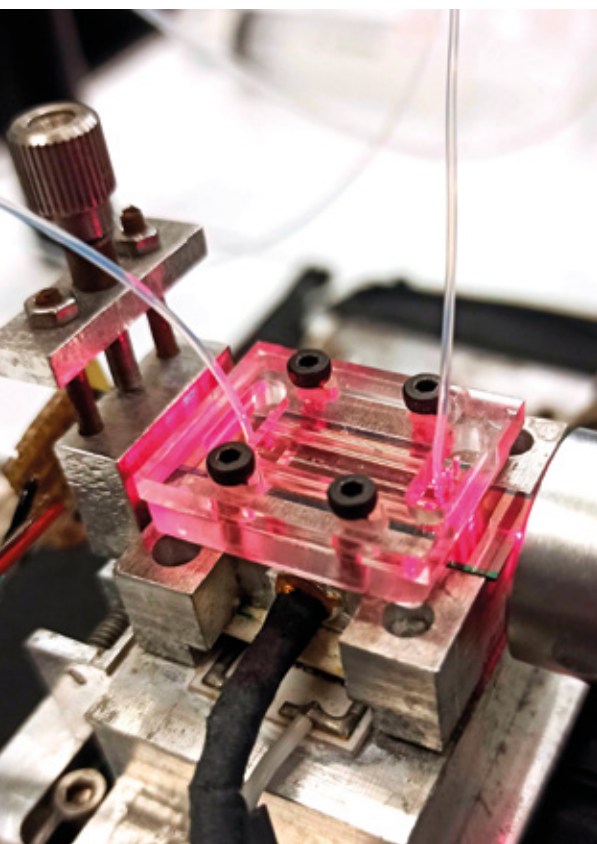
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CONGRESSES  
ORGANISATION



4

TECHNOLOGY TRANSFER  
MILESTONE



technology for the monitoring of acquired brain injury and recovery biomarkers, providing with a new tool able to identify and quantify multiple brain biomarkers in blood with high sensitivity and in a short time, for a better evaluation of patients' condition after brain injuries and the efficacy of the rehabilitation treatments.

With the excellent results achieved so far, we are now expanding the research line related to the development of novel ultrasensitive photonic nanosensors integrating porous materials (metal-organic frameworks) as specific receptors and nanointerferometers for the fast and specific detection of minute concentrations of chemical compounds for environmental quality control.

During 2022 we have successfully finalised the European project for COVID-19 diagnostics (CoNVaT), by demonstrating two advanced nanophotonic biosensors, one for the rapid diagnosis of the SARS-CoV-2 virus by directly detecting the coronavirus entities in a faster-than-20-minutes assay. And a second one for serological test, fully validated with hundreds of clinical samples for the direct detection of anti-SARS-CoV-2 immunoglobulins in COVID-19 patients, confirming excellent diagnostic performance. These new point-of-care biosensors are now be employed for a better surveillance and early warning to prevent and control future epidemics in a new ICRA-EU granted project (MUSECOV), focussed in providing a better understanding of the global circulation of animal coronavirus and their genetic evolution under different constraints and situations.

Within a granted Next Generation funds project (PHITBAC), coordinated by the Group, we are collaborating with academic institutes, hospitals and companies to provide a new, disruptive, and versatile point-of-care nanobiosensor technology for the diagnosis and clinical management of bacterial infectious diseases. The groundbreaking diagnostic device will provide a rapid detection of most relevant pathogenic bacteria, including an on-site identification of antibiotic resistance, and a personalized monitoring of antimicrobial therapy effectivity.



**4**

AWARDS

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**28**

OUTREACH IMPACTS

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**1**

THESIS

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**3**

COURSES

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extended information



# NANOELECTROCATALYSIS AND SUSTAINABLE CHEMISTRY GROUP

## MAIN RESEARCH LINES

- Electrocatalysis for renewable energy conversion (e.g. green hydrogen production and fuel cells)
- Electrochemical reduction of carbon dioxide into renewable fuels and chemicals
- Electrochemical activation and partial oxidation of methane
- Sustainable electrosynthesis of value-added chemicals
- Surface nanostructuring and atomic ensemble control
- Multimetallic and multifunctional nanomaterials
- Elucidating molecular mechanisms with spectroelectrochemistry and electrochemical mass spectrometry
- Visualising active sites at the atomic level with electrochemical scanning probe microscopy

## GROUP MEMBERS

### **Escudero Escribano, María**

ICREA Research Professor and Group Leader

### **Sánchez Peña, Pilar**

Postdoctoral Researcher

## GROUP LEADER

### MARÍA ESCUDERO ESCRIBANO

ICREA Research Professor and Group Leader



María Escudero Escribano was born in Cáceres (Spain) in 1983. She graduated in Chemical Engineering from the University of Extremadura and obtained her PhD in Chemistry from the Institute of Physical Chemistry 'Rocasolano' (Spanish National Research Council) and the Autonomous University of Madrid in 2011. She carried out her postdoctoral research at the Technical University of Denmark (2012-2015) and Stanford University (2015-2017). In 2017, María joined the University of Copenhagen as a Tenure-track Assistant Professor and Group Leader, and was promoted to Associate Professor with tenure in 2021. She joined ICN2 as an ICREA Research Professor in September 2022.

The NanoElectrocatalysis and Sustainable Chemistry (NanoESC) Group, led by María, investigates tailored electrochemical interfaces and nanomaterials for renewable energy conversion and production of sustainable fuels and chemicals. María is a *Villum Young Investigator* from the Villum Foundation (Denmark) and a co-PI of the Center for High Entropy Alloy Catalysis (CHEAC). In 2022, María has been awarded a *Consolidator Grant from the European Research Council (ERC CoG)* with her project on atomic-scale tailored materials for electrochemical methane activation and production of valuable chemicals (*ATOMISTIC*).

María has published over 65 articles in peer-reviewed journals including *Science*, *Nature Chemistry* and *Nature Materials* and she is the co-inventor of three patents or patent applications. She is a member of the Editorial Board of numerous peer-reviewed journals. She has received several prestigious awards at international and national levels in recognition of her groundbreaking research. These awards include the *European Young Chemist Award (Gold Medal) 2016*, the *Princess of Girona Scientific Research Award 2018*, the *Electrochemical Society Energy Technology Division Young Investigator Award 2018*, the *Spanish Royal Society of Chemistry Young Researchers Award 2019*, the *Clara Immerwahr Award 2019*, and the *Journal of Materials Chemistry Lectureship 2021*.



**2**  
**ARTICLES**

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**1**  
**FUNDED PROJECT**

## OVERVIEW

The group, established at the ICN2 in September 2022, combines electrochemistry, materials science and atomic-scale characterisation to elucidate design principles for the discovery and development of novel electrocatalyst nanomaterials for renewable energy conversion and storage, as well as the production of sustainable fuels and chemicals.

Electrocatalysis plays a key role in renewable energy conversion and storage technologies. Discovering and developing new materials that are active, stable, and selective catalysts remains a grand challenge for many important electrocatalytic reactions. Our research aims to address this challenge by investigating the structure of the catalytically active sites at the atomic level, developing advanced electrocatalyst nanomaterials, and gaining mechanistic understanding of relevant energy conversion reactions.



**5**

**CONTRIBUTIONS**

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**1**

**AWARD**

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**1**

**CONGRESS  
ORGANISATION**

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**2**

**OUTREACH IMPACTS**

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extended information





# NANOMEDICINE GROUP

## MAIN RESEARCH LINES

- Nanomaterials as vector systems for therapeutic and diagnostic applications
- Development of graphene and 2D materials in medicine
- Clinical translation of bioelectronic devices
- Discovery of novel biomarkers and therapeutic targets in oncology and neurology

## GROUP MEMBERS

### **Kostarelos, Konstantinos**

Senior Group Leader

### **Battisti, Tommaso**

Postdoctoral Researcher

### **Cardoso Neves, Juliana**

Postdoctoral Researcher

### **Despotopoulou, Despoina**

Research Assistant

### **Garcia Ortega, Glòria**

Postdoctoral Researcher

### **Hernández Lobato, Noelia**

Doctoral Student

### **Lozano Valdés, Maria de les Neus**

Senior Researcher

### **Murillo Cremaes, Nerea**

Specialist Technician

## GROUP LEADER

### KOSTAS KOSTARELOS

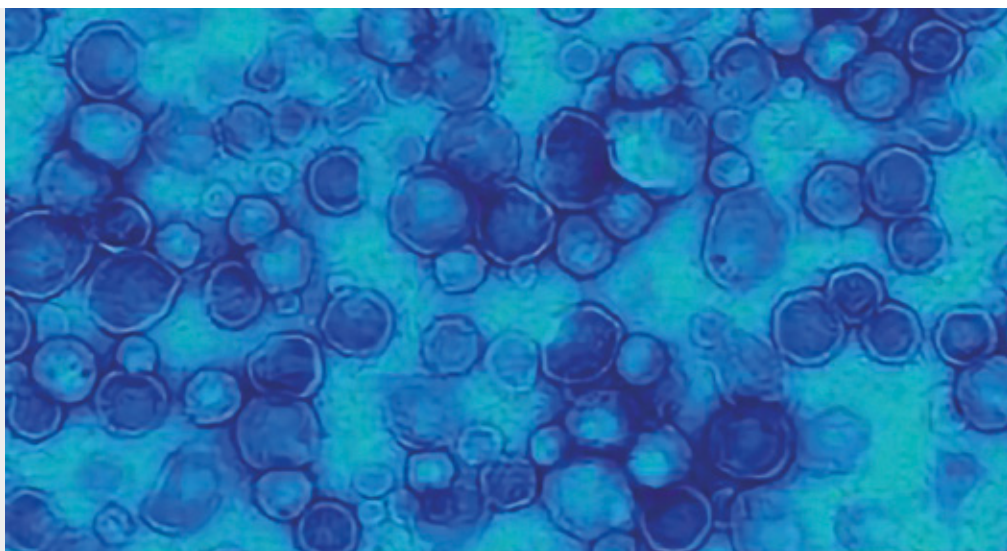
Severo Ochoa Distinguished Professor and Group Leader



Prof. Kostas Kostarelos read Chemistry at the *University of Leeds* and obtained his Diploma in Chemical Engineering and his PhD from the Department of Chemical Engineering at *Imperial College London*, studying the steric stabilization of liposomes using block copolymer molecules.

He carried out his postdoctoral training in various medical institutions in the USA (*UCSF, Memorial Sloan-Kettering Cancer Center, Cornell*). Following his promotion to Assistant Professor of Genetic Medicine and Chemical Engineering in Medicine at *Cornell University Weill Medical College*, he relocated to the UK as the Deputy Director of *Imperial College Genetic Therapies Centre* in 2002. In 2007 Kostarelos was awarded the first personal Chair of Nanomedicine in the UK and was Head of the Centre for Drug Delivery at the UCL School of Pharmacy in London.

The whole Nanomedicine Lab was recruited by the *University of Manchester* in 2013, while Prof. Kostarelos also maintained an Honorary Professorship with *University College London*.



Currently, Kostarelos is Professor and Chair of Nanomedicine at the Faculty of Biology, Medicine and Health, leads the Nanomedicine Lab and is a member of the *National Graphene Institute* and the *Manchester Cancer Research Centre*, all at the *University of Manchester*. He has been invited to Fellowships with the Royal Society of Chemistry, Royal Society of Medicine and Royal Society of Arts, all in the UK. He was awarded the Japanese Society for the Promotion of Science (JSPS) Professorial Fellowship in 2010.

In 2019 he joined the ICN2 as Severo Ochoa Distinguished Professor and Group Leader, while retaining his appointments and research team at the *University of Manchester*.



**10**  
**ARTICLES**



**2**  
**FUNDED PROJECTS**



6

CONTRIBUTIONS

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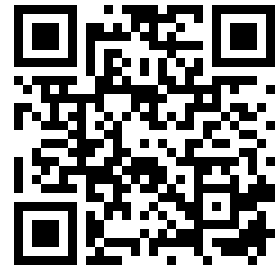
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CONGRESS  
ORGANISATION

## OVERVIEW

The Nanomedicine@ICN2 group, established at the end of 2019, is dedicated to the development of nanomaterials and devices for therapeutic and diagnostics applications. It has strong links with the *Nanomedicine Lab* at the *Faculty of Biology, Medicine and Health at the University of Manchester*, with Prof. Kostas Kostarelos leading both teams. Graphene and 2D materials have a central role in a number of research lines carried out by the group in the context of the Graphene Flagship and beyond. The group also works on liposomes and other nanoparticle systems for various biomedical applications, ranging from cancer therapeutics to neurodegenerative disease interventions.

Visit our website for  
extended information



# NANOSTRUCTURED FUNCTIONAL MATERIALS GROUP

## MAIN RESEARCH LINES

- **Nanoscale functional polymers for brain diseases & regenerative medicine**  
Main areas of impact:
  - Healthy aging
  - Inflammatory and infectious diseases
  - Regenerative medicine
- **Chromogenic & emissive nanomaterials for energy efficient devices**  
Main areas of impact:
  - Smart windows
  - Devices and security

## GROUP MEMBERS

### **Ruiz Molina, Daniel**

CSIC Research Professor and Group Leader

### **Abellanet Vidal, Jofre**

Visiting Degree Student

### **Alfonso Triguero, Paula**

Doctoral Student

### **Baqueró Álvarez, Eduardo**

Visiting Degree Student

### **Battal, Fatin**

Visiting Master Student

### **Bolaños Cardet, José Daniel**

Visiting Doctoral Student

### **Carrascull Marín, Aleix**

Research Support Technician

### **Cavaliere, Ivana**

Doctoral Student

### **Crueira Solsona, Ferran**

Visiting Doctoral Student

### **Depré, Morgane**

Visiting Master Student

## GROUP LEADER

### DANIEL RUIZ-MOLINA

CSIC Tenured Scientist



Daniel Ruiz-Molina got his PhD in Chemistry with a thesis on polyradical dendrimers at the *Institut de Ciència de Materials de Barcelona* (ICMAB-CSIC) under Prof. Jaume Veciana's tutorship. Then he obtained a postdoctoral position at the *University of California San Diego* (USA), where he spent three years working on single molecule magnets and molecular switches.

Since 2001 he has held a permanent position as a Spanish National Research Council researcher, most recently at the ICN2, where he is the leader of the Nanostructured Functional Materials Group. His main research areas include the fabrication of hybrid colloids and surfaces, biomimetic functional nanostructures, and micro- or nanoparticles for smart applications and encapsulation and delivery systems.

#### **Dueñas Arrastio, Nahia**

Research Support Technician

#### **Fortuño Mateos-aporicio, Anna**

Visiting Degree Student

#### **Gallus, Izabela Joanna**

Fellowship Doctoral Student

#### **Gómez Herrera, Roger**

Doctoral Student

#### **González Benitez, Pau**

Visiting Degree Student

#### **González Laredo, Alvaro**

Visiting Degree Student

#### **Julià López, Alejandro Ricar**

Postdoctoral Researcher

#### **Lesta Alfeirán, Daniel**

Research Support Technician

#### **López Moral, Alba**

Visiting Doctoral Student

#### **Mancebo Aracil, Juan**

Postdoctoral Researcher



## NEW PROJECTS & MILESTONES

Molecular materials are uniquely placed to spur a revolution in the next decades, thanks to their ability to accommodate a wide span of functionalities, and the possibility to fine-tune them to suit a variety of technological purposes. However, while these materials already show optimal behaviour either in solution, as single crystals or as microcrystalline powders, their integration into functional devices still poses a scientific challenge, since, once incorporated into solid matrices or hybrid devices, they often lose (at least partially) their inherent properties and/or their response efficiency.

Our objective at the Nanostructured Functional Materials research group (NANOSFUN) is to develop new strategies to obtain molecular (bio)nanostructures, with adapted properties and smart responses to external stimuli, which can be incorporated into solid matrices, surfaces or as stable colloidal suspensions, while retaining their initial features and performance. For this, a wide range of molecular and biological building blocks are employed, using Nature as a strong source of inspiration. We work with the idea that ultimate control on every length scale and material interfaces is required to reach the intrinsic limits and functions of these (supra)molecular materials, and with the aim of finding applications for them oriented at improving our everyday life.

### **Méndez Sánchez, Joaquim Alex**

Visiting Degree Student

### **Mora De la Serna, Roger**

Visiting Degree Student

### **Moreno Villaecija, Miguel Ángel**

Specialist Technician

### **Mundet López, Oriol**

Visiting Degree Student

### **Muñoz Pérez, Noel**

Research Support Technician

### **Otaegui Rabanal, Jaume Ramón**

Visiting Doctoral Student

### **Parra Sánchez - Camacho, Alex**

Visiting Degree Student

### **Parrón Onate, Sara**

Visiting Degree Student

### **Pepió Tárrega, Belén**

Research Support Technician

### **Pérez Becher, Ramiro**

Visiting TFG Student

### **Pérez Castro, Jennifer Ana**

Postdoctoral Researcher

### **Roscini, Claudio**

Senior Researcher

### **Sánchez Homs, Júlía**

Visiting Degree Student

### **Suárez García, Salvio**

Senior Postdoctoral Researcher

Our main lines of research are the following:

### **Nanoscale functional polymers for brain diseases and regenerative medicine**

The NANOSFUN group is deeply involved in the development of polymeric nanoparticles and coatings for health and social welfare. This embraces mostly, though not exclusively: I) Nanoparticles for diagnosis and therapy, II) Fine-tuning of the hydrophobic/hydrophilic balance, biocompatibility or other additional properties via surface (bio)functionalization and III) Thin films for the regeneration of human cells/tissues allowing for the proper functioning of organs or surgical adhesives and appliance bonding.

#### **Trinidad Torras, Arnau**

Visiting Degree Student

#### **Vallan, Lorenzo**

Research Support Technician

#### **Viader Godoy, Núria**

Visiting Degree Student

#### **Villar Álvarez, Eva María**

Postdoctoral Researcher

#### **Zarich Carrillo, Vicca Valeria**

Visiting Degree Student

#### **Zhang, Junda**

Doctoral Student



**9**

**ARTICLES**

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**11**

**FUNDED PROJECTS**

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**1**

**TECHNOLOGY TRANSFER  
MILESTONE**





**27**

CONTRIBUTIONS

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**4**

AWARDS

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**2**

THESES

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**4**

OUTREACH IMPACTS



**1**

CONGRESS  
ORGANISATION

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**1**

BOOK CHAPTER

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**1**

COURSE

We work both with commercial FDA-approved polymers, as well as with novel biopolymers, specifically designed for improved performance. A large part of our activities is devoted to the development of novel families of polymers based on coordination chemistry and catechol.

The areas where these materials produce impact are mainly healthy aging, inflammatory and infectious diseases, and regenerative medicine.

### **Chromogenic and emissive nanomaterials for energy efficient devices**

We aim to develop advanced nanostructured molecular materials that smartly modify their optical properties (i.e. absorption and emission) as a response to external stimuli, such as pH, temperature and light. These materials are key to the engineering of near-future commercial products that try to tackle social and environmental needs, such as sustainability, comfort and security. The main materials we develop for these applications are: I) UV/vis/NIR-light induced color-changing films and coatings for rewritable devices, anticounterfeiting technologies and dynamic photoprotective coatings, II) Temperature-responsive fluorochromogenic micro/nanocomposites for thermal optical sensing and temperature-dependent optical filters, and III) Vis/NIR activated upconverting fluorescent materials for energy conversion, anticounterfeiting technologies and (bio) imaging.

For this, we follow novel and emerging concepts, principally based on the micro/nanoencapsulation of oil or phase-change materials mixtures of molecular dyes (such as spirooxazines, spiropyrans, porphyrins and polycyclic aromatic hydrocarbons), which allow advanced, tuneable and customizable optical change effects of different degrees of sophistication: from highly fast to irreversible responses, multi-responsiveness, multiple outputs (colour, fluorescence), threshold-

based changes, invisible (to the human eye) optical variations.

The principal areas in which these technologies find application are smart windows, smart devices and security (such as anticounterfeiting).

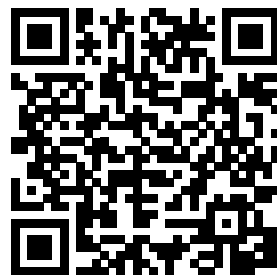
### **Collaborations with industry and technology transfer**

In addition to our fundamental research activities, we have established ourselves as a reference group in joint projects with the private sector across two fundamental areas:

- 1) Micro/Nanoencapsulation of active ingredients
- 2) Photo/Thermochromism.

NANOSFUN currently has 50 m<sup>2</sup> of lab space devoted exclusively to applied-science research, fully equipped and capable of scale-up work up to 10 L. Our early advances have prompted us to pursue market-oriented research through dedicated spin-off companies (*Futurechromes S.L.* and *Distinkt S.L.*).

**Visit our website for extended information**



# NANOSTRUCTURED MATERIALS FOR PHOTOVOLTAIC ENERGY GROUP

## MAIN RESEARCH LINES

- **Photovoltaics: Next-generation thin film, organic, hybrid, dye-sensitised, halide perovskite and all-oxide solar cells**
- **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**

## GROUP MEMBERS

### **Lira Cantu, Mónica**

CSIC Research Professor and Group Leader

### **Alcalá Ibarra, Alex**

Visiting Degree Student

### **Ansari, Fatemeh**

Postdoctoral Researcher

### **Baumann, Fanny Amanda Karolina**

Doctoral Student

### **Degani, Matteo**

Visiting Doctoral Student

### **Karimipour, Masoud**

Postdoctoral Researcher

### **Lorenzo Barriendos, Pol**

Visiting Degree Student

### **Marsal Mercader, Gina**

Visiting Degree Student

## GROUP LEADER

### MÓNICA LIRA-CANTÚ

CSIC Research Scientist



After completing a Bachelor's degree in Chemistry in 1992, Dr Monica Lira-Cantu obtained her Master's and PhD degrees in Materials Science at the *Institut de Ciència de Materials de Barcelona* (ICMAB) and the *Universitat Autònoma de Barcelona* in 1995 and 1997, respectively. She worked as a postdoctoral fellow with *Schneider Electric* and ICMAB until 1998. From 1999 to 2001 she was a permanent senior staff chemist at *ExxonMobil Research & Engineering* (formerly *Mobil Technology Co*) in New Jersey (USA), establishing a group on energy-related applications.

Dr Lira-Cantu has received various awards, as well as visiting scientist fellowships at the following laboratories: *Universitetet i Oslo* (Norway) (ESF, 2003), *RisDTU Nationallaboratoriet* (Denmark) (AGAUR, 2004/05), and *Center for Advanced Science and Innovation* (Osaka University, Japan) (Canon Foundation in Europe, 2006). She is group leader of the Nanostructured Materials for Photovoltaic Energy since 2006. She obtained a tenured track position at *Consejo Superior de Investigaciones Científicas* (CSIC) in 2007 and was promoted to Scientific Researcher in 2017.

#### **Paingott Parambil, Ashitha**

Doctoral Student

#### **Pereyra Marina, José Carlos**

Research Support Technician

#### **Ruiz Raga, Sonia**

Senior Researcher

#### **Sisó Moliné, Rut**

Visiting Master Student

#### **Tanko, Kenedy Tabah**

Doctoral Student

#### **Vehí Lorente, Eudald**

Visiting Degree Student

#### **Zambrzycki, Marcel**

Fellowship Doctoral Student

#### **Zemmouche, Pierre-Antoine**

Fellowship Degree Student

She is currently evaluator for the European Commission for the ERC Starting, Consolidator and Advanced grants. Since 2021 she is panel member of the new PE11 Materials Engineering of the ERC Advanced Grants. She has coordinated and organised more than 18 scientific conferences and is scientific referee for more than 20 international and European research agencies, and 52 scientific journals. Dr Lira is a member of the editorial board of *SN Applied Science* (Nature), *Journal of Materials Chemistry C* (RSC), *Journal of Physics Energy* (IOP), *Journal of Photonics for Energy* (SPIE) and *Frontiers in Energy Research: Solar Energy* (Frontiers). Since 2016 she is a member of the advisory board for the Nanotechnology and Chemical Science degree (INCQ) of the *Instituto Tecnológico y de Estudios Superiores de Monterrey* (ITESM, Mexico). In 2021 she became president of the National Advisory Board of the ITESM (Mexico) for the INT career.

The research interests of Dr Lira lie in the synthesis and application of nanostructured materials for highly efficient and high stable next-generation thin-film solar cells: halide-perovskite, dye-sensitised, alloxide and organic solar cells. Her group has developed halide perovskite solar cells with > 21% efficiency and 1000 h stability under continuous illumination. The group also focuses on the application of solar cells in printed batteryless, self-powered electronics for the IoT (on flexible, transparent and/or smart materials).

Dr Monica Lira-Cantu has more than 125 scientific publications, among them more than 110 journal articles, 1 edited book, 10 book chapters, 9 patents. According to Google Scholar, she has more than 9000 citations overall and H index of 50.

## 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. Specifically, our contribution is in the area of solution processable metal oxides (classical and complex), halide perovskites (Pb-free, 2D and 3D) and, more recently, 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, with more than 15 years of experience in the field, is internationally recognized 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 2. 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. More recently, we have initiated the development of novel MXenes and 2D materials. 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.



6

ARTICLES

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4

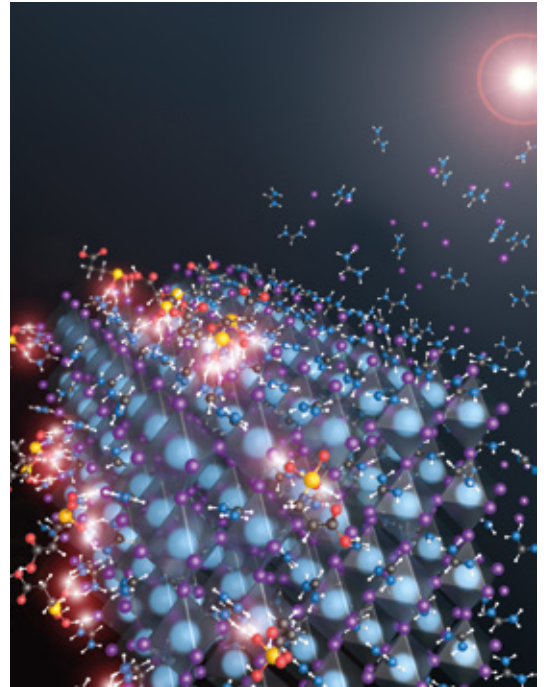
FUNDED PROJECTS

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28

CONTRIBUTIONS

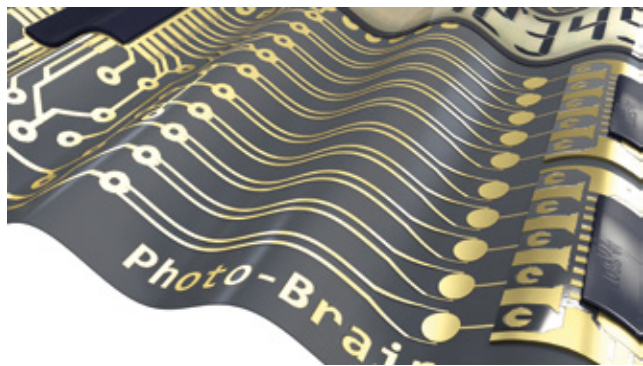


Another major goal of the group is the synthesis of nanostructured materials, especially those involving transition metal oxides (TMOs), via the application of low-cost and solution processing methods. They have many possible applications as main active materials or barrier layers, but also as materials 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 terms of efficiency and lifetime. We are now functionalising these oxide surfaces by anchoring self-assembled monolayers with selected 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.





**4**

**CONGRESSES  
ORGANISATION**

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**2**

**AWARDS**

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**1**

**THESIS**

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**1**

**OUTREACH IMPACTS**

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# NOVEL ENERGY-ORIENTED MATERIALS GROUP

## MAIN RESEARCH LINES

- Hybrid electrode materials for supercapacitors 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.

## GROUP MEMBERS

### **Gómez Romero, Pedro**

CSIC Research Professor and Group Leader

### **Pokhriyal, Anukriti**

Doctoral Student

### **Bengoa Abraham, Leandro Nicolás**

Senior Postdoctoral Researcher

### **Fabián Puerta, Verónica**

Visiting Doctoral Student

### **Gonzalez Gil, Rosa Maria**

Postdoctoral Researcher

## GROUP LEADER

### **PEDRO GÓMEZ-ROMERO**

CSIC Research Professor



Prof. Pedro Gómez-Romero completed his BS and MS in Chemistry at the *Universitat de València* (Spain), before going on to earn his PhD in chemistry with distinction at *Georgetown University* (USA) in 1987. A CSIC researcher since 1990, he worked at the *Institut de Ciència de Materials de Barcelona* (ICMAB) from 1990 to 2007, spending a sabbatical year as a NATO Senior Research Fellow at the *National Renewable Energy Laboratory* (USA) in 1998-99. In 2007 he moved to the former *Nanoscience and Nanotechnology Research Centre* (CIN2) as group leader of the NEO-Energy lab. When CIN2 became ICN2 in 2013, Prof. Gómez-Romero became group leader of the Novel Energy-Oriented Materials Group, heading up projects on hybrid organic-inorganic nanostructures, nanocomposite materials for energy storage and conversion.

CSIC Full Professor since 2006, Prof. Gómez-Romero is Fellow of the *Royal Society of Chemistry* (UK) since 2014 and was the vice-director of MATGAS between 2010 and 2013. In 2017 he received the CIDETEC prize for research in electrochemistry. He has authored over 200 scientific publications in international peer-reviewed journals (> 17500 cit. h=64 Google scholar). He is the scientific editor of the books *Functional Hybrid Materials* (P. Gómez-Romero, C. Sánchez (Eds.) (Wiley-VCH 2004)) and *Metal Oxides in Supercapacitors* (D.P. Dubal, P. Gomez-Romero (Eds.) (Elsevier, 2017)).

#### **Parpal Gimenez, Monica**

Visiting Master Student

#### **Quiñones Acuña, Judith**

Research Support Technician

#### **Rueda García, Daniel**

Visiting Technician

#### **Thomas, Sharin Maria**

Doctoral Student

#### **Zhu, Jun-Jie**

Fellowship Doctoral Student

He is co-founder of the start-up *Napptilus Battery Labs* (2021-) for the production of fast-charging energy storage devices.

Prof. Gómez-Romero is also the author of four award-winning popular science books (*Metaevolución. La Tierra en el espejo*, Celeste, 2001; *Un planeta en busca de energía*, Síntesis, 2007; *Creadors de futur*, Bromera, 2016; and *Nanomundo*, Material/El País, 2016). Editor of *cienciateca.com* (<https://cienciateca.com>) and the creator of the Youtube science channel *TECNOSFERA* (<https://www.youtube.com/c/tecnosfera>).



**10**  
**ARTICLES**

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**5**  
**FUNDED PROJECTS**

## NEW PROJECTS & MILESTONES

In 2022 we have reactivated our work on materials and devices for ground-breaking energy storage. The incorporation in the group of Dr. Rosa M. González Gil as a post-doc and project manager has helped a lot to do it with full thrust.

The pandemic emergency has led way to the supply crisis. This, together with the growing climate emergency, adds urgency to reaching our goals. Our emphasis should change from the writing of highly-cited articles to the production of materials and energy storage technologies with direct impact on our society.

These applied targets have been fostered by the endowment of several new 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.

Concerning new projects, we must also highlight the award of a TED project to develop a new type of Zn-Air battery, based on polyoxometalates (POMs) as bifunctional electro-catalysts under near-neutral pH conditions. In parallel, the incorporation in the group of Dr Leandro N. Bengoa with a Marie S. Curie Fellowship focused on a converging Zn-Air project reinforces this general line of work. These two new milestones represent the materialization of our R+D compromise on Zn-based energy storage, as previously envisioned in the strategic plan of the group.

2022 witnessed Jun-Jie Zhu’s PhD Thesis defense (“Hybrid Electrode Materials based on Polyoxometalates for their First-Time Application in Organic Electrolyte Supercapacitors”). Dr Zhu is already working in the battery section of BYD, the leading Chinese electric vehicle manufacturer.

In our group, presential congresses were reduced to a minimum, with online participation gaining weight. 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.

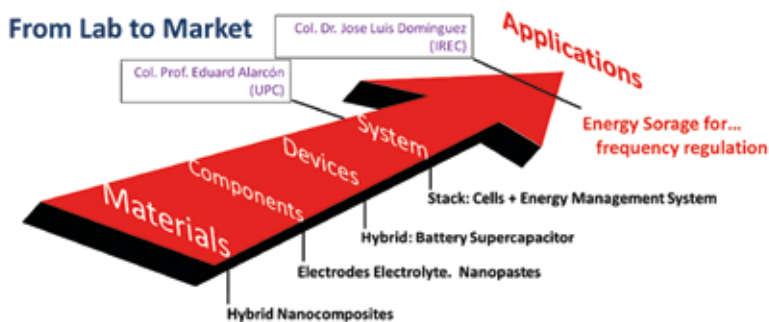
We give more details about each research line in the following paragraphs.

## 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). Two PhD thesis works are presently tackling this topic (Anukriti Pokhriyal and Lipeng Wang) from different points of view. We have recently published a review article on the employment of polyoxometalates in energy applications, a topic in which our group was a pioneer.

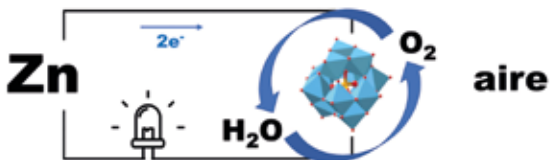
## Modelling final applications of hybrid devices for improved energy storage

As part of Anukriti Pokhriyal's PhD thesis activities, we have started a subline of work related with power engineering modelling of hybrid energy storage devices. We modelled the type of devices she has developed for her thesis in final applications and, specifically, in frequency regulation needed in variable wind-power generation. This work is being carried out through a collaboration with Dr Jose Luis Domínguez (IREC). It is part of our effort to take our research out of the lab, as summarized in this figure:



## 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 (figure below)



## 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 2022 Ms. Sharin M. Thomas has joined the group to work on her PhD thesis on this topic. Collaboration with a Portuguese group working on triboelectric nanogenerators is being initiated.



**2**

**CONTRIBUTIONS**

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**1**

**THESIS**

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**6**

**OUTREACH IMPACTS**

## **Nanopastes and nanogels**

Nanopastes are composites made at the nanoscale of solid electrode nanoparticles (nanocarbons, inorganics and their hybrids) and electrolytes. We have filed a new patent with our spin-off company to exploit these electrodes with nanopastes and nanogels.

Our materials can be tailor-made for many different applications, but our favourite, and the one we are working hard to develop with our start-up (Napptilus Battery Labs), takes the form of fast-charging long-lived energy storage devices. In this respect, it should be noted that in addition to the optimization of the micro- and nano-structure of our materials, the use of pastes represents an additional challenge that is being tackled through an Industrial PhD (Doctorat Industrial, GenCat) carried out by Verónica Fabián, which highlights the importance of device design.

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extended information**



# OXIDE NANOPHYSICS GROUP

## MAIN RESEARCH LINES

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

## GROUP MEMBERS

### **Catalán Bernabé, Gustau**

ICREA Research Professor  
and Group Leader

### **Bernad Paretas, Xavier**

Visiting Degree Student

### **Casals Montserrat, Blai**

Postdoctoral Researcher

### **Cordero Edwards, Rohini Kumara**

Postdoctoral Researcher

### **De Luca, Gabriele**

Senior Postdoctoral Researcher

### **Domingo Marimón, Neus**

CSIC Distinguished Researcher

### **Ganguly, Saptam**

Doctoral Student

### **Liu, Ying**

Postdoctoral Researcher

### **Mirzamohammadi, Nona**

Doctoral Student

### **Pesquera Herrero, David**

Senior Postdoctoral Researcher

### **Saeed, Umair**

Doctoral Student

### **Spasojevic, Irena**

Doctoral Student

### **Stefani, Christina Georgia**

Doctoral Student

## GROUP LEADER

### GUSTAU CATALÁN

ICREA Research Professor



Prof. Gustau Catalán earned his degree in physics at the *Universitat de Barcelona* in 1997 and his PhD, also in physics, at *Queen's University of Belfast* in 2001. He held research positions at the *Institut Mediterrani d'Estudis Avançats* in Mallorca (2002-2004), the *University of Groningen* (2004-2005) and the *University of Cambridge* (2005-2009). In 2009, he was appointed ICREA Research Professor and joined the ICN2 as leader of the Oxide Nanophysics Group. At the ICN2, with the help of an ERC Grant, he set up one of the world's first laboratories of flexoelectricity.

Prof. Catalan's scientific interests cover a variety of physical properties of oxides, from ferroelectricity to metal-insulator transitions, and from flexoelectricity to domain wall physics, with a focus on how these properties change at reduced dimensions.

## NEW PROJECTS & MILESTONES

### SCIENTIFIC HIGHLIGHTS

This year has been bittersweet. We are sad but proud of the departure of Dr Neus Domingo, who has gone to Oak Ridge to become the group leader of what is probably the biggest atomic force microscopy laboratory in the world. Congratulations! Other departures from the group include Dr Blai Casals, now a lecturer at the *Universitat de Barcelona*, Dr Gabriele De Luca, currently a Ramon y Cajal research fellow at ICMA, and brand-new Dr Christina Stefani and Dr Irena Spasojevic, who defended their PhD thesis and moved on to postdoc positions at the UAB. Congratulations to all and we look forward to continuing collaborating. These departures have been partially compensated by new arrivals, including two PhD students (Nona Mirzamohammadi

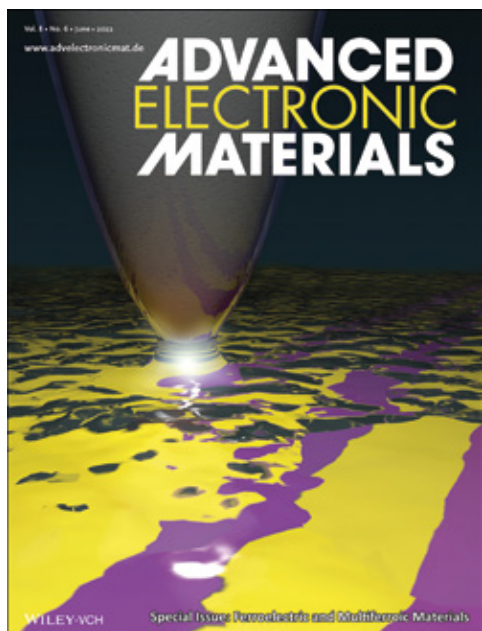
and Umair Saeed) and a senior postdoc, Dr Kumara Cordero-Edwards, who will be in charge of our atomic force microscopy laboratory.

As their parting shot, Dr Neus Domingo and Dr Irena Spasojevic published a study on how relative humidity affects the ability to write domains on ferroelectric thin films [*Adv. Func. Mat.* 8, 2100650 (2022)]. The writing dynamics also opens a window into the structure of the very thin layer of adsorbate water that coats the surface of ferroelectrics. This article was the cover for the special issue and has been highlighted as one of the most downloaded papers of *Advanced Electronic Materials* in 2021.



Dr David Pesquera has been very active too, leading a research line on free-standing oxide films. Among other papers, he was the lead author of an invited review about this topic [*J. Phys.: Cond. Mat.* 34, 383001 (2022)]. An interesting way of combining some of the best qualities of free-standing films (i.e., their mechanical decoupling from a rigid substrate) with those of epitaxial thin films (good crystalline order) is by exploiting so-called Van der Waals epitaxy. We have exploited this growth technique to measure, for the first time, the effect of bending (flexoelectricity) on epitaxial thin films of ferroelectric BaTiO<sub>3</sub> [*Physical Review B* 106, 024108 (2022)].

On a last note, this year also saw the publication of our final farewell to the late great Prof. James F. Scott, a friend, a mentor, and a giant of the field of ferroelectrics. Our biography compiling his life and most significant scientific advances was published in the *Biographical Memoirs of Fellows the Royal Society* [Volume 73, 395-420, (2022)].



## 7 ARTICLES



## 6 FUNDED PROJECTS

## PROJECTS

We have a FET-Open Project (TSAR, '*Topological Solitons in Antiferroics*') to study topological structures in antiferroelectrics, a national project to study functional oxide membranes (FOxMe) in collaboration with the Nanomaterials Growth Unit and ICMAB, another national project to study surface functionalization of ferroelectrics (SURFER) and a "*Strategic Project Oriented to the Ecological Transition and Digital Transition*" to study pyroelectric and electrocaloric effects in low dimensional ferroelectrics (PYROMETHER), in collaboration with the ICN2 group of Thermal Properties of Nanoscale Materials. Also, Dr David Pesquera has been awarded a "*La Caixa Junior Leader*" grant and is leading a BIST Ignite project in collaboration with ICFO to take the research on oxide membranes to the next level. In addition, the Catalan government has awarded us a CRG (Consolidated Research Groups) grant to support our research on Oxide Physics.

Visit our website for  
extended information



**14**  
CONTRIBUTIONS

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**2**  
THESES

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**1**  
AWARD

# PHONONIC AND PHOTONIC NANOSTRUCTURES GROUP

## MAIN RESEARCH LINES

- Nanophononics and topological matter
- Nanophotonics
- Nanoscale thermal transport
- 2D materials
- Optomechanics
- Nanofabrication

## GROUP MEMBERS

**Sotomayor Torres, Clivia Marfa**  
ICREA Research Professor and Group  
Leader

**Albrechtsen, Marcus**  
Visiting Doctoral Student

**Alzina Sureda, Francesc**  
Senior Researcher

**Andrés, Dominik**  
Administrative Assistant

**Céspedes Urquieta, Francisco**  
Doctoral Student

**Chávez Angel, Emigdio**  
Senior Researcher

**Chen, Zhangfu**  
Visiting Doctoral Student

**Florez Peñaloza, Omar Enrique**  
Doctoral Student

## GROUP LEADER

### CLIVIA M. SOTOMAYOR TORRES

ICREA Research Professor



ICREA Research Prof. Dr Clivia M. Sotomayor Torres was awarded her PhD in physics in 1984 by the *University of Manchester* (UK). She then held tenured academic appointments at the *University of St. Andrews* and the *University of Glasgow* in the UK, before becoming a C4 professor at *Universität Wuppertal* (Germany) in 1996. From 2004 to 2008 she was a research professor at the *Tyndall National Institute, University College Cork* (Ireland). Since May 2007 she has been an ICREA Research Professor based at the *Catalan Institute of Nanoscience and Nanotechnology* (formerly, the ICN).

She has received awards from the *Royal Society of Edinburgh*, the *Nuffield Foundation* and an *Amelia Earhart Fellowship* from *Zonta International* (USA). In 2020 she was awarded an *ERC Advanced Grant* to lead a five-year project aiming to develop a disruptive technology based on phononic interconnects to reduce energy consumption of electronic circuits.

#### **Guilhem, Madiot**

Senior Postdoctoral Researcher

#### **Jacobo Martín, Alejandra**

Research Engineer

#### **Jaramillo Fernández, Juliana**

Postdoctoral Researcher

#### **Landrieux, Simon**

Fellowship Master Student

#### **Mitterhuber-Gressl, Lisa Maria**

Visiting PostDoctoral Researcher

#### **Ng, Ryan Cecil**

Postdoctoral Researcher

#### **Nizet Ruiz, Paul**

Visiting Master Student

#### **Pan, Bingcheng**

Fellowship Doctoral Student



Prof. Dr Sotomayor Torres, who is a member of the Academia Europea, is author of 602 scientific works, 555 of which are indexed (ORCID, WoS, Researcher ID: E-8418-2010), has an h-index of 50 and over 10,900 citations. She was a guest professor at the P. Sabatier Univ. Toulouse and at KTH in Sweden. In 2022-23 She was the Mittelsten-Scheid guest professor at the University of Wuppertal, Germany. She leads a strong team working on phonon engineering and is actively engaged in European research. She represents the ICN2 in the Nanoelectronics AENEAS Joint Undertaking (Chamber B).

During 2022 Prof. Sotomayor Torres held the following commissions of trust:

- Member of the *Expert Committee for the Excellence Strategy of German Universities*
- ERC panel member
- Evaluator for the Ministry of Education of Singapore Panel EP5
- Member of the *AENEAS Scientific Council*
- Vice chair of the Scientific advisory board of *Silicon Austria Lab*
- Advisor to the EIC project manager in the portfolio "Responsible Electronics"
- Member International Evaluation Panel of Aalto University' School of Engineering

### **Peral Guillamón, Ariadna**

Scientific Group Administrator

### **Poblet, Martin**

Senior Postdoctoral Researcher

### **Puig Vilardell, Eulalia**

Visiting Degree Student

### **Sklan, Sophia Robin**

Senior Postdoctoral Researcher

### **Sledzinska, Marianna**

Research Engineer

### **Tan, Pu**

Fellowship Doctoral Student

### **Tran, Thomas**

Visiting Doctoral Student

### **Xiao, Peng**

Doctoral Student



**17**  
ARTICLES



**10**  
FUNDED PROJECTS



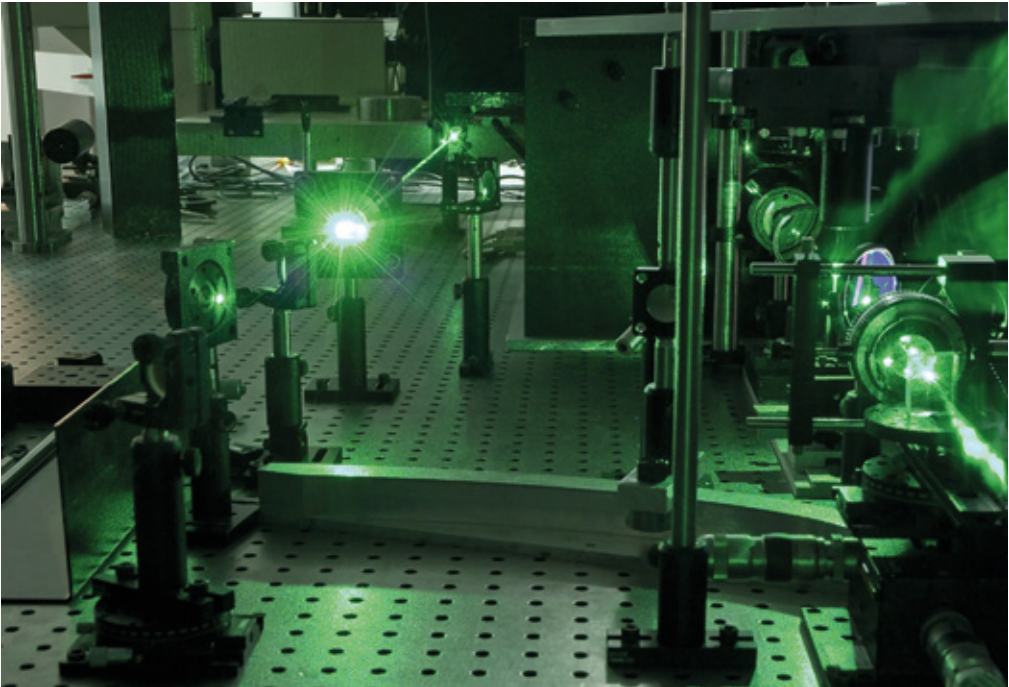
**4**  
CONGRESSES  
ORGANISATION

## NEW PROJECTS & MILESTONES

During 2022, the group worked on the following eight projects:

- LEIT, *Lossless Information for Emerging Information Technologies*, GA 101099125, ERC, AdG.
- NANOPOLY, *Artificial permittivity and permeability engineering for future generation sub wavelength analogue integrated circuits and systems*, GA 829061, H2020 FET Open project.
- TOCHA, *Dissipationless topological channels for information transfer and quantum metrology*, GA 824140, H2020 FET Proactive project.
- NANOSMART, *NANO components for electronic SMART wireless Systems*, GA 825430, H2020 ICT project.
- MAGNIFIC, *Materials for a next-generation (nano-)opto-electro-mechanical systems*, GA 101091968, HORIZON-CL4.
- MINERVA, *Making new electronic devices from amorphous materials*, Ref. PCI2021-122092-2A, NextGenerationEU/PRTR.
- MUSICIAN, *Multifunctional silicon integrated NOEMS for broadband access networks*, Ref. CI2022-135001-2, Plan Estatal de Investigación Científica y Técnica y de Innovación 2021-2023.
- FOWLING, *Free-space optomechanics with light-emitting materials*, GA 897148, MSCA-IF-2019.

The Phononic and Photonic Nanostructures group achieved important research results during 2022, an overview of which is given below.



In preparation for experiments to connect a phonon source to a topological phononic waveguide, we demonstrated the realisation of a coherent phonon source at around 7 GHz, realised in silicon-on-insulator based on the physics of light localisation, which enhanced the coupling between photons and phonons resulting in a phonon laser.

We advanced our band structure simulations and designed crystalline and nano-crystalline silicon membrane-based non-trivial topologically protected phonons waveguides operating in the hypersound. A mechanical waveguide was engineered which exhibited a nearly 7 GHz gap width centred at 6.7 GHz. Furthermore, two guided phonon modes were detected by Brillouin light scattering. The results published in *Nature Comms.* were accompanied by a “News and Views” article in the same issue.

The mechanical properties of homogeneous 2D materials and their

structural integrity were investigated applying strain around the critical values. The impact of this work is in the field of flexible devices based on MoS<sub>2</sub>. We have also studied the effect of polycrystallinity and interlayer stacking in the mechanical properties of 2D materials. Thermal transport in homogeneous, polycrystalline, bilayers and heterostructures of 2D materials has been a hot topic in 2022 focusing on the role of interfaces in the thermal transport and the implications for energy harvesting and heat guiding.

Progressing in phonon engineering, phononic crystal structures supporting supersonic bound states in the hypersound were designed and studied experimentally, proving obstructed leakage.



**21**

CONTRIBUTIONS

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**2**

THESES

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**1**

AWARD

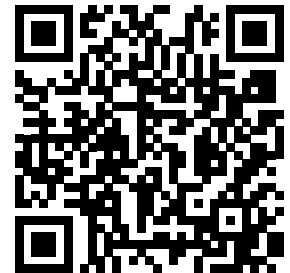
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**1**

BOOK CHAPTER

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# PHYSICS AND ENGINEERING OF NANODEVICES GROUP

## 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

## GROUP MEMBERS

### **Valenzuela, Sergio Osvaldo**

ICREA Research Professor and Group Leader

### **Aguilar Merino, Patricia**

Visiting Master Student

### **Aoki, Motomi**

Fellowship Doctoral Student

### **Camosi, Lorenzo**

Postdoctoral Researcher

### **Cañete Arche, Alejandro**

Visiting Degree Student

### **Costache, Marius Vasile**

Senior Researcher

### **Fernández Aguirre, Iván**

Doctoral Student

### **Figueroa García, Adriana Isabel**

Visiting Professor

### **Galceran Vercher, Regina**

Visiting Professor

### **Giurgea, Flavius Catalin**

Visiting Master Student

## GROUP LEADER

### **SERGIO O. VALENZUELA**

ICREA Research Professor

[SOV@icn2.cat](mailto:SOV@icn2.cat)



Sergio O. Valenzuela obtained his PhD in Physics in 2001 at the *Universidad de Buenos Aires* (Argentina) and held research positions at *Harvard University* and the *Massachusetts Institute of Technology* (MIT). Since July 2008 he has been an ICREA Research Professor and leader of the ICN2 Physics and Engineering of Nanodevices Group. His research is focused on the unique properties of materials with nanoscale dimensions, motivated by both their intrinsic scientific interest and their potential for advanced electronic applications. His work encompasses spintronics, quantum computation with superconducting circuits and quantum metrology. Together with his collaborators, he has pioneered the use of non-local devices to study the spin Hall effect and of thermopiles to isolate the magnon drag in ferromagnetic materials, and he has implemented novel qubit control and spectroscopy methods.

Prof. Valenzuela was awarded the 2001 *Giambigi Prize* and the 2009 *IUPAP Young Scientist Prize* in Magnetism for his contributions to the field of spintronics, as well as an ERC Consolidator Grant in 2012. He has authored over 80 articles (*Nature*, *Science*, *Reviews of Modern Physics*, *Nature Materials*, *Nature Physics*, *Nature Nanotechnology*, *Physical Review Letters*, among others), four patents, and five books or book chapters. He is an elected Member of the *Academia Europaea* and a Fellow of the *American Physical Society*.

#### **Gómez Carbonell, Carmen**

Research Engineer

#### **Guillet, Thomas**

Postdoctoral Researcher

#### **Herling, Franz**

Postdoctoral Researcher

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#### **Martinez Armesto, Luis**

Visiting Degree Student

#### **Rongione, Enzo Fayçal**

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#### **Sierra García, Juan Francisco**

Senior Researcher

#### **Svetlik, Josef**

Doctoral Student

#### **Tena Zuazolacigorruga, Mireia**

Visiting Master Student

#### **Valero Guillén, David**

Research Support Technician

#### **Yang, Shuoying**

Postdoctoral Researcher

#### **Zatko, Victor**

Postdoctoral Researcher

## NEW PROJECTS & MILESTONES

In 2022 the Physics and Engineering of Nanodevices Group (PEN) continued its work under the H2020 Graphene Flagship programme to develop spintronic applications with graphene and related 2D materials. The group has experimentally investigated the presence of proximity-induced spin orbit fields and magnetic exchange by means of spin transport methods. It has also continued making progress in exploring the spin properties of materials with large spin-orbit interaction—in particular, topological insulators grown in a dual-chamber molecular beam epitaxial (MBE) system—and has developed multilayer all-2D spin torque devices, demonstrating magnetization switching down to a few monolayers. Related work will continue with the support of a FLAG-ERA JTC 2021 Project: ‘2D MagNETic meMOries: Scalable growth and hYbrid electrical operation’ (MNEMOSYN).

Work has also been carried out within the context of the new project “Engineering the Spin and Thermoelectric Properties the Nanostructured Two-Dimensional Materials (ENGINE2DM)”, supported by the Spanish Ministry of Economy, Industry and Competitiveness (MINECO), dedicated to the study of the spin Hall effect, of the charge and spin transport properties of graphene, of the electrical injection and detection of hot carriers, and of the spin-to-charge conversion efficiency in graphene/metal hybrids.

The group coordinates two European projects launched in 2019 (TOCHA and 2DSPINMEM, described below) and participates on the newly launched quantum initiative, coordinated by ICFO, to develop quantum transduction approaches. It is also



7

ARTICLES

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11

FUNDED PROJECTS

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13

CONTRIBUTIONS

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3

CONGRESSES  
ORGANISATION

a member of the *SpinTronicFactory network*, established to coordinate EU spintronics activities, and represents the Bellaterra node of the Spanish Spintronics Network.

The TOCHA project (“Dissipationless topological channels for information transfer and quantum metrology”, FET-PROACTIVE), funded under the Horizon 2020 EU Research and Development Programme, has the ambition of harnessing topological concepts for future generation of devices and architectures across which information can flow with low losses. This conceptually simple, yet technologically and fundamentally challenging requirement is crucial for the development of technologies in fields ranging from information processing to quantum communication and metrology. In each of these areas, the dissipation of information is a key hurdle that leads, for example, to unacceptable thermal loads or error rates.

The 2DSPINMEM project (Functional 2D materials and heterostructures for hybrid spintronic-memristive devices, M-ERA) explores group-IV monochalcogenides (IV-MCs) materials and aims to perform the first ever evaluation of their potential as memristors, as well as to implement graphene-based heterostructures to control graphene spin properties by changing the memristive setting of the chalcogenides.

The EIC-Pathfinder Project “Phase-sensitive Alteration of Light colorAtioN in quadri-parTite gaRnet cavity” (PALANTIRI), coordinated by Spintec (France), was launched in October 2022 to develop quantum coherent frequency upscaling. The work of the group is centred on the excitation of magnon modes in magnetic insulating structures, based on YIG and patterned by a variety of methods, using microwave excitation.



2

AWARDS



1

OUTREACH IMPACT

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# SUPRAMOLECULAR NANOCHEMISTRY AND MATERIALS GROUP

## MAIN RESEARCH LINES

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

## GROUP MEMBERS

### **Maspoch Comamala, Daniel**

ICREA Research Professor and Group Leader

### **Albalad Alcalá, Jorge**

Postdoctoral Researcher

### **Aydin, Funda**

Fellowship Postdoctoral Researcher

### **Bricio Sanchez, Alex**

Visiting Degree Student

### **Broto Ribas, Anna**

Research Assistant

### **Cano Sarabia, Antonia**

Senior Researcher

### **Carné Sánchez, Arnau**

Senior Researcher

### **Cavalieri, Juan Pablo**

Doctoral Student

### **Coi, Michele**

Research Assistant

### **Coldea, Pau Florín**

Visiting Doctoral Student

### **Cortés Martínez, Alba**

Research Assistant

### **Fonseca García, Javier**

Postdoctoral Researcher

## GROUP LEADER

### DANIEL MASPOCH

ICREA Research Professor



Dr Daniel Maspoch is a chemist who has always maintained a rewarding balance between fundamental and applied research, with pioneering developments in the field of porous reticular materials and delivery systems. He is author of over 185 articles and 6 book chapters. In 2021 and 2022, he got the prestigious ERC Advanced Grant and a second ERC Proof-of-Concept Grant, respectively. In addition, he was awarded an ERC Consolidator Grant in 2014, and his first ERC Proof-of-Concept Grant in 2019. In 2015, he was bestowed with the *Premio Marcial Moreno Mañas* Lectureship and in 2020 with the Research Excellence Award from the Spanish Royal Society of Chemistry, while in 2022 he was appointed new Corresponding Academician of the Physical and Chemical Sciences Section, in the specialty of Materials Science, by the Royal Spanish Academy of Science (RAC).

#### **García Cobeña, Carla Pierina**

Visiting Degree Student

#### **García Jimeno, Sonia**

Postdoctoral Researcher

#### **Gil Bonillo, Marta**

Visiting Degree Student

#### **Gómez Navascués, Leyre**

Postdoctoral Researcher

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#### **Handke, Marcel**

Postdoctoral Researcher

#### **Hernández López, Laura**

Doctoral Student

#### **Imaz, Inhar**

Senior Researcher

#### **Khobotov Bakishev, Akim**

Doctoral Student

#### **McGee Renedo, Sofia**

Research Assistant

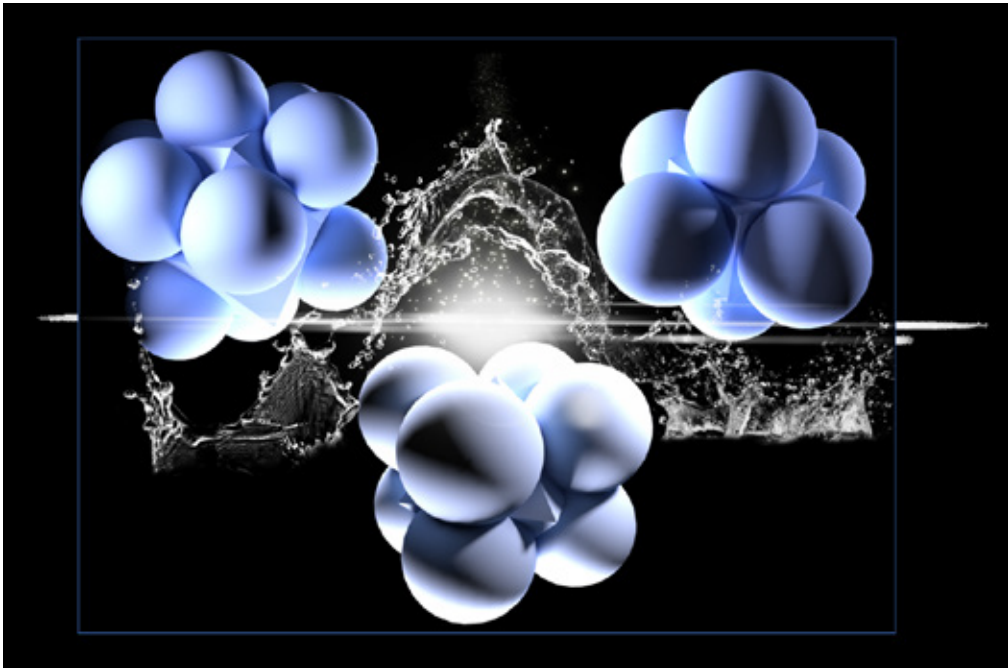
#### **Meng, Lingxin**

Fellowship Doctoral Student

#### **Ortín Rubio, Borja**

Research Assistant





**Pena Pozo, Gerard**

Research Assistant

**Roztock, Kornel**

Visiting Postdoctoral Researcher

**Ruiz Relaño, Sara**

Research Assistant

**Salmerón Vergara, Rafael**

Visiting Degree Student

**Sánchez Naya, Roberto**

Postdoctoral Researcher

**Sanmartí Espinal, Marta**

Scientific Project Manager

**Suárez del Pino, José Antonio**

Specialist Technician

**Turitich Cantero, Libni Mariot**

Fellowship Doctoral Student

**Von Baeckmann, Cornelia**

Postdoctoral Researcher

**Yang, Yunhui**

Doctoral Student

**Zhang, Xiang**

Fellowship Doctoral Student

From the technology transfer side, several technologies and materials developed by his group have been transferred –through licensing patents or signing technology transfer contracts– to various companies. The high technological and socioeconomical impact of his research is supported by: the co-development of three technologies based on delivery systems that are available on the market (LuctaCaps®, Fungipol@CP and a product of Lipofer™ family); the signature of 4 technology transfer contracts; the filling of 12 patents, from which 4 have been licensed; the co-founding of the spin-off company Ahead Therapeutics; and the collaboration with 15 private companies (e.g. KAO Co., LG Display, CEPESA, LACER, etc.) through bilateral projects/contracts.

Dr Maspoch graduated in Chemistry at the Universitat de Girona and obtained his PhD in Materials Science at the Universitat Autònoma de Barcelona & Institut de Ciència de Materials de Barcelona working in the group of Prof. Jaume Veciana and Prof. Concepció Rovira. He then moved to Northwestern University, where he worked as a postdoctoral fellow in the group of professor Chad A. Mirkin. Since September 2011 he is ICREA Research Professor and Group Leader at the Institut Català de Nanociència i Nanotecnologia (ICN2).



**13**  
**ARTICLES**

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**10**  
**FUNDED PROJECTS**

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**22**  
**CONTRIBUTIONS**



## NEW PROJECTS & MILESTONES

In 2022, three projects carried out by the group came to an end, specifically: Genesis, supported by the European Commission; POSE, supported by the Spanish Ministry of Science, Innovation and Universities – AEI; and Meta2nol, funded by the Fundación Ramón Areces. In the framework of these projects, novel materials (e.g., new catalysts) and devices (e.g., sensors and membranes) made of porous reticular materials were developed. 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 HybMOFs, funded by MCIN/AEI under the *Acciones de dinamización “Europa Excelencia”* call, which aims at using DNA nanotechnology and reticular chemistry to design hierarchical, multi-component, porous materials based on DNA-guided assembly of pre-synthesized nanoscale molecular cages.

On the other hand, during 2022 the group has started five new projects. The first, SAFEON –supported by ERC under its Proof-of-Concept– aims to approach new antimicrobial coatings to the market. The second and third, DISASSEMBLE and MOFTONIC, both funded by the Spanish Ministry of Science, Innovation and Universities – AEI, focus on the full disassemble of reticular materials to obtain clusters and cages and on the self-assembly of colloidal MOF particles, respectively. The main objective of the fourth project, RemoveAs, supported by the Spanish Ministry of Science, Innovation and Universities – 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.

The group has also continued to collaborate with companies to bring customised micro- and nano-encapsulation technologies to the market, working in parallel with different entities.



**5**

AWARDS

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**2**

THESES

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**3**

OUTREACH IMPACTS

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**1**

BOOK CHAPTER

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# THEORETICAL AND COMPUTATIONAL NANOSCIENCE GROUP

## 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
- Artificial Intelligence and machine learning techniques to accelerate the building of realistic and adaptative structural and electronic models of highly disordered 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)

## GROUP MEMBERS

### **Roche, Stephan**

ICREA Research Professor and Group Leader

### **Alcazar Guerrero, Pedro**

Doctoral Student

### **Alcón Rovira, Isaac**

Postdoctoral Researcher

### **Canonico Armas, Luis Manuel**

Postdoctoral Researcher

### **Cummings, Aron William**

Senior Researcher

## GROUP LEADER

### STEPHAN ROCHE

ICREA Research Professor



ICREA Prof. Stephan Roche is working at the Catalan Institute of Nanosciences and Nanotechnology-ICN2 and BIST. He leads the “*Theoretical and Computational Nanoscience*” group which focuses on physics of Dirac materials (graphene & topological insulators) and 2D materials-based van der Waals heterostructures. He pioneered the development of linear scaling quantum transport approaches enabling simulations of billion atoms-scale disordered models ([www.wlsquant.org](http://www.wlsquant.org)). He studied Theoretical Physics at ENS and got PhD (1996) at *Grenoble University* (France); worked in Japan, Spain & Germany; was appointed as assistant Prof. in 2000, CEA Researcher in 2004 and joined ICREA in 2009. He received the *Friedrich Wilhelm Bessel prize* from the *Alexander von Humboldt Foundation* (Germany). Since 2013, he has been very active in the Graphene Flagship, currently as leader of the workpackage SPINTRONICS and is acting as DIVISION leader. Finally, he is leader and coordinator of the “Quantum Communications” activities at ICN2.

#### **Galvani, Thomas, Jean-François**

Postdoctoral Researcher

#### **García Aguilar, Jose Hugo**

Senior Postdoctoral Researcher

#### **Kaya, Onurcan**

Doctoral Student

#### **Martínez Romeral, Jorge**

Visiting Master Student

#### **Medina Dueñas, Joaquín Eduardo**

Doctoral Student

#### **Tomut, Andrei Voicu**

Fellowship Master Student

## NEW PROJECTS & MILESTONES

In 2022 the group published the following relevant works:

### **Two-dimensional materials prospects for non-volatile spintronic memories**

After more than a decade leading the European task force in 2D materials-based spintronics, Prof. Roche has coordinated a major overview of the state-of-the-art of the field and of the challenges currently faced in the development of non-volatile memories in general and, specifically, of those employing spintronic mechanisms such as spin-transfer torque (STT) and spin-orbit torque (SOT). Collaborating with Graphene Flagship's partners CNRS, CEA and Thales (France) and imec (Belgium), researchers at the National University of Singapore, as well as industrial partners at Samsung Electronics (South Korea) and Global Foundries (Singapore), an in-depth discussion about the advantages of the co-integration of 2D materials in these technologies has been provided, giving a panoramic of the improvements already achieved as well as a prospect of the many advances that further research can produce, in particular in SOT-RAMs. A possible timeline of progress during the next decade is also traced.

### **Electrical control of spin-polarized topological currents in monolayer $\text{WTe}_2$**

In this work, the TCN group and collaborators have demonstrated the possibility for fully coherent electrical manipulation of the spin orientation of topologically protected edge states in a low-symmetry quantum spin Hall insulator. By using a combination of ab initio simulations, symmetry-based modelling, and large-scale calculations of the spin Hall conductivity performed using in-house LSQUANT ([www.lsquant.org](http://www.lsquant.org)), it is shown that small electric fields can efficiently



**10**  
ARTICLES



**10**  
FUNDED PROJECTS



**8**  
CONTRIBUTIONS

vary the spin textures of edge currents in monolayer  $1T'$ -WTe<sub>2</sub> by up to a 90-degree spin rotation, without jeopardizing their topological character. These findings suggest a new kind of gate-controllable spin-based device, topologically protected against disorder and of relevance for the development of topological spintronics.

### **Unveiling the multiradical character of the biphenylene network and its anisotropic charge transport**

Recent progress in the on-surface synthesis and characterization of nanomaterials is facilitating the realization of new carbon allotropes, such as nanoporous graphenes, graphynes, and 2D  $\pi$ -conjugated polymers, following experimental pioneering work at ICN2. One of the latest examples is the biphenylene network (BPN), which was recently fabricated on gold and characterized with atomic precision. This gapless 2D organic material presents uncommon metallic conduction, which could help develop innovative carbon-based electronics. Using first principles calculations and quantum transport simulations, the TCN group has provided new insights into some fundamental properties of BPN, which are key for its further technological exploitation. We predict that BPN hosts an unprecedented spin-polarized multiradical ground state, which has important implications for the chemical reactivity of the 2D material under practical use conditions.

### **Toward optimized charge transport in multilayer reduced graphene oxides**

In the context of graphene-based composite applications, a complete understanding of charge conduction in multilayer reduced graphene oxides (rGO) is highly desirable. However, these rGO compounds are characterized by multiple and different sources of disorder depending on the chemical method used for their synthesis. Most importantly, the precise role of interlayer interaction in promoting or jeopardizing electronic flow remains unclear. Thanks to the development of a multiscale computational approach combining first-principles calculations with large-scale transport simulations, the TCN group and co-workers have discovered interesting transport scaling laws in multilayer rGO, explaining why diffusion worsens with increasing film thickness. In contrast, contacted films are found to exhibit an opposite trend when the mean free path becomes shorter than the channel length, since conduction becomes predominantly driven by interlayer hopping. These predictions are favourably compared with experimental data and open a road toward the optimization of graphene-based composites with improved electrical conduction.

## Magnetism, symmetry and spin transport in van der Waals layered systems

The discovery of an ever-increasing family of atomic layered magnetic materials, together with the already established vast catalogue of strong spin-orbit coupling and topological systems, calls for some guiding principles to tailor and optimize novel spin transport and optical properties at their interfaces. Here, we focus on the latest developments in both fields that have brought them closer together and make them ripe for future fruitful synergy. After outlining fundamentals on van der Waals magnetism and spin-orbit coupling effects, the TCN group and co-workers discuss how their coexistence, manipulation and competition could ultimately establish new ways to engineer robust spin textures and drive the generation and dynamics of spin current and magnetization switching in 2D-materials-based van der Waals heterostructures. Grounding our analysis on existing experimental results and theoretical considerations, we draw a prospective analysis about how intertwined magnetism and spin-orbit torque phenomena combine at interfaces with well-defined symmetries and how this dictates the nature and figures of merit of spin-orbit torque and angular momentum transfer. This will serve as a guiding role in designing future non-volatile memory devices that utilize the unique properties of 2D materials with the spin degree of freedom.



2

CONGRESSES  
ORGANISATION

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1

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1

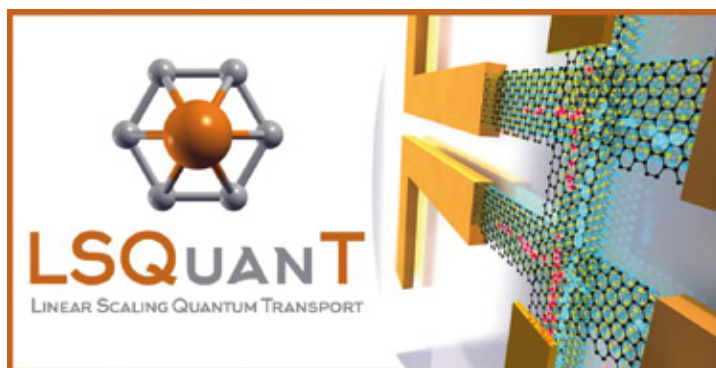
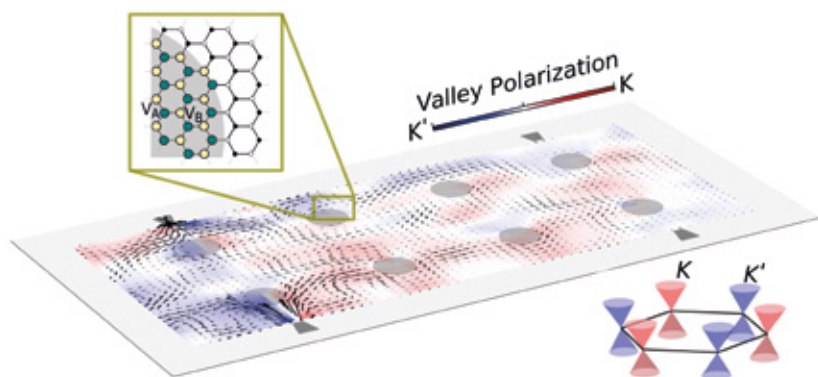
COURSE

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3

OUTREACH IMPACTS



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# THEORY AND SIMULATION GROUP

## MAIN RESEARCH LINES

- Development of theoretical methods, numerical algorithms and simulation tools for atomic-scale simulations: towards massive HPC facilities
- Computational tools: SIESTA development and its connection with other codes and computational infrastructures like AiiDA
- First-principles simulations at the nanoscale
- Physical properties and chemical processes in materials

## GROUP MEMBERS

### **Ordejón Rontomé, Pablo Jesús**

Distinguished Researcher, Group Leader and Director

### **Akhtar, Arsalan**

Research Assistant

### **Alonso Pruneda, José Miguel**

CSIC Tenured Scientist

### **Bertini, Marco**

Fellowship Doctoral Student

### **Castillo Robles, José María**

Visiting Doctoral Student

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### **De Freitas Martins, Ernane**

Visiting PostDoctoral Researcher

### **Escartín Esteban, José María**

Senior Siesta Developer

### **Farris, Roberta**

Postdoctoral Researcher

### **Febrer Calabozo, Pol**

Doctoral Student

## GROUP LEADER

### PABLO ORDEJÓN

Distinguished Researcher, Group Leader and Director



Prof. Pablo Ordejón earned his degree in physics (1987) and his PhD in science (1992) at the *Universidad Autónoma de Madrid*. He worked as a postdoctoral researcher at the *University of Illinois at Urbana-Champaign* (USA) from 1992 to 1995 and as assistant professor at the *Universidad de Oviedo* from 1995 to 1999. In 1999, he obtained a research staff position at the *Institut de Ciència de Materials de Barcelona* of the *Consejo Superior de Investigaciones Científicas* (CSIC). In 2007 he moved to the former CIN2 (now ICN2) as the leader of the Theory and Simulation Group, where he is currently a CSIC Research Professor. Since July 2012 he has served as Director of the ICN2.

He has published more than 210 scientific articles, which have received over 30,000 citations (h-index of 59). He was co-editor of EPL (formerly *Euro Physics Letters*) from 2010 to 2015, and is member of the Editorial Boards of the *Physica Status Solidi* journals since 2004 and *Nanomaterials* since 2018.

#### **García Mota, Mónica**

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#### **Protik, Nakib Haider**

Postdoctoral Researcher

#### **Sharifian, Ali**

Doctoral Student

#### **Wittemeier, Nils**

Doctoral Student

#### **You, Jinxuan**

Research Assistant

He oversaw the Condensed Matter Physics subject area of the Physics Panel of the *Spanish National Evaluation and Foresight Agency* (ANEP) from 2003 to 2006, and was the head of the Physics and Engineering Panel of the Access Committee to the *Spanish Supercomputing Network* from 2005 to 2011. He became a fellow of the *American Physical Society* in 2005, and received the Narcís Monturiol medal from the Catalan Government in 2018.

His research is focused on the development of efficient methods for electronic structure calculations in large and complex systems, with contributions to the development of techniques for large-scale atomistic simulations based on first-principles methods such as SIESTA. He has also been involved in the study of the fundamental properties of materials at the atomistic level. His current interests include electronic transport in nanoscale devices and electronic processes at surfaces and 2D materials, among many others. He maintains frequent collaborations with industrial laboratories on the simulation of material processes at the atomic level. He is a co-founder of the spinoff company *SIMUNE*.



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**16**  
ARTICLES



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**8**  
FUNDED PROJECTS



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**30**  
CONTRIBUTIONS

## NEW PROJECTS & MILESTONES

The Theory and Simulation group has continued focusing much of its efforts on three flagship H2020 projects:

MaX (Materials design at the eXascale), one of the eight European Centres of Excellence in high-performance computing (HPC) Applications supported by the EU under its H2020 e-infrastructure funding programme. 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 a first period of three years (2015-2018), the grant was renewed for the 2018-2021 term, with an increased budget and the inclusion of new groups and codes to the team.

Work during this year has been centred in adapting SIESTA for its execution in GPU-accelerated architectures. These will be the building blocks of the coming European pre-Exascale supercomputers financed by the European High-Performance Computing Joint Undertaking (EuroHPC JU), which are currently being commissioned in three HPC centres (BSC in Spain, CINECA in Italy and CSC in Finland).

INTERSECT, a project focused on integrating materials simulation codes into an industry-class package for the design of electronic devices. The resulting IM2D framework—an interoperable material-to-device simulation platform—will integrate some of the most used open-source materials modelling codes (Quantum ESPRESSO and SIESTA) with models and modelling software for emerging devices (GinestraTM), via the SimPhony infrastructure for semantic interoperability

and ontologies, powered by the AiiDA workflow engine, and its data-on-demand capabilities and apps interface.

NFFAEurope, a project funded under the H2020-INFRAIA-2014-2015 call “Integrating and opening existing national and regional research infrastructures of European interest”. The NFFA (Nanoscience Foundries and Fine Analysis) 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 2020, a new proposal submitted to continue the activities of NFFA for a new 5-year period was approved by the EC, and therefore the group will continue providing services to transnational users during the next years.

Besides, we continue with our work within the project financed by the Spanish Ministry (PGC2018-096955-B-C43), entitled “*SIESTA and its interoperability for new challenges in atomistic simulations*”, and have joined two other national projects led by ICN2 experimental groups, to provide theoretical support: project “*SURFER: Química Física de Superficies Ferroelectricas*” (PI: Neus Domingo, ref. PID2019-109931GB-I00), and project “*STEAMY: Steering hEAt flow in layered Material sYstems*” (PI: Klaas Tielrooij, ref. PID2019-111673GB-I00).

The group has participated in two important articles describing the current status and latest developments of SIESTA and ABINIT, two of the most commonly used open-source Density Functional Theory codes for the determination of materials properties from first principles, published in a special issue of the *Journal of Chemical Physics* in 2020.

Important efforts have also been devoted to two topics in which the group has made important contributions during the last years: understanding electronic

instabilities in materials showing Charge Density Waves, and the physics of 2D materials (and, in particular, Transition Metal Dichalcogenides and nanostructured graphene).

Finally, two new research lines launched in 2019 have matured and started to produce significant results in 2020. The first one is the study of superconducting materials, in particular the interplay with spin-orbit effects and proximity effects, a line brought to the group by Dr. Gabor Csire (ProBIST COFUND Postdoctoral Researcher in our group) that has produced a significant number of publications in 2020. Dr. Csire is adapting his methodology to SIESTA, which will soon be able to tackle superconductivity in systems with strong spin-orbit coupling and in non-homogeneous materials. The second is the development and application of a methodology to study the chemical processes taking place at the interface between electrified surfaces and liquid electrolytes. This will open the way to



**2**

**AWARDS**

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**1**

**THESIS**

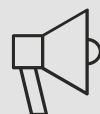
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**2**

**CONGRESSES  
ORGANISATION**

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**2**

**OUTREACH IMPACTS**

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**2**

**COURSES**

studying, for the first time, electrochemical processes in which a potential is applied to the electrodes, from first-principles and with atomic detail, allowing the study of problems related to electrochemistry, batteries, electrocatalysis, photocatalysis, corrosion, etc. Prof. Pablo Ordejón, who is leading this research line, was invited to present preliminary results at the 2020 March Meeting of the American Physical Society. This work has led to a new collaboration of the Theory and Simulation group with Prof. Ivan Cole, from the RMIT (Melbourne, Australia), a world leader in the theoretical and experimental study of corrosion in materials and on the development of corrosion inhibitors. The T&S group at ICN2 and the RMIT are currently sharing one PhD student and one Postdoctoral Researcher to carry out this collaboration. Additionally, Prof. Ordejón is working with Dr. Alberto García (ICMAB) on the application of these techniques for the development of materials for batteries, within the EU-H2020 project BIG-MAP.

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# THERMAL PROPERTIES OF NANOSCALE MATERIALS GROUP

## 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 membranes, 2D materials and single nanowires, characterized by DC and AC-methods.
- 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 OLEDs and solar cells

## GROUP MEMBERS

### **Rodríguez-Viejo, Javier**

UAB Professor and Senior Group Leader

### **Amorós Llonch, Carlota**

Visiting Degree Student

### **Bar, Tapas**

Postdoctoral Researcher

### **Casi Pullés, Xavier**

Visiting Degree Student

### **Fraxedas Calduch, Jordi**

CSIC Scientific Researcher

### **Gómez Torres, Hugo**

Doctoral Student

### **González Miguez, Sara**

Visiting Doctoral Student

## GROUP LEADER

### JAVIER RODRÍGUEZ-VIEJO

UAB Professor and Senior Group Leader



Javier Rodríguez-Viejo is Full Professor of Applied Physics at the Autonomous University of Barcelona (Universitat Autònoma de Barcelona, UAB) and leads the Group of Thermal Properties of Nanoscale Materials at the UAB and the ICN2. He performed the experimental part of his doctoral thesis at the *Institut des Matériaux et Procédés* CNRS, France and received his PhD in Physics from UAB in 1992. He continued his studies as a postdoctoral researcher at the Massachusetts Institute of Technology, working on the synthesis of highly-luminescent CdSe(ZnS) quantum dots and the deposition of thin film quantum dot composites by electrospray organometallic chemical vapor deposition. In May 1997 he was appointed Associate Professor of Applied Physics at the Physics Department of UAB and in 2011 became Full Professor at the same university. He has been visiting scientist at *Air Products* in Allentown, US (July-August 2008) and Harvard University (May-September 2016).

#### **González Silveira, Marta**

UAB Senior Researcher

#### **Lopeandia Fernández, Aitor**

UAB Senior Researcher

#### **Pastor Cifre, Neus Marina**

Visiting Degree Student

#### **Rodríguez López, Marta**

Visiting Doctoral Student

#### **Rodríguez Tinoco, Cristian**

UAB Senior Researcher

#### **Ruiz Ruiz, Marta**

Visiting Doctoral Student

#### **Vea Falguera, Xavier**

Visiting Master Student

#### **Vila Costa, Ana**

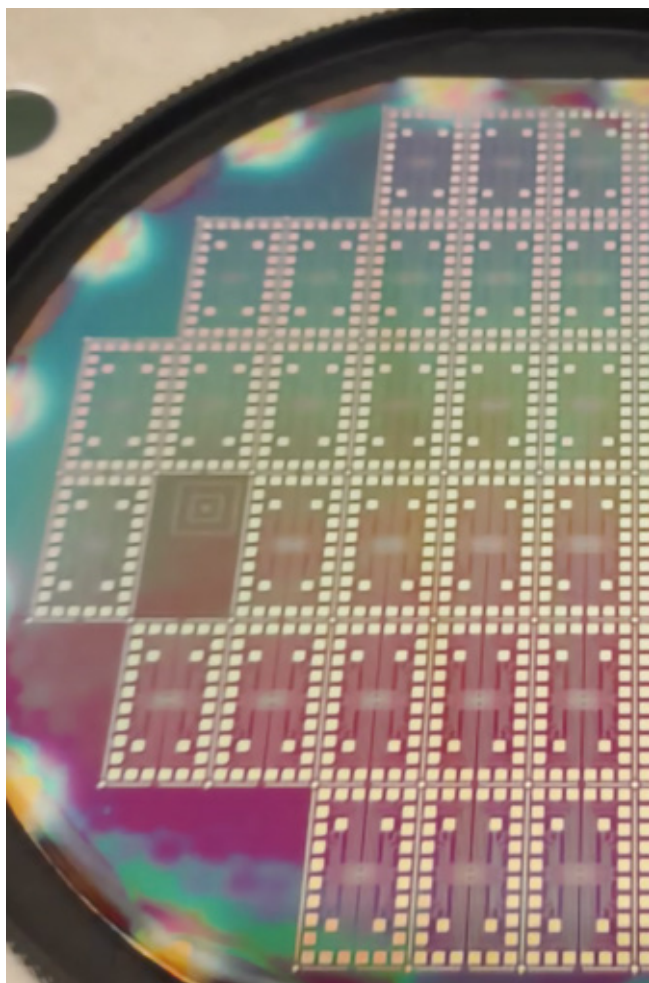
Visiting Doctoral Student

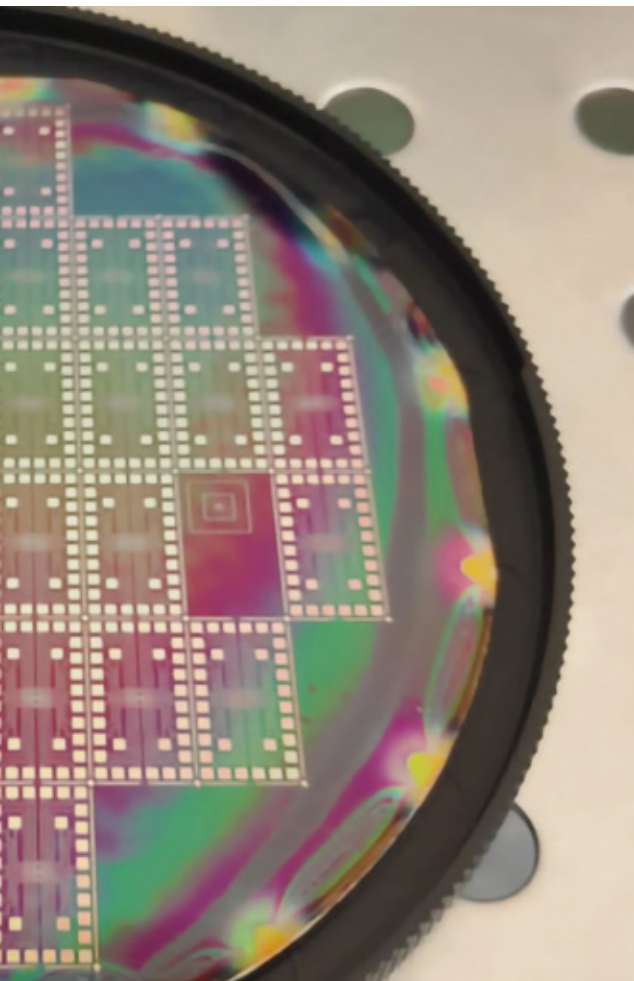


His research interests revolve around thermal properties at the nanoscale in a variety of materials spanning from thin film organic glasses to single semiconductor nanowires. Nanocalorimetry, a technique developed in his group between 2003-2005, has been used since then to understand the influence of thickness on phase transitions of a variety of materials, including antiferromagnetic transitions in 1.5 nm thick layers or glass transitions in organic glasses down to 4 nm thickness. A related field in which Prof. Rodríguez-Viejo is interested is nanoscale thermal transport and thermoelectricity, with a special focus on understanding the impact of size and disorder in the thermal conductance of a variety of materials.

He currently gives lectures at the UAB at undergraduate and graduate level on Introductory Physics, Physics of Nanomaterials, Phase Transformations and Quantum Physics. He is actively involved in the PhD Programme of the UAB's Physics Department (Physics and Materials Science), of which he has been supervisor over the period 2003-2008. Since May 2019 he is the coordinator of the Master in Advanced Nanoscience and Nanotechnology, in which various institutes participate: UAB, ICN2, ICMAB, and IMB-CNM. He has also supervised many PhD students.

Prof. Rodríguez-Viejo has been the Vicedirector of MATGAS, a non-profit research organization with partnership from Air Products, UAB and CSIC, representing UAB from March 2008 to April 2015. His team received the *Fundación Repsol Entrepreneurs' Prize in the Ideas category* in 2015 and the *Projects one* in 2016. He is co-founder of FutureSiSens, a start-up devoted to the development and commercialization of new thermal sensors. Outside work, he enjoys birdwatching and mountain hiking and is an enthusiastic volleyball fan with three family members actively playing this sport.





**7**  
ARTICLES

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**1**  
FUNDED PROJECT

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**2**  
CONTRIBUTIONS

## NEW PROJECTS & MILESTONES

Prof. Rodríguez-Viejo joined the ICN2 in 2021, where he started the new “Thermal Properties of Nanoscale Materials” group (while keeping his research group at the UAB). During 2022 the two laboratories, AFM and nanocalorimetry lab, have become fully operational. They include a high-vacuum nanocalorimetric setup, to measure phase transitions in ultrathin layers, and a high-vacuum evaporation chamber, to allow for co-evaporation of small organic molecules and simultaneous characterization by *in-situ* nanocalorimetry, as well as several topographic AFM with temperature stages to follow *in-situ* the kinetics of phase transitions.



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THESIS

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4

OUTREACH IMPACTS

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1

BOOK CHAPTER

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COURSES

In collaboration with the Oxyde Nanophysics group we have started a new project: PYROelectric free-standing Membranes for THERmal Energy Recovery (PYROMETHER), TED2021-131363B-I00. The goal is to investigate pyroelectric and electrocaloric effects of single-crystal free-standing (anti)ferroelectric oxide membranes using the nanocalorimetric chips as suitable platforms for direct measurements. We also aim to analyse the suitability of oxide AFE/FE membranes as potential materials towards an efficient pyroelectric energy conversion of heat into electricity. As a first step during 2022 we are measuring the heat capacity of thin film oxide membranes.

The group has also demonstrated a novel methodology to measure the heterogeneous transformation of ultrathin ultrastable glasses. It benefits from the mechanical instabilities created in tri-layer stacks during the melting of an intermediate layer to image by AFM the changes in topography. This work is based on the upgrade of a commercial Atomic Force Microscope for real-time imaging of temperature dependent phase transitions.

Within the EU project EMPIR Nanowires, and in collaboration with IMB-CNM-CSIC, we have developed suspended platforms to measure thermal transport in single nanowires.

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

## MAIN RESEARCH LINES

- Quantum materials
- Transport and dynamics of heat and charge
- Terahertz technologies
- Photodetection

## GROUP MEMBERS

**Tielrooij, Klaas-Jan**

Junior Group Leader

**Block, Alexander**

Postdoctoral Researcher

**De La Bastida Chiza, Ronny Omar**

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**Farris, Roberta**

Postdoctoral Researcher

**Faycal Rongione, Enzo**

Postdoctoral Researcher

**Koutsogianni, Afroditi**

Research Assistant

**Liu, Bohai**

Postdoctoral Researcher

**Mehew, Jake Dudley**

Postdoctoral Researcher

**Saleta Reig, David**

Doctoral Student

**Sontakkey, Nupur Vijay**

Research Assistant

**Swiniarski, Michal**

Postdoctoral Researcher

**Varghese, Sebin**

Doctoral Student

## GROUP LEADER

### KLAAS-JAN TIELROOIJ

Junior Group Leader



Klaas-Jan Tielrooij founded the Ultrafast Dynamics in Nanoscale Systems group at ICN2 in October 2018 as a Junior Group Leader. In 2022 he was promoted to Senior Group Leader. He also works as a part-time Associate Professor at *Eindhoven University of Technology* (the Netherlands). Before joining the ICN2, he was a Research Fellow at the *Institute of Photonic Sciences* (ICFO). Between 2018 and 2020, he was Visiting Professor at the *Graduate School of Excellence Material Science in Mainz* (Germany). He obtained his Ph.D. from the *University of Amsterdam* (the Netherlands) in December 2010. Klaas-Jan has received several prizes, including the Dutch national Physics Thesis Prize, and competitive personal grants including ERC Starting and Proof of Concept grants and a Spanish Ramón y Cajal grant. Prof Tielrooij has authored more than 60 peer-reviewed publications, with more than 8,000 citations, and he has given more than 40 invited talks.

## NEW PROJECTS & MILESTONES

In 2022, the group reached important milestones. First of all, several unique, home-built ultrafast optical, optoelectronic, and optothermal techniques are now operational and providing interesting data. This includes two techniques developed by the group: a spatiotemporal thermoelectric photocurrent microscopy technique that can follow heat flow of electrons with femtosecond temporal and nanometer spatial accuracy (see *Nat. Nanotechnol.* 16, 1195 (2021)); and a novel technique to extract the thermal diffusivity of thin films, which does not require any material input parameters (see *Rev. Sci. Instr.* 94, 034903 (2023)).

The group published important publications on understanding the flow both electronic and phononic heat in quantum materials (*Adv. Mater.* 34, 2108352 (2022), *ACS Nano* 16, 3613 (2022), and *Phys. Rev. B* 106 115422 (2022)). These projects involved several collaborators, including researchers from ICN2 (Spain), *ULiege* (Belgium), *University of Pisa* (Italy), and *University of Manchester* (UK).

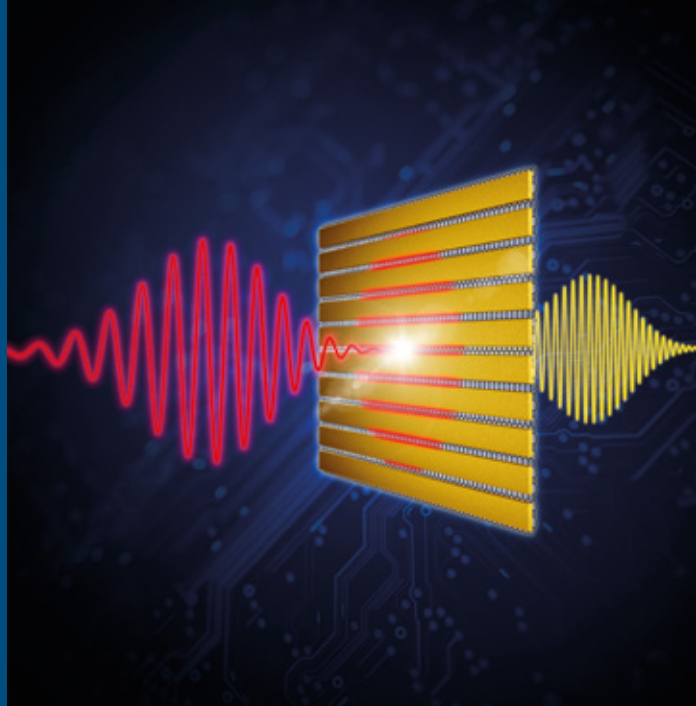
Finally, in *Light, Sci. & Appl.* 11, 315 (2022), the group collaborated with HZDR (Germany), among others, to demonstrate terahertz third harmonic generation with close to a milliwatt of output power, which is a promising result with possible applications in next generation wireless communication technologies.



**5**  
ARTICLES



**5**  
FUNDED PROJECTS



In 2022, the group was awarded an ERC Proof of Concept grant (*COOLGRAELE*), initiated joint projects with *Eindhoven University of Technology* (the Netherlands) and the *Eindhoven Hendrik Casimir Institute*, and was awarded an AGAUR grant from the *Generalitat de Catalunya* (SGR).

During 2022, the group hosted Prof. Alessandro Principi, Senior Lecturer at *University of Manchester*, who is a long-term collaborator of the group. In the same year, Flavius Giurgea finished his joint MSc project with the group of Prof Sergio Valenzuela, Ronny de Bastida started a MSc project in the group, and Patricia Alguilar started a joint MSc project with the group of Prof. Sergio Valenzuela.

Several new members joined the group in 2022: a warm welcome to Nupur, Michal, Afroditi, Bohai and Enzo!



**12**  
CONTRIBUTIONS

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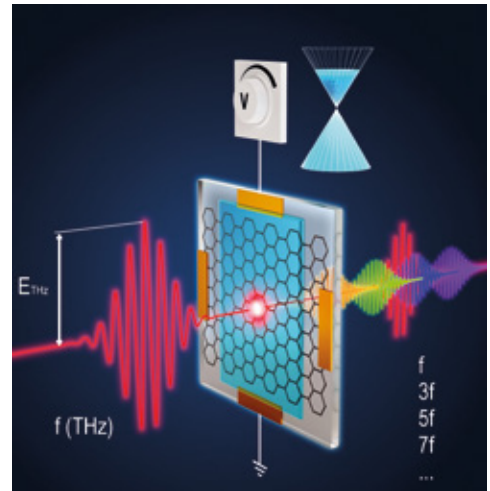


**1**  
CONGRESS  
ORGANISATION

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**3**  
COURSES



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# RESEARCH SUPPORT DIVISION

Research at the ICN2 is assisted by the Research Support Division, a centralised infrastructure that provides shared access to specialised equipment, services and expertise. It offers ICN2 research groups and neighbouring centres a broad range of advanced services for the development of new methods, materials and instruments, and in doing so it fosters multidisciplinary collaborations within the institute and beyond. Led by Dr **Gustavo Ceballos**, the division is made up of three Research Support Units and a series of Core Research Facilities. It is staffed with highly-qualified scientists and technicians with diverse skillsets, who bring added value to the ICN2 and all of its research groups.

## RESEARCH SUPPORT UNITS

Led by scientists with extensive research experience, the units develop novel experimental equipment, setups and techniques. Their combined expertise enables the ICN2 research groups to conduct experiments at the frontier of science in a way that would not be possible without specialised support.

- Electron Microscopy Unit **p.162**
- Instrumentation Unit **p.166**
- Nanomaterials Growth Unit **p.168**

## CORE RESEARCH FACILITIES

The Core Research Facilities constitute a body of specialised equipment, technologies and services. Very much service-oriented, these facilities are run by highly-qualified personnel and allow ICN2 scientists to efficiently and cost-effectively meet their ambitious research goals.

- Biolab Facility **p.172**
- Mechanical Workshop Facility **p.174**
- Molecular Spectroscopy and Optical Microscopy Facility **p.175**
- Nanofabrication Facility **p.177**
- Photoemission Spectroscopy (XPS&UPS) Facility **p.180**
- X-Ray Diffraction Facility **p.181**

# ELECTRON MICROSCOPY UNIT

## 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 nanotubes and graphene
- Exploration of 2D layered inorganic nanotube systems
- Electron microscopy studies of the interaction of nanomaterials and biological entities

## UNIT MEMBERS

### **Ballesteros Pérez, Belén**

CSIC Research Scientist and Unit Leader

### **Belarre Triviño, Francisco Javier**

Research technician of the electron microscopy sample preparation Lab.

### **Mundet Bolós, Bernat**

Research Engineer

### **Rosado Iglesias, Marcos**

Specialist Technician

### **Villaret Ribot, Marta**

Visiting Undergraduate Student

## UNIT LEADER

### BELÉN BALLESTEROS

Unit Leader



Dr Belén Ballesteros earned her degree in Chemistry with Honours at the *Universitat Autònoma de Barcelona (UAB)* in 2001, before going on to obtain her PhD in 2006 at the *Institut de Ciència de Materials de Barcelona (ICMAB-CSIC)*.

During her doctoral studies, she undertook research stays at various European universities, including *Universiteit Twente* (Netherlands), *Universitetet i Oslo* (Norway), *University of St Andrews* (UK) and *Universidad de la Laguna* (Spain). In July 2006 she began postdoctoral work at the University of Oxford, where she worked in electron microscopy imaging and the nanoanalysis of carbon nanotubes, inorganic nanotubes and related materials. She has led the ICN2 Electron Microscopy Unit since April 2009.

Dr Ballesteros has authored 95 peer-reviewed articles with over 2400 citations.

The ICN2 Electron Microscopy Unit focuses on the use of advanced electron microscopy techniques for nanoscience and nanotechnology research and applications. The main aim of the Unit is to provide scientific-technical support to the ICN2 research lines and to external scientists and private companies, as well as developing and implementing novel techniques. The laboratory has active collaborations with other research institutions and is becoming increasingly involved in European networks, such as the NFFA project and ReMADE@ARI. It provides researchers and students an extensive range of processing services to help them carry out their research activities.

## FACILITY

The ICN2 Electron Microscopy facilities are located in the basement of the ICN2 building and in the JEMCA platform in the ALBA synchrotron.

## NEW PROJECTS & MILESTONES

The electron microscopy unit focuses on the use of 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 2022, the new Double Aberration-Corrected Transmission Electron Microscope with monochromator and a Focused Ion Beam were installed in the JEMCA and ICN2 respectively. These state-of-the-art equipment, partially funded with ERDF funds and with contributions of ICN2, CSIC, ICMAB, UAB and ALBA, represent a leap in quality in the tools that the Unit provides to the local scientific community.

In 2022 the Unit incorporated a new member, Dr Bernat Mundet. The Unit also hosted Marta Villaret as a visiting undergraduate student from the UAB.

Aside their daily fundamental activities, during 2022 the members of the Unit were involved in the organization of the third edition of the ICN2 *ArtMeetsNano Image Contest*. Also, Dr Ballesteros took part in the organization of the *LeaderSHE* seminars, a new series of lectures given by outstanding women who succeeded in reaching leadership positions in different professional fields. This initiative, promoted by the Equal Opportunities Committee, aims at inspiring young female researchers and professionals to pursue leading roles in academia, industry or any other work environment. Dr Ballesteros was also part of the scientific committee of the *XXXVII Trobades Científiques de la Mediterrània*.

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.

The Unit devoted efforts to the NFFA-Europe infrastructure project, providing access to the ICN2 electron microscopy facilities to a number of researchers from other institutions.



4

ARTICLES



1

FUNDED PROJECT



1

CONTRIBUTION



**3**

**CONGRESSES  
ORGANISATION**

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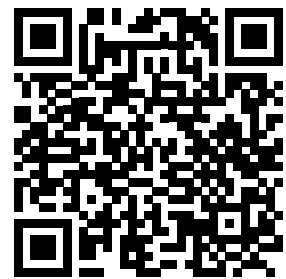


**2**

**OUTREACH IMPACTS**



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# 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 modeling.
- Data acquisition for experimental measurements.
- 3D computer-aided design (CAD) of precision devices.
- Expertise in vacuum technology, including high vacuum (HV) and ultra-high 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.

## UNIT MEMBERS

### **Ceballos Mago, Gustavo**

Head of Research Support Division and Unit Leader

### **Maymó i Camos, Marc**

Research Engineer



# 2

**FUNDED PROJECTS**

## UNIT LEADER

### GUSTAVO CEBALLOS

Head of Research Support Division - Instrumentation Unit



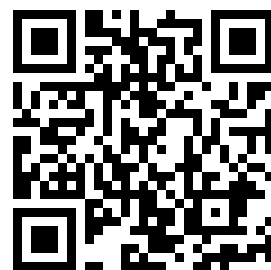
Dr. Gustavo Ceballos received his degree in Chemistry from the *Universidad Central de Venezuela* in 1989. He completed his Ph.D. in 1996 at the *Institut für Physikalische und Theoretische Chemie der Universität Bonn* in Germany. Following that, he conducted postdoctoral studies at the *Institut für Experimentalphysik der Freie Universität Berlin* until 1997. From 2001 to 2002, he worked at the Low-Temperature Scanning Tunnelling Microscopy Group at the *Fritz Haber Institute of the Max Planck Society* in Berlin. Subsequently, from 2002 to 2006, he served as a research scientist at the XSTM and Low-Temperature STM of Nanostructures Division at the *Laboratorio Nazionale TASC-INFM* in Trieste, Italy. In 2006, he joined ICN2 as a senior scientist and established the Instrumentation Unit. Dr. Ceballos actively participates in research conducted by the *ICN2 Atomic Manipulation and Spectroscopy Group*.

Throughout his career, he has been involved in modifying existing instruments and developing new setups to meet the requirements of his experimental work.

## NEW PROJECTS & MILESTONES

In 2022, 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. Furthermore, the unit actively participated in dissemination activities, utilizing their expertise to design and construct prototypes and technology demonstrations.

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# NANOMATERIALS GROWTH UNIT

## MAIN RESEARCH LINES

- 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)

## UNIT MEMBERS

### **Santiso López, José**

CSIC Tenured Scientist and Unit Leader

### **Saeed, Umair**

Doctoral Student

### **Caicedo Roque, José Manuel**

Research Engineer

## UNIT LEADER

### JOSÉ SANTISO

CSIC Tenured Scientist and Unit Leader



Dr José Santiso earned his degree in Physics at the *Universitat Autònoma de Barcelona* (UAB) in 1988, later obtaining his PhD from the *Universitat de Barcelona* (UB) in 1993.

After his doctoral studies, he worked as a visiting scientist at *Cambridge University* (UK) from 1994 to 1996. He then joined the *Institut de Ciència de Materials de Barcelona* (ICMAB) as a research associate and became a CSIC tenured scientist in 2002. In 2007 he moved to the former CIN2 as the leader of the Pulsed Laser Deposition and Nanoionics Group, which later became the ICN2 Nanomaterials Growth Unit. In 2012 he received the *Somiya Award* from the *International Union of Materials Research Society* (IUMRS) for his contributions to solid state ionics. He completed several stays at different laboratories: in 2014 he joined for three months the *International Institute for Carbon-Neutral Research* (I<sup>2</sup>CNER, Kyushu University) thanks to a grant from the *Japan Society for the Promotion of Science*; in 2015 stayed at the *Massachusetts Institute of Technology* (USA) for a three-month period; and between 2018 and 2019 he joined for a few months the *Universidad Técnica Federico Santamaría in Valparaíso* (Chile).

Dr Santiso has authored more than 140 articles, with about 2690 citations and h-index of 28.

## 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 co-ablation 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.



4

ARTICLES

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2

FUNDED PROJECT

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3

CONTRIBUTIONS

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 MoS<sub>2</sub>, 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.



**2**

**COURSES**

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# BIOLAB FACILITY

The ICN2 Biolab is a transversal facility that provides scientific advice and hands-on training in the field of Cell Biology, Microbiology and Molecular Biology, as well as technical support to conduct basic and applied research activities involving biological agents. These activities include the cultivation and manipulation of bacterial and fungal cells, animal cells, viruses, human and animal samples, and other biological material in order to study their interaction with nanostructured material like nanoparticles and biomedical nanodevices. The ICN2 Biolab is a Biosafety Level 2 laboratory (BSL-2) and complies with the legal requirements for activities with biological agents of higher risk groups. Therefore, all work performed in the Biolab is done after appropriate training following BSL-2 guidelines and according to national and international biosafety standards.

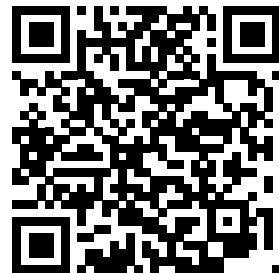
The ICN2 Biolab Facility has received funds from the CENanoTech project (2015 FEDER/S-16). In turn, the CENanoTech project is funded through the call for unique institutional R&D infrastructures launched by the Universities and Research Secretariat of the Regional Ministry of Economy and Knowledge of the Government of Catalonia, with funding received from the European Regional Development Fund (ERDF) under the Operational Programme Catalonia 2014-2020. The project has also been co-funded by the Severo Ochoa Programme, granted by the back then Spanish Ministry of Economy and Competitiveness (SEV-2013-0295).

## FACILITY MEMBERS

### **Dietrich, Manuela**

Senior Laboratory Officer  
of the Biolab Facility

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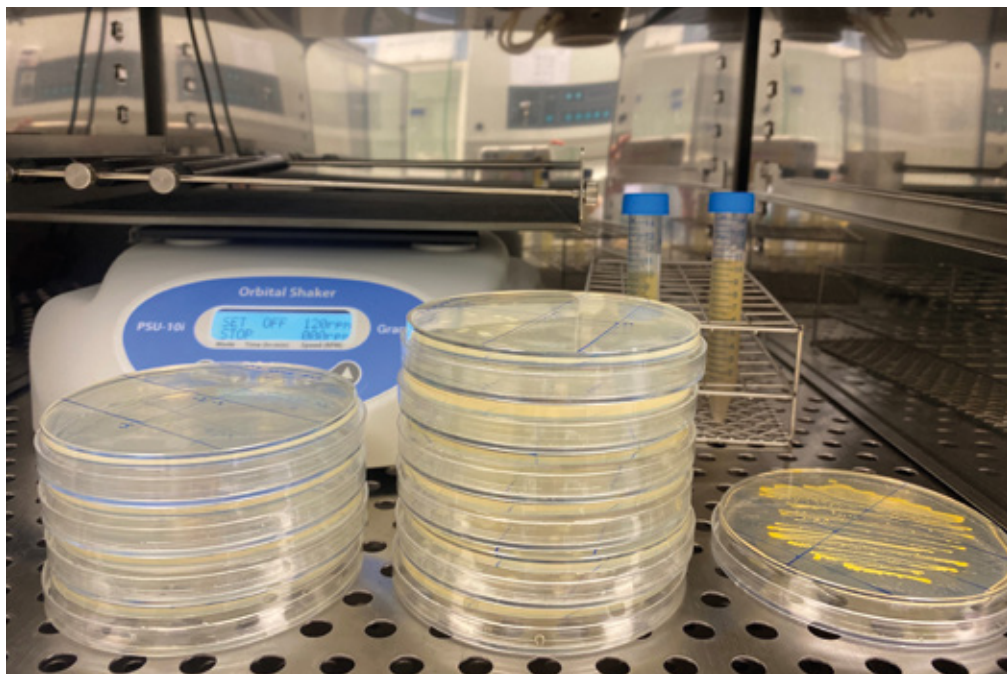


## AVAILABLE TECHNIQUES

- Biological Safety Cabinets (class II)
- CO<sub>2</sub> 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, dry bath, ultrasonic bath
- vortex, pipettes
- Refrigerators, freezer and ultra-freezers

## NEW PROJECTS & MILESTONES

In 2022, 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 last year 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. 2022 was also the year of a thorough revision of all the documents of the Institutional Biosafety Program to keep up to date with current legal requirements and procedures. In addition, the webpage of the Biolab Facility has been updated with information about newly acquired equipment and a new section about access criteria.



# MECHANICAL WORKSHOP

The main objective of the Mechanical Workshop is to assist ICN2 researchers with the production and development of mechanical components. If capacity allows, tasks are also carried out for customers outside.

The facility is equipped with state of the art CNC machine tools, conventional lathes and milling machines, as well as welding and fabrication equipment. We are further equipped with a CAD/CAM package to enhance the design and manufacturing capabilities.

The Workshop is characterized by flexibility, quality and cooperation, and the tasks are carried out by a highly qualified personnel. The staff is available to assist researchers in the design assessment and feasibility, the material selection and the sourcing of associated components.

## 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

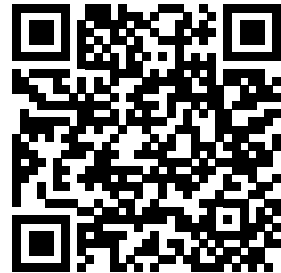


## FACILITY MEMBERS

### León Lavin, Rafael

SO Senior Technician for the Mechanical Workshop Facility

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# MOLECULAR SPECTROSCOPY AND OPTICAL MICROSCOPY FACILITY

The ICN2 Molecular Spectroscopy and Optical Microscopy Facility is a set of laboratories providing access to state-of-the-art equipment for the physicochemical and structural characterisation of materials at the macro and nano scales. In addition to routine analyses, it also provides a range of highly demanding techniques and applications, thereby meeting researchers' need for basic and specific scientific analysis.

Besides technical support and training for user-operated equipment, the facility also offers case studies, not only to inform and advise researchers, but also to actively participate in the planning and developing of specific experiments and/or devices that enhance the performance of existing equipment.

## 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

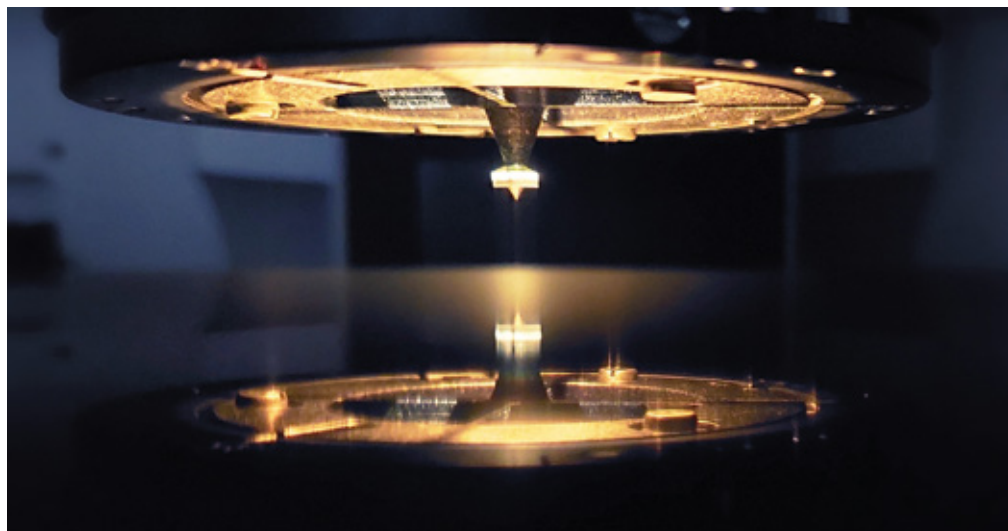
- Dip cell for measurements of zeta potential in organic solvents available

## FACILITY MEMBERS

### Saiz Poseu, Javier

Research technician of the Molecular Spectroscopy and Microscopy Facility





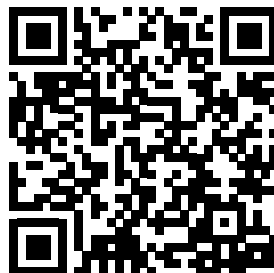
#### Optical microscopy

- Fluorescence
- Polarization
- Variable temperature (r.t. - 372 K)
- Software packages: time lapse, Z-stack and extended focus

#### Contact angle

- Static and dynamic
- Surface free energy of solids
- Surface and interfacial tension of liquids
- Work of adhesion
- Advancing and receding contact angles and evaluation of a roll off angle by tilting table method

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# NANOFABRICATION FACILITY

The ICN2 Nanofabrication Facility focuses on the design and development of nanofabrication methods and techniques for basic and applied research in nanoscience and nanotechnology.

It provides researchers and students an extensive range of processing services to help them carry out their research activities. It also offers support, assistance and training to allow the researchers and other users to safely and efficiently operate the equipment available. The facility is designed to support the fabrication and characterisation of nanoscale materials and structures, and the integration of devices at all length scales.

The facility's mission is to provide high quality services to both internal and external users.

The Nanofabrication Facility is scientifically directed by the ICN2 Nanofabrication Committee led by Prof. Laura Lechuga and made up of ICN2 researchers who are experts in the area. The Committee establishes the strategic guidelines of the service and at the same time it is a dynamic source of new synergies for the development of the activity within the Facility.

## FACILITY MEMBERS

### **Borrisé Nogue, Xavier**

Research Engineer

### **Pérez Rodríguez, Raúl**

Senior Laboratory Officer for the  
Nanofabrication Laboratory

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## MISSION AND VISION

The Nanofabrication Facility is a cross-groups, general user facility, designed to support the ICN2 research effort. The facility is open to all trained personnel on a recharge basis, including ICN2 as well as external personnel. It is our mission to provide a state-of-the-art facility for advanced device fabrication at the micro- and nano-scale.

In addition to providing essential micro and nanofabrication capabilities for mainstream research on electronic, optoelectronic and 2D materials and devices, this facility is intended to facilitate the pursuit of research in emerging, interdisciplinary, and rapidly growing fields such as biomedical and biochemical lab-on-a-chip devices, heterogeneous integrated circuits, photonics and phononic devices and nanoscale science and technology.

The Nanofabrication Facility aims to deliver outcomes that will have real impact for users, by ensuring that it is easy to access, agile in how it applies engineering expertise to respond quickly and accurately, and always seeking opportunities to enhance the quality of services that are available.

## FACILITY

The Nanofabrication Facility Lab is a 100m<sup>2</sup> cleanroom type laboratory that offers equipment for the fabrication and characterization of micro- and nanodevices and structures. It is a specially designed and constructed room in which the air supply, air distribution, air filtration, materials of construction and operating procedures are regulated to control airborne particle concentrations to meet appropriate cleanliness levels. Our facility is classified as ISO Class 6 and 7 which means that there are at most 1,000 or 10,000 particles  $\geq 0.5 \mu\text{m}$  per ft<sup>3</sup>, respectively

The Facility is segmented in three dedicated rooms: ISO 6 room for Lithography processes and two ISO 7 rooms for etching and deposition processes.

## 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

## NEW PROJECTS & MILESTONES

In 2022, 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 optical microscope was installed to allow calibrated measurements in the micron scale. 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. This will enhance the existing nanofabrication services at the ICN2 and will also improve users experience regarding these techniques, while making the trainings easier and shorter. With a focus on dry etching and photolithography 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

The Photoemission Spectroscopy Facility is equipped with a state-of-the-art X-Ray Photoelectron Spectroscopy (XPS) and Ultraviolet Photoelectron Spectroscopy (UPS) system (SPECS PHOIBOS 150 hemispherical energy analyser) that enables chemical and electronic characterisation of the surface of a wide range of materials. It provides services to both internal and external users for routine XPS and UPS analysis, as well as for long-term experiments to characterise the electronic structure of samples requiring in-situ preparation and modification.

## 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

## FACILITY MEMBERS

### Sauthier, Guillaume

Research technician of the  
Photoemission Spectroscopy Facility

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# X-RAY DIFFRACTION FACILITY

X-ray Diffraction (XRD) is a powerful non-destructive technique for characterizing crystalline materials in many different solid materials (organic, inorganic, and metallorganic). While most other analytical techniques provide elemental or molecular information from a sample, XRD is unique in providing a wide range of information on structures, crystalline phases, lattice parameters preferred crystal orientations, and other structural parameters such as, particle size, strain, stress, and crystal defects.

The ICN2 x-ray diffraction facility is dedicated to support the research activities of ICN2 groups, the surrounding research community or private companies. The facility has the suitable equipment and knowledge for dealing with nanopowders and thin films materials. Samples usually come from the fields of Chemistry, Physics, and Material Science.

The XRD facility is equipped with two versatile and advanced Malvern PANalytical diffractometers: a Multipurpose Diffractometer (MPD) for powder materials and a Materials Research Diffractometer (MRD) for thin films.

The instruments allow to perform routinary powder analysis and phase identification, to more sophisticated measurements, including grazing angle diffraction, X-ray reflectometry, diffuse scattering studies in nanopowders (SAXS), high-resolution analysis and reciprocal space mapping in epitaxial films, in-plane diffraction, as well as diffraction under non-ambient conditions (High temperature and controlled atmosphere).

## FACILITY MEMBERS

### **Padilla Pantoja, Jessica**

Research Technician of the X-ray  
Diffraction Facilities

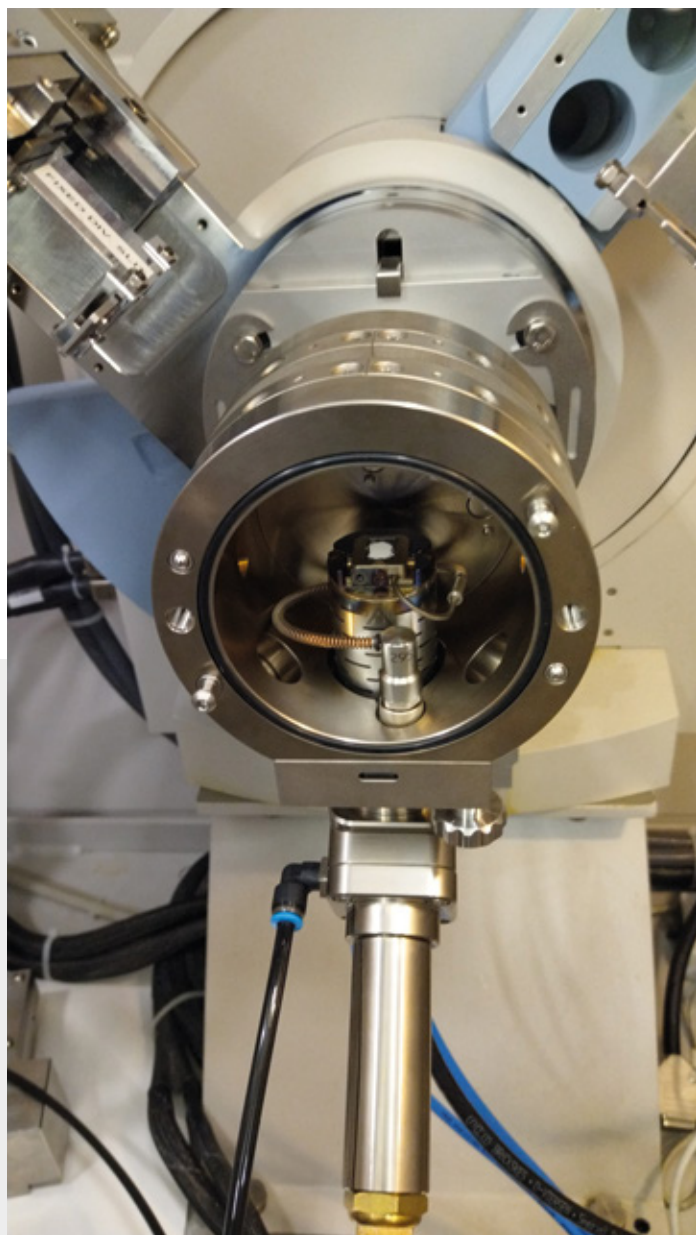
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extended information**



In addition, a new accessory (TTK600-Anton Paar) is available at MPD. The Low-Temperature Chamber is a non-ambient attachment for powder X-ray Diffraction studies from -20°C to 600°C. Also different set-ups allow investigating samples in reflection and transmission geometry (Capillaries) using different atmospheres (vacuum, air or inert gases).

## FACILITY

The ICN2 X-ray Diffraction Facility has 40m<sup>2</sup> and is located in the 0 Floor, in the opposite side to the reception entrance.



*New Low-Temperature Chamber (TTK600) installed at the Powder Diffractometer (MPD) for in-situ XRD studies.*

## 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 also applying low temperature (up to 100 °C) with controlled atmosphere (photoactivated phase transitions, photostriction, etc.)



# STRATEGY DEVELOPMENT

The main mission of the ICN2 Strategy Development is to anticipate and provide advanced response to the challenges faced by the institute on the long and short term. This involves staying abreast of trends at the local, national and international levels, and working to strengthen the centre's position and responsiveness to them. Internally it strives to lead by example to drive forward key organisational changes and alignment on matters that will shape the future of the ICN2.

## 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

## MEMBERS



**Navia, Margarita**  
Head of Strategy

**Almar, Ylenia**  
Strategy Development Assistant

**Benítez, Nùria**  
Institutional Strategy Development





# BUSINESS AND INNOVATION

The ICN2 Business and Innovation team is dedicated to fostering the rapid transfer of innovative knowledge from the nanoscale to society and industry. The team's objective is to safeguard and commercialise ICN2 research findings, establish R&D and licensing agreements with industrial partners, initiate novel collaborations with both private and public sectors, and create new networking channels.

These innovation mechanisms serve to bridge the gap between scientific research and market application, expand the collaborative network for our scientists, and ensure that public science generates resources that contribute to the continuous advancement and improvement of scientific endeavours. The year 2022 has proven to be exceptionally productive in terms of knowledge transfer, further emphasising the team's commitment to its mission.

## MAIN ACTIVITIES

In 2022, ICN2 evaluated 14 new technologies with the potential for patenting, and 10 Invention Notifications were registered. Five new European priority patents were deposited. Three international PCT patent extensions were requested, along with the extension of 11 patents in national phases, and three Industrial Secrets were deposited with notarial registration. The B&I team currently manages 40 families of active patents.

14 confidentiality agreements and five material transfer agreements were signed with companies and other entities for the evaluation of possible technology licences, research projects, and collaborations. Contacts were maintained with 112 companies.

Furthermore, 16 new R&D projects were initiated, along with three industry support services. 13 competitive valorisation projects were awarded to ICN2 from local, national and European funding agencies.

Five patent licences and one Know-how licence were signed for the following technologies and companies:

- 1- With Inbrain Neuroelectronics, S.L.  
Circuit for the multiplexing and read-out of variable-resistance sensor arrays.
- 2- With Inbrain Neuroelectronics, S.L.  
System of graphene transistors for measuring electrophysiological signals.
- 3- With Inbrain Neuroelectronics, S.L.  
Acquisition device to limit leakage current in electrophysiological signal recording devices.
- 4- With Inbrain Neuroelectronics, S.L.  
Design and fabrication of flexible arrays of graphene SGFETs for electrocorticography.



5- With Distinkt, S.L. A photoinduced thermochromic or thermoluminescent composition.

One spin-off company was created: Distinkt, S.L. ([www.distinkt.tech](http://www.distinkt.tech)), which develops safety inks based on microencapsulated photochromic materials created by Daniel Ruiz's group. The total number of spin-off companies created by ICN2 has risen to 15, including two previous CSIC companies.

Two entrepreneurship training sessions were held for novice researchers at the Institute. They were organised by the Business & Innovation Department staff and focused on Industrial and Intellectual Property and Science to Business. Five commercial products are available on the market, from which €63,669 in royalties from sales have been received.

In 2022, an annualised income of €838.953 was obtained from private contracts and licenses.

## MEMBERS



**Pablo José Pomposiello**  
Head of Business and Innovation

**Claudia Nieva**  
Business Development

**Jordi Reverter**  
IP and Technology Transfer

**Andrés Cano**  
Business Development





# MANAGEMENT AND SERVICES

# MANAGEMENT AND SERVICES

Research at the ICN2 is underpinned, protected and promoted by a comprehensive set of management and support services. Overall responsibility for these services, distributed across departments and areas, lies with the ICN2 General Manager Mr Lluís Bellafont. 2021 slowly brought us back to a new normality thanks to a huge effort led by the ICN2 administration together with the research community.



## COMPETITIVE FUNDING

HEAD:  
**MIREIA MARTÍ  
BARROSO**

The ICN2 Competitive Funding Department is dedicated to assisting researchers in managing competitive funds obtained from participating in tenders and projects, ensuring compliance with the terms and requirements of various funding agencies throughout each project's lifespan. This support includes comprehensive assistance for proposal preparation and submission, along with fulfilling all administrative and reporting obligations for active grants and budget management.

The department's philosophy is grounded in fostering a fluid dialogue with researchers, where the assigned project manager becomes the primary contact for all aspects of project management. This approach enables researchers to focus predominantly on the technical development of their projects, minimising their involvement in financial control and deadlines.



## FINANCE

HEAD:  
**JUDIT  
VELA**

The Finance Department at ICN2 is bifurcated into two primary sectors: administration and accounting.

The administrative team orchestrates the institute's entire array of administrative functions. Each research group, unit, facility, and department is assigned a dedicated contact person, tasked with managing all administrative operations. This arrangement facilitates seamless communication and ensures the service is tailored to meet their specific needs. This

team also handles the management of sales and invoicing.

Conversely, the accounting team is entrusted with comprehensive financial reporting and oversight. Reporting is executed both internally and externally, in compliance with the legal obligations mandated by the Spanish tax authority, among other public entities, trustees, dashboards, and internal economic reports. The team's remit encompasses financial analysis, budget surveillance, treasury operations, and public tenders.



## HEALTH AND SAFETY AREA

OFFICER:  
**JOSE ANTONIO  
PÉREZ**

On 2021 Corona strike back again in different stages with large peaks of infection. In this context, H&S Area played a fundamental role adapting and developing new ICN2 contingency measures in a fast-moving situation to successfully minimize the spread of the virus inside our premises with the invaluable help of all ICN2 community.

One of the most important challenges acquired regarding to the pandemic is mental wellness at work. 2021 saw a creation of a Psychosocial working group with the aim to work on the psychosocial risk factors, propose solutions and come-up with better strategies to deal with them acting as a **channel of communication where people**

**can share their psychosocial work-related causes of distress.** In addition, H&S area started to lay the foundations to develop teleworking strategies with particular attention on their risk management.

Regarding to research safety our lab safety program included 16 safety visits to laboratories, 250 corrective actions and 8 risk assessments related to new facilities. It was launched a innovative safety information campaign concerning the use of protection gloves, including thermal and cryogenic renewals as well. During last years over 400 safety courses were completed, and new training actions developed as fire extinction or first aid.



As contributing in nanosafety, in July 2021 the ICN2 took part in a pilot study, which is part of the EU funded NanoExplore Project, to study possible adverse effects of working with nanoparticles. During the week-long campaign, biological samples were collected from ICN2 volunteers as well

as environmental data analysing ambient air in the labs. The current first stage of the project is devoted to evaluating which biological markers provide best information about exposure to nanomaterials and ultrafine particles and their adverse health effects in the working environment.



## HUMAN RESOURCES

HEAD:  
**JULIO  
GÓMEZ**

The ICN2 Human Resources Department focuses on the people of the ICN2, providing effective talent attraction, selection, development, and assessment processes, as well as a set of user-friendly guidelines and tools. Its mission is to support growth and career development through the nurturing of an appealing institutional environment.

The department's policies contribute to making the ICN2 a workplace where people can thrive, share their experiences, and exchange new ideas. In 2021, the institute renewed the European Commission's HR Excellence in Research logo (HRS4R) in recognition of its commitment to career development, equal opportunities, transparency, and favourable working conditions.

2022 marked the return to normality after a strange period due to the COVID pandemic. The teleworking policy was approved as an alternative way to work. Additionally, 2022 was synonymous with reporting. Several reports were prepared for the Severo Ochoa review and the CERCA evaluation, among others. In response to the increased demand for information in recent years, work began with a supplier to improve the process of obtaining data from our current

systems. The writing and legal requirements follow-up of the new Equal Opportunities and Diversity Plan was an important project in which HR was involved and focused during the last months of 2022.

Under the Severo Ochoa and HRS4R umbrellas, the first year of the BIST Mentoring Programme concluded with excellent feedback from the involved mentors and mentees, allowing the second edition to proceed. Furthermore, the initial trainings of the Postdoc Programme path were scheduled, and we continued with the established activities within the ICN2 PhD Programme.

In 2022, we worked on developing a Training tool software that will enable us to monitor the PhD students included in the ICN2 PhD programme and launch training activities and registration for the entire community. The most recent monitoring was conducted using the tool, and the goal is to launch the training section in 2023. The preparation of a psychological support programme with external professionals for our community was also initiated in 2022. Several seminars and workshops were conducted to help promote the mental health of our ICN2 members.



## INFORMATION TECHNOLOGY

HEAD:  
**JAVIER GONZÁLVEZ**

The IT Department at ICN2 is dedicated to providing technical support for information technology issues within the ICN2 community, ensuring the smooth operation of its services and infrastructure. This department oversees all aspects of IT infrastructure, including networking, communications, security, and servers. The team offers assistance to ICN2 users in their daily IT-related tasks, projects and purchases, as well as graphic design and website design and maintenance needs.

Throughout 2022, we have focused on implementing new applications that enhance and optimise our work processes. Additionally, we have introduced security solutions that build on our efforts since 2020 to protect more effectively against attacks. Some notable projects include:

- New ticketing tool: Freshservice
- Cloud backups for the Microsoft 365 suite: Metallic

- Specific anti-ransomware solution: microCLAUDIA
- New software self-installation portal for users: Software Center

Moreover, we have actively collaborated with other departments on various projects, such as:

- Training and PhD Programme
- Document management system

With these and other implementations, our goal is to achieve a significant improvement in infrastructure and solutions while continuing to strengthen the relationship between the IT Department and the rest of ICN2.

Additionally, the IT Department has continued to support the Institute's graphic design needs for both online and offline media, working closely with the Marketing and Communication Department.



## MAINTENANCE AND SERVICES

HEAD:  
**XAVIER  
ROS**

The ICN2 Maintenance and Services Department was established in 2007 with the objective of maintaining existing spaces and overseeing the construction of a new building. Currently, the department manages facilities across two buildings and plays a vital role in shaping new spaces.

The main building (ICN2 building), with a constructed area of 6,565 m<sup>2</sup>, is structured into 50 research laboratories, 13 shared spaces (e.g., warehouses, meeting rooms, dining room) and 14 common laboratories that provide cross-disciplinary support to research activities. Notable among these are a Biolab and a Nano-manufacturing Room, which commenced operations in 2018.

The second building boasts a usable area of 560 m<sup>2</sup>, distributed across 9 research laboratories, 43 workstations and 4 infrastructure spaces.

The Maintenance and Services Department has been instrumental in managing various challenges, ensuring that all laboratories and spaces remain in optimal conditions, undertaking building remodelling projects, and overseeing the management of external service providers such as those involved in cleaning, gardening, reception, security, courier and post.



## MARKETING AND COMMUNICATION

HEAD:  
**ÀLEX  
ARGEMÍ**

The ICN2 Marketing and Communication Department offers a variety of services to facilitate and optimise the dissemination of knowledge generated at the ICN2. Its objective is to maximise impact across all key stakeholder groups while adhering to the principles of responsible research and innovation (RRI).

Among its responsibilities, the department manages the ICN2 website, social networks, and institutional image. It coordinates graphic design tasks to ensure that the quality of visual support material matches the level of scientific excellence being developed at the ICN2. The department is also responsible for producing written content for public and internal purposes, with a focus on engaging diverse audiences, from the internal community to industry and interested laypeople.

In 2022, the department continued to strengthen its audio-visual services and developments, including hybrid events, high-quality video coverage, and professional editing. These initiatives added a new layer of impact and possibilities to the ICN2's dissemination capabilities. The What The Física YouTube Channel, curated for a broad audience, showcased recent breakthroughs by young researchers from the ICN2 and neighbouring institutions, further expanding our reach.

The Marketing and Communication Department also supports and leads the organisation of high-impact events that elevate the ICN2's profile in various contexts and delivers a strong focus on education and outreach. NanoEduca, one of the flagship projects promoted by this department with Severo Ochoa funds and in collaboration with partnering institutions, was recognised with the 2018 National Scientific Communication Prize awarded by the FCRI and the Catalan Government. In 2022, NanoEduca received a boost from the involvement of the Societat Catalana de Nanociència i Nanotecnologia, acting as ambassadors of new online content for Catalan schools and beyond. Educational and dissemination activities now incorporate online and hybrid formats, utilising innovative tools to ensure interactive and engaging events.

Our social networks, including YouTube, Twitter, and LinkedIn, have experienced steady growth, positioning us among the most influential national research institutions. In terms of transparency and accountability, the department plays a pivotal role in institutional reporting and meeting Open Access requirements.



## TECHNICAL MANAGEMENT SUPPORT AREA

COORDINATOR:  
**ESTEFANÍA  
LATORRE**

In September 2019, a new unit was created within ICN2's administration: Technical Management Support Area, Public Tenders and Management, which reports directly to ICN2's General Manager. The activity performed by this unit is divided into two distinct areas.

On the one hand, this unit provides technical and management support to the ICN2 General Manager. It includes advising on legal issues, preparing the ICN2 compliance procedure or anti-corruption

guide, coordinating and managing the signing of documentation, collecting data and preparing reports for internal purposes and to be provided to external bodies, such as the Generalitat de Catalunya.

On the other hand, it is in charge of the management of ICN2's public contracting of services, supplies and works, through public tenders and minor contracting files, based on Law 9/2017 of 8 November, on Public Sector Contracts.



# EVENTS AND DISSEMINATION

## SCIENCE AND INDUSTRY

ICN2 researchers actively contribute to the nanoscience and nanotechnology communities, not only by conducting cutting-edge research but also through their involvement in organising internationally recognised scientific events. In collaboration with management and support teams, ICN2 researchers maintain a strong presence at trade fairs as well. In 2022, the institutional agenda saw an increase of in-person events, while the ICN2 continued to innovate with hybrid event formats and interactive tools to foster engagement and knowledge sharing.

### CONFERENCES AND WORKSHOPS

#### Severo Ochoa Workshop on the present and future of Nanomedicine

May 2022, ICN2



The Severo Ochoa Workshop on the Present and Future of Nanomedicine took place on May 26, 2022, at the ICN2. Organized by group leader Prof. **Laura Lechuga**, the event aimed to bring together researchers in the field of nanomedicine, clinicians from relevant hospitals, and healthcare industry experts to discuss recent advances in the field and effective procedures for transferring new technologies into clinical practice. Nanomedicine is an emerging area of research that leverages progress

in nanoscience and nanotechnology to provide personalized medicine solutions, such as early disease detection, more effective therapies, and individualized patient follow-up.

The workshop featured distinguished researchers from the nano-community, eminent clinicians, and healthcare industry experts presenting the latest advances in nanomedicine and discussing the challenges and opportunities for implementing new technologies into clinical practice. Strategies need to be developed to bridge the gap between research laboratories and medical facilities, bringing nanomedicine closer to patients and society.

The event commenced with a welcome message from Prof. Laura Lechuga and a plenary talk by Prof. **Kostas Kostarelos**,

leader of the ICN2 Nanomedicine Group. The day's program included short presentations by ICREA Prof. **Víctor Puentes**, Dr **Mary Cano**, and Dr **Giulio Rosati**, among others, and concluded with a roundtable discussion chaired by

Dr **María Soler**. The afternoon session featured a plenary talk by Dr Ibane Abasolo from Vall d'Hebron Institute of Research (VHIR) and additional presentations by Prof. **Daniel Ruiz-Molina**, ICREA Prof. **José Garrido**, and Prof. Laura Lechuga.

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## Severo Ochoa Workshop on Ultrafast Physics

May 2022, ICN2



On May 30, 2022, the ICN2 hosted a new event in the Severo Ochoa Workshops series, focusing on the latest trends in ultrafast physics. The workshop, organised and chaired by Dr **Klaas-Jan Tielrooij**, leader of the ICN2 Ultrafast Dynamics in Nanoscale Systems Group, aimed to demonstrate the utility of ultrafast measurements in various research fields, such as chemistry and biology. The

workshop covered ultrafast dynamics in a wide range of systems, including liquids, biological matter, oxides, 2D materials, and organic semiconductors.

The event brought together esteemed professors from prominent research centres across Europe, including the Politecnico di Milano (Italy), the Max Planck Institute for Polymer Research (Mainz, Germany), the University of Basel (Switzerland), Freie Universität Berlin (Germany), the University of Geneva (Switzerland), Cambridge University (UK), and the Cavendish Laboratory (UK). The workshop served as a platform to share insights, discuss cutting-edge ultrafast physics research, and explore the potential of ultrafast measurements for advancing scientific knowledge in a variety of disciplines.



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## Quantum Matter Conference: a very successful second edition in Barcelona

*June 2022, Barcelona*



The second edition of the Quantum Matter Conference, held in Barcelona from June 21 to 23, 2022, successfully concluded with extensive participation from academia, research, and industry representatives. Building on the positive reception of the first edition in Bilbao in 2021, the conference facilitated the exchange of scientific results, ideas, and networking opportunities among experts in quantum information and materials.

The comprehensive scientific program, featuring plenary talks, parallel oral sessions, and a poster session, was complemented by an industrial forum and exhibition to bridge the gap between academia, research, and entrepreneurship, fostering the implementation of new quantum technologies in real-world applications.

The Catalan Institute of Nanoscience and Nanotechnology (ICN2) played an active role in organizing the conference and contributed through various talks, posters, session chairing, and hosting a booth in the exhibition space. ICN2 speakers and chairpersons included ICREA Prof. Stephan Roche, ICREA Prof. Sergio O. Valenzuela, and Prof. Pablo Ordejón.

The ICN2 booth provided an opportunity for attendees to interact with researchers, as well as members of the Marketing and Communication Department and the Business and Innovation Area, who offered insights into the institute's extensive portfolio of activities related to quantum materials, simulations, and technologies. With over 400 international participants, the Quantum Matter 2022 Conference reinforced the success of its inaugural edition in Bilbao.

The event was organized by the Phantoms Foundation, ICN2, the Donostia International Physics Center (DIPC), and the Spanish Council for Scientific Research (CSIC), with support from partners such as the Barcelona Institute of Science and Technology (BIST), the Institute of Photonic Sciences (ICFO), and the Quantum Technologies Platform of the CSIC (QTPEP-CSIC).

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## Materials of the Nano- and the Micro-World: a conference by Clúster MAV

March 2022, hybrid event



On March 16, the Advanced Materials Cluster of Catalonia (Cluster MAV), in collaboration with the Institute of Materials Science of Barcelona (ICMAB-CSIC), the Catalan Institute of Nanoscience and Nanotechnology (ICN2), and the Institute of Microelectronics of Barcelona (IMB-CNM-CSIC), held a hybrid conference on “Materials of the Nano- and the Micro-World.” The event aimed to promote innovation and technology transfer in materials science and was open to companies operating in this field. The conference consisted of two sessions, starting with six presentations showcasing cutting-edge material technologies developed by the participating research institutes. The second session offered a guided tour of select laboratories and facilities across the three centres.

Dr. **Elena Del Corro García**, a researcher in the Advanced Electronic Materials and Devices Group at ICN2, introduced the activities of GraphCAT, a community aimed at making Catalonia an international reference for developing and transferring graphene technologies to the industry. Dr. **Salvio Suárez García**, a postdoctoral researcher in the Nanostructured Functional Materials Group (Nanosfun) at ICN2, provided an overview of functional surface coatings’ possible applications. He also discussed Futurechromes, a spin-off company originating from the Nanosfun group. During the second part of the event, attendees who were present in person were offered a tour of some of the laboratories at the three centres.

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## Graphene Conference 2022

July 2022, Aachen, Germany



The 12th edition of the Graphene Conference series, the largest European event focused on graphene and 2D materials, took place in Aachen, Germany, from July 5-8, 2022. Organized by the Phantom Foundation in collaboration with various research institutes and companies, including ICN2, ICREA, RWTH Aachen University, Technische Universität Dresden, UC Louvain, BeDimensional, and AMO, the conference has become the primary in-person gathering for the global graphene community.

The four-day event featured discussions on the latest advances in 2D materials technologies, spanning theory and simulation, fabrication, characterization, and applications in various fields. The program included plenary sessions, parallel workshops, doctoral student presentations, a poster session, and an industrial forum, with an exhibition space for research institutes and industries to showcase their services or products and foster new connections.

ICN2 played a significant role in organizing the conference, with ICREA Prof. **Stephan Roche**, leader of the Theoretical and Computational Nanoscience Group, serving as a member of the Organising Committee. Numerous ICN2 researchers participated in the event, contributing talks, posters, and serving as chairpersons. Invited speakers included Dr **Aron W. Cummings**, Dr **José Hugo García Aguilar**, Dr **Marianna Sledzinska**, Prof. **Kostas Kostarelos**, ICREA Prof. **Arben Merckoci**, and ICREA Prof. **José A. Garrido**. Additional oral contributions were made by group leader Dr **Klaas-Jan Tielrooij**, postdoctoral researchers Dr **Luis M. Canonico Armas**, Dr **Roberta Farris**, and Dr **Jake D. Mehew**, and PhD students **Christian M. Schäfer**, **Sebin Varghese**, **Nils Wittemeier**, and **Onurcan Kaya**. PhD student **Pedro Alcazar Guerrero** and research assistant **Joaquín E. Medina Dueñas** presented a poster.

The ICN2 also hosted a stand at the exhibition, with representatives **Andrés Cano De la Fuente** from the Business and Innovation Area, and Dr **Virginia Greco** from the Marketing and Communication Department. They were available to discuss the ICN2's research activities, particularly in graphene and 2D materials technologies, and to connect with other research centers and companies interested in networking and establishing new collaborations.

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## Trends in Nanotechnology International Conference (TNT2022-nanoBalkan)

October 2022, Tirana (Albania)



The Trends in Nanotechnology International Conference (TNT2022-nanoBalkan) took place in Tirana, Albania, from October 3-7, gathering representatives of research centers, companies, and institutions to share scientific activities, discuss current projects, and shape future policies. Organized by ICN2, the Phantom Foundation, and the Academy of Sciences of Albania & NanoAlb, the event included high-level scientific talks, strategic meetings, an industrial forum, and an exhibition. ICREA Prof. **Arben Merkoçi**, leader of the ICN2 Nanobioelectronics and Biosensors

Group, was a key player in launching this new conference and strengthening ICN2 relations with Albania, the Czech Republic and the Balkans in general.

Many ICN2 researchers attended the event, contributing presentations, posters, and participating in strategic discussions. The conference featured a plenary session, parallel sessions, and satellite meetings. An exhibition allowed research centers and companies to showcase their technologies, with ICN2 hosting a stand to share information and establish contacts.

The conference facilitated further cooperation between ICN2 and the Albanian Academy of Science and assessed the ongoing NanoAlb project. Two satellite events were held, including the SUSNANO project kick-off meeting and a workshop on nanotechnologies focusing on cooperation between Albania, Japan, and Spain. The next edition of the conference is scheduled for autumn 2023 in Tirana.

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## CATRIN-ICN2 Workshop

October 2022,



In October, a delegation from ICN2 visited the Czech Advanced Technology and Research Institute (CATRIN) to explore collaboration opportunities in nanoscience and nanotechnology. The 'CATRIN-

ICN2 Workshop' took place on October 17-18, with representatives from both institutes discussing ideas and future R&D collaborations. ICN2 members, including Prof. **Pablo Ordejón**, ICREA Prof. **José Antonio Garrido**, and ICREA Prof. **Arben Merkoçi**, visited CATRIN's laboratories and facilities. Other ICN2 researchers participated online. A Memorandum of Understanding was signed between the two institutes in May 2022 to establish scientific cooperation and exchange ideas, knowledge, and researchers.

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## 4 Years From Now (4YFN) – Mobile World Congress

March 2022, Barcelona



At the 2022 Mobile World Congress (MWC), ICN2 showcased the future of neurotechnology and batteries through its spin-off companies, INBRAIN Neurotechnologies and Napptilus Battery Labs. The 4 Years From Now (4YFN) event, part of MWC, is dedicated to pioneers and groundbreaking innovators, making it the perfect platform for ICN2 to share its achievements.

Dr. **Carolina Aguilar**, CEO of INBRAIN Neurotechnologies, participated in a round table discussion titled “Frontier Tech Programme (I): Frontier Materials.” Alongside

other researchers and John Hoffmann, CEO at GSMA, she shared the success story of the high-density, high-resolution graphene intelligent neural systems developed by her company. INBRAIN Neurotechnologies was founded on the research conducted by ICN2’s Advanced Electronic Materials and Devices and Nanomedicine Groups, in collaboration with other research centers like IMB-CNM-CSIC.

Additionally, Dr. **Pedro Gómez** and Dr. **Daniel Rueda** presented the accomplishments of Napptilus Battery Labs, an ICN2 spin-off from the Novel Energy-Oriented Materials Group. At their booth, they demonstrated their innovative battery design, which has the potential to revolutionize battery technology. Both spin-offs highlight ICN2’s commitment to cutting-edge research and technology, showcasing its impact on the global stage at MWC.

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## Graphene Week 2022: 10 years of Graphene Flagship

September 2022, Munich, Germany



The 2022 edition of Graphene Week took place in Munich, Germany from September 5 to 8. The conference focused on recent advances in graphene and 2D material

research, as well as their latest applications. Hosted at the BMW Welt museum and exhibition center, this event gathered multidisciplinary experts in the field.

The conference opened with a plenary talk by Nobel Prize laureate Sir Andre Geim, who discussed the exotic properties of 2D empty space. Graphene Week also included various parallel sessions dedicated to fundamentals, processing, and applications, as well as thematic or satellite meetings, an industrial exhibition, and a poster session.

Since the Graphene Flagship turned ten years old, this year's conference celebrated success stories of research and innovation, as well as collaboration fostered by the flagship. A Graphene Innovation Forum focused on technology transfer and commercialization of applications enabled by graphene and related materials.

The event also featured special sessions dedicated to the European Chips Act, diversity in graphene, and EU-US research collaborations to enhance synergies within the community. Several members of the ICN2, including Group Leaders ICREA Prof. **José Antonio Garrido** and ICREA Prof. **Stephan Roche**, attended and contributed talks and posters to the conference.

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## Barcelona Deep Tech Summit

*September 2022, Barcelona*



The Barcelona Deep Tech Summit brought together the scientific and technological entrepreneurship community for a dense programme of discussions, roundtables, and pitches for investors on September 22. The event aimed to bring disruptive technologies to the market and gathered scientists, investors, start-ups, and larger companies. Thematic roundtables tackled topics such as artificial intelligence, next-generation communication systems, 3D printing, health, and quantum technologies.

ICREA Prof. **José Antonio Garrido** participated in the deep tech discussion on health applications, public-private technology transfer, and collaboration with hospitals. The event also included a Start-ups Exhibition, the Barcelona Deep Tech Match to connect start-ups with corporates, and an Investment Forum for investors interested in advanced materials, artificial intelligence, blockchain, robotics, photonics, electronics, quantum computing, and space technologies. The ICN2 Business and Innovation Area attended the event, with Dr **Claudio Roscini**, senior researcher in the ICN2 Nanostructured Functional Materials Group and CTO of ICN2 spin-off Futurechromes, participating in the Industrial Forum.

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## Foremost Photonics 2022

October 2022, Italy



The Foremost Photonics 2022 workshop, organised by the Nanophotonics Europe Association (NEA), took place in Erice (Italy) from October 10 to 14. The workshop was attended by key players in nanophotonics who discussed their latest research results and shared their vision about the future of the field and actions to put in place to advance young researchers' careers in this field.

The Nanophotonics Europe Association (NEA) was founded from the EU Network of Excellence established with PhOREMOST, a project funded through the EU-FP6 programme between 2004

and 2009. The Association's founding members are the ICN2, the Institute of Photonic Sciences (ICFO, Barcelona, Spain), the European Laboratory for Non-Linear Spectroscopy (LENS, Florence, Italy) and the Sapienza University of Rome (Italy).

The workshop was organised by a new generation of nanophotonics researchers and funded by NEA. Several scientists from the ICN2 attended the workshop, including Prof. **Laura M. Lechuga**, leader of the Nanobiosensors and Bioanalytical Applications Group, who gave a presentation about "nanophotonics biosensors for ultrasensitive health diagnostics at the point-of-need," and ICREA Prof. Dr **Clivia Sotomayor-Torres**, leader of the ICN2 Phononic and Photonic Nanostructures Group, who participated in a roundtable discussion and talked about "the need for associations and collaborative projects in science".

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## PuzzleX

November 2022, Barcelona



PUZZLE X is a vibrant event dedicated to advanced materials and frontier technologies for a new world. Its second edition, held from November 15 to 17,

2022, in Barcelona, concluded after three days filled with flash presentations, demonstrations, and roundtable discussions. The event attracted entrepreneurs, researchers, investors, and deep tech professionals interested in designing the world to come.

This year's edition focused on exploring how bold ideas and frontier technologies, including quantum computing, printed atoms and materials, sentient cities, molecular food, and synthetic bio-intelligence, will impact humanity and shape the future of

people, cities, industries, societies, and our planet. The thread linking all these perspectives and developments is the need to create a more sustainable and prosperous future.

The ICN2 participated in the event, with contributions in talks and roundtables by a few researchers, participation in a poster session dedicated to young scientists, and a booth in the exhibition area showcasing research developed at the institute. The booth also featured three of the ICN2 spin-off companies, Cooling Photonics, GraphenicaLab, and FutureChrome, which showcased their products. In addition, the CEOs of these

companies had the possibility to share their experience and gain more visibility in a roundtable discussion opened to questions from the public and chaired by Dr **Pablo Pomposiello**, Head of the ICN2 Business and Innovation Area.

PUZZLE X, an event conceived by Dr. Zina Jarrahi Cinker, was organized by MATTER Inc. (previously AMPT) and Fira Barcelona and supported by the Government of Spain, Generalitat de Catalunya, and Ajuntament de Barcelona. With about 3000 attendees, the event proved successful again. To learn more about the topics and the program, you can visit the PUZZLE X website.

## EVENT ATTENDANCE

Throughout 2022, many other events were attended by researchers from the ICN2. Further information can be obtained from the respective group sections. The Institute's researchers participated in numerous international conferences, contributing a total of 220 oral presentations, 141 of which were delivered as invited speakers. Additionally, 27 poster presentations were delivered by the researchers.



## OUTREACH AND EDUCATION SECTOR

The participation of ICN2 in educational and outreach activities represents a long-term investment in raising the profile of nanoscience and the role of the ICN2 within society. Its efforts are having a growing impact with consolidated programmes and new initiatives opening new communication channels with a number of audiences. Actions in this area are a joint effort between the institute's Departments and scientists.

### EDUCATIONAL PROGRAMMES

The ICN2 is a regular and active participant in the following regional and national science education programmes:

#### NanoEduca Programme



The NanoEduca Programme, which was awarded the 2018 National Science Communication Award (FCRI and Generalitat de Catalunya), concluded its 2021-2021 edition on May 10 with a special event at the Faculty of Science of the Universitat Autònoma de Barcelona (UAB). The programme includes training for high-school teachers and an experiment kit, the NanoKit, related to

the world of nano. Distributed to schools throughout Catalonia via the Catalan Ministry of Education, the NanoKit offers teachers a set of interactive experiences in nanoscience linked to subjects like Chemistry, Physics, Mathematics, and even Philosophy.

The event was attended by teachers and students from participating high schools, and featured presentations on nanoscience and nanotechnology, a roundtable with members of the Catalan Association of Nanoscience and Nanotechnology (SCN2), and the award ceremony for the NanoEduca 2022 Video Contest.

Hosted by Àlex Argemí, Head of the Marketing and Communication Department of ICN2, the event began with a welcome by Prof. Gemma Garcia

Alonso, Dean of the Faculty of Science at UAB, followed by a presentation on the “beauty of the nanoworld” by Dr. Jordi Diaz Marcos (UAB). SCN2 members then participated in a roundtable discussion and answered questions from students about scientific research, academic careers, and applications of nanotechnology and materials science. The event concluded with the announcement of the NanoEduca 2022 Video Contest winners, who created videos on nanotechnology and its practical applications.

NanoEduca is an initiative of the University of Barcelona (UB), the Catalan Institute of Nanoscience and Nanotechnology (ICN2), the Autonomous University of Barcelona (UAB), and CESIRE (Centre for specific pedagogical resources to support educational innovation and research) of the Department of Education of the Generalitat de Catalunya.

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## STEAMConf Barcelona 2022

*October 2022, Barcelona*



The STEAMConf Barcelona, an education and learning-focused event, will take place on October 13-15, 2022, at the Vèrtex building at Universitat Politècnica de Catalunya. This year's edition will bring together some of the most successful international and local projects promoting learning in science and technology with a humanistic approach. A new agreement between the Barcelona Institute of Science and Technology (BIST) and STEAM

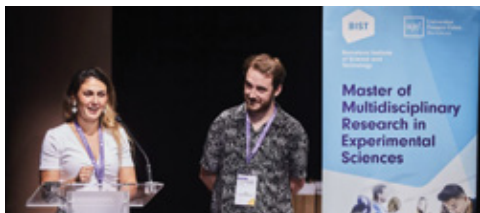
SokoTech from the Fundació Ciència en Societat was signed, which will strengthen collaborations between the learning community and cutting-edge science and technology. The ICN2 presented new educational materials designed in collaboration with IRB and BIST.

The event is organised by BIST, UPC, and STEAM SokoTech, in collaboration with the Barcelona City Council and the Generalitat de Catalunya's Department of Education. This edition will focus on project-based learning at the boundary of Hands, Mind, and Passion, which aims to make the learning process creative, meaningful, and inspiring, powered by the ability to transfer and apply it to new and complex situations in a constantly changing environment.

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## BIST Master of Multidisciplinary Research in Experimental Sciences

September 2022, Barcelona



On September 12, 2022, the Barcelona Institute of Science and Technology (BIST) celebrated the graduation of the 2021-2022 class of the Master of Multidisciplinary Research in Experimental Sciences (MMRES), the fifth edition since the Master's Programme was launched in September 2017. The ceremony took place

at La Pedrera Auditorium and brought together 85 students and supervisors from all MMRES editions, including the 22 students of the 2022-2023 class. The event also marked the opening of the new academic year.

The MMRES program is designed to provide students with hands-on research training and experience in the labs of the BIST centers, with a focus on gaining experimental skills. The program was adapted to the COVID-19 pandemic, offering online content, virtual visits to research spaces, and research collaborations in small groups.

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## Master in Quantum Science and Technology in Barcelona



The Master in Quantum Science and Technology offers students a unique opportunity to specialize in an expanding field of research. The program is the result of a coordinated effort between several universities and research institutions, providing students with specialized knowledge in quantum physics, quantum materials, computing, simulation methods, communications, sensing, and other applications of quantum science.

ICN2 opened its laboratories to the new students of the MQST program, providing them with a firsthand look at the research related to quantum materials and the sophisticated equipment used to simulate, synthesize, and characterize these materials. The laboratory tour showcased the use of scanning tunnelling microscopes to build nanostructures atom by atom, the study of ultrafast phenomena that take place at the nanoscale, and how multi-layered materials with special properties are built by growing and stacking different two-dimensional materials. The program aims to attract students with a Bachelor's degree in Physics or Physical Engineering who are interested in expanding their knowledge and skills in this exciting and rapidly developing field of research.

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## Crazy for Physics (*Bojos per la Física*)



The Crazy for Physics programme, promoted by Fundació La Pedrera, engaged high school students and their families in a closing ceremony held in Barcelona. The event was coordinated by the ICN2 and IFAE, and included researchers from other excellence centers such as UAB, ICMAB, ICFO, and Alba Synchrotron. ICREA Prof. Stephan Roche, Group Leader of the ICN2 Theoretical and Computational Nanoscience, delivered a speech about the advances in quantum computing, which are leading to a third revolution that will be developed by new researchers.

This event marked the end of the 7th edition of Crazy for Physics, a programme aimed at stimulating talent and techno-scientific vocations among high school students. The program offers participants exciting experiences that explore the biggest and smallest scales of the universe and provides a sense of what it is like to be a physics researcher. The ICN2 and IFAE coordinated the six previous editions, and other participating institutions included the UAB, ICMAB, ICFO, ICE, UB, and Alba Synchrotron. The Crazy for Physics program provides participant students with experiment-based experiences and is an excellent way to introduce high school students to the field of physics research.

## EVENTS TARGETING A YOUTHFUL AUDIENCE

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### ***UAB's Dissabtes de la Física (Physics Saturday)***

*February 2022, Barcelona*



The ICN2's participation in the Dissabtes de la Física programme, organised by the Autonomous University of Barcelona, highlights the institute's commitment to promoting physics among young students. The programme offers a series of conferences followed by visits to laboratories or other interactive activities. On Saturday 26 February 2022, ICN2's Marketing and Communication Department, together with Dr. Sara Martí Sánchez from the Advanced Electron Nanoscopy Group, prepared a set of

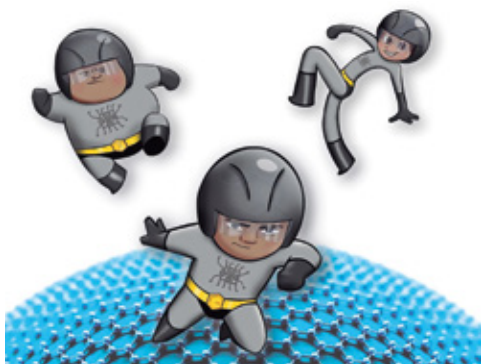
activities related to the nanoscale and quantum computing.

After completing the activities, the students attended a talk by Dr. Sara Martí about observing nanomaterials for quantum applications. ICN2's Head of Marketing and Communication, Àlex Argemí, and Communication Officer, Joana Pi-Suñer, reflected on the results of a test answered by participants and commented on the role of ICN2 in different applications of research results. Two students were awarded for their sharp answers to the test with a "Nano is the new Rock'n'roll" T-shirt and the book by Prof. Laura Lechuga "Una científica saltando vallas". The ICN2's participation in the Dissabtes de la Física programme provides an excellent opportunity to engage young students in the field of physics research and to showcase the institute's cutting-edge research and facilities.

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### **Festival 10alamos9 - Vermú de Nanociència**

*May 2022, Barcelona*



10alamos9 is a festival that aimed to bring nanoscience and nanotechnology closer to the public by showing in an entertaining and accessible way how these fields have already changed the way we live. The festival's 2022 edition took place on May 31, featuring a series of engaging talks, activities, and workshops across Spain.

As part of the festival, 200 students visited the ICN2, the ICMAB, the UAB Faculty of Sciences, and the CNM to participate

in nanoscience workshops held at each institution. They also attended talks by experts in the field of nanoscience, which provided insights into the latest developments and research. Additionally, a round table session was conducted by Master and PhD students and workers related to the nanoscience sphere. The speakers shared their experiences and answered questions posed by the students, demonstrating the diversity of career paths in nanoscience.

The 10alamos9 festival was an excellent opportunity to promote scientific culture and engage the public in the field of nanoscience and nanotechnology. Its latest edition was a success, inspiring and educating people about the exciting world of nanoscience. It also included a series of online talks named “Vermú de Nanociencia”.

## OTHER OUTREACH

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### #100tífiques

*February 2022, Barcelona*



The #100tífiques programme aims to promote STEM careers among young students by creating female role models and increasing awareness of the role women play in science. Organized by the Barcelona Institute of Science and Technology (BIST) and the Catalan Foundation for Research & Innovation (FCRI), the programme includes talks in schools throughout Catalonia on the International Day of Women and Girls in Science, which is held on February 11.

With a strong involvement of the ICN2, the fourth edition of the programme began with a Networking Meet-up, held at the Paranimf of the University of Barcelona on February 4, where nearly 50% of the 472 women researchers and technologists participated. The event featured presentations by speakers from various institutions and organizations, including the FCRI and BIST, on the position of women in science and gender issues in science. The #100tífiques talks have grown from 115 women researchers and 103 schools in its first edition in 2019 to more than 450 women scientists and technologists and more than 400 schools in its fourth edition.

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## “Survival vs Resilience” workshop - Fundació Èpica – Fura dels Baus

July 2022, Barcelona



The Fundació Èpica – Fura dels Baus collaborated with ICN2, ICFO, BIST, UOC, HLRS, and UB to present an experimental workshop that mixed science with scenic arts. The “Survival vs Resilience” workshop began with experts sharing scientific knowledge with a group of 30 creators who used it to create a compelling script. The performance included four interlinked elements, tackling different concepts such as graphene and its properties, brain-

computer interfaces, fake news, and the concept of personality. The event triggered many questions and discussions among scientists, creators, and the public, showing the innovative forms science communication can take when different worlds like academic science and scenic arts merge.

The idea of the workshop arose from an informal conversation two years ago, which became a performance presented last weekend. The need to disseminate GraphCAT, a project funded with FEDER funds and coordinated by ICN2, ICFO, and BIST to bring graphene closer to Catalan industry, was the perfect excuse to start the discussion. The successful workshop has demonstrated the effectiveness of bringing together different worlds to create new and innovative experiences.

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## NanoEduca Teacher training event



The NanoEduca training program, aimed at secondary and high school teachers to facilitate the inclusion of nanoscience and nanotechnology in school curricula. One of the sessions was held online from the ICN2 with the ICn2 Marketing and Communication Department presenting the nanokit and other educational resources. Over 50 teachers participated,

discovering the experimental tools included in the NanoKit, different online resources for classroom use, and the new virtual education proposal, NanoEduca 2.0.

The NanoKit is an educational kit designed for young students and contains a set of experiments related to nanoscience and nanotechnology, offering students an opportunity to familiarize themselves with these topics before university. The kit includes activities linked to curricular areas, from theoretical and fundamental science to real applications of these technologies. With the NanoEduca training program, teachers are equipped to teach these rapidly growing fields to young students, providing them with the tools to understand and participate in the impact of nanoscience and nanotechnology in our lives.

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## Hortensia Roig children's literature award



Andrea Navarro Ruiz, a mathematical engineer, has been awarded the Hortensia Roig Prize for children's literature for her book 'Elsa y el club de los números'. The award ceremony was held on September 28 in Valencia, and the prize includes €8,000 and the publication and distribution of 3,000 copies of the book nationwide. The book was chosen unanimously by the jury, which included Professor **Laura**

**Lechuga**, leader of the NanoBiosensors and Bioanalytical Applications Group at the ICN2. The story was praised for its ability to incorporate scientific and technical concepts into school activities and games.

The prize is part of an initiative by Hortensia Roig, President of EDEM Escuela de Empresarios, and aims to promote children's literature that promotes values such as education, innovation, and entrepreneurship. The runner-up for the prize was 'Margarita no es nombre de flor' by Celina Ranz Santana. Andrea Navarro Ruiz's 'Elsa y el club de los números' will be available in Spain's main bookshops in December, providing a new and exciting way for children to learn about mathematics and science.

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## Festa de la Ciència

*June 2022, Barcelona*



The ICN2 participated in the Festa de la Ciència, an annual science fair held by the Barcelona City Hall. In its 15th edition, the fair offered a diverse and engaging programme including a debate hosted by the ICN2. Dr **Vicky Puig** and Dr **Amador Pérez** from the ICN2 Advanced Electronic Materials and Devices Group, together with **Àlex Argemí**, ICN2 Head of Marketing and Communication, discussed the opportunities and implications of the BrainCom project and presented an app,

VRainCom, to explore the project results and the facilities and people that made it possible.

The VRainCom app, available for Android and iOS, introduces some key elements of the project, allows users to visit different laboratories involved in the project, and meet the researchers behind this exciting research, and ends up with some questions oriented at triggering a discussion about the ethical implications of neuro-implants. All participants received an adapter to turn their smartphones into a VR device and explore VRainCom in virtual reality. The discussion went beyond the BrainCom project, exploring the positive and negative potential uses of such technologies. The debate concluded with a call to continue developing excellent science together with the necessary regulations that allow society to prioritize the applications demanded.



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## VRainCom App at the ECSITE Annual Conference

May 2023, Heilbronn, Germany



ICN2 showcased VRainCom, an application for virtual reality, at the ECSITE Annual Conference. The app introduces users to the BrainCom project results, which focuses on restoring speech and communication in aphasic patients with upper spinal cord, brainstem, or brain damage. With VRainCom, users can immerse themselves in three of the project's partner institutions and explore research labs and meet experts, concluding with questions that trigger reflection around the ethical implications of BrainCom's technology.

**Àlex Argemí**, Head of the Marketing and Communication Department, presented VRainCom during a session showcasing innovative communication projects at the ECSITE conference. BrainCom is a European project led by the ICN2 together with national and international partners. While the moral and ethical implications have been debated within the scientific community, VRainCom allows the public to engage with the technology and to participate in the conversation. The app is already available for Android and iOS, and an adapter for immersive viewing is highly recommended.

## COMMUNITY-BUILDING

The ICN2 also organises a series of events designed to build and consolidate community within both the ICN2 and the immediate scientific context.

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### ICN2 NanoSeminars



The NanoSeminars is a series of events organized by the ICN2, aiming to promote knowledge sharing and idea exchange among world-class researchers and young scientists. The NanoSeminars focus on three thematic areas, namely Nano in Medicine & Health, Nano in Physics, and Nano in Chemistry and Materials. The series about Medicine & Health is a collaboration between the Nanomedicine Lab at the University of Manchester and the ICN2.

Each event in the NanoSeminars includes a main lecture by the guest scientist, preceded by a short presentation from a junior researcher on a related topic. The combination of the two presentations offers a chance for lively discussions and participation on topics of common interest to the attendees and institutions involved. The ICN2 hosted a total of 16 NanoSeminars in 2022, covering four in Medicine & Health, seven in Physics, and five in Chemistry & Materials. Videos of the recorded lectures are available for viewing shortly after the event is held.

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### LeaderSHE Programme



The LeaderShe seminar series is an initiative by the ICN2 Equal Opportunities Committee to bring successful women

from different fields to share their experience in reaching a leadership position in their professional lives. In 2022, the series continued with three inspiring talks by philosopher Marina Garcés, computer scientist Dr. Nuria Oliver, and professional water polo player Mati Ortiz.

Marina Garcés, a renowned philosopher and essayist, gave a thought-provoking talk in December 2022 entitled “Filosofía en femenino: una voz impropia”. In her

talk, she offered an overview of her career and reflected on the challenges related to reaching out to society. Dr. Nuria Oliver, a computer scientist, cofounder and Director of ELLIS Alicante, Chief Data Scientist at DataPop Alliance, and first Director of Research in Data Science at Vodafone, shared her personal journey through Artificial Intelligence. In her talk, she discussed her work in computational

models of human behavior, human computer-interaction, mobile computing and big data for social good. Finally, Mati Ortiz, a professional water polo player, spoke about her outstanding career path, achievements, and challenges as a high-performance sportswoman. All these talks provided a variety of perspectives on a common theme and offered deeply inspiring insights to all attendees.

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## Open Knowledge Programme



The ICN2 Open Knowledge Programme, initiated in 2014, serves as a platform for sharing knowledge within the ICN2 community. Coordinated by the Human Resources Department as part of the ICN2 Training Plan, each group or unit interested in participating proposes a set of seminars addressing a broad topic from various perspectives. These talks are recorded for on-demand viewing on the ICN2 website Events page.

Since the programme's inception, 10 open knowledge modules have been created, covering a wide range of topics. In 2021, two new live events were added to the

knowledge database available on the ICN2 website. One edition, dedicated to the ICN2 Research Support Facilities, featured presentations by Dr **Jessica Padilla** on the ICN2 X-Ray Diffraction Facility and Dr **Manuela Dietrich** on the ICN2 Biolab. In another event, Dr **Pablo Pomposiello**, Leader of the Business and Innovation Department, and **Jordi Reverter**, Intellectual Property and Technology Transfer Officer, discussed the processes of protecting intellectual property and finding business opportunities for translating research outcomes into industry applications.

In 2022, the ICN2 Electron Microscopy Unit members, led by Dr **Belén Ballesteros**, provided an overview of their research activities and technical services in an Open Knowledge Programme event. The seminar focused on microscopy techniques and sample preparation, further enriching the knowledge database.

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## Women Talent Programme



On 7 March 2022, the ICN2 hosted the Women Talent Programme Final Event in celebration of International Women's Day. Organised by the ICN2 Equal Opportunities Committee, the programme aims to provide visibility and financial support to female researchers, particularly those in the early stages of their careers, by awarding the best PhD theses, articles published in peer-reviewed journals, and project grants received by women from the ICN2.

Chaired by Dr Neus Bastús, Dr Sonia Raga Ruiz, and Nuria Benítez, the event featured presentations by winners of previous editions, a panel discussion, and the 2021 Awards ceremony. The panel discussed the effectiveness of these tools for promoting women in scientific careers and specifically addressed the ICN2 Women Talent Programme. Dr Neus Domingo, a main promoter of the Women Talent Programme and currently a group leader at the Oak Ridge National Laboratory in the US, remotely participated in the discussion.

Prof. Pablo Ordejón, group leader and director of the ICN2, presented the awards to the winners of the 2021 edition of the programme, recognising achievements in PhD theses and publications by predoctoral and postdoctoral researchers.

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## BIST Master Training Day and Colloquium at the ICN2



On April 4, ICN2 hosted a training day for students of the BIST Master of Multidisciplinary Research in Experimental Sciences. The event featured a lecture by Prof. Alireza Dolatshahi-Pirouz, Assistant Professor at the Technical University of Denmark (DTU), where he leads the #TeamBioEngine group, focusing on advanced materials for applications in nanomedicine, electronics, and tissue engineering.

The training day began with a discussion session exclusive to BIST Master's students, followed by a public talk by Prof. Dolatshahi-Pirouz as part of the BIST Colloquium Series 2021-22, titled "From Tissue Engineering to

Cybernetics." ICREA Prof. **Arben Merkoçi**, leader of the ICN2 Nanobioelectronics and Biosensors Group, chaired the session. Afterward, Dr. **Ruslán Álvarez** and Dr. **Giulio Rosati**, postdoctoral researchers in Prof. Merkoçi's group, guided the students on a tour of some ICN2 laboratories.

The BIST Master of Multidisciplinary Research in Experimental Sciences is a full-time, one-year program that provides students with hands-on research training in a multidisciplinary research environment. Students spend two-thirds of their time working in top research centers under the guidance of internationally renowned researchers. The program is designed for those planning to pursue a PhD or research career in fundamental science and technology and is open to candidates with degrees in health sciences, engineering, computer sciences, or basic scientific disciplines (chemistry, physics, biology, or mathematics).

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### III Event on Gender Equality by SOMMa



The ICN2 hosted the III Event on Gender Equality on June 17, organized by the Severo Ochoa - María de Maeztu alliance (SOMMa). The event gathered members from various centers within the alliance to discuss current challenges, share experiences from previous equal opportunity programs, and propose new actions to increase diversity in the research environment.

The event began with a keynote speech by Jakob Feldtfof Christensen, Founder and Director of DIVERSUnity, a company specializing in training and consultancy services for research centers on equality,

diversity, and inclusion in international research environments and administration.

The conversation continued with three parallel roundtables, each addressing a specific topic: Effective communication of gender plans and actions; Using gender plans to effectively improve gender equality; and Mentoring programs. Participants were encouraged to actively engage in the discussions, with conclusions reported at the event's wrap-up and documented for future reference.

A final discussion concluded the event, with both the keynote speech and closing discussion recorded and available as a video on the ICN2 YouTube channel. This event exemplifies the ongoing commitment to promoting gender equality and diversity within the research environment and fostering open dialogue and collaboration within the SOMMa alliance.

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### BIST Annual Conference

*November 2022, Barcelona*



The 6th edition of the Barcelona Institute of Science and Technology (BIST) Conference took place from November 8-11, focusing on three main themes: precision medicine, the intersection of art and science, and

diversity in STEM careers. Over 250 people from the BIST Community, including ICN2, and 2000 high school students participated in the event, which was held at the Centre de Cultura Contemporània de Barcelona (CCCB).

The main conference day on November 10 was dedicated to the topic of precision medicine. The day featured a welcome speech by Prof. Joan Guinovart, an introductory speech by the new BIST Director Dr. Eduard Vallory, and a presentation of a new program to promote women's leadership in science by BIST Director of Programmes Núria Bayó. The conference included a keynote

presentation, flash talks and posters by young researchers, and additional talks and roundtables.

On November 8-9, two satellite events took place online. The first event was dedicated to exploring the encounter between art and science, while the second event addressed gender bias and diversity issues in the research world. The final day of the BIST Conference, November 11, coincided

with the first day of the 2022 Setmana de la Ciència and focused on outreach and educational activities with high school students.

Members of the ICN2 community played significant roles in the organization of the conference. Prof. **José A. Garrido** and Prof. **Víctor Puntes** served on the Scientific Committee, while Àlex Argemí was a member of the Organising Committee.

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## MBADay with Barcelona Global

*October 2022, ICN2*



Barcelona Global held its fourth edition of the Barcelona MBA Day on October 20, where over 600 MBA students from five renowned business schools visited various entrepreneurial, industrial, and scientific centers in Barcelona, including the ICN2. The ICN2 hosted a group of students who

interacted with the ICN2 Business and Innovation team, the Nanobiosensors and Bioanalytical Applications Group led by Prof. **Laura M. Lechuga**, and the Nanostructured Functional Materials Group led by Prof. **Daniel Ruiz-Molina**.

The visitors learned about the ICN2's strategies to bring research closer to industry, innovative nanobiosensors for diagnosing diseases, and new intelligent materials for various applications. The event aimed to introduce these international students from the world's top business schools to Barcelona's civic, business, and research leaders.



Throughout the year, the ICN2 researchers were involved in **12 press releases** on various topics such as energy, fundamental physics, nanomedicine, acquisition of new equipment with FEDER Funds, awarded grants including ERC Grants, and the advancements made by the spin-off company INBRAIN Neuroelectronics.

In addition to the online impacts, media tracking tools utilized by the ICN2 primarily focused on Catalan and Spanish media, reported **69 mentions of the ICN2 and its researchers in printed press, 8 radio appearances and 2 TV appearances.** The ICN2 Marketing and Communication Department's consistent efforts have played a vital role in ensuring the Institute's research and advancements continue to reach wider audiences and benefit society at large.

**FUNDACIÓN LA CAIXA**

## CaixaResearch estudia las posibilidades de revertir la ceguera actuando sobre la retina

La entidad social celebró un debate para abordar proyectos que buscan recuperar la visión de las personas ciegas o con deficiencia moderada

**LA MISMA**

**S**egún los datos de la Organización Mundial de la Salud (OMS), se estima que se proyecta en el mundo más de 200 millones de personas con deficiencia visual o ceguera en el mundo en el 2050. Por ello, la Fundación La Caixa organizó el pasado día 23 de mayo un debate sobre la ceguera para abordar proyectos que buscan recuperar la visión de las personas ciegas o con deficiencia moderada.

El debate se celebró en el marco del programa de actividades de la Fundación La Caixa, en colaboración con el Centro de Investigación Biomédica en Red sobre Enfermedades Neurodegenerativas (CNB) y el Instituto Cajal. El debate estuvo moderado por el Dr. Juan Carlos García, director del CNB y presidente del Comité de Investigación Biomédica de la Fundación La Caixa.

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Un científico se conecta a la retina de un paciente ciego.

La Fundación La Caixa apoya la labor de los científicos de la Red de Investigación Biomédica en Red sobre Enfermedades Neurodegenerativas (CNB) y del Instituto Cajal.

## "El Covid nos pilló con un sistema científico precario"

El mundo científico debería haber estado preparado para el Covid-19, pero el sistema científico actual no lo estaba. El mundo científico debería haber estado preparado para el Covid-19, pero el sistema científico actual no lo estaba.



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## La UCA inviste doctora honoris causa a Laura María Lechuga

• "Ser mujer en un mundo de hombres no me ha puesto fácil el camino" • Premio "Personas al servicio de la sociedad" 2020

La Universidad de Cádiz (UCA) ha investido doctora honoris causa a Laura María Lechuga, investigadora del Instituto Cajal y del Centro de Investigación Biomédica en Red sobre Enfermedades Neurodegenerativas (CNB). Lechuga es una científica destacada en el campo de la neurociencia y la neurodegeneración.

El acto de investidura se celebró el pasado día 23 de mayo en el aula magna del edificio de Ciencias de la UCA. Lechuga recibió el título de doctora honoris causa de manos del rector de la UCA, Juan Carlos García. El acto estuvo moderado por el Dr. Juan Carlos García, director del CNB y presidente del Comité de Investigación Biomédica de la Fundación La Caixa.





*Annual Report 2022*

© **Institut Català de Nanociència i Nanotecnologia (ICN2)**

Marketing and Communication Department

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