INL Annual Report 2022

INTERNATIONAL IBERIAN
NANOTECHNOLOGY
LABORATORY

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01. Foreword

Foreword

Paulo Jorge Peixeiro de Freitas

Deputy Director General

> *thank you all for the contributions to make INL a stronger and better institution by the end of 2022, and let us keep working to improve where we need and excel in what we do.*

Dear friends and colleagues,

The year of 2022 ended with INL strengthening its participation in a variety of European programs, increasing commissioned research and services to about 15% of our total turnover and entering a new phase in collaboration with Portuguese industry with the approval of INL´s participation in 16 PRR agendas (the Portuguese Resilience and Recuperation Plan arising after the 2020-2021 Covid pandemic). Our total turnover has surpassed for the first time the €20M.

In terms of human resources, INL is now home to over 430 people, among which close to 250 are staff members, and about 180 are associated members (visitors, PhD students, Master students, university professors). INLers come from 33 countries, with larger contingents from Portugal and Spain. The researchers are engaged within 23 research groups including 2 with a strong engineering background. Our research core facilities, the Micro and Nanofabrication (MNF), the Advanced Electron Microscopy and Imaging Spectroscopy (AEMIS), the Nanobioimaging (NBI), and the X-ray facilities, have improved their service offer and attracted a larger number of external users.

In scientific terms, our scientific production has reached 286 articles in 2022, with several publications in highly cited journals either of general or specific scientific areas. Our areas of activity encompass health, energy, advanced materials and new computing paradigms, nanotechnologies for environment, smart farming, and food applications, and nanoelectronics/nanophotonics towards smart digital nanosystems. Transverse technical areas have sprouted in nanosafety, sensor development, microfluidics, and more recently data handling-artificial intelligence. Our innovation activities led to, 5 patents filed and 2 granted. Our present patent portfolio includes 26 patent families.

INL through its members was involved at different international activities with contributions given at different levels for the European materials 2030 Manifesto that led to the Advanced Materials Initiative, contributions to the EU Chips Act through helping to frame national contributions for IPCEI (Important Projects of Common European Interest). INL was also actively involved in organising/coordinating national activities at the battery level, and at the cryo-microscopy level, becoming the site for the first Portuguese Cryo-TEM.

INL saw by August 2022 the departure of our former Director General, Prof. Lars Montelius, who completed his two-term assignment. I thank Lars for his dedication to INL and for the years devoted to help us grow and increase our international footprint. The INL Council is actively pursuing the search for a new DG.

In summary, thank you all for the contributions to make INL a stronger and better institution by the end of 2022, and let us keep working to improve where we need and excel in what we do.

02.
About INL

About INL

INL, the International Iberian Nanotechnology Laboratory is an intergovernmental research and technology organisation founded by Spain and Portugal in 2009, headquartered in Braga, northern Portugal.

INL works under an international legal framework to perform interdisciplinary research, and deploy nanotechnologies for the benefit of society. Its strategic research areas provide understanding on fundamental phenomena which then bring the foundation for new technologies to be developed. As these new technologies move through our innovation pipeline, the aim is to tackle today's main challenges faced by humanity, addressing the priorities outlined by the United Nations Sustainable Development Goals, in particular those related to clean water, clean energy, zero hunger, good health and well-being, among others.

The mission of INL is broad yet simple: using nanotechnologies to explore interfaces.
It defines our approach towards the unknown, towards new possibilities, towards intersections of opportunities.

The aim is to understand today's problems, create solutions based on nanotechnologies, and bring these together to promote innovation at a worldwide level. Thus, INL's vision is to become a recognised leading global nanotechnology innovation hub.

Mission – Exploring Interfaces

Vision – To become a recognised leading global nanotechnology innovation hub

03.
INL Key Numbers

INL Key Numbers

The INL community now includes close to 430 people, among staff (MPE) and associates (MPA).

MP
TOTAL MEMBERS OF THE PERSONNEL

425

FEMALE **237**

MALE **188**

MPE
EMPLOYEE MEMBERS OF THE PERSONNEL

244

FEMALE **139**

MALE **105**

184 SCIENTIFIC MEMBERS

60 NON-SCIENTIFIC MEMBERS

77 FELLOWS

167 STAFF MEMBERS

MPA
ASSOCIATED MEMBERS OF THE PERSONNEL

181

FEMALE **98**

MALE **83**

98 PHD STUDENTS

4 ASSOCIATES

42 ADVANCED STUDENTS

39 OTHER MPA'S

SCIENTIFIC MEMBERS

365

SUPPORT UNIT MEMBERS

60

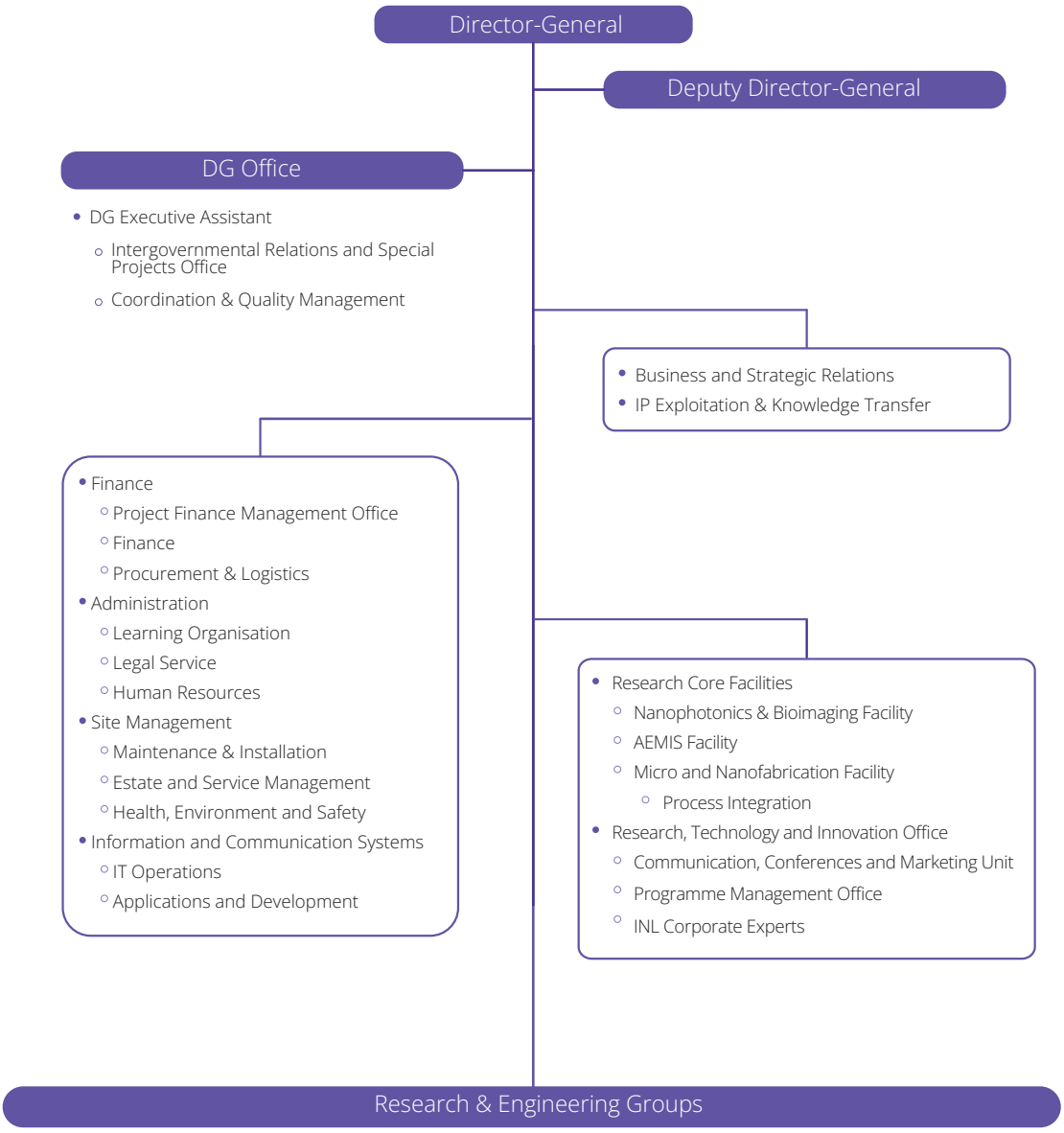
NATIONALITIES

33

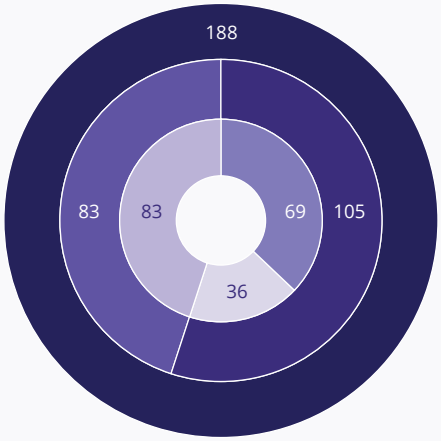
MPE: 28

MPA: 15

Organisational Chart



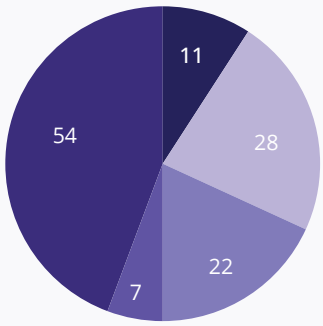
- 2D Materials and Devices
- Atomic Manipulation for Quantum Nanotechnology
- Atomic Structure-Composition of Materials
- Food Processing and Nutrition
- Food Quality and Safety
- Integrated Micro and Nanotechnologies
- Medical Devices
- Nanodevices
- Nanofabrication for Optoeletronic Applications
- Nanochemistry
- Nanomaterials for Energy Storage and Conversion
- Nanomedicine
- Nanosafety
- Nanostructured Materials
- Nanostructured Solar Cells
- Natural and Artificial Photonic Structures and Devices
- Quantum and Linear Optical Computation
- Spintronics
- Systems Engineering
- Technology Engineering
- Theory of Quantum Nanostructures
- Ultrafast Bio and Nanophotonics
- Water Quality



- Total Women in Science
- Total MPA
- Total MPE
- MPA: In Science
- MPE: In Science
- MPE: Others

	INL Key Numbers (2022)
Members of Personnel	425
Employees	244 (Female 139, Male 105)
Employee Nationalities	33
Visitors to INL Website	62,136
Participants in Events & Conferences	5744
Events	61
Publications	286
Citations	9275
h-index	80
PhD Vivas *	16 (10 with complete stay at INL and 6 with partial stay at INL)
MSc Vivas *	51
Published patent families	26

* Complete list in Appendix



Events Numbers

- External
- Scientific
- General
- Partnerships Events
- Internal

04.
Research Excellence

Research Excellence

In 2022, the INL community was back to the laboratory with normal schedules and no restrictions. It was soon realised that new challenges had to be faced, based on the global changes that had happened. During this first post-pandemic year, several European and worldwide initiatives took place. These proved to be in alignment with the four main RTI institutional goals, thus reinforcing the significance and relevance of INL's RTI strategy.

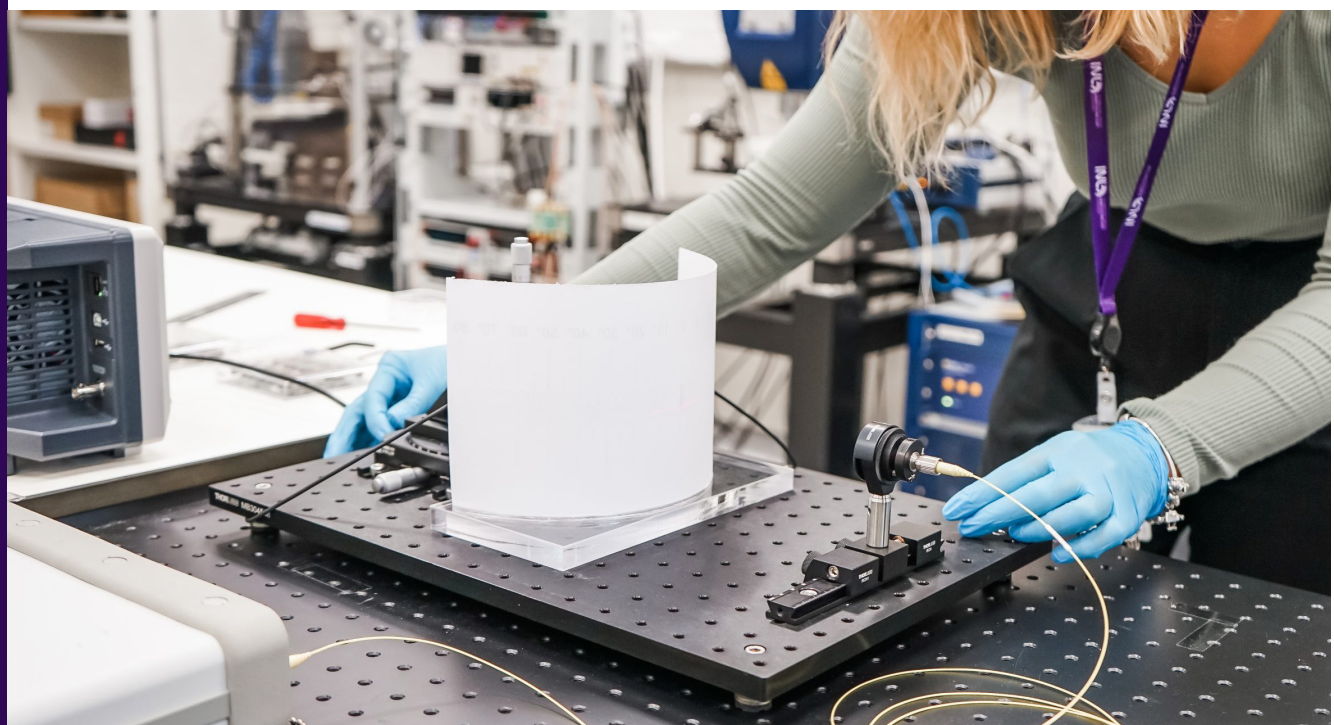
For instance, INL, through its members, was involved in several international activities with contributions to the European materials 2030 Manifesto that led to the Advanced Materials Initiative, and with contributions to the EU Chips Act through helping to frame national contributions for IPCEI (Important Projects of Common European Interest). These initiatives are well aligned with INL's RTI institutional goals, respectively **fostering a digital society enabled by nanotechnology** and **the development of next-generation disruptive computational technologies.**

In the same way, the EC opened a safe-and-sustainable-by-design (SSbD) consultation period, providing a window of opportunity to **promote carbon neutrality and environment sustainability enabled by nanotechnology solutions to achieve clean energy supply, waste reduction, and recycling.** The contribution of INL to improve societal health and wellbeing by **personalising food and medical technologies** is becoming ever more relevant.

This good alignment between the INL strategy and the big trends and drivers allowed INL to be ready for contributing to the definition of the Portuguese Plan for Recovery and Resilience (PRR) and increasing INL's footprint and visibility at international level, participating in different research projects and initiatives where INL is now playing an instrumental role.

The six thematic areas developed at INL, internally referred to as "RTI Clusters", are the following: Advanced Materials and Computing, Clean Energy, Food for the Future, Precise Personalised HealthTech, Smart Digital NanoSystems, and Sustainable Environment.

Transversal topics among these areas are: Nanosafety, Sensors, Microfluidics, and Data handling/Artificial Intelligence, having internally organised groups and communities to address each of these areas. A communication plan for each of our six thematic areas was also developed and implemented during 2022, with the aim to increase INL's international visibility and disseminate in a coordinated way the progress achieved on how these areas feed several industries and markets.



Several initiatives and events which brought opportunities for multi-disciplinary scientific discussions included:

- **The BioIberoamerica 2022 Congress,** a 3-day event that brought together scientists, entrepreneurs, industry, and clinicians who develop their research and work in the area of Biotechnology, was the biggest event in partnership, counting with 235 attendees in total.
- **The biggest event organised and held at INL during 2022** was the INL Summit 2022, with 300 participants and the presence of Elvira Fortunato, Minister for Science and Technology.
- **As an external event, it can also be highlighted the Open Innovation Testbeds Village**, organised at the Conference on Industrial Technologies IndTech 2022, Grenoble, with 17 booths and approximately 300 participants.
- **The INL Colloquia Series continued in 2022,** where guest speakers included Prof. Wojtek Chrzanowski from the University of Sydney Nano Institute, Prof. Luis Liz Marzán from CIC biomaGUNE, and Dr. Nianjun Yang from the Institute of Materials Engineering, University of Siegen in Germany.
- **Traditional scientific events also held during 2022 were:** the monthly webinar given by new researchers joining INL, and the internal Annual Research Symposium in which the research and engineering groups presented their previous year's highlights through talks and short video presentations.

Research & Engineering Groups

Research and development occur at the core of INL, within the 23 research and engineering groups. These form the base from where all our scientific outcome, technological developments, and innovation opportunities arise from. The next section shows a highlight from each of these groups.

05. Research & Engineering Groups

Atomic Manipulation for Quantum Nanotechnology

Group Leader
Zhongchang Wang

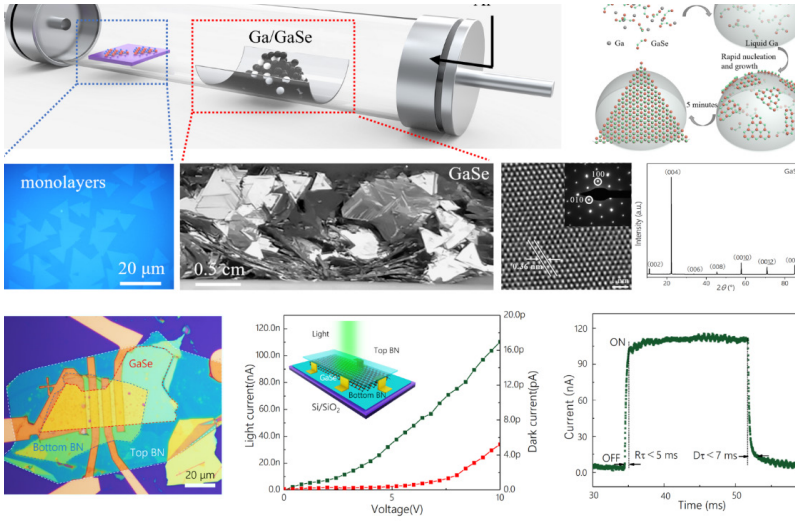
Associates
Bin Wei
Tianqi Guo

The group develops new calculation methods to pre-screen novel 2D van der Waals materials with both air stability and high Curie temperature. These predicted 2D materials are further experimentally synthesised by home-made chemical vapour deposition and chemical vapour transport systems for the state-of-the-art magnetic and information storage applications. The group also focuses on exploring structure-property interplay of 2D magnetic and nanomaterial systems at the atomic scale, by combining atomic-resolution imaging with atomistic calculations.

> **The group leader was elected Fellow of International Association of Advanced Materials (FIAAM).**

An ultrafast crystal growth process was developed, requiring low energy consumption and having the capability of producing crystals of excellent quality. It was demonstrated that large-sized GaSe crystals with a lateral size of 0.5 to 1 cm can be obtained within a short period of 5 min. X-ray diffraction (XRD) and scanning transmission electron microscopy (STEM) studies clearly indicate that the as-grown crystals have a good crystallinity. A fabricated few-layer GaSe-based photodetector exhibited low dark current of 21 pA and fast response of 34 ms, under 405 nm illumination.

To read the article: https://doi.org/10.1007/s12274-022-4253-2



a) and b) sketch of the growth setup and the optical microscopy and atomic image of GaSe. c) optical microscopy of the GaSe photodetector device and optoelectronic performance of the GaSe photodetector.

Research lines:

- Development of ferroelectric and ferromagnetic 2D materials
- Development of prototype information storage devices and integrated chips at nanometre scale based on atomically thin 2D materials
- Development of 2D materials for energy storage
- Fundamental research on quantum electron transport in confined systems and ferroelectric and magnetism in reduced dimensions

Group Leader
Paulo Ferreira

Staff Researcher
Enrique Carbó

Research Fellow
Cristiana Alves

PhD Candidates
Bruno Oliveira
Fátima Zorro
Francisco Figueiredo
Rafael Ferreira

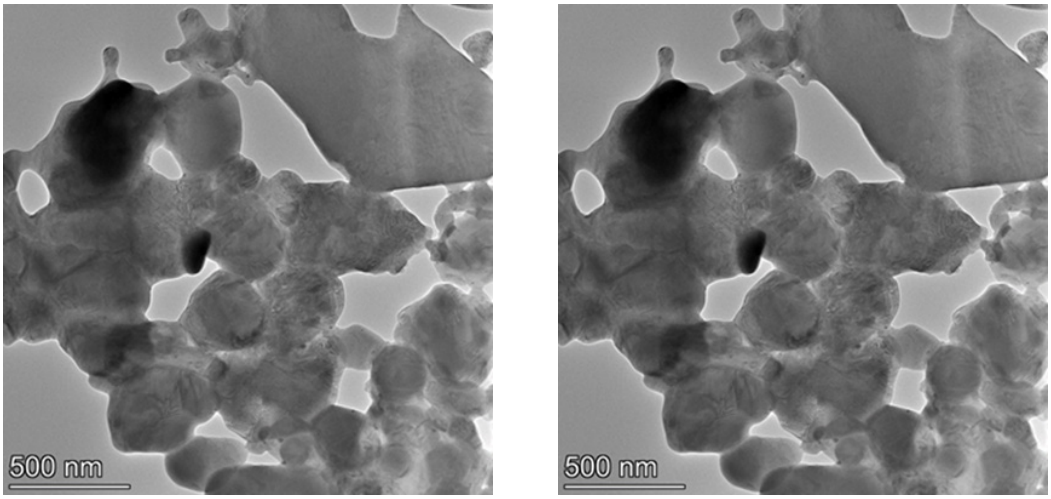
Advanced Student
Ricardo Machado

Atomic Structure-Composition of Materials

The group focuses on the study of the atomic structure, atomic composition and defect behaviour of nanomaterials, through in-situ transmission electron microscopy (TEM), aberration-corrected TEM/STEM, EELS/EDS and DPC techniques. In particular, their interest aim at the understanding of the relationships between the atomic structure, composition and the properties of nanomaterials, and the fundamental mechanisms governing the behaviour of materials. The material systems of interest include battery materials, proton exchange membrane fuel cells, catalyst nanoparticles and 2D materials.

> **Participation in two PRR agendas, namely in the "New Generation Storage" and the "Moving2Neutrality" agendas. The group will use advanced transmission electron microscopy to understand the behaviour of active materials for lithium-ion and sodium-ion batteries, as well as catalysts for the production of hydrogen.**

As the demand for developing environmentally friendly and energy-efficient technologies continues to increase, it is critical to devise processes that produce materials at a lower cost. Flash sintering is a viable alternative, leading to a reduction of the processing times from hours to seconds, concomitant with a significant decrease in operating temperatures. In this group, they have for the first time flash sintered the oxide semiconductor material $La_{0.75}Sr_{0.25}Cr_{O3}$ at room temperature, instead of c.a. 1800° C if sintered conventionally.



TEM images of a $La_{0.75}Sr_{0.25}Cr_{O3}$ lamella, a) before and b) after flash sintering.

Research lines:

- Mapping the atomic structure and composition of layered and spinel battery cathodes
- Understanding the degradation of nanocatalysts in proton exchange membrane fuel cells by combining identical location TEM with 3D tomography
- Monitoring the influence of atomic defects in 2D nanomaterials by diffraction phase contrast
- Understanding the fundamental mechanisms of flash sintering in semiconductor oxides

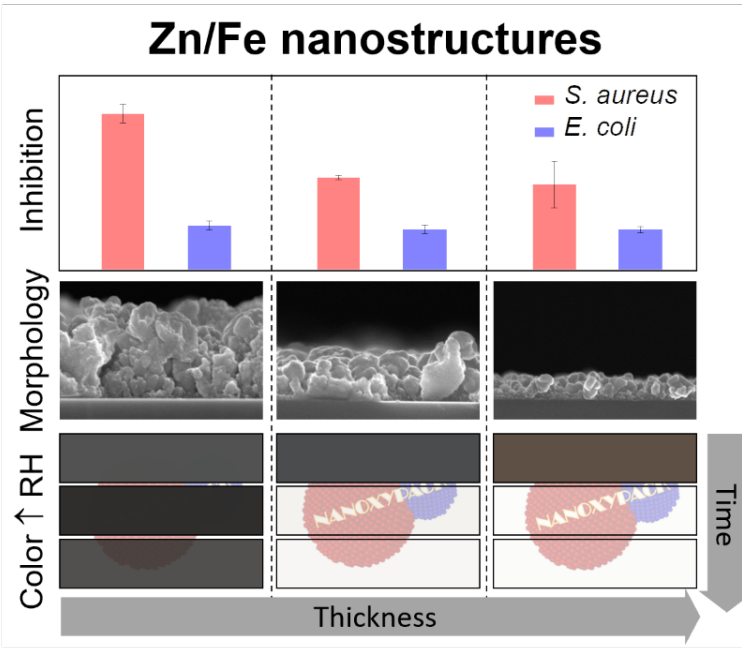
Food Processing and Nutrition

This group develops nanotechnology-based solutions for building a healthier, trustworthy and sustainable future food system, optimising materials and processes throughout the entire food value chain to ensure authenticity and to bring tastier and safer food to consumers.

> **They were a promotor and founder of the Iberian Food Technology (IFT) Lab, a joint initiative that was approved in the November 2022 Iberian Summit.**

The group has obtained Zn and Fe metallic and bimetallic nanostructures with active and intelligent properties for food packaging. These nanostructures combine unique properties such as oxygen scavenging capacity, chromatic, and antibacterial properties, which can help improve the safety, shelf life, and nutritional value of food products. In addition, these nanomaterials can help reduce the need for preservatives and other additives, making food healthier and more sustainable.

To read the article: https://doi.org/10.3390/nano12122104



Effect of nanoscale Zn/Fe multilayers thickness on the antimicrobial capacity and responsiveness to the relative humidity of poly(lactic acid)-based materials

Research lines:

- Smart, active and edible food packaging solutions based on micro and nanomaterials and advanced coating technologies
- Food personalisation enabled by using micro- and nano-encapsulation, advanced processing/ manufacturing and cellular agriculture technologies
- Development of miniaturised, automated, and sensorised *in vitro* models of human digestion and intestinal epithelium

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Inmaculada Ortiz Gómez
Laura Loaiza
María Flórez Mora

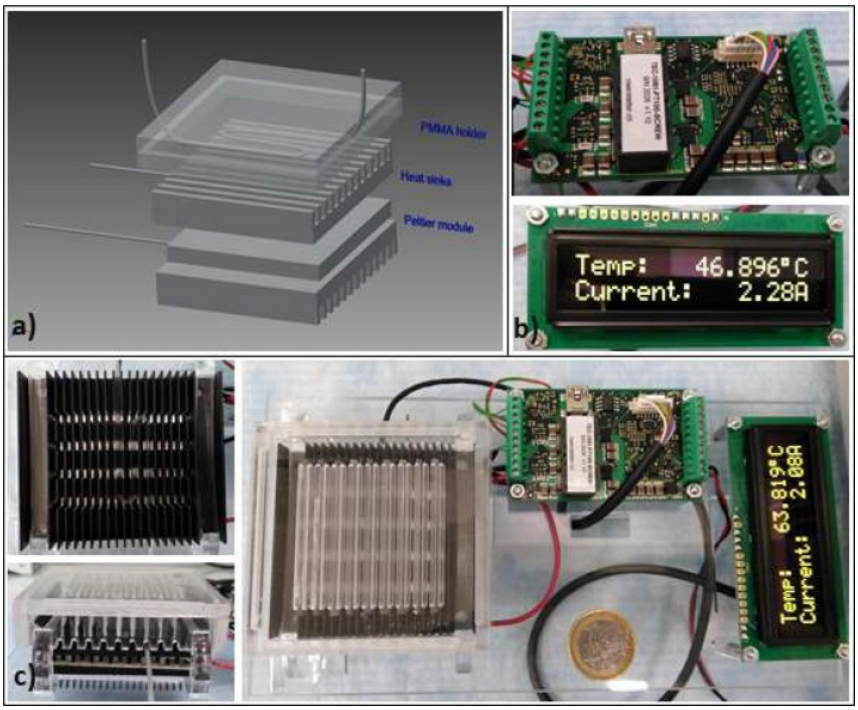
Food Quality and Safety

This group tackles some of the main concerns regarding food safety, food authenticity and food quality. The research group combines combine molecular biology with microfabrication to develop advanced analytical devices, which are portable and faster, ready to be used in decentralised and low-income environments. They also develop both targeted and non-targeted methods to detect the presence of allergenic ingredients, foodborne pathogens and antimicrobial resistant (AMR) microorganisms, and fraudulent practices in food products.

> **The group started the Horizon Europe project TITAN, a consortium with 27 European partners, which aims to enhance food transparency in order to transform the food system through digital and advance tools.**

The group designed, fabricated and tested a portable and miniaturised prototype for the specific detection of gluten-containing cereals in food samples by isothermal DNA amplification, couple with naked-eye detection. The prototype contains an integrated heating system, circumventing the need for additional equipment for the amplification reactions.

To read the article: https://doi.org/10.1016/j.microc.2022.108115



Miniaturized prototype for isothermal DNA amplification: a) Peltier module, supporting box with aluminium heat sinks and PMMA plates; b) TEC controller and display; c) Tubing chamber and experimental setup.

Research lines:

- Miniaturised and faster analytical devices
- Development of fast, cheap and reliable analytical approaches
- Integration of advanced miniaturised devices with blockchain technology and artificial intelligence to contribute to the digitalisation of agri-food industry

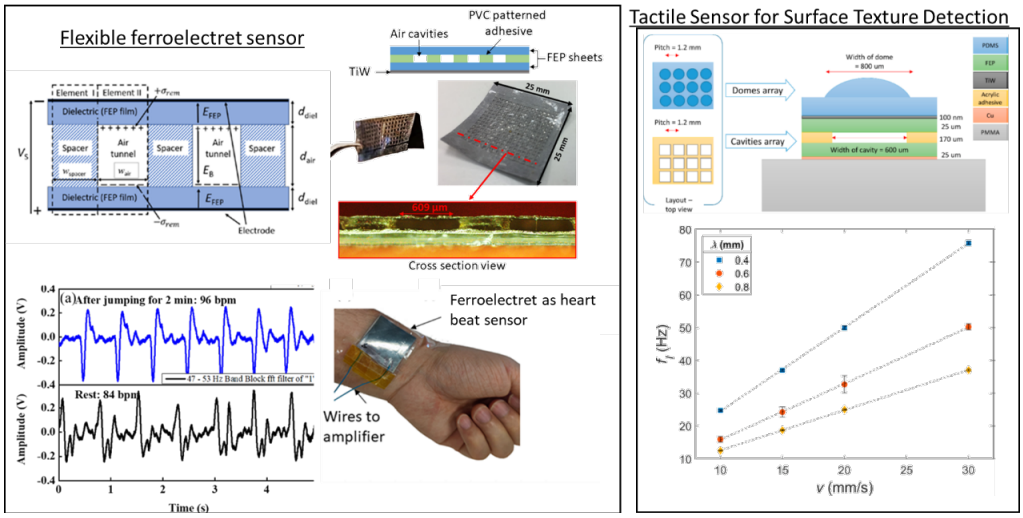
Integrated Micro and Nanotechnologies

The group develops applied research on polymeric and silicon-based micro-electromechanical systems (MEMS), inkjet-printed sensors, gas and passive sensors, micro-opto-electromechanical systems (MOEMS), diffractive optics, and microlenses. They also work on advanced integration technologies, such as microfabrication process integration, microfluidics integration, and packaging.

> **In 2022 the group secured both industrial and public funding for research on MEMS physical sensors, at high TRLs, for the next three years.**

The group contributed significantly for the demonstration of electrects (ferroelectrect and piezoelectrects) in several areas such as force sensing, wearable applications, digital memory and self-power transducers.

To read the article: https://doi.org/10.1109/TDEI.2022.3173462



Left side: flexible ferroelectret sensor for heart beat measurement, right side: ferroelectret for surface texture measurement.

Research lines:

- Development of MEMS and flexible devices
- Development of micro optical elements
- Advanced integration technologies

Interim Group Leader
Lorenzo Pastrana

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João Vieira
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Jorge Cabral
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Kate Cox
Manuel Pereira
Maria Cortez
Mathieu Galliou
Matilde Abreu
Nuno Rodrigues
Patrícia Soares
Pedro Bandarra
Pedro Sousa
Ricardo Magalhães
Tomás Belo
Wesley Floricourt

Associates
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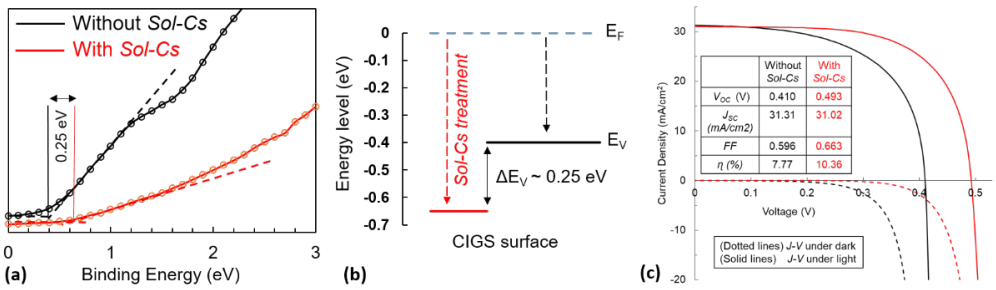
Christian Rossi
Pedro Santos
Rafael Cerqueira

Nanostructured Solar Cells

The group performs research and development activities around the general topic of energy materials. A strong focus is on the development of advanced thin-film solar cells (mainly Cu(In,Ga)Se_2-based, also known as CIGS), implementing micro- and nanostructuring, their characterisation on the nanometre scale, and the growth of chalcogenide 2D materials and devices for optoelectronic applications. It also develops and applies nanoscale scanning probe microscopy (SPM) methods to characterise CIGS materials and thin-film solar cell devices, as well as 2D materials.

> **Within this group, the successful execution of two Portuguese-funded projects (MiconCell and STAR-SOL) on micro-structured CIGS solar cells, and one MSCA Individual Fellowship project (UL-Flex-Cell) on flexible CIGS solar cells is highlighted.**

Within UL-Flex-Cell, the group developed an alternative, low cost, solution process for the surface treatment of CIGS as a new route to incorporate Cesium (Cs) for improving the solar cell performance. This treatment changes the surface morphology of the CIGS, resulting in an improvement of the solar cell efficiency from ca. 8% to 10%. X-ray photoelectron spectroscopy (XPS) results revealed the depletion of copper and the presence of Cs at the surface of the CIGS thin film. Ultraviolet photoelectron spectroscopy (UPS) showed the lowering of the valence band maximum by around 0.25 eV after the treatment, which plays a positive role in reducing the interfacial recombination. High-resolution transmission electron microscopy (HR-TEM) showed the presence of Cs and depletion of Cu at the grain boundaries of the CIGS thin film.



(a) UPS measurement of the Cu(In,Ga)Se_2 thin film with (red lines) and without (black lines) Cs solution treatment (Sol-Cs) after DI water rinsing. (b) A 0.25 eV shift on the valence band edge is observed for the Sol-Cs sample. (c) Typical light (solid lines) and dark (dotted lines) J-V curves of CIGS solar cells fabricated using pulsed hybrid reactive magnetron sputtering with (red lines) and without (black lines) Sol-Cs treatment.

Research lines:

- Development of advanced thin-film solar cells by the implementation of micro-and nanostructures
- Development and application of scanning probe microscopy techniques for the characterisation of solar cell and two-dimensional materials and light-induced phenomena at the nanometre scale
- Development of growth and fabrication processes for chalcogenide 2D materials and devices
- Energy materials

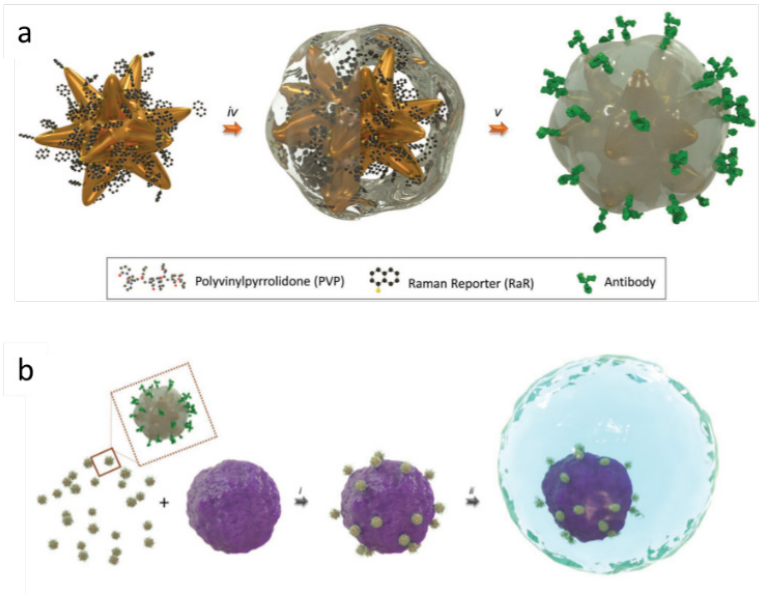
Medical Devices

The group is dedicated to translational medical research in close collaboration with hospitals. Their main focus lies on the development of tools and solutions based on microfluidics, biosensors and nanotechnology towards early diagnosis and better understanding of diseases.

> **Sara Abalde-Cela was awarded the EIC Pathfinder project 3DSecret. This unique project aims to understand cancer metastasis by looking at this process from a radical new perspective, a bottom-up holistic approach: from cancer single-cells to 3D spheroids.**

The group developed a method for highly sensitive single-cell multiplex phenotyping using microdroplets and surface-enhanced Raman scattering (SERS). The aim is to apply this technology for high throughput analysis of circulating tumour cells, or circulating tumour cells (CTCs), to analyse tumour heterogeneity. The analysis of single cells is key in order to understand the origin and evolution of cancer to provide an accurate prognosis. Our integrated opto-fluidic platform paves the way towards the multiplex and automated characterisation of cell populations in cancer patients.

To read the article: https://doi.org/10.1002/adom.202201500



a) Schematic representation of the conjugation of gold nanostars (GNS): The GNSs were labelled with 1-NAT to use as RaR for the indirect detection of membrane surface proteins of cancer cells (left); GNSs@1-NAT were coated with a thin layer of silica (middle), to allow the biofunctionalisation with antibodies that will recognize cancer cells (right). b) Schematic representation of the labelling of cancer cells (purple spheres) with SERS tags and their encapsulation in microdroplets for single-cell analysis.

Research lines:

- Non-invasive disease monitoring (biomicrofluidic systems to isolate disease biomarkers from body fluids)
- Early and accurate disease diagnosis (nanobiosensors to study and evaluate disease biomarkers)
- Disease modelling (biomimetic 3D organ-on-a-chip systems to model processes in disease evolution and treatment)
- Medical instrumentation technology development

Group Leader
Lorena Diéguez

Staff Researchers
Alar Ainla
Pieter De Beule
Sara Abalde-Cela

Research Fellows
Ahmed Mahmoud
Alexandre Chícharo
Ana Sofia Martins
Carlos Honrado
Diogo Poeta Miguens
José Tamagno Pesqueira
Maria Relvas
Marta Aranda
Paulina Piairo

Research Engineer
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PhD Candidates
Adriana Carneiro
Alexandra Teixeira
Cláudia Lopes
Javier Vega
Pedro Conceição

Advanced Students
Diogo Moreira
Hugo Silva
José Paiva
Luke Marren
Renata Matos
Rodrigo Marinho
Tomás Neves

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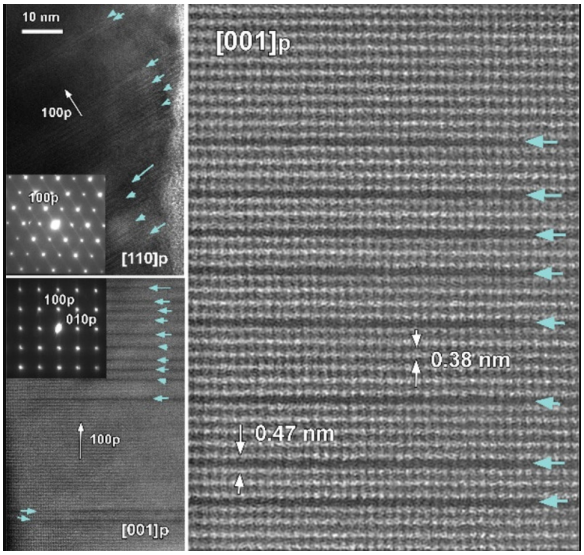
Nanochemistry

The group combines complementary efforts of enthusiastic synthetic chemists, materials scientists, and coating engineers to develop and investigate nanotechnology solutions for emerging and future applications in the field of sustainability and circular economy. More specifically, the group uses well-defined nanostructured materials to create efficient products for coatings, carbon capture and utilisation, water treatment, air purification, thermoelectrics, photovoltaics, and catalysis.

> **Juliana Sousa and Soraia Fernandes secured significant funding from private companies to develop innovative materials and solutions for carbon dioxide capture.**

Within EU H2020 SpinCat project, the group is making high-performing and durable catalysts out of earth-abundant and cheap elements that replace current scarce and expensive platinum-group-metal catalysts in water electrolysis. The group developed the synthesis route to perovskites using an environmentally-friendly deep eutectic solvent. The catalysts exhibit an intrinsically high concentration of oxygen vacancies, demonstrating high electrocatalytic activity for oxygen evolution reaction.

To read the article: https://doi.org/10.1021/acsami.1c24223



Representative low-magnification [110] TEM and [001] HAADF–STEM (left panels) as well as high-resolution [001] HAADF–STEM (right panel) images together with the corresponding SAED patterns (insets) for $LaCoO_3$ after alkaline OER stability testing

$LaCoO_3$ was the best-performing electrocatalyst for water oxidation in alkaline medium, exhibiting current densities of 10, 50, and 100 mA cm^{-2} at respective overpotentials of ca. 390, 430, and 470 V, with a Tafel slope of 55.8 mV dec^{-1}.

Research lines:

- New materials and multi-functional coatings for sustainable solutions (water monitoring and treatment, air purification, smart cities, raw materials, manufacturing of added-value goods)
- Advanced nanomaterials for application in energy and catalysis focusing to reduce the dependence on critical raw materials (thermoelectric materials, catalysis, CO_2 conversion)

Nanodevices

The group works with state-of-the-art components, in particular magnetoresistive sensors and thin-film-based elements, integrating these with electronics system and microfluidics.

These are applied to a variety of applications in ICT (industrial sensors), health (biosensors, neuroelectrodes), food and environment (biosensors), with close collaboration with industry and hospitals.

> **Together with the Systems Engineering group and other relevant external partners, they successfully completed the EU-funded project iGRAPE, https://i-grape.eu/, with a workshop and a field demo of the developed technologies for the assessment of grape maturation.**

Briliant Prabowo and Elisabete Fernandes developed a pump-free microfluidic chip as a sample-prep module to enhance the magnetic labelling efficiency for two ischemic stroke biomarkers, used for patient stratification: cellular fibronectin (c-Fn) and matrix metallopeptidase 9 (MMP9). The chip is operated based on capillarity without any external power source nor battery. This microfluidic unit reduced the labelling time from 1 hour to 15 minutes.

To read the article: https://doi.org/10.1007/s00216-022-03915-w

The magnetoresistive biochip platform has been explored as a point-of-care technology for the stratification of stroke patients for intravenous thrombolysis treatment, bacterial and viral infections, as well as cancer.

Research lines:

- Magnetoresistive sensors and pilot line
- Biosensors (magnetoresistive and others)
- Novel sensing platforms

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Tiago Laranjeira

Associates
Paulo Fernandes

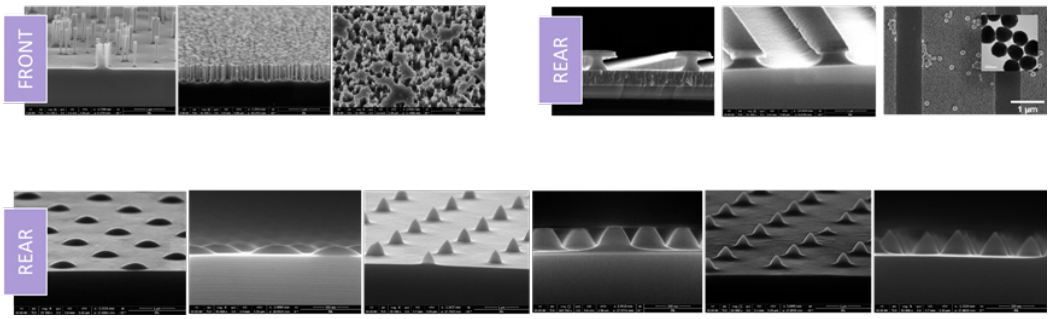
Nanofabrication, Optoelectronics and Energy Applications

The NOA group focuses in the incorporation of nanotechnology in optoelectronic and energy devices with a strong industrial and innovation potential. Recently, they started working in machine learning and computer vision, using neural networks for the energy management of photovoltaic platforms. The core competences of the group are bottom-up nanofabrication and characterisation of optoelectronic materials and devices.

> **The group coordinated INL's participation in two of the largest competitive funding programs that INL participated, New Generation Storage NGS (with the participation of 11 INL groups) and R2UTechnologies (with the participation of 6 INL groups).**

In new solar cell architectures, in collaboration with several partners, such as Uppsala University, Hasselt University, imec and the NIL company Obducat, the team developed an ultrathin solar cell with a light-to-power conversion efficiency above 15%, matching the state of the art. Several industrial up-scalable nanofabrication and deposition processes were also demonstrated, having a vast potential for efficiency increase with several optical and electrical improvements.

To read the article: https://doi.org/10.1038/s41528-023-00237-4



Several nanostructures that interact with light can be integrated in a solar cell: at the front for a broad-band wavelength effect and at the rear for specific wavelength intervals.

Research lines:

- New optoelectronic and energy materials, and advanced characterisation techniques
- Development of architectures for optoelectronics and energy devices
- Advanced platforms for asset management

Nanomaterials for Energy Storage and Conversion

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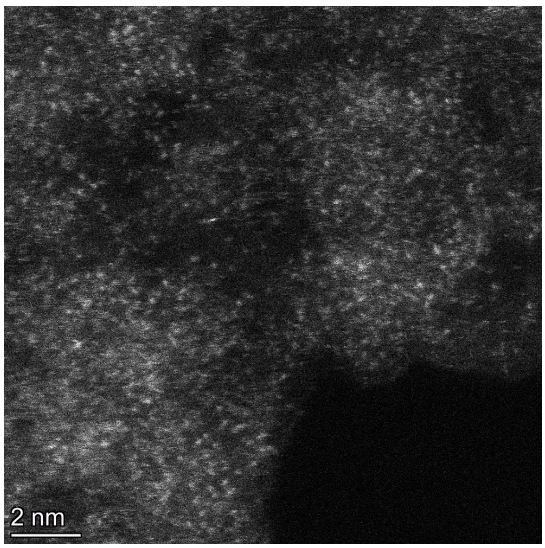
The group conducts fundamental and application-oriented research on new functional materials that can be used for electrochemical energy storage and conversion. The group has extensive competences in nanomaterials synthesis and materials' electrochemistry, and is committed to developing energy materials that can improve the overall performance of water electrolysers, next-generation batteries and photoelectrochemical cells.

> **The group was the main organiser of the Symposium Q: Advanced materials for (photo) electrochemical energy conversion III, held in Warsaw, Poland, at the European Materials Research Society (E-MRS) Fall 2022 meeting.**

In order to address the pressing need for electrocatalysts for large-scale deployment of water electrolysers, the group developed highly active catalysts for the hydrogen evolution reaction (HER), with significantly reduced metal contents. Several atomically dispersed catalysts (e.g., Ru, Ir, Pt, Ni) have been successfully prepared, allowing the efficient utilisation of metal atoms to a maximal extent.

To read the article: https://doi.org/10.1016/j.apcatb.2022.121318



The singly-dispersed Ru catalysts show a high turnover frequency and mass activity, outperforming many Ru-based HER catalysts under similar conditions.

Research lines:

- Advanced catalytic materials for electrochemical energy conversion
- Solar fuel production
- Advanced electrode materials for rechargeable batteries and supercapacitors

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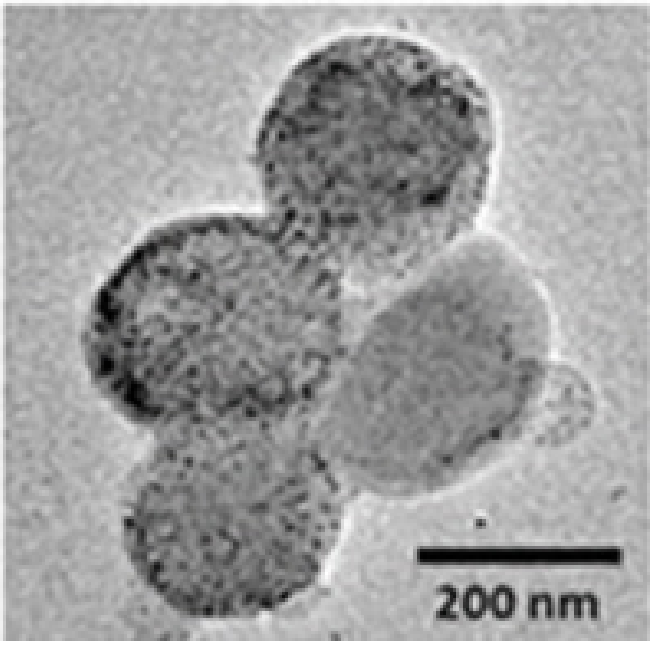
Nanomedicine

The group focuses on the development of diagnostic and therapeutic approaches towards an early and unequivocal diagnosis and treatment of diseases, with strong focus on cancer and inflammatory conditions. In the last years, starting from fundamental understanding of nanomaterials physico-chemical properties and disease and biological pathways, the group has applied a cross-disciplinary research focused on the development of effective nanostructure-based formulations for precise and accurate disease diagnosis / monitoring, therapy and theranostics.

> **A European patent application was filed related to a versatile functionalisation strategy of magnetic carriers for specific *in vivo* tumour targeting, triggered with magnetic hyperthermia.**

The use of superparamagnetic nanoparticles (SPIONs) and lipid matrices enables the integration of imaging and controlled drug delivery for the development of theranostic probes. Within the NANOTHER project, a detailed systematic variation of different key factors highlighted the crucial role of surfactant concentration on the final performance of the magnetic nanocomposite, namely: Fe content, surfactant concentration and magnetic wax nanocarriers concentration and number. This resulted to be even more relevant that the magnetic loading itself. In general, the group discovered that the multiplex correlation between these key factors determines the potential intra- and inter-particle dipole-dipole magnetic interactions, which might be playing a major role in the final magnetic wax formulation functional performance.

To read the article: https://doi.org/10.1021/acsanm.2c03537



TEM image of magnetic hybrid theranostic nanocomposites.

Research lines:

- Theranostic probes
- Animal free validation platforms

Nanosafety

The group works on developing methods to assess the safety and toxicity of nanomaterials, ranging from the evaluation of possible effects on humans to the impact on the environment. To achieve this, they have four lines of action:

1) organ-on-a-chip;

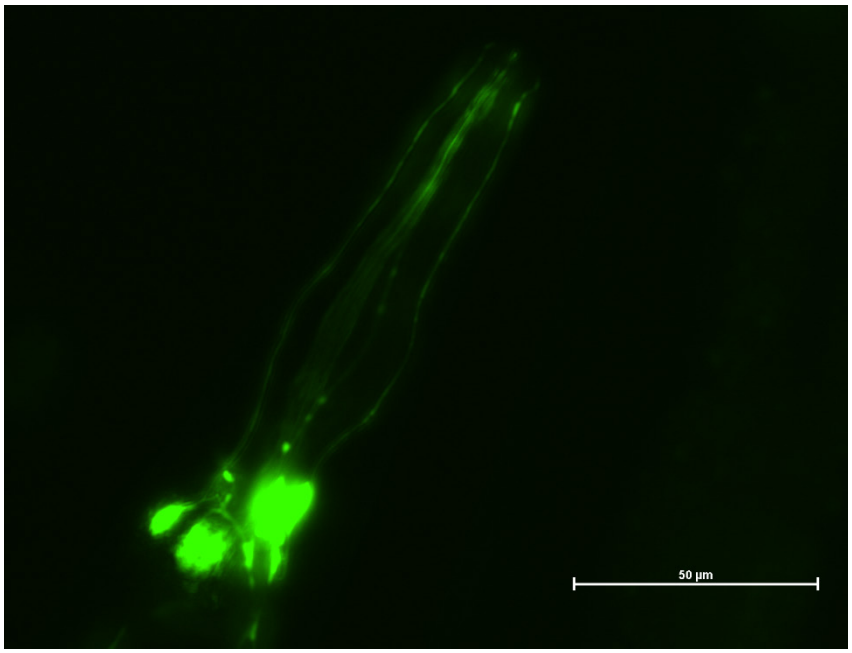
2) genetic and epigenetic effects using in vitro and bridging *in vivo/in vitro* models;

3) nanotoxicology and immuno nanotoxicology;

4) *in silico* methods with emphasis in cheminformatics, QSAR, QSPR, and QSTR modelling.

> **As coordinators, the group was granted two European Projects: LEARN, with an overall budget of nearly 8 million euros, and iCare, with an overall budget of 3 million euros.**

The use of *C. elegans* was standardised as a biomonitor to evaluate particulate matter in relation to alterations in development and neurological effects. This methodology bridges *in vivo/in vitro* models, useful for genetic and epigenetic studies.



Dopaminergic neuron in the head area of *C.elegans.*

Research lines:

- *In vitro* systems to evaluate the effects of nanoparticles and nanomaterials, using organ-on-a-chip technologies and avoiding the use of animals or human samples
- Evaluation of epigenetic patterns of cells exposed to nanoparticles and nanomaterials
- Quick and reliable evaluation of the toxic potential of different nanoparticles and nanomaterials
- Development of *in silico* processes to evaluate nanomaterial properties

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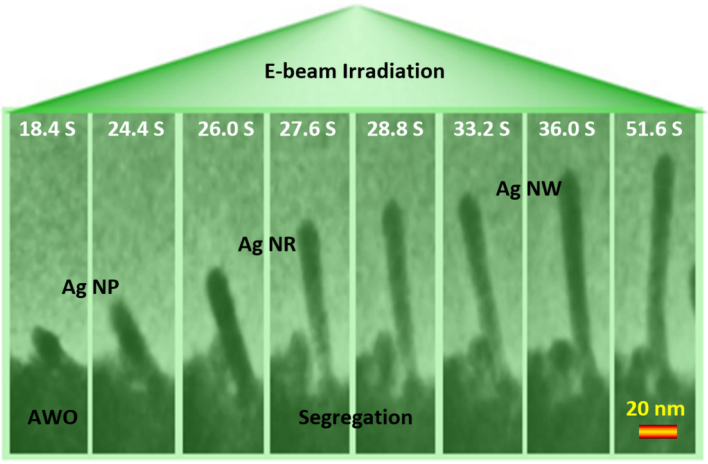
Nanostructured Materials

The group studies fundamental aspects and dynamic phenomena of nanomaterials at the atomic scale. This is achieved by employing state-of-the-art aberration-corrected TEM/STEM imaging and *in situ* experimentation, in combination with image processing, simulations and theoretical calculations.

> **Leonard Francis was recognised as Fellow of the International Association of Advanced Materials (FIAAM) for contributions to 'Surface and Interface Phenomena 2022-2026'.**

The group has been carrying out *in situ* investigations on nucleation and crystallisation dynamics, uncovering the existence of non-classical mechanisms. *In situ* experiments at the atomic scale provided understanding on the formation of the initial crystal nucleus, which can help answer questions about the stability of nanoclusters and the smallest achievable nanocrystal size in synthesis. These investigations help enrich the theory of crystallisation and materials fabrication-related phenomena.

To read the article: https://doi.org/10.1021/acs.chemrev.1c01067



Fabrication of Ag Nanowires by Electron Beam Irradiation within the TEM.

Research lines:

- Metal nanoparticles and clusters
- Novel phases: 1D and 2D materials
- *In situ* TEM

Natural and Artificial Photonic Structures and Devices

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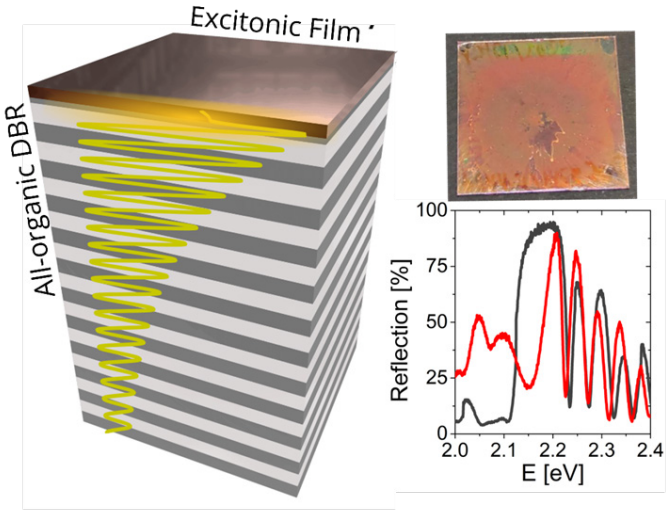
The group is focused in developing sustainable photonic nanomaterials that can substitute current paradigms in photonic technologies. Their study aims at natural photonic systems as either biotic photonic nanomaterials or as bioinspiration. A strong focus of the group is set on the growth and extraction of biotic nanomaterials whose optical properties can be competitive with synthetic technologies to provide a green and sustainable source of advanced materials for photonic applications. The group is also developing nanomaterials inspired by the light-harvesting strategies of photosynthesis in plants and algae to tailor absorption and energy transport, for more efficiently and adaptive energy harvesting and storage.

> **The NASCADIA project kicked-off this year. The aim is to modify and extract the nanoporous silica from diatom microalgae to achieve advanced photonic devices from natural sources.**

The group demonstrated that multilayer nanostructures formed only by organic materials inspired by nature enables exotic optical properties. In collaboration with international teams, they demonstrated properties such as broadband tuneable strong reflectance, slow light absorption enhancement and tailored photo-luminescence in the full visible spectrum. Moreover, this complex optical response is tuneable, paving the way towards the development of active devices based on photonic structures made of all-polymer and near-zero index materials.

To read the article: https://doi.org/10.1515/nanoph-2022-0419



All-organic photonic structure supporting Tamm optical states. Light is efficiently confined at the interface between two substructures, an excitonic layer and an all-organic distributed Bragg Reflector (DBR)

Research lines:

- Natural materials for advanced photonic applications
- Biomimetic photonics for substitution of raw-critical materials in quantum technologies and energy harvesting
- Integration of atomically thin materials in photonic devices

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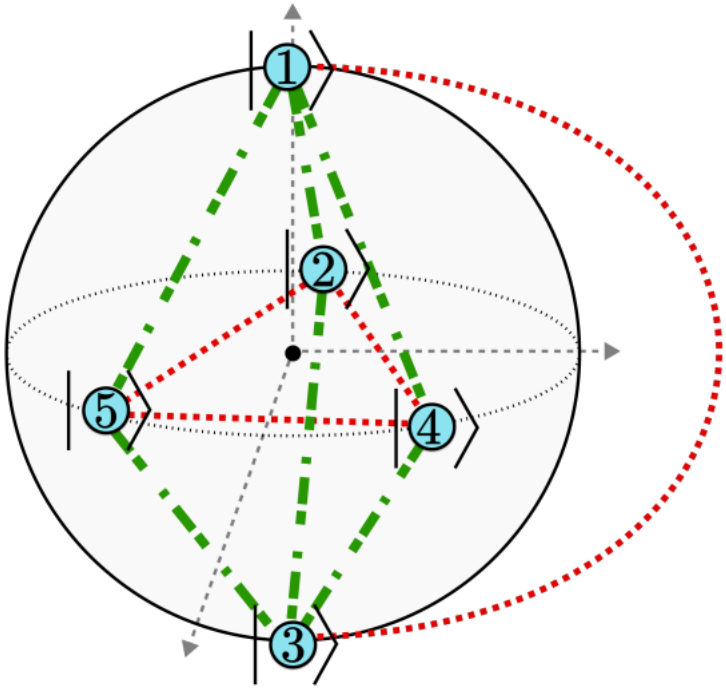
Quantum and Linear-Optical Computation

Quantum information science has the potential to revolutionise information processing, in the form of dramatically faster quantum algorithms and novel protocols for cryptography, metrology, and sensing. The group explores the features of quantum theory that enable advantage in quantum information processing tasks, in particular, those present in photonic implementations of quantum computers. There is not a single way to harness these quantum effects, so studying different models of quantum computation enables us to pinpoint different ways to get quantum systems to work their magic.

> **The group coordinates the Horizon Europe Digital project FoQaCiA – Foundations of quantum computational advantage, which started in 2022 and whose consortium consists of 7 partners in Europe and 4 associate partners in Canada.**

In the preprint "Inequalities witnessing coherence, nonlocality, and contextuality", Ernesto Galvão, Rui Soares Barbosa, and Rafael Wagner proposed a theoretical framework capable of unifying the description of coherence and contextuality, two essential quantum phenomena useful for computation and other quantum information protocols.

To read the article: https://doi.org/10.48550/arXiv.2209.02670



Visualisation of qubit states that can be used to witness coherence in the new proposed framework.

Research lines:

- Foundations of quantum computation
- Photonic quantum computation
- Quantum software engineering

Spintronics

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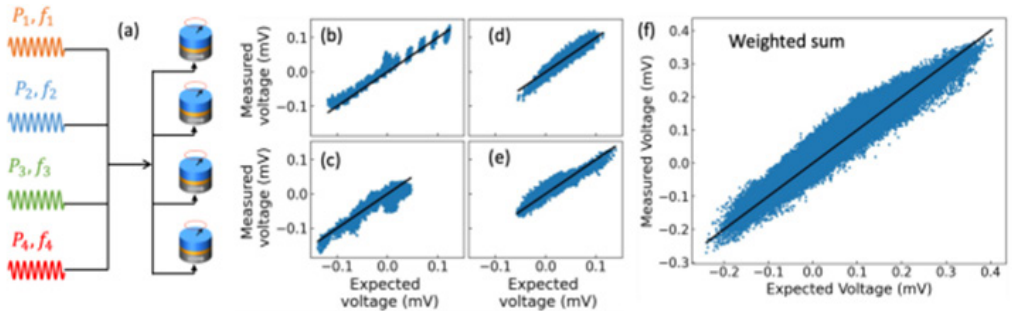
The group explores two research lines, both which rely heavily on the development and exploitation of devices based on magnetic tunnel junctions. The first line concerns the development of ultra-sensitive magnetoresistive sensors. This activity has a wide range of applications (sensing of linear motion, angular motion, electrical currents, magnetic imaging, ultra-weak magnetic fields) for which the group is involved with several industrial partners, including the creation of a pilot line for the production of magnetoresistive sensors at INL and the use of these sensors within novel paradigms of machine condition monitoring.

The second line, having several highly competitive European projects, concerns spin dynamics and spin transfer torque nano-oscillators for future and emerging technologies. Spintronic nano-oscillators are extremely versatile DC->RF and RF->DC transducers which are being proposed as key building blocks for novel energy harvesting nano-devices, ultra-low power IoT Communication systems and new disruptive paradigms for computation and information processing.

With experimental data from magnetic tunnel junctions fabricated at INL, collaborators at the CNRS-Thales joint laboratory in Palaiseau, through the FET-Open RadioSpin Project, demonstrated the classification of RF signals, which is a key step for embedded radiofrequency artificial intelligence at low energy cost. This result was achieved by leveraging the intrinsic dynamics of magnetic tunnel junctions to process multiple analogue RF inputs in parallel and perform synaptic operations. The experimental results were used to perform RF signal classification with a simulated neural network, which was trained and then benchmarked with respect to a conventional software-based network.

To read the article: https://doi.org/10.48550/arXiv.2211.01131



Schematic of each MTJ receiving four RF inputs. (b-c-d-e) Measured voltage (dots) versus expected voltage (solid line). For each plot, all combinations of input powers (from 1 to 11 μW by 2 μW steps) and weights values where measured. (f) Measured voltage (dots) versus expected voltage (solid line) for the sum. All combination of the four sets of powers and weights were measured.

Research lines:

- Magnetoresistive sensors
- Spin dynamics and spin transfer torque nano-oscillators

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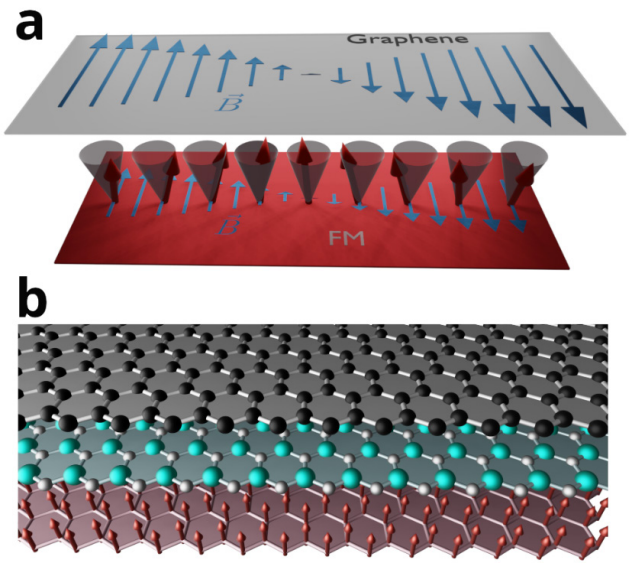
Theory of Quantum Nanostructures

Two fundamental questions are addressed by this group. One addresses the study on how to design matter with atomic-scale precision, to promote the emergence of non-trivial quantum behaviour, such as quantum entanglement and topological states. The other question deals on how to exploit non-trivial quantum behaviour for applications in quantum simulation and quantum sensing. Systems of interest include two-dimensional materials, open-shell nanographenes, and individual magnetic atoms on surfaces. The group uses a variety of tools to study these quantum systems, including the development of quantum algorithms to model correlated systems using quantum computers.

> **Ricardo Ortiz Cano, former member of our group, rreceived the Award *Ex-aequo* to the Best Doctoral Thesis in Condensed Matter theory from GEFES, the Condensed Matter Physics Division of the Spanish Royal Physics Society.**

The group predicted a new type of quantum excitation, composed of a magnon hosted by a ferromagnetic two-dimensional crystal and a plasmon hosted by a graphene layer placed up to several microns away. This new excitation can be leveraged to carry out optically-detected magnetic resonance of ferromagnetic monolayers, a feat that cannot be accomplished with standard methods.

To read the article: https://doi.org/10.48550/arXiv.2211.08949



Schematic depiction of the heterostructure where strong plasmon-magnon coupling is predicted to occur. a) Artistic rendition of the plasmon magnetic field, that emanates from the graphene layer and reaches the magnetic layer, and the precession of the spins in a magnon state, with the same wave vector than the plasmon, in the magnetic layer. b) Scheme of the structure that would display the effect, including a graphene monolayer, a boron nitride decoupling layer and the magnetic monolayer. The plasmon-magnon coupling is still large for decoupling layers as thick as 5 microns.

Research lines:

- Emergent electronic properties in Van der Waals heterostructures
- Atom-by-atom design of quantum states
- Quantum computing for quantum simulation

Ultrafast Bio- and Nanophotonics

The group conducts research on light-matter interactions and control, focusing on three main areas:

i) Advanced Bioimaging and Sensing, where nanofunctionalised surfaces and particles with ultrafast laser technology are used to reach new imaging and sensing regimes in terms of resolution and multiparameter functional imaging, collaborating with researchers and innovators to apply novel techniques for novel therapeutics or improved diagnostic tools;

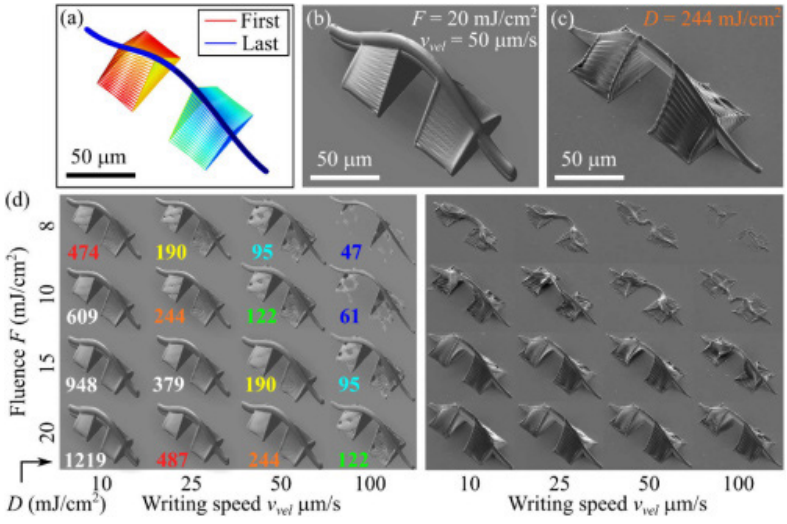
ii) Quantum Photonics, in which the group aims to understand and deploy the emission of single quantum emitters in 2D materials or in 3D crystals which may play a key role if properly integrated into photonic controllable platforms;

iii) Photonic Integrated Devices, where the group aims to develop photonic integrated chips and advanced characterization tools to help address the challenges of new paradigms in computation and other key enabling nanotechnologies.

> **Ricardo Miguel Ribeiro Adão, first PhD candidate of the group, received his PhD degree with summa cum laude distinction, in frame of the Photonics Laser and Vision programme from the University of Vigo.**

Mastering of precise fabrication of polymer in 3D and 2D was successfully demonstrated and exploited in various new application areas including 3D waveguides, achievable via two-photon polymerization (TPP)-based micro-printing. Fabricated 3D waveguides show optical transmission properties in agreement with simulations, demonstrating that the developed morphology prediction methodology is beneficial for the development of versatile on-chip and potentially inter-chip photonic interconnect technology.

To read the article: https://doi.org/10.1364/OE.449641



Design, morphological simulation, and fabrication of parameterised waveguides with hollow support structures via Two-Photon Polymerization (TPP) 3D microprinting.

Research lines:

- Advanced bioimaging and sensing
- Photonic integrated devices
- Quantum photonics-enhanced technologies

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Tânia Rebelo

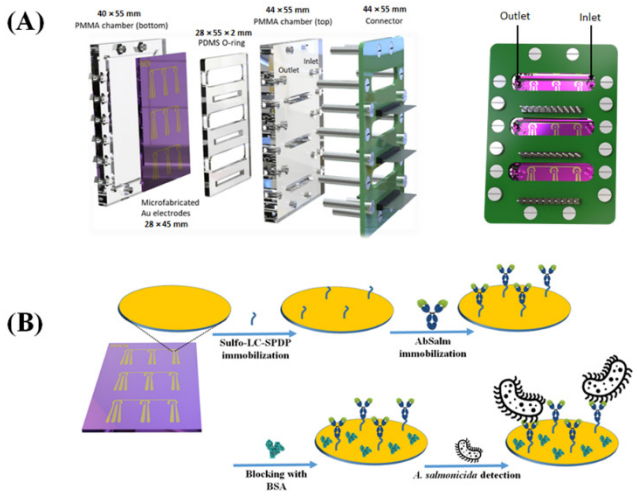
Water Quality

The group develops portable and automated measuring devices for the detection and quantification of contaminants or hazardous compounds in water. To this aim, electrochemical and Raman-based sensors are used, with tailored selective molecules and materials; molecularly imprinted polymers and covalent organic frameworks. The group also evaluates the risks of the release of nanomaterials in the aquatic environment studying nanomaterials fate, transformation, ecotoxicity and bioaccumulation.

> **NANOCULTURE, an Atlantic Area InterReg project that has been running since May 2019, finished in October 2022. This interdisciplinary consortium with partners from Spain, Portugal, Ireland, United Kingdom and France had its final event at INL on the 22nd of September with the participation of highly relevant actors from the food and nanosafety field.**

We recently presented a novel portable label-free ultrasensitive electrochemical immunosensor for *Aeromonas salmonicida* detection in seawater. The device, designed and fabricated at INL in collaboration with the Technology and Systems Engineering groups, consists of a fluidic integrated electrochemical-cell-chip with independent chambers enclosing three electrochemical cells. This technology supports the use of low-cost and portable instrumentation that concedes the ultrasensitive, simple, and fast quantification of the *A. salmonicida*. To the best of our knowledge, this is the first portable sensing system for the detection of *A. salmonicida* in seawater samples, which provides a promising online monitoring platform for the detection of this bacterium in aquaculture facilities.

To read the article: https://doi.org/10.1007/s00216-022-04219-9



3D illustration of the integrated electrochemical-cell-chip (ECC). (A) The ECC consist on an array of nine microfabricated electrochemical cells inside a PMMA case (top and bottom parts) and a PDMS O-ring on top of the gold electrodes, which defines the three chambers. The PMMA top part has holes for the insertion of the inlet and outlet tubing on the chambers, and an opening for the spring-loaded pins connected to the sensors, welded in the connector. (B) Schematic illustration of the stewise fabrication of the immunosensor.

Research lines:

- Portable and unassisted detection systems for water contaminants
- Econanosafety – sensors for nanoparticles, econanotoxicity, and nanomaterials fate and bioaccumulation

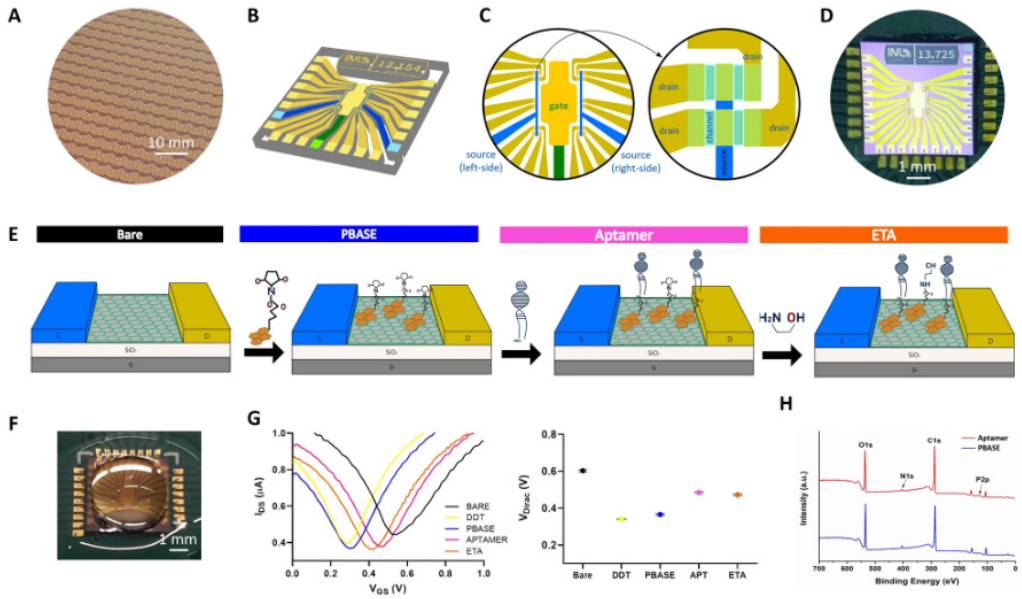
2D Materials and Devices

The group focuses on 2D material growth, transfer, and chip fabrication, using cleanroom technology. Sensors are developed based on functionalised chemical vapour deposition (CVD) single-layer graphene liquid-gate transistors for biosensing devices with electrical transduction. They also develop packaging solutions for device control and readout electronics, from rigid to flexible devices. These 2D materials have been applied to inks, pastes and slurries, which can be used to fabricate flexible devices at a low cost in electromagnetic shielding, membranes for efficient liquid filtration, gas sensors, and energy harvesters.

> **The group had an accepted patent, jointly with University of Minho, CSIC from Spain (Consejo Superior de Investigaciones Científicas) and the National Institute of Technical Aerospace from Portugal, entitled "Biosensor for the detection of hepatitis C virus". The invented biosensor consists of a graphene multi-transistor chip covalently functionalised with an aptamer.**

In collaboration with the School of Medicine of the University of Minho, dopamine detection was achieved in a record-low concentration (attomolar) in a Parkinson's disease animal model, and the dopamine-depleted brain homogenates from reserpine-treated animals. Dopamine is an essential neurotransmitter that underlies several brain disorders.

To read the article: https://doi.org/10.1186/s12951-022-01695-0



Graphene aptasensor multitransistor arrays (gMTAs) for dopamine detection. (E) Schematic of graphene biofunctionalization process for each EG–gFET in the gMTAs. (F) Photograph of a gMTA with a phosphate-buffered saline (PBS) droplet on top of the sensor area. (G) Representative transfer curves from one EG–gFET as measured in 1 × PBS after each biofunctionalization step (left). Average value of the charge neutrality point (VDIRAC) after each functionalisation step. (H) X-ray Photoelectron Spectroscopy (XPS) survey for graphene samples with PBASE (blue) and PBASE + aptamer (red)

Research lines:

- Development and cleanroom fabrication of graphene biosensing chips, including the control electronics
- Advanced processing of 2D materials for technological applications, including flexible electronics
- Cost-effective radio-frequency devices based on graphene
- Single-photon emitters for quantum optical technologies

Group Leader
Pedro Alpuim

Staff Researchers
Andrea Capasso
Jérôme Borme

Research Fellows
João Fernandes
Siva Nemala

Research Engineer
Rodrigo Wrege

PhD Candidates
Ivo Colmiais
Mafalda Abrantes
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Telma Domingues
Vitor Silva

Advanced Students
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Gabriel Moreira
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Hugo Vieira
Sara Ribeiro
Tiago Pereira
Vicente Lopes

Associates
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Gabriel Ferreira
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João Rodrigues
Laís Lopes
Fátima Cerqueira

Group Leader
João Piteira

Research Fellows
Accel Abarca
Mitesh Parmar
Sigit Yuwono

Research Engineers
Álvaro Geraldes
António Leite
Carlos Marques
David Araújo
José Fernández-Ahúja
Roberto Laranjeira
Thiago Fernandes

Advanced Student
Francisco Barreira

Associate
Rui Machado

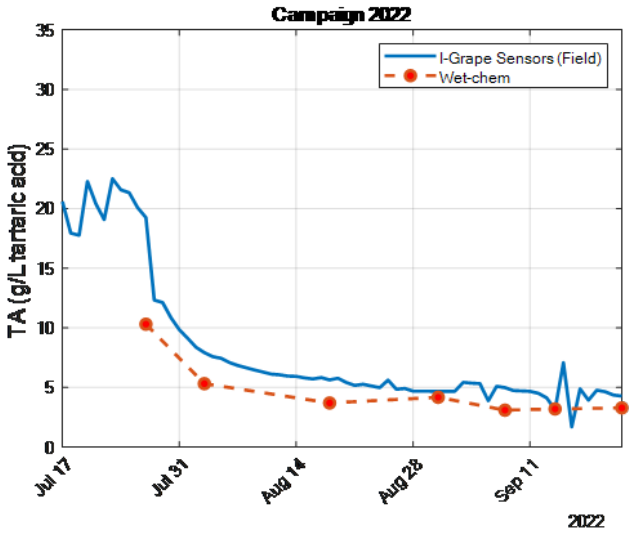
Systems Engineering

The focus of this group is to bring nanotechnology developed at INL into form-factors compatible with applications in the areas of ICT, health, agri-food and environment. These applications demand a high level of miniaturisation and integration of sensors and readout electronics. These can only be achieved via custom-designed microelectronics solutions, in particular with CMOS technologies that enable both high-performance and cost-effective mainstream adoption for such devices. The group focuses on system integration of advanced sensing and actuating technologies, while optimising the integration of analogue mixed-signal conditioning, data acquisition and processing functions into "smart" system-on-chip (SoC) or System-in-Package (SiP) hardware devices.

> **The i-GRAPE Project, represented by INL and SOGRAPE at the 19th edition of the COTEC Portugal Innovation Summit, was recognised with the "Innovation in XPERIENCE 4.0 Ecosystem" Award, under the theme "Real-time monitoring of production and maturation conditions".**

The i-GRAPE project coordinated by INL (Nanodevices and Systems Engineering groups) and with the participation of Sogrape, INESC-MN, UNIMI, U. Fribourg, and Automation SRL, was concluded in August 2022 with a workshop and field demo of the developed technologies. The final prototype is a wireless microspectrometre able to acquire and process real-time information on grape maturation parameters for harvesting prediction.

To read the article: https://i-grape.eu/



The figure shows the total acidity extracted continuously from the iGRAPE microspectrometer IoT device, from July 17th to the harvest date, and the wet chemistry results obtained from discrete sampling.

Engineering topics:

- Advanced CMOS hybrid devices
- Smart system integration
- Ultra-low power and autonomous wireless sensor networks

Technology Engineering

Group Leader
Marco Martins

Research Engineers
Adriano Pedro
Duarte da Mota
Ensieh Iranmehr
Fábio Martins
François Burdin
Jaymin Patel
João Moura
Luis Paula
Miguel Ferreira
Victor Joco

The group is a cohesive, multifaceted engineering team that promotes INL's core R&D&I, particularly in the area of system engineering. It aims to expand the installed capacities for an interdisciplinary approach to transform concepts into high-quality nanotechnology-based products and services.

> **The multidisciplinary team is composed of engineers from different areas, namely mechanical, electronic, computer engineering and physics, working closely together with researchers to enable a faster and more effective knowledge transfer.**

The group concluded several prototypes and replicas for:

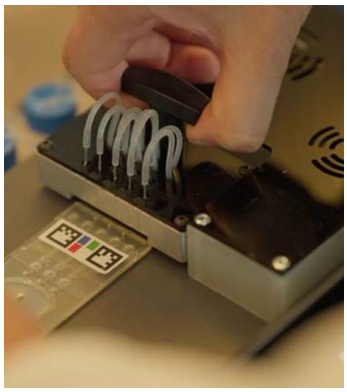
a) an automated system for total microcystin-LR quantification in freshwater (in collaboration with the Water Quality Group);

b) an integrated micro total analysis system for DNA/RNA (in collaboration with the Food Quality and Safety Group);

c) a data acquisition platform for magnetoresistive sensors for applications within Industrial Tool Condition Monitoring (in collaboration with the Spintronics Group);

d) a portable detection system for Aeromonas salmonicida in seawater aquaculture systems (in collaboration with the Water Quality Group);

e) a lamp-on-a-disk system employing advanced heating methods and enhanced computer vision for colourimetric and/or fluorescent detection (in collaboration with the Food Quality and Safety Group).

(a)  (b)  (d) 

Engineering topics:

- Mechanical engineering
- Artificial intelligence and computer vision
- Computer engineering
- Electronic engineering

06. Research and Technology Advisory Committee

RTAC: Research and Technology Advisory Committee

The RTAC is a committee that gathers internationally-renowned scientific experts from various fields in which INL has research activity. Their mission is to assess INL's scientific programmes and policy to provide an external advising view of the research and technology efforts being performed at INL. Its role includes the review of the performance of each of INLs Research and Technology Programmes and Research Groups. Members of the RTAC are meant to share their experience and knowledge in their own research areas and provide guidance to INL with a fresh perspective.

In 2022, the RTAC members participated on a 3-day review of the achievements and changes of the INL programmes implemented since the last meeting in June 2021. The meeting took place at INL from the 11th to the 13th of April 2022 in the form of laboratory visits and discussions with the staff, together with meetings with the different cluster leaders. The RTAC members fully enjoyed the face-to-face meetings and discussions as well as the demonstration of the projects and experimental work being held. They appreciated the effort to put into practice the recommendations made after the RTAC meeting in June 2021 and the progress made along those lines.

Their conclusions highlighted that the INL evolution and development are very good and continue to be so despite the past pandemic crisis. They encouraged the teams to keep the same enthusiasm and proactivity. Regarding improvement recommendations, they alerted that INL should focus on less topics and strategically select those in which the INL infrastructure and multidisciplinarity can have a strong impact. They also recommended to reinforce the role of the six RTI clusters in project streamlining and strategic positioning. Strategic positioning was further emphasised, ensuring the integration of projects into the respective programmes in relation to the international crisis, in particular in the field of batteries. Their conclusions also noted that, although INL has a good gender balance in the overall number of its members, the balance is not maintained in the higher levels, as for example in the number of women group leaders or women in high management positions. They also encouraged INL to strive to increase their visibility as a centre of excellence on the world stage. They recognised INL's evolution in the last 18 months as impressive, and even more when taking into account the restrictions and the complicated situation faced due to the COVID-19 pandemic.

François Rossi
Joint Research Centre, The Netherlands - Chair

Maria José Alonso Fernandez
CIMUS Research Institute, Santiago de Compostela, Spain

Pedro Alvarez
Rice University, US

Juergen Brugger
EPFL, Lausanne, Switzerland

Vincent Cros
CNRS/Thales Joint Lab, Palaiseau France

Chris Elliott
IGFS, Queen's University, Belfast UK

Alke Fink
University of Fribourg, Switzerland

James Gimzewski
UCLA, US

Laura M. Lechuga
ICN2, Barcelona, Spain

Nuno Sousa
University of Minho, Braga, Portugal

Ayodhya Nath Tiwari
EMPA, Switzerland

Maria Varela del Arco
Complutense University of Madrid, Spain

Manuel Martin-Lomas
CIC Biomagune, San Sebastian, Spain

07.
Research Core Facilities

Research Core Facilities

Research, Development, and Innovation are supported by the Research Core Facilities of INL, a centralised infrastructure that provides access to advanced equipment, techniques, and expertise. It operates as an open-access facility and offers INL Research Groups and researchers from academia and the industrial sector a portfolio of services ranging from design to fabrication and characterisation. It is composed by the Micro and Nanofabrication (MNF), the Advanced Electron Microscopy, Imaging and Spectroscopy (AEMIS), the Nanophotonics & Bioimaging (NBI) and the X-Ray Diffraction (XRD) facilities.

The key activity is to provide technology services that enable rapid prototyping, small series production and advanced characterisation. In the years to come, the facilities will continue to direct the efforts towards increasing further the volume and impact of services.

Besides defining a diversified portfolio of services, an ecosystem of key users is being fostered by focusing on international promotion, market expansion and segmentation and the integration of our facilities in strategic infrastructure networks.

Upgrading and renewing core facilities to keep up with the future challenges is also a priority for INL. To this end, an investment plan for the next decade is being designed considering the current state-of-the-art and the depreciation and obsolescence of current assets.

Chief Operations Officer
Margaret Costa

Head of Facility
Enrique Carbó

Facility Manager
Alec LaGrow
Helder Fonseca
José Rodrigues
Mariana Carvalho
Oleksandr Bondarchuk
Oliver Schraidt

Research Engineers
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Andrea Gouvêa
Joana Santos
José Fernandes
Mohamed Belmoubarik
Paulo Coelho
Sai Krishna
Tiago Oliveira

Staff Researcher
Carlos Calaza

Cleanroom Technicians
Ana Araújo
Sérgio Martins

User Ecosystem

Develop specific business models to foster an ecosystem of external users

Service Portfolio

Diversify service portfolio to showcase INL capabilities

Upgrade Facilities

Analyze current state-of-the-art and market to upgrade key equipment

Facility	Usage Hours	# of Users	# of serviced International Groups	# of Licenses	External users/ services
Micro and Nanofabrication	22 745	96	18	808	241 (number of runsheets)
AEMIS	6 308	103	17	92	94
Nanophotonics & Bioimaging	11 664	205	20	246	-
X-Ray	1 639	52	12	21	8

A good example of the institutional activities throughout 2021–2022 are projects that provide access to advanced research infrastructure (RI) for users from across Europe and beyond. INL is a partner in two such major projects that received funding from the H2020 framework.

ASCENT+ project is focused on providing access for users working in the area of nanoelectronics and on related materials and devices. In ASCENT+, INL is one of five access providers, which also include several Fraunhofer institutes, IMEC, CEA-Leti, and Tyndall. Work on about five ASCENT+ user projects has been performed in 2022.

NFFA-Europe | Pilot (NEP) project has a broader scope than that of ASCENT+, providing access for users working in nanoscience and nanotechnology. In NEP, INL is one of about 20 access providers that offer access to more than 180 techniques. Work on one NEP user project has been performed in 2022. INL also hosted a NEP Training School in September of 2022 for 16 external participants and lecturers.

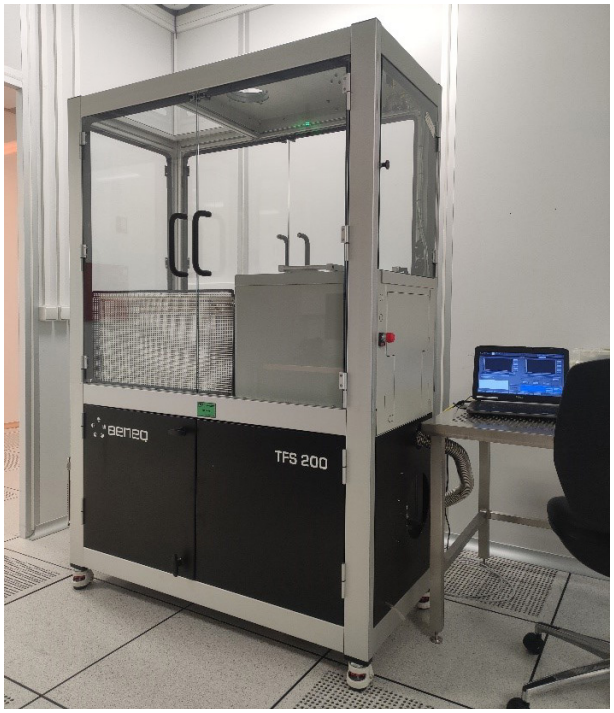
In both of these user-access projects, users can be from academia or industry and projects vary from fundamental research to applied research and development. INL offers access to the cleanroom fabrication and nanocharacterisation at AEMIS facility in both projects.

Micro and Nanofabrication (MNF)

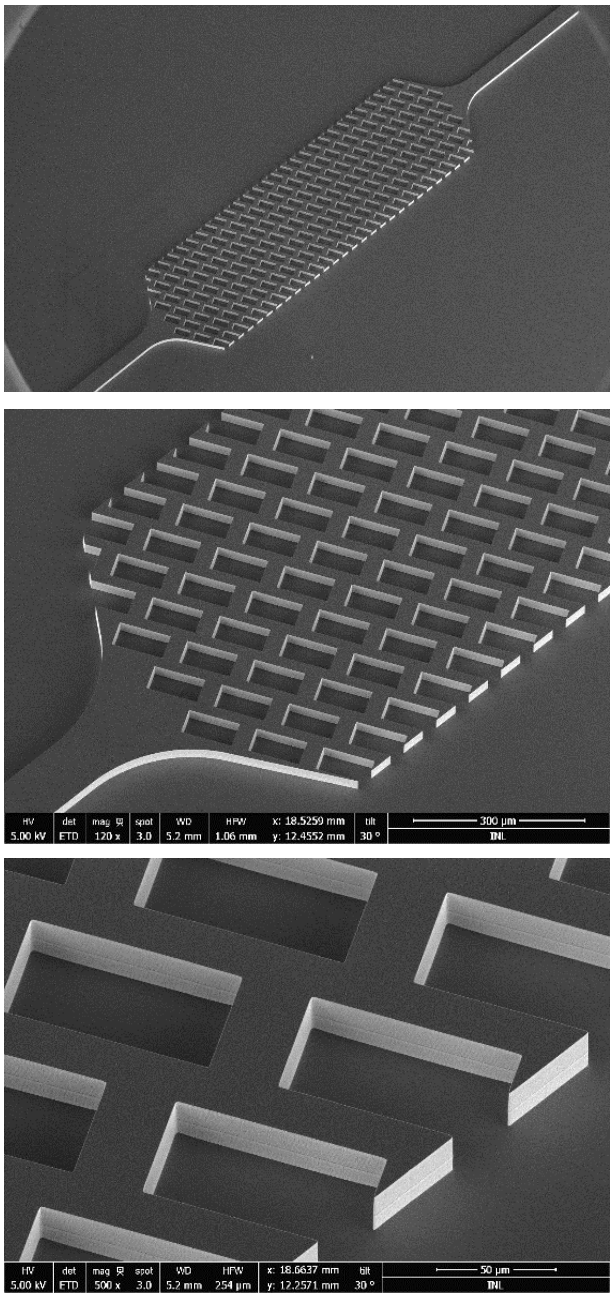
In 2022, the Micro and Nanofabrication Facility reinforced its capabilities in advanced chip packaging with the acquisition of a Pick-and-Place system. It has also complemented existing techniques with the recommissioning of the Atomic-Layer Deposition System and the upgrade of the Ion Milling system as well as increasing redundancy with new optical microscopes and a new Plasma Asher system.

In terms of activity, the MNF Facility strengthened on-going collaborations with industrial partners and enlarged its portfolio of customers. Currently, a balance has been reached between the internal usage and the usage for external services.

In 2022, invoicing €1.9M was achieved from cleanroom services, covering operational costs.



BENEQ Atomic Layer Deposition system recommissioned and installed in the cleanroom



Silicon Master for microfluidic channel replication in PDMS.

Achievements & Milestones

This year the main achievements in terms of cleanroom process development included the qualification of new recipes for High Aspect Ratio Deep Silicon Etch and High-topography Resist Lift-Off. In terms of revenue, a 50% income increase arose from Commissioned Services, including new collaborations in the field of Si masters for nanophotonic applications and microfluidic devices and new industrial partnerships that increased customer retention with the kick-off of new projects. The customer satisfaction continues on a positive trend, enforced by the continuous improvement based on two ISO certifications: ISO 9001 & NP4457 (Surveillance Audit in May) and ISO 13485 (Surveillance Audit in December). This year, within the context of INL's partnership with the University of Minho, the MNF Facility hosted micro and nanofabrication practical classes from the Physics Engineering Programme.

New Equipment

- Plasma Asher
- Spin Rinse dryer
- Atomic-layer deposition (recommissioning and relocation to the cleanroom)
- 2 optical microscopes
- Pick-and-Place system
- Upgrade RIBE module from Ion Milling with High Resolution Spectrometre

Advanced Electron Microscopy, Imaging and Spectroscopy (AEMIS)

In 2022, the AEMIS Facility was strengthened in the Life Science area by acquiring the first dedicated Cryo-Electron Microscope (EM) in Portugal, which will act as the central node of the National Advanced Electron Microscopy Network for Health and Life Sciences. Additionally, AEMIS has hired a new research engineer in this field to further support the new dedicated Cryo-EM, as well as other electron microscopes which have been so far oriented towards Material Science services.

Recently purchased Glacios 200 kV Cryo-TEM for Health and Life Sciences

Achievements & Milestones

Among the achievements from 2022, the main highlight was the kick-off and coordination of the National Advanced Electron Microscopy Network for Health and Life Sciences (CryoEM-PT) – Part of the Portuguese Roadmap of Research Infrastructures. The facility also successfully completed the surveillance audit for the ISO 9001 & NP4457. Additionally, several open training sessions were provided, including the biannual electron microscopy course held this year, aiming to provide theoretical and practical sessions focused on developing a basic understanding of the principles and operation of electron microscopy and spectroscopy techniques (INL, May 16-20). Several other schools were hosted, including the first Nffa.eu Pilot Training School on "Fine-analysis tools for nanocharacterisation", and several other seminars and talks both at INL, online, and abroad.

Equipment acquired

- Dedicated Cryo-TEM: ThermoFisher Scientific Glacios 200 kV.
- Leica Automatic Plunge Freezer EM GP2.
- Air-free transfer TEM holder (ZoNexus)

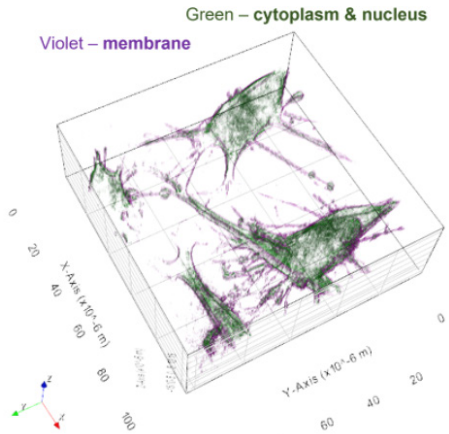
Nanophotonics & Bioimaging (NBI)

In 2022, the Nanophotonics and Bioimaging Facility reinforced its capabilities with the integration of new equipment (NanoSight, Malvern) and the 3D Phase Holotomographic microscope (3D Cell Explorer, Nanolive) . The Woollam M2000 Ellipsometer was transferred to the cleanroom as its use is directed more towards sensitive samples.

a)

b1)

b2)



The NBI facility granted user access to new tools, the (a) NANOSIGHT NS300 from Malvern Panalytical and a (b1) 3D Cell Explorer from Nanolive (b2) shows an example label free image with digitally staining of the refractive index contrast.

Achievements & Milestones

- Active participation in Portuguese Platform of Bioimaging (PPBI) and Red Española de Microscopía Óptica Avanzada (REMOA) network meetings and advanced courses (Salamanca, 23-25/11/22, https://spaom2022.org/), consolidating and evaluating network membership, respectively.
- ISO 9001 & NP4457 surveillance Audit (May 25) – Certification

Courses Offered

- Co-hosted the Day of Light webinar in May 2022 event (https://youtu.be/o1putjq8HTM).

08. Financial Summary

Financial Summary

In 2022, INL achieved a robust financial and operational performance – growing the total income by 10.5% compared to 2021, and delivering operating results, excluding the investment subsidy and before depreciation of €2.7M and net profits after depreciation of €791k.

The RTD-funded programs have increased by 14.2% and the commissioned research by 25.1%, bringing the average funding rate to 74%.

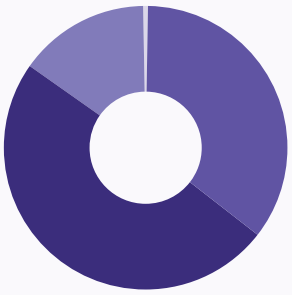
Due to the increment of the average funding rate, the increment of the commissioned research, the robust portfolio of RTD projects, continuous cost control measures, and expanding the digitalization and integration of support processes, INL's operational margin, before the investment subsidy, achieved a positive balance of €2.7M.

A summary of this is included in the table below, followed by a summary of competitive funded projects that started in 2022 with granted funding for the next years to come.

EUR '000

Financial Performance	2019	2020	2021	2022
Income	**17 382**	**15 975**	**18 393**	**20 330**
Member State Contributions	7 000	7 070	7 141	7 214
RTD Programmes	7 621	6 767	8 800	10 048
Services & Industrial RTD	2 761	2 139	2 452	3 068
Expenditure	**(17 540)**	**(15 986)**	**(17 746)**	**(17 626)**
Personnel Costs	(11 337)	(10 528)	(11 083)	(11 841)
Consumables	(2 803)	(2 286)	(2 422)	(2 341)
Services and Other Recurrent Expenses	(2 277)	(2 294)	(3 150)	(2 363)
Maintenance	(1 121)	(878)	(1 091)	(1 082)
Operating Margin	**(157)**	**(11)**	**647**	**2 704**
Investment Subsidy	1 313	799	900	1 760
Depreciations	(5 265)	(5 360)	(4 772)	(3 672)
Net Profit & Loss	**(4 110)**	**(4 572)**	**(3 224)**	**791**
Financial Ratios	**2019**	**2020**	**2021**	**2022**
Total Assets	74 307	70 714	68 216	73 024
Equity	40 723	36 152	32 927	33 719
Debt to Equity ratio	82%	96%	107%	117%
Operating Margin	-1%	0%	4%	13%
Funded Expenses ratio	59%	56%	63%	74%

€ 20.3 MILLION
OPERATING INCOME in 2022



35,5% Member State Contributions

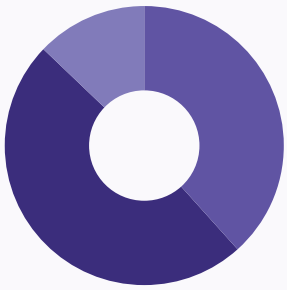
49,4% External grant funding*

14,7% Other external funding**

0,4% Other receipts***

* Excluding investment subsidies.
** Includes income from services to private and public institutions, training courses and conference fees.
*** Includes interest earned and extraordinary incomes.

€ 18,4 MILLION
OPERATING INCOME in 2021



38,8% Member State Contributions

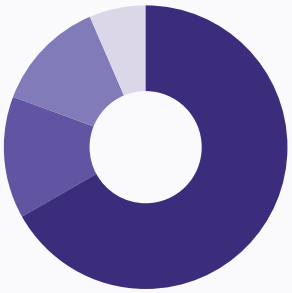
47,8% External grant funding*

13,3% Other external funding**

0,0% Other receipts***

* Excluding investment subsidies
** Includes income from services to private and public institutions, training courses and conference fees.
*** Includes interest earned and extraordinary incomes.

€ 17,6 MILLION
OPERATING EXPENDITURE* in 2022



67,2% Personnel Costs

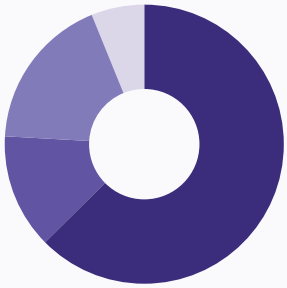
13,3% Consumables

13,4% Services and Other Recurrent Expenses

6,1% Maintenance

* Excluding depreciations.

€ 17,7 MILLION
OPERATING EXPENDITURE* in 2021



62,5% Personnel Costs

13,7% Consumables

17,8% Services and Other Recurrent Expenses

6,2% Maintenance

* Excluding depreciations.

09. Competitive Funded Projects

Competitive Funded Projects

The EU Recovery and Resilience Facility, and its subsequent development at the level of the Member States of INL, is a programme to implement a set of reforms and investments aimed at recovering economic growth after the pandemic. This is an extraordinary programme in which INL participates on various agendas within the Portuguese PRR, with a very relevant impact on regular activity and job creation which will represent a 45% growth of the headcount during the period of the programme.

From an internal perspective, 2022 was a very intense year regarding the coordination of external and internal competitive funding to feed high-risk high-gain ideas that showed the potential to be disruptive. These included continued participation in H2020 and Horizon Europe calls and initiatives, participation in the PRR agendas, collaboration with other institutions, and internal seed grants and focused innovative research projects.

The achievements attained were the result of long-term efforts that started years before. These are possible thanks to the efforts in maintaining our scientific infrastructure and funding acquisition in top shape.

The sections below describe the awarded projects from competitive calls and commissioned research. INL aims to continue engaging in efforts towards funding research, facilitating technology transfer, addressing inequalities of innovation access at all levels, and closing skill gaps.

Total Funding from Competitive Funding in RTD Programmes

The year 2022 was an exceptional one, with the approval at the end of 2022 of INL participation in 16 PRR agendas, totalling around €50M (from 2023 to 2025 or mid 2026). Including the PRR programmes, INL had several projects approved during 2022, amounting to €61.5 million in competitive external funding. These new projects join funds previously awarded and many of them are still running in 2023. The following table summarises approved competitive funds during 2022.

Action Type	Budget	Nº Projects
Individual Fellowships	981,613.72	6
Innovation Actions	51,440,968.30	19
Research & Innovation Actions	7,666,541.75	11
Coordination & Support Actions	1,631,040.00	4
TOTAL	**61,720,163.77**	**40**

Breakdown of Granted Projects per thematic RTI area

INL RTI Clusters	%
Advanced Materials and Computing	5
Clean Energy	24
Foodture	15
Precise Personalised HealthTech	16
Smart Digital NanoSystems	25
Sustainable Environment	15

Breakdown of Horizon 2020/Horizon Europe Granted Projects

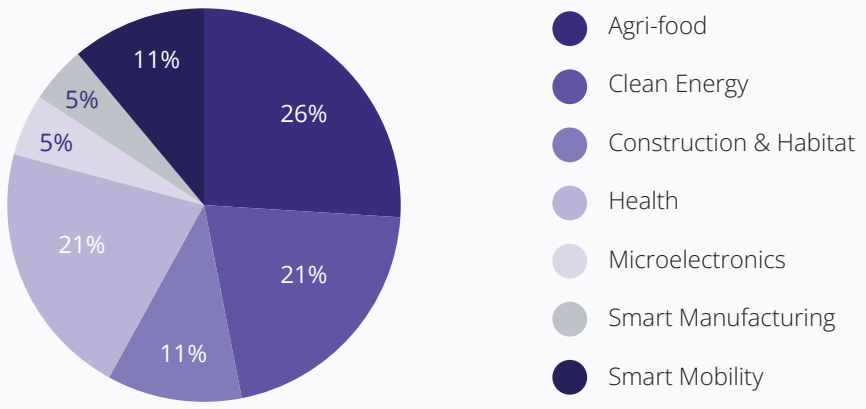
In 2022, we received funding support from the European Commission's Horizon 2020 and Horizon Europe programmes. These are significantly contributing to our overall success, which amounted to €11.2 million, 20 grants, with a 23% success rate.

	#	Budget	INL as Coordinator	INL as Partner	INL as host institution
Individual grants	4	€ 661,830.72	0	0	4
Innovation projects	3	€ 1,392,500.00	0	3	0
Research projects	10	€ 7,566,548.50	5	5	0
Coordination & Support Actions	3	€ 1,569,040.00	2	1	0
Total	**20**	**€ 11,189,919.22**	**7**	**9**	**4**
Success rate:	**23%**				

Breakdown of granted projects with industry

INL aims to play a leading role, at international level, in facilitating and coordinating the implementation of nanotechnology-based research programmes and projects that generate valuable compounded knowledge, products and services for the benefit of industry and society.

To these means, INL was granted 19 projects in 2022, of which 16 are PRR agendas, two are Innovation Actions through the Horizon Europe programmes, and one is an innovation project through EIT - European Institute of Innovation and Technology. These now become part of the total of 60 ongoing granted projects with industry.



10. Commissioned Research Projects

Commissioned Research Projects

The main goal for INL commissioned research services is to ensure that over the next years, INL can reach an equilibrium between privately funded projects, public projects (National and European) and the base funding provided by the member states.

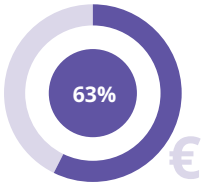
This means that the commissioned research activities will need to grow at a faster pace compared to the evolution of the other sources of income, expecting to reach the €3.5M turnover by the end of 2023. This is expected to keep increasing, namely by new tech transfer agreements that will propel innovation further.

During the year 2022, INL's overall turnover overcame the €3M mark. This was mainly due to the growing engagement from the research groups in private R&D projects and also the outstanding performance from the services provided by the Micro and Nanofabrication Facility, which beat all the budget forecasts. This means that several management decisions leaning INL towards the development of higher TRL technologies are now ensuring an integrated convergence of all research groups, facilities and supporting units in one single mindset oriented towards the targeted markets. The achievements accomplished in 2022 provide the momentum that will keep driving us towards growing our commissioned research services over the coming years.

Commercial Activities Highlights

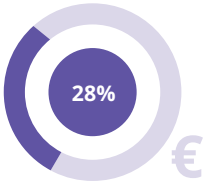
	2021 (Executed)	2022 (Executed)
Domestic	€ 640K	€ 1.129K
International	€ 1.814K	€ 1.923K
TOTAL	**€ 2.454K**	**€ 3.052K**

Turnover distribution by Facilities and Research Groups



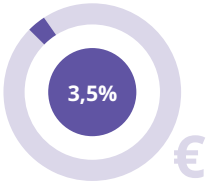
Cleanroom

€ 1919K



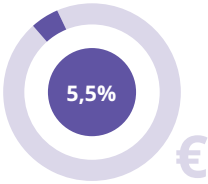
Research Groups

€ 858K



AEMIS

€ 106K



Other Services

€ 167K

11. Intellectual Property & Knowledge Management

Intellectual Property & Knowledge Management

A strong IP portfolio is an important enabler for bringing nanotechnology solutions to the society and for creating jobs. The INL portfolio comprises patents on core technologies, trademarks protecting the INL brand and design rights covering the appearance of creative works. As an international organisation, INL has a patent filing strategy for international competitiveness. It may start with a Provisional Portuguese Patent, but always goes through European Patent application filing and/or the international (PCT) route for obtaining the option to national patent rights in different countries at 2,5 years after the priority date.

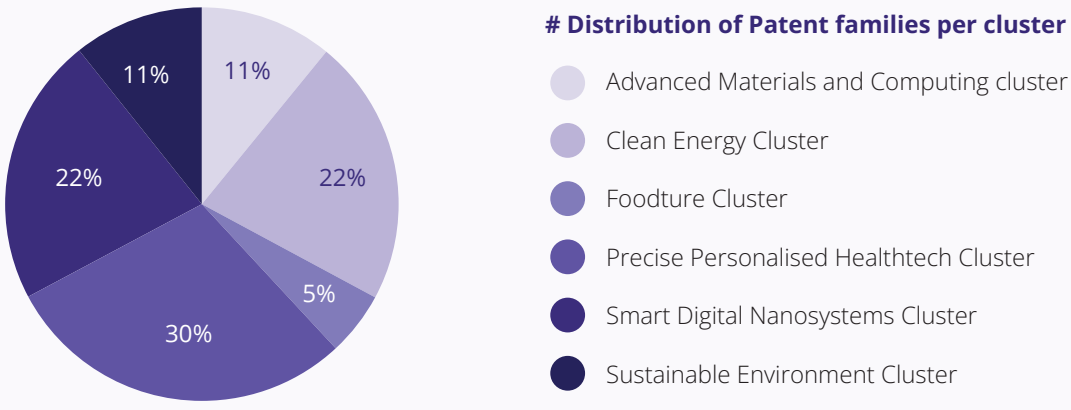
After 10 years of building this IP portfolio, INL generally has:

Invention Disclosures per Year	20
Patent Applications per Year	6 to 8
Joint Applications (with other entities)	50%

The IP Board (a committee which selects the inventions to be protected) filters and selects 30 - 35% of the total inventions to go to patent applications or trade secrets.

The next figure shows the distribution of patent families among the INL RTI Clusters and application fields.

During this year, the most active in patent application were in the Healthtech area followed by Clean Energy and Smart Digital Nanosystems areas.



In 2022, 12 innovation disclosures were registered, 5 new patents were filed, and 2 patents were granted.

During last years, INL has led and participated in several projects (national and international) where the main focus was to boost and promote the entrepreneurial mind-set (through acceleration programs, coaching, mentoring, technical support). The IP exploitation at INL has started mainly through Entrepreneurs and INL spin-out companies (almost 4 INL spin-outs). During 2022, relevant developments took place such as the Spin-out Policy, the establishment of the Spin-Out Advisory Committee (SOAC) as well as the INL Royalty Policy.

12. International Business Advisory Board

IBAB: International Business Advisory Board

Members since 2017
Björn Segerblom (Chairman)
Gerard de Bourbon
Carlos Oliveira
Magnus Ryde
Adam de Sola Pool

Members since 2021
Hans Möller

Members since 2022
Ursula Hultkvist Bengtsson

Alumni Members
Massimo Gentili
Yvonne Mårtensson
António Murta
Beth Topolovsky

The initial focus of the IBAB was to help INL develop deeper commercial relationships and processes to broaden its research base and revenue sources. During the initial years (2017-2019), IBAB was primarily utilised as a sounding board, critic, and inspirer regarding the strategies and operations of INL, as well as for brainstorming sessions to identify industrial focus areas and international corporate customers/partners. In particular, some of the key issues that were discussed and reviewed by IBAB were:

1) expansion of international memberships beyond Portugal and Spain;

2) the subset of nanotechnologies to focus on;

3) expansion of the industrial/commercial footprint.

The main activities of IBAB have been to support the roll-out of the INL 2030 Strategic plan. IBAB members have, in conjunction with INL staff, drilled down in each subject area and assisted in the formulation of both, the industrial target definitions and the expansion of the international base. Two key activities held during 2022 were the Mentorship Programme and the INL RTI Cluster Coaching Programme. Additionally, three IBAB members have been designated as INL Ambassadors in their home regions: Björn Segerblom (Hong Kong), Gerard de Bourbon (EU) and Adam de Sola Pool (Boston, USA).

The Mentorship program is considered by mentees as very useful, with their personal development being the key focus. The IBAB recommends expanding it to other INLers for their future benefit/growth. The Cluster Coaching Programme has also been well received and has further potential into a proposed 3rd phase. In terms of INL's business development capacity, the IBAB noted the need to strengthen this area significantly to better bring INL technologies to the market and society.

IBAB activities terminated by the end of 2022. INL thanks all its members for their valuable contribution.

13. Intergovernmental Relations

Intergovernmental Relations

INL has the objective of promoting and improving INL relations not only with the INL Member States, fostering Iberian cooperation, but also at an international level. The relations with the governments of other countries and entities are essential for the progress and sustainability or INL's activity. With this objective, great effort was invested in increasing INL's international and Iberian footprint. In 2022, the establishment of new institutional relationships with governments, organisations and entities from other countries was promoted through networking activities, direct and inverse missions, and business-to-business meetings, among others, with the aim to set collaboration frameworks, bilateral agreements, as well as other initiatives such as calls financed by the governments own funds, to strengthen the international role of the institute and nurture the different activities that enable INL to bring research and technologies to society.

One of these agreements dealt with the establishment of the Iberian Food Technology (IFT) Lab, which aims to set up a distributed and collaborative research centre of excellence across Spain and Portugal's borders to increase the competitiveness of the Iberian food sector by fostering the incorporation of advanced technology into the market, taking as pillars the valorisation of endogenous natural ingredients and healthy foods as well as the food sustainability in the Iberian Peninsula. This IFT Lab is a committed decision taken during the Viana do Castelo Iberian Summit.

Since 2020, INL was involved in the intergovernmental discussions towards the creation of the Iberian Energy Storage Research Center (CIIAE) in Cáceres, Spain, and currently promoting Iberian cooperation in clean energy research and innovation. At the XXXIII Spain-Portugal Summit (November 2022), dedicated to cooperation in science and innovation, INL was highlighted by both governments as "a relevant structure that in collaboration with the CIIAE will make an essential contribution to the Iberian energy storage strategy".

During 2022 INL also welcomed institutional visits from INL member states representatives as well as other countries representatives: governments, embassy delegations, and regional representatives.

One of the most important events during 2022, was the visit by the Portuguese Prime Minister António Costa and the President of the Government of Spain Pedro Sánchez, accompanied by the respective Minister for Science, Technology and Higher Education, Elvira Fortunato, and Minister for Science and Innovation, Diana Morant.

14. Science Communication & Outreach

Science Communication & Outreach

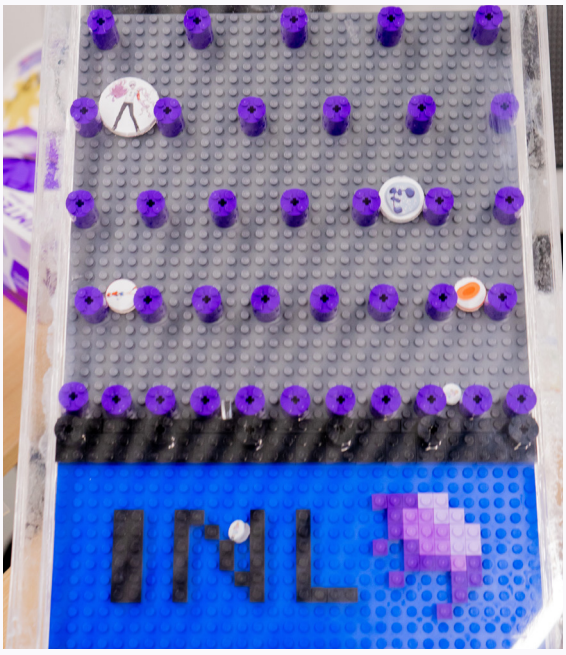
In 2022, INL also dedicated efforts on developing science communication and outreach activities. Communicating our research and sharing scientific knowledge is one of the goals of INL. A few highlights from 2022 can be found below:

Hands-on Demonstrations

Is it possible to use microchips to diagnose cancer?

In this interactive demo we explained how we design and fabricate microchips for medical applications. Cancer cells have very different properties from healthy cells. With the scientific knowledge about the different characteristic of each cell type, it is possible to design personalised micro-chips for cancer diagnostics.

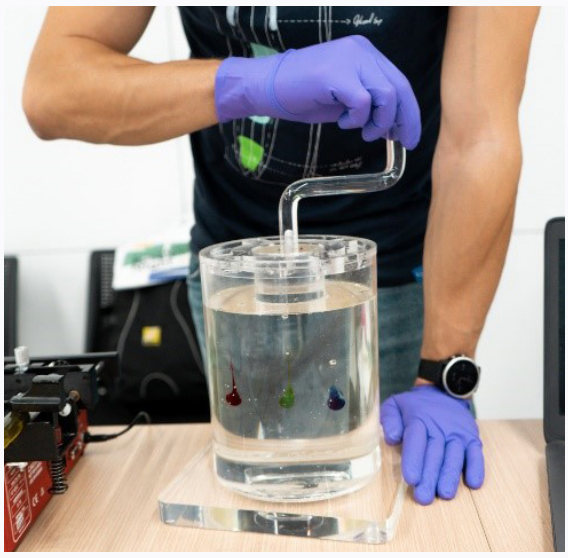
Team: Carlos Honrado, Victor Calero, Adriana Vilaça and Patrícia Rodrigues



Fluidics at different scales: science or magic?

At the micro and nanoscales, fluid viscosity takes over inertia and the flow becomes laminar. This means that fluids will flow in parallel layers without mixing, very much like the slow movement of a flowing glacier. Unlike turbulent flow, laminar flow is linear, predictable, and reversible, allowing us to control it with precision. With this hands-on demonstration, we explore the concept of laminar flow and its multiple applications to health, food and the environment.

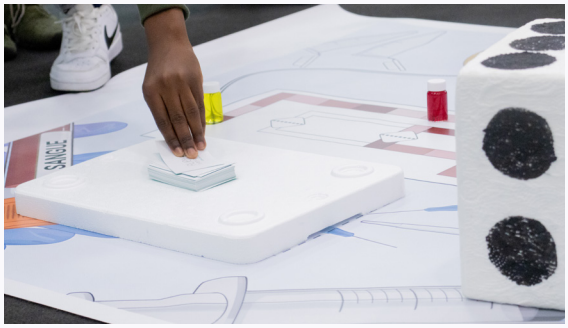
Team: Miguel Xavier, Patrícia Rodrigues, Mafalda Neto, Catarina Gonçalves, Helena Macedo



'What is a liquid biopsy?'

INL and the spin-off RUBYnanomed are working on a diagnostics system which is able to detect early-stage tumours. This fun game was created to provide an interactive learning tool about cancer, liquid biopsy and diagnostic tools.

Team: Adriana Carneiro and Madalena Silva



INL was present at these events to promote science communication and outreach:

European Researchers' Night

'Science for Everyone – Sustainability and Inclusion' was the motto that framed the event in 2022, committed to raise awareness about the role of science in achieving sustainability and inclusion goals among school students and different audiences, while identifying key societal concerns about climate change and sustainable growth and linking them to science-oriented solutions and proposals. Our diverse programme included games, hands-on activities, a photo booth, and the ERN2022 Photo Exhibition.

Team: Laura Rodriguez-Lorenzo, Ana Vieira, Marília Santos, Patricia Taladriz, Miguel Xavier, Catarina Gonçalves, Helena Macedo, Mafalda Neto, Patrícia Rodrigues, Victor Calero, Adriana Vilaça, Andrea Cruzx, Elisabete Fernandes, Teresa Oliveira, Diogo Aguiam, Patrícia Barroso, Mariam Debs, Gina Palha, Catarina Moura

FIC.A – International Science Festival

During 7 days, the mission of FIC.A science festival was to inspire and capture the attention of children and adults, create new audiences for science and use art to communicate exciting science and technology. INL researchers participated in fun demonstrations about nanotechnology and sensors, developed an interactive game for schools, a hands-on workshop about transistors, participated in an informal session to talk about the multicultural community at INL, and there was also a poetry reading gathering with poems written by an INL researcher.

Team: Elisabete Fernandes, Accel Abarca, Adriana Carneiro, Madalena Silva, Luís Soares Barbosa, Catarina Moura

Science and Art

Scale.Travels is an INL initiative launched in 2015 that aims at fostering a multidisciplinary and hybrid approach between science, technology and arts to innovate through creativity in nanotechnology. This residence programme aims at bringing media artists and researchers into convergence, embedded in a real laboratory environment inside INL's unique facilities during a 1- to 2-week period.

'Surviving the impact of raindrops' by Jana Winderen

January 29th - April 30th

This exhibition was a sound installation that resulted from an artistic residency carried out by Jana Winderen with the Water Quality research group at the INL. Composed of eight channels, this installation was based on recordings that the sound artist made under and above the water surface, of fish, crustaceans, aquatic insects, and bats.

Lago Libidinal, by Jonathan Uliel Saldanha

May 12th - August 15th

Developed by Uliel Saldanha with Luís Soares Barbosa from the Quantum and Linear-Optical Computation research group, the installation 'Lago Libidinal' was a multi-scale system that appeared as an extension of the stage piece with the same name. The surface of an artificial lake served as a mirrored interface where a viral ecosystem reveals a lymphatic network of inorganic derivatives that fed on the continuous flow of data referring to stock market fluctuations.

n.d'edit._128_33_Blue_Dot_by Ana Guedes

September 24th - December 31st 2022

'n.d'edit._128_33_Blue_Dot_' was an audiovisual installation by Ana Guedes, where she explored the cultural coordinates and references to a common collective imagination that mirrored the multiple fronts of a moment of crisis on a planetary scale. This was inspired as she accompanied the Integrated Micro and Nanotechnology (IMiNa) research group through the nanomanufacturing processes of new accelerometers with aerospace applications in the collection of gravitational waves data, monitoring models of terrestrial water bodies, and flood and drought patterns resulting from the climate crisis.

Outreach

World Food Day

https://www.youtube.com/watch?v=QpEGO8ktG_g

Highlighting the challenges faced by today's food value chain, INL researchers from the Foodture cluster explained several technologies being developed at INL.

INL scientists engage with students

INL welcomed students from various academic levels, from grade school and high school, all the way to technical college and universities. INL community members also visited various schools, engaging with students while running simple experiments about nanotechnology.

INL scientists engage with society

Special missions were held throughout the year to bring science to schools, cultural centres, and hospitals through the Mission NERD programme, which aims at demystifying science while conveying the power of uniqueness and knowledge sharing to and with all citizens.

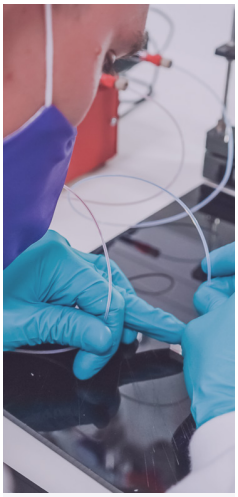
Visit the INL cleanroom

https://www.youtube.com/watch?v=wr-E3eaVfS4&t=47s

A short visit to the INL cleanroom guided by Research Engineer Andrea Gouvêa, explaining the context of microfabrication for the general public.

INL RESEARCH NEWS

Quantum

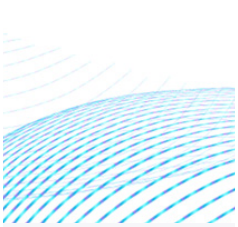


InNPeC

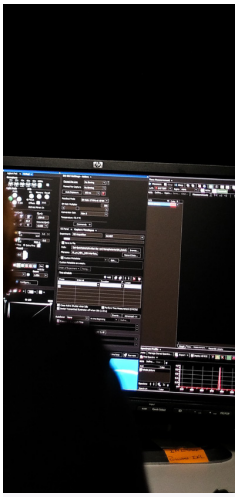
Microdigest

MiconCell

NovaCell



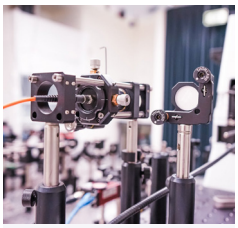
SpinCat



Diamond4Brain

Nanoculture

Marewind

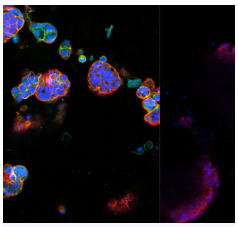


QU-BOSS

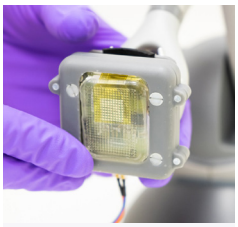
TrustEat

Kesper

Nanobiosensor



Gastric

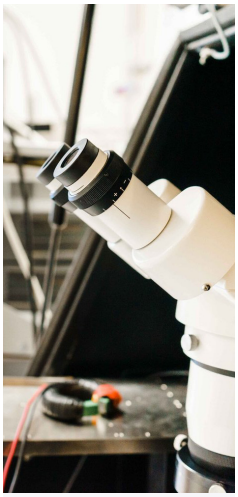


Product in Touch

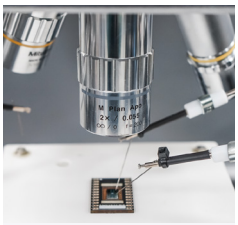
STAR-Sol

3D nanofood

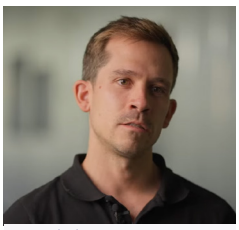
NeuralGrab



SpinAge



Link4Sustainability



Food cluster

Sinfonia

15. INL Community

INL Community

INL stands with the power of community, and that was evident last year with several internal activities that brought employees together.

INL hosted the 1st ESRA - Early-Stage Research Association meeting: a bottom-up initiative led by PhD candidates performing their thesis at INL. Several activities were already organised by ESRA to help early stage researchers work together through their scientific journey and future careers.

The Staff Association gathered for an info session, where it was great to see everyone getting involved and committed to improving life at INL.

An internal research symposium was held, where grand achievements were highlighted, and challenges for the year ahead were discussed. In the end, the members celebrated the occasion with a multicultural potluck lunch powered by INLers.

And since food is a must in our community gatherings, INL made sure it was a constant: there were several Friday Chats where INLers met for a coffee and idea exchange; employee celebration led to partying at a Summer Dinner that started with an astounding sunset and ended with an all-night dance rally; and the community gathered for an autumnal afternoon of chestnuts roasting and mulled wine - all of which were delicious and the perfect excuse to bring everyone together.

Finally, INL's Christmas gathering was a wonderful way to end the year, with employees sharing stories, laughter, and good cheer.

It was a great year for community building at INL, looking forward to the next adventures together.

16. Quality Management System

Quality Management System

The Quality Management System (QMS) implemented at INL since 2016, continues to be an instrumental tool for continuous improvement and excellence of INL Operations. It is a driver for the overall implementation of quality methodologies and process optimization that increased our level of success, with focus on continuous improvement, customer satisfaction and compliance with applicable requirements.

Beyond these positive effects, certification processes were and continue to be a major benefit for INL, as it enables us to access partnerships, key markets, gaining customers' trust and achieving international quality recognition, as QMS certification is not only preferred but required.

2022 in review

2022 marks the maturity of INL Integrated Management System, comprising processes, requirements and standards of different scopes and natures, all intrinsically articulated to result in a unified framework oriented towards common objectives.

In May, INL QMS reached the final stage of its second three-year cycle of certification in accordance with ISO 9001, with the outstanding record of 0 nonconformities for the sixth year in a row. This system promotes the adoption of a process approach when developing, implementing and improving effectiveness, and enhancing customer satisfaction by meeting requirements.

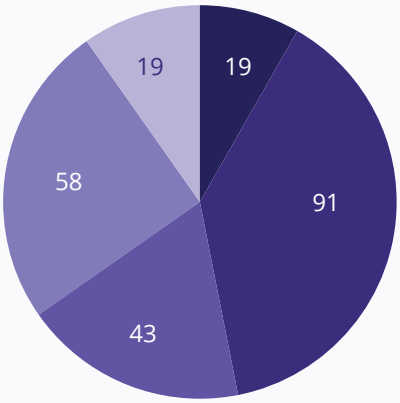
The same month also marked the successful conclusion of the first official certification cycle of INL Research, Development and Innovation Management System. This system - that sets INL Innovation model, supported by interfaces and interactions between the scientific and technological knowledge, and creativity mind set – is designed, implemented and certified in accordance with the NP 4457 standard. There are plenty of areas to improve in this ever-changing field, but no nonconformities were appointed.

The end of the year also brought another important achievement, closing of the first cycle of certification of the activities related with the design, development and testing of nanotechnology-based solutions for use in medical devices, in accordance with the standard ISO 13485, which specifies the requirements for a management system where an organization needs to demonstrate its ability to provide Medical Devices and related services that consistently meet customer and applicable regulatory requirements. No nonconformities or deviations were identified during the three-year process.

The maintenance of the system is a continuous process that comprises a set of activities ranging from documentation development and management, nonconformity management (internal and external), customer satisfaction assurance, suppliers' evaluation, continuous improvement management, KPI monitoring, culminating in the external audit management, with a scope of action that goes from the RTI area to the corporate functions and site management units.

The year 2022 also brought new challenges for Quality Management at INL, with the implementation of the OECD Good Laboratory Practices (GLP) in the Nanosafety GLP Laboratory. This standard defines a set of rules and criteria for a quality system concerned with the organisational process and the conditions under which non-clinical health and environmental safety studies are planned, performed, monitored, recorded, reported and archived. The official certification of the Nanosafety GLP Lab is planned for 2023.

In line with the INL strategy of fostering Commissioned Services, the CQM Office has been engaged with industrial partners, to meet customer requirements and produce quality-related deliverables, including on-site customer audits.



Quality in numbers

- Audits (Internal, Official, Second-part/Customers)
- Quality Trainings
- Number of Improvement Opportunities - Total IO
- Number of Occurrences Analysed – Total Occurrences
- Number of Processes

Customer Satisfaction

Besides continuous feedback, periodic satisfaction surveys are launched to measure the performance of activities/services. This information is key for enabling the identification of improvement areas and to work on the optimisation of INL activities.

In 2022, the overall Customer Satisfaction Rate was 4.4. This global number results from the overall scores assigned to the different services.

Customer Satisfaction Rate

4.4
(on a scale of 1 to 5)

The Customer Satisfaction Rate results from the weighed average result obtained from:

Satisfaction surveys: INL User Facilities (Internal and External Users), Industrial Partners, Quality Management System, INL Social Services (Cafeteria, Nursery, Guest House)

Service desk scores: Information and Communication Systems, Estate and Service Management, and Health, Environment and Safety

17. Institutional Growth

Institutional Growth

With the continued effort of increasing the maturity of INL as an organisation, several initiatives were implemented in 2022. These covered different aspects, mainly institutional, organisational development and key processes and procedures. The overall purpose was to further strengthen INL in its institutional components and core operational elements. In this regard, it is worth highlighting the following activities:

- **The creation of an Ad Hoc Independent Administrative Tribunal (AHIAT),** as part of an overall assessment of the Internal Justice System of INL, which included the development of a Disciplinary Procedure, an Appeals Procedure, and the establishment of the Joint Advisory Disciplinary Board (JAAD) and the Joint Advisory Appeals Board (JAAB);
- **A review of the Staff Rules,** with impact on the employment policy of INL related to the need of mitigating the risks associated to the execution of projects from the Portuguese Plan for Recovery and Resilience (PRR) and securing the financial sustainability of INL;
- **A process of particular significance,** called to have a high organizational impact, is related to the **HRS4R excellence stamp**. As part of this process, the Endorsement Letter, the GAP analysis and the Action Plan were carried out;
- **A wide review of the HR Recruitment & Selection (R&S) Procedure and the constitution of specialised boards:** the R&S Boards and the Indefinite Contract Review Board;
- **The Research Ethics Committee started formally its activities,** and will play an essential role on the R&D activities of INL, with the adoption of the INL Ethics Code, Guidelines for good research ethical standards, and the ethical assessment of R&D;
- **The annual review of basic salaries of employed members of the personnel,** has been carried out based on the changes of the cost of living in Portugal for the year of 2021;
- **With the gradual return to normality after the period of the pandemic,** the Flexible Working Arrangements Policy was updated in line with general market standards;
- **Internal operational actions** also took place to streamline research lines. Laboratory space was also optimised, for emerging collaborations and new expected research equipment acquisitions.

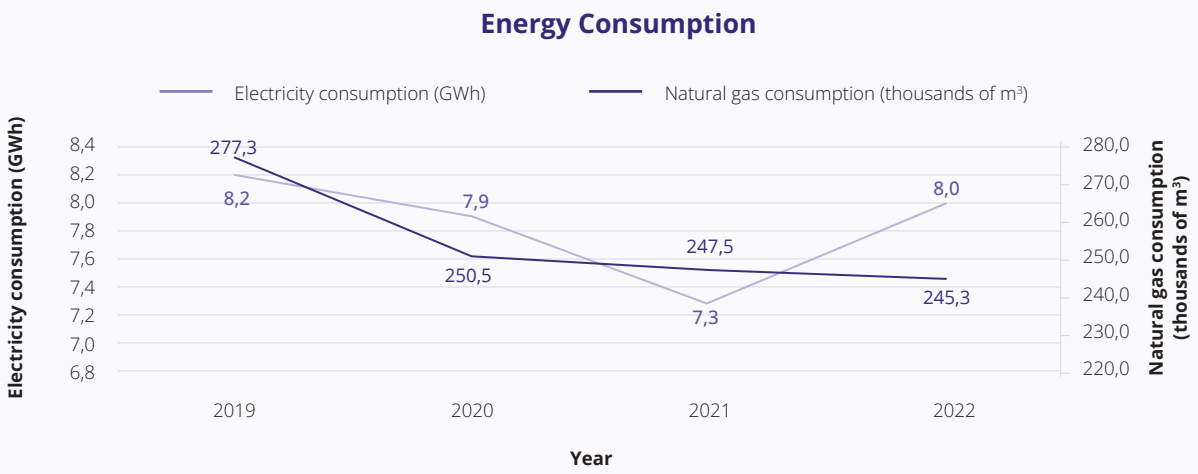
18. Infrastructure and Site Management

Infrastructure and Site Management

At INL reducing carbon footprint and minimizing the environmental impact is a priority.

This includes implementing energy management strategies, upgrading to highly energy-efficient equipment and systems, and involving employees. INL energy consumption represents a large portion of the operational costs. Reducing this consumption is meant to promote energy efficiency and decrease CO_2 emissions, complying with the required energy rationalisation plans.

Waste reduction and recycling are also important aspects of reducing INL's environmental impact. A comprehensive recycling program for materials such as paper, plastic, glass, metal, electronics, and hazardous waste is an effective way to reduce the amount of waste generated by INL.



Metrics are compared to the base year of 2019. INL is committed to continuing towards sustainability.

-2%

Reduction in electricity

-12%

Reduction in natural gas

Health Environment and Safety

This year two new processes were completed: the Safety Policy Committee Terms of Reference and the INL Health Environment and Safety (HES) Policy. Five risk assessments and seven internal audits were held to keep health and safety protocols in compliance. Activities for Health Environment and Safety also included one fire drill and one internal audit, as part of the ISO 9001 certification plan.

HES Action Plan 2022

In order to continuously improve best practices, INL developed a HES Action Plan in 2022, carrying out audits and visits to assess the compliance with applicable HES requirements, emergency compliance and any dangerous and risky situations that need to be eliminated or, if not, at least minimised.
From the various audits and visits in 2022, there were 127 actions, where 41 of these are already treated and 86 are in progress.

Employee Involvement

In 2022, the HES held the third edition of the annual consultation with INLers on the Health & Safety Perception Survey.

Safety at Work

INL has established an Occupational Health Programme with medical exams being performed during the time of admission of Members of Personnel and periodically repeated. For pregnant INLers, in order to prevent potential health and safety risks in the workplace, a specific risk assessment related to work exposures and/or activities is developed.

Periodically at INL, the following parameters are evaluated:

- *Legionella* Monitoring (monthly)
- Noise and Illuminance Levels Monitoring (annually)
- Internal Air Quality Levels Monitoring (annually)
- Water quality (monthly)

Hazardous Waste Management

Due to the specific research activity carried out at the INL, namely using hazardous chemicals and biological agents, it is crucial to promote the minimal production of these wastes and ensure all the conditions for the correct disposal of all hazardous wastes produced. In this regard, strong effort is done namely by having a "Management Plan for hazardous wastes" implemented with success. Trainings (on-site and on-line), supply of containers for the different types of wastes and informative leaflets are examples of the existent support in this regard.

Estate and Service Management

INL has been adopting sustainability measures for some time now, continuously looking for ways to improve in this fundamental area.

For instance, regarding electronic waste, INL had a 13% decrease in the use of lamps, compared to the previous year, a 17% decrease on electric and electronic equipment waste despite the increase in personnel, and a stable use of batteries and accumulators. Other actions taken included the use of hand dryers instead of paper towels, optimisation of water used for garden irrigation, and the substitution of plastic cups for paper cups.

Building Maintenance and Operations

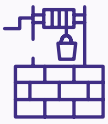
Sustainability in maintenance operations is an increasingly important consideration for companies and organisations. This is because not only does it help minimise the environmental impact of the operation, but it can also help improve its overall performance and reduce costs.

A key aspect of sustainability in maintenance is the use of energy-efficient equipment and systems. INL had a 15% increase in the cost of chilled water production due to the hot weather conditions, increasing energy use to maintain the needs of the equipment and infrastructure. On the other hand, the reported 19% reduction in compressed air usage is a significant success. It was achieved through pressure optimisation and by integrating compressors into a network using an advanced sequencer.

INL has also taken steps to reduce water consumption and adopt responsible water management practices. The consumption of mains water decreased by 25%, which was mainly due to the installation of flow reducers at various points. Concerning the consumption of ultrapure water, it has decreased by 12% as a result of optimising its annual sanitisation maintenance schedule.

-24%

Mains water



-3%

Borehole water

-12%

Ultrapure water

-19%

Compressed air

metrics compared to the year of 2021

19. Appendix

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ANALYST

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Highly Efficient and Stable Saline Water Electrolysis Enabled by Self-Supported Nickel-Iron Phosphosulfide Nanotubes With Heterointerfaces and Under-Coordinated Metal Active Sites

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Single-atom Ir and Ru anchored on graphitic carbon nitride for efficient and stable electrocatalytic/photocatalytic hydrogen evolution

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Dealloyed Octahedral PtCu Nanoparticles as High-Efficiency Electrocatalysts for the Oxygen Reduction Reaction

ACS APPLIED NANO MATERIALS

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PhD Graduates

Atomic Structure and Composition of Materials

- **Francisco Rosário Figueiredo**, A robust study on the Ataxin-3 fibrillization pathway for the discovery of new inhibitory compounds, University of Porto

Food Processing and Nutrition

- **Maria Alexandra Barroso Azevedo**, Development of lipid-based nanosystems using biosurfactants for encapsulation of vitamins, University of Minho
- **Maria Daniela Silva**, Development of a new approach to control otitis media pathogens, University of Minho

Food Quality and Safety

- **Foteini Roumani**, Fast molecular methods for the detection of spoilage funghi (in food products), University of Santiago de Compostela
- **Joana Carvalho**, Miniaturized devices for DNA analysis of food and environmental samples, University of Santiago de Compostela
- **Sarah Azinheiro**, Fast, affordable and multiplexed foodborne pathogen detection on miniaturized devices, University of Santiago de Compostela

Nanochemistry

- **Liliana Gonçalves**, CO_2 methanation over bimetallic catalysts supported on carbon materials with tailored surface properties, University of Porto

Nanofabrication for Optoelectronic Applications

- **José Miguel Cunha**, Industrial relevant electrical passivation of thin film solar cells interfaces, University of Aveiro

Nanomaterials for Energy Storage and Conversion

- **Zhipeng Yu**, Advanced materials for electrochemical energy conversion: from self-supported catalytic electrodes to atomically dispersed catalysts, University of Porto

Nanomedicine

- **Maria Daniela Silva**, Development of a new approach to control otitis media pathogens, University of Minho

Quantum and Linear-Optical Computation

- **Carlos Eduardo Tavares**, Foundations for quantum algorithms and complexity, University of Minho

Spintronics

- **Asfand Tanwear**, Fabrication of nanoscale magnetometers integrated with active analogue/digital systems for wearable applications, University of Glasgow
- **Leandro Jorge Ferreira Martins**, Fabrication and characterization of spin torque vortex oscillators, University of Porto

Ultrafast Bio- and Nanophotonics

- **Ricardo Miguel Ribeiro Adão**, Generating, controlling and deploying light for emerging photonic integrated technologies, University of Vigo

Water Quality

- **Soraia Patrícia Silva Fernandes**, Covalent organic frameworks to capture hazardous compounds from water, University of Aveiro

2D Materials and Devices

- **Patrícia Daniela Cabral da Silva**, Immuno-field-effect transistor platforms based on 2D materials for early detection do biomarkers do ischemic stroke, University of Minho

MSc Graduates

Atomic Structure-Composition of Materials

- **Francisco Rosário Figueiredo**, A robust study on the Ataxin-3 fibrillization pathway for the discovery of new inhibitory compounds, University of Porto

Food Processing and Nutrition

- **Bárbara Beatriz Caldas Dias**, Functional materials for intelligent food packaging, NOVA School of Science and Technology, University of Lisbon
- **Débora Lemos Gadelha de Oliveira**, Oleogels loaded with antimicrobials and antioxidants for the extension of food shelf life, University of Minho
- **Enrico Brigada**, Surface impermeabilization of paper using bio-based polymer coating for food packaging application, Università Carrolica Del Sacro Cuore
- **Maria Inês Guedes,** Optimization of cell seeding-on-a-chip using co-cultures of Caco-2 and HT29-MTX, NOVA School of Science and Technology, University of Lisbon
- **Mariana Brandão Nogueira Alves**, Sustainable strategies to obtain stable natural food colors from natural pigments, University of Coimbra
- **Simão Pedro Vaz Sampaio**, Sustainable materials for the development of flexible electronics, University of Minho

Food Quality and Safety

- **María Vidal Suárez**, Detec*ción de Streptococcus Agalactiae* mediante el empleo de nanopartículas de oro y doble amplificación para el diagnóstico de sepsis de transmission vertical, University of Oviedo
- **Nicolás Mauricio Russo Martínez**, Detección de *Enterococcus faecalis* mediante el empleo de nanopartículas de oro y doble amplificación para el diagnóstico precoz de infecciones en recién nacidos, University of Oviedo
- **Sara Sofia Fernandes Pereira**, Development of chitosan nanoparticles with antimicrobial activity against *Listeria* monocytogenes, University of Minho

Integrated Micro and Nanotechnologies

- **Tomás Torres Martins**, Development of 3-axis MEMS magnetometers based on Lorentz force, University of Minho

Laboratory for Nanostructured Solar Cells

- **Ana Carolina Silva Duarte**, Fabrication of $Cu(In,Ga)Se_2$ micro-concentrator photovoltaics, University of Minho
- **Diana Sofia Azevedo de Oliveira**, Impact of alkali-post deposition treatment on $Cu(In,Ga)Se_2$ solar cells, University of Minho
- **Diego Garzon**, Chemical bath deposition of Zn1-xSnxOy films as buffer layers for $Cu(In,Ga)Se_2$ solar cells, University of Porto
- **José Fonseca**, Semi-Transparent $Cu(In,Ga)Se_2$ solar cells for window applications, University of Minho
- **Miguel Madeira**, Sputtering-based process for the deposition of $Cu(In,Ga)Se_2$ micro solar cells, NOVA School of Science and Technology, University of Lisbon
- **Pedro Sousa**, Hydrogen-doped Indium Oxide as transparent back contact for $Cu(In,Ga)Se_2$ thin film solar cells, NOVA School of Science and Technology, University of Lisbon
- **Wesley Floricourt**, Point contact passivation layers for $Cu(In,Ga)Se_2$ solar cells on transparent back contacts, University of Nantes

Medical Devices

- **Ana Sofia Oliveira Martins**, Engineering a metastasis-on-a-chip system towards studying cell invasion and drug efficacy in lung cancer, University of Minho
- **Carolina Rodrigues**, An integrated liquid biopsy microfluidic device for the isolation, recovery, encapsulation and sorting of circulating cancer cells, University of Minho

- **Daniel António Martins André**, Resistive pulse nanopore sensing of nanoparticles – steps towards physical detection of viruses, NOVA School of Science and Technology, University of Lisbon
- **Madalena Rosa Correia Calado**, Pressure-driven resistive pulse nanopore sensing for the characterization of extracellular vesicles, NOVA School of Science and Technology, University of Lisbon
- **Maria Madalena Sousa da Silva**, Preclinical validation of an optofluidic system for the detection of minimal residual disease in acute myeloid leukemia, University of Minho

Nanofabrication for optoelectronic applications

- **Diana Mesquita**, Preparation, optimization and characterization of the main layers of Perovskite solar cells, University of Minho
- **Pedro Filipe Ribeiro Bertoluci**, Life cycle assessment of interface passivation processes in thin film solar cells, University of Porto
- **Rita Alexandre**, Development of nanoimprint lithography processes for state-of-the-art light management strategies to be integrated in CIGS solar cells, NOVA School of Science and Technology, University of Lisbon

Nanomedicine

- **Ana Cristina Marques Ribeiro**, Magnetic hyperthermia assisted genetic amplification, University of Minho
- **Bruna Filipa Ferreira da Silva**, *In silico* and *in vitro* assessment of novel purine derivatives as anticancer agents, University of Minho
- **Mónica Alexandra da Costa Cerqueira**, Treatment of a triple-negative breast cancer through externally triggered target-less drug carrier, University of Minho
- **Vasco Daniel Ferreira Peixoto**, Addressing tumor chemotherapy resistance through smart drug delivery, University of Minho
- **Vasco Rafael Rocha dos Santos**, Lipidomic Profiler using NMR-phenotypic traits, University of Minho

Nanosafety

- **Samantha Faria Oliveira da Costa**, Development of a skin-on-a-chip device for toxicological evaluation of nanomaterials, University of Minho

Natural and Artificial Photonic Structures and Devices

- **José Nuno Rocha Gama**, Integration of 2D materials on biomimetic photonic structures, University of Minho
- **Rafael Alexandre Antunes** Vilarinho, Natural growth of light-harvesting nanostructures from microalgae for bioinspired energy solutions, University of Minho

Quantum and Linear-Optical Computation

- **Ana Filipa Gonçalves de Carvalho**, Simulating Linear-optical Quantum Computers, University of Minho
- **Daniel Almeida Carvalho**, On conditional quantum control, University of Minho
- **Gilberto Rui Nogueira Cunha**, Quantum Bayesian reinforcement learning, University of Minho
- **Renato Alberto Soares de Brito**, Quantum reinforcement learning: a heuristic approach to solve deterministic MDPs, University of Minho

Spintronics

- **Maria Barbosa Gracio**, MgO based Magnetic Tunnel Junctions Doped with Paramagnetic Impurities: Towards Quantum Energy Harvesting, University of Porto
- **João Miguel Soares da Silva**, Vortex Nano-Oscillators Based on Magnetic Tunnel Junctions for Neuromorphic Applications, University of Porto

Ultrafast bio- and Nanophotonics

- **Hugo Miguel Virtuoso Simões Sebastião**, Development of device control and real-time data analysis methods for a nonlinear multiphoton fluorescence lifetime imaging microscopy (MP-FLIM) system, University of Coimbra

- **Joana Isabel Craveiro Tátá**, Development of a polymeric Mach-Zehnder interferometer based photonic integrated chip for optical sensing, NOVA School of Science and Technology, University of Lisbon
- **Luís Manuel Mano da Costa**, Functionalized nanodiamonds to target axons in Parkinson's disease cell models, University of Minho
- **Luís Miguel Cosme Leston**, Advanced microscopy to study the localization of fluorescent nanodiamonds relative to axons of neuronal cells, NOVA School of Science and Technology, University of Lisbon

Water Quality

- **Helena Sofia Neto**, Assessing a novel anti-virulence therapy against drug-resistant bacterial infections using the zebrafish in vivo model, University of Minho
- **Maria Loureiro Catarino**, Nanoplastics' and environmental microplastics leachates' aquatic ecotoxicity: adaptation to nanotoxicity, University of Minho
- **Sara Sofia Fernandes Pereira**, Development of chitosan nanoparticles with antimicrobial activity against listeria monocytogenes, University of Minho

2D Materials and devices

- **Diogo Francisco Veiga Baptista**, Radiofrequency circuits based on graphene technology, University of Minho
- **João Duarte Gonçalves Azevedo**, Graphene-DNA origami-based nano-electro-mechanical-system, University of Minho
- **Mafalda Inês Gonçalves Abrantes**, Graphene field-effect transistors functionalization for neurotransmitter biosensing, University of Minho

Systems Engineering

- **Francisco António Andrade Barreira**, High voltage switch design in standard CMOS technology for a MEMS inclinometer, University of Minho

Support Units Members

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- Lars Gösta Montelius

Director-General Deputy (until August)

- Paulo Freitas

Director-General *interim* (from September)

- Paulo Freitas

DG Executive Assistant

- Cristina Louro

Coordination and Quality Officer

- Ana Teixeira

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Chief Administration Officer

- Fernando Torres

Administration Assistant

- Carla Oliveira

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- João Martins
- Patrícia Oliveira
- Raquel Ferreira
- Renata Silva
- Rita Milhazes

Human Resources Assistant

- Catarina Gomes

Learning Organisation Developer

- Elisabeth Nilsson (until July)

Legal Service Manager

- José Lobo

Legal Service Officers

- Rita Gomes
- Rita Silva

Business and Strategic Relations

Chief Business and Strategic Relations Officer

- Paula Galvão (until March)
- Paulo Freitas (from April)

Business and Strategic Relations Officers

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- Francisco Guimarães
- Mariana Fernandes
- Marina Brito
- Marina Dias
- Michela Mattaloni
- Monike Rocha
- Nuria Barros

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- Gustavo Rocha

Finance Manager

- Rui Fonseca

Finance Officer

- Fátima Ferreira

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- Patrícia Carvalho
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- André Teixeira
- Paulo Vaz

Procurement and Logistics Assistant

- João Pinto

Project Finance Assistants

- Nuno Montenegro
- Sara Moreira

Project Finance Officers

- Hélder Gomes
- Nelson Almeida
- Susana Bastos

Information and Communication Systems

Applications and Development Manager

- José Gonçalves

IT Operations Manager

- Adelino Correia

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- Paulo Pires

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Intergovernmental Relations and Special Projects Officers

- Cristina Padilha
- Pedro Carneiro (until August)
- Sonia Pazos

IP Exploitation & Knowledge Transfer

Chief Intellectual Property Officer

- Ulf Håkanson (until August)

Intellectual Property Officer

- Ana Vila

Research, Technology and Innovation Office

Chief Operations Officer

- Mariam Debs

Corporate Expert

- Dmitri Petrovykh

Communication, Conferences & Marketing Officers

- Filipa Bernardo
- Gina Palha
- Inês Costa
- Patrícia Barroso

Science Communication Officer

- Catarina Moura

Site Management

Chief Site Management Officer

- Hugo Cortez

Estate and Service Officer

- Cláudia Sousa

Estate and Service Assistant

- Claudia Fernandes

Health, Environment and Safety Officers

- Filipa Valente
- Margarida Santos

Maintenance & Installation Officers

- Cassiano Teixeira
- Hélder Linhares
- Miguel Tomé

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