INTERNATIONAL IBERIAN
NANOTECHNOLOGY
LABORATORY

ANNUAL REPORT 2017-2018

https://inl.int/

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FOREWORD

INL 2018 Annual report

2018 at INL was a great year. It was our 10th anniversary. We celebrated with an impressive and very successful INL 10 Years Anniversary Summit. Further, our science has been highlighted in numerous important publications in the most highly rated international scientific journals. Our direct industrial services have grown considerably.

The last few years at INL have been very dynamic. In all kind of numbers (turnover, number of people, number of projects, etc), we have grown roughly 4 times in the last 3 years period. We are now actively participating in many European projects and we are part of most of the important European Technology Platforms within Nanotechnology and Advanced Materials sector. We have contributed to the local environment with strong ties to the city of Braga, the Norte region of Portugal and Galicia in Spain and with strong links to many universities in Portugal and Spain. We have engaged in several coordination and support actions aiming to foster an eco-system regionally, nationally and European wide. An important strategic activity is our engagement in the Quantum Science, Technology and Materials domain. Further, recently, we did some strategic organizational changes to better highlight INL as a large scale research infrastructure that offer services through the Corporate Labs in a User Facility perspective. During 2018, we were recognized and awarded with the Bartolomeu de Gusmão Award for our successful activities within the intellectual propertys domain, an activity that has been further increased at INL during the last year. During the last years we have excelled in managing to secure external funding from all possible sources, a very successful activity that has been instrumental for the fast and accelerated growth of INL.

We have continued the effort to build relations with companies worldwide. We have established a large international network and we are having representation in several places worldwide. We have implemented an International Business Advisory Board populated with very experienced experts. We are running entrepreneurship-oriented projects and we have several incubated companies. We have had a lot of meetings, workshops and conferences at INL. The largest one being MNE, the annual Micro- and NanoEngineering conference, the 43rd in sequence, held in 2017. Another great success during 2017 was the 2nd INL OPEN HOUSE. Our annual INL SUMMIT series with the theme "*Nanotechnology: The New Economy"* has been very successful. One of the most important processes at INL in the last years has been ISO 9001 Certification. The INL Quality Management System is instrumental for the development of INL into a smoothly operational unit. Another important highlight was the establishment of the Programme Management Office (PMO). Its aim is to define and articulate the INL Programmes, frame our Goals and Objectives, assess and coordinate our projects and the position of INL. Our Scale Travels programme with Artist in residences is a success and brings new concepts to INL. Our recent Scale Zero initiative brings a further dimension to all INLers regarding an active engagement in and for sustainability.

A key feature of our first decade has been the development and growth of our capacity. In a sense we have been laying the foundations which will allow us to better deploy this capacity in the coming years to more effectively foster the use of nanotechnology for addressing the grand challenges of today in areas such as clean water, food waste reduction, energy efficient society, early diagnostics, new and better ways of preventing diseases etc. In this context, our intergovernmental standing is a great asset and we can play a huge role in the international efforts to make our world a better place.

INL is today a research-intense organization. We create knowledge. We do also deliver knowledge to the "business market". The most characteristic features of INL today are a rapid growth, a changing organisation and a strong focus on developing a sustainable business model, as well as an international footprint. Our greatest assets are our multi-cultural and inter-disciplinary personnel, our complete laboratory and our ability to recruit the right people and obtain the needed resources.

Our ambitions for **INL tomorrow** are three folded. We aim to **Excel in Research** and become known for our high-quality research activities. Such activities shall be directed towards grand challenges and we shall avoid incremental research activities. We shall be bold and get ourselves engaged in developing concepts directed to have disruptive character. Secondly, we aim to engage in novel coordination and support actions aimed to **foster an eco-system**, locally and internationally. And thirdly, we aim to deliver compounding knowledge and **be an integrating solution provider** based on our knowledge and skills generated through research projects in combination with our partners capacities. The new paradigms in the research area at European and International levels show that it will be governed by integration. It will be more and more needed to be able to articulate missions, i.e. "building cathedrals" instead of "cutting stones". The actors that excel in articulation, and as a consequence also excel in integration and compounding knowledge, will be the winners in the research as well as in the market domains. So, multi-dimensional integration as a tool is a must for the future.

Digitalization will lead to a new way of doing business. The new economy will be fast and dynamic. **The key for future is the working methodology connecting various knowledge in a meaningful way.** The diffusion of nanotechnology into society will accelerate. We will see more and more of technical gadgets such as wearables that will help to monitor and sense various things around us. The nanotechnology and advanced materials will be inserted or embedded into almost any business and industrial sector making the products more intelligent and adaptive. The boundary between a physical object and an emotional subject will be kind of removed and technical devices will become more subject-like, having emotional ingredients making human-machine interactions more human-centric. This could be applied in e.g. robotics being deployed in the care sector of having more emotional services to be offered in the homes of our elderly population. Other areas are industrial manufacturing and buildings that, with embedded sensors, will allow predictive maintenance and self-reporting buildings to appear mediating a lot of risks of today. In the food-sector we will witness several disruptive changes as a consequence of our abilities to measure data in food in an easy and rapid way, that in turn will help us to further understand how different food-components can be applied as predictive maintenance of our bodies. Being an enabling technology, Nanotechnology delivers functionalities that are useful in many different application areas or sectors, and thereby also enables economic growth. In order to fully capitalize the inherent values, there is a need for a designed-based nano-ideation process combining design, nanotechnology, business models and sustainability that will enable and accelerate radical innovations.

Let me finish by thanking all INLers for their passionate work and devotion to the development of INL. Let me also say a big thank you to all our partners and friends worldwide that help us to develop.

And let me round up by repeating the INL core values: **Committed and Proud!**

Enjoy the reading of our latest comprehensive report.

All the very best.

Lars Montelius
Director-General

MESSAGE
from the President of INL Council

"The total income of INL went from 8.5M€ in 2015 to 14M€ in 2018, representing a 66% growth rate over the course of just 5 years. And the number of collaborators went from 66 in 2014 to 319 in 2018, from almost 40 countries, with a gender balance close to 50-50."

During the last two years, the International Iberian Nanotechnology Laboratory has come closer than ever to what José Mariano Gago aimed when the idea of building a joint scientific project from Portugal and Spain was born in his mind. I am pretty sure that Mariano Gago would be very proud of what INL has accomplished since its official activity started, back in 2008.

Presently, INL has 107 ongoing projects financed directly by the EU, by Interregional funds, and by Portugal, representing an overall budget of 25.5M€, covering the period between 2017-2021.

The total income of INL went from 8.5M€ in 2015 to 14M€ in 2018, representing a 66% growth over the course of just 5 years. And the number of collaborators went from 66 in 2014 to 319 in 2018, from almost 30 countries, with a gender balance close to 50-50.

INL has also become increasingly attractive to international talent, from scientific research and other areas as well, with a total of 4348 applicants to 71 job positions opened, resulting in an average of 61 applicants per job opening, from 87 countries. And this was in 2018 only.

It is all these people – the right people – who are behind INL growing innovation activities, with a particular focus on four industrial and business sectors: Auto mobility, Bio-Medical Devices, Food, and Nanotechnology enabled Blockchain business models for safety and trust.

We are now entering the next decade of INL which will continue to be marked by a constant growth, a changing organisation and a strong focus on developing a sustainable business model as well as an international footprint, not only by increasing its presence in all continents but also by attracting new member-states.

The Strategic Development Plan of this Intergovernmental Scientific Research Organization addresses major challenges such as: circular economy, digitalization of society, urbanisation, aging population, Industry 4.0, IoT, management of knowledge, and last but not least, climate change.

INL has great assets when it comes to solve difficult, challenging and complex research questions being based on its interdisciplinary research culture and also on the large mixture of persons from different cultures and scientific backgrounds.

INL has developed immensely the last years, and it is now a research driven organization with a solid body and an innovative mind. It creates and delivers knowledge, being able to add value to businesses, with a model that Invents, Integrates, and Innovates.

It has been quite a journey, and I can't wait to see what INL will turn into, for the benefit of all of us.

Paulo Ferrão
President of the INL Council
2016 - 2018

INL GOVERNANCE
INL Council

The Council is the sovereign body of INL in which all member states are represented. It is composed by three representatives of each Member State, one of whom must be a scientist.

The role of the Council is to govern the INL by determining its policy in scientific, technical and administrative matters, approving and following up its programme of activities and approving its budget, based on proposals of the Director-General, who is the Chief Executive Officer of the Laboratory and its legal representative, appointed by the Council.

From 2016 to 2018, the Council was presided by Paulo Ferrão, President of the Portuguese Foundation for Science and Technology. The vice president was Marina Villegas, Director of the Spanish State Research Agency.

DIRECTORATE

Director-General
Lars Montelius

Deputy-Director General
Paulo Freitas

Advisory Board

The INL Advisory Board is the main advisory body to the Council and meets in the days leading up to the Council Sessions.

MEMBERS

Yvan Bruynseraede
KU Leuven

Manuel Martín-Lomas
CIC biomaGUNE

Helmuth Möhwald
Max-Planck-Institute of Colloids and Interfaces

Carlos Oliveira
InvestBraga

Mihail C. Roco
Nacional Science Foundation

Francois Rossi
European Commission
Joint Research Centre

Julia Yeomans
The Rudolf Peierls Centre for Theoretical Physics

International Business Advisory Board (IBAB)

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 knowledge, products and services for the benefit of industry and society.

To support achieving these goals, INL has established during 2017 an International Business Advisory Board (IBAB), with the mission to:

- Provide critical strategic guidance in INL´s business development strategy.
- Identify any recent or long-term developments and/or concerns of industry which are likely to have a significant impact on INL's activities.
- Help or support INL on major strategic initiatives, such as the establishment of innovative research activities, fund-raising initiatives etc.
- Explore other ways in which INL can catalyze, encourage and foster a higher level of industry involvement in its research activities.
- Advise and review on best practices for INL's Incubation and Acceleration initiatives.
- Promote INL and scout new relationships for INL among individuals or companies in order to expand the pool of potential industrial collaborations.
- Select on a yearly basis one industry-related research project as the winner of the INL Industry Project Prize.
- Attend commercial conferences in the region of the Board Member as a representative of INL.
- The IBAB is composed of high level industry executives with a wealth of experience in areas related with business consulting, management, supporting start-ups and on creating start-up investment funds.

Members are appointed for an initial three-year term and shall be eligible for reelection for a maximum of a second term.

Members of the International Business Advisory Board:

Adam de Sola Pool

Antonio Murta

Björn Segerblom

Carlos Oliveira

Gerard De Bourbon

Magnus Ryde

Massimo Gentili

INL 10th ANNIVERSARY

Milestones & achievements

10 YEARS 2008-2018

INTERNATIONAL IBERIAN NANOTECHNOLOGY LABORATORY

This year we celebrate ten years of passionate research, quality and technological growth.

The INL was born in 2008, ten years ago. And this year we celebrate ten years of passionate research, quality and technological growth addressing the societal challenges of our times.

After several discussions and extensive investigations, the governments of Spain and Portugal decided that nanotechnology would be an excellent fit for an intergovernmental research organization to be built in the heart of Braga. After signing the agreement in 2005, the idea went from paper to construction of what is now INL. But, as we all know, an organization is not defined only by its infrastructures or equipment but by the people who work on it every day for the benefit of society through the application of nanotechnology in the most diverse areas. Many, many people have passed through INL, leaving an indelible mark.

It is us, our partners, companies and local citizens that make INL what it represents today and we strive every day to become the leading international research hub in nanotechnology.

Thank you for the ten remarkable years of warmth, friendship, and support. We absolutely couldn't have done it without you, nor can we take the next steps without your continued support.

With deep appreciation,

Lars Montelius
Director-General

10 YEARS IN NUMBERS

+30
Nationalities

100's
Collaborations with companies

State-of-the-Art
Electron Microscopy Imaging and Spectroscopy Facility

+250
Researchers

1000 m²
State-of-the-Art
Cleanroom Facility

State-of-the-Art
Nanophotonics Flagship Facility

104M€
Total Investment amount up to 2018

48% / 52%
Near to gender balance

2005

Decision of Portugal and Spain to set up a joint R&D institution in Braga.

2008

Signature of the Headquarters Agreement with the Portuguese State and assignment of the land by the Portuguese State to the INL;

Beginning of the construction of the facilities.

2009

Inauguration of the facilities by the King of Spain, the President of the Portuguese Republic and ministers of science from Portugal and Spain.

2011

Authorization for the award of the 2nd tender for the purchase of scientific equipment.
Creation of the following Research Groups:

- *Microfabrication and Exploratory Nanotechnology*
- *Nanochemistry*
- *Nanodevices*
- *Nanomaterials for Energy Storage and Conversion*
- *Nanostructured Solar Cells*
- *Spintronics*
- *Systems Engineering*
- *Theory of Quantum Nanostructures*

2012

Visit from the Princes of Spain.

2014

Lars Montelius appointed as INL Director-General;

Creation of the following Research Groups:

- *Ultrafast Bio- and Nanophotonics*

2016

Visit from the President of the Portuguese Republic.

Launching of QuantaLab project, with University of Minho;

Creation of the following Research Groups:

- *2D Materials and Devices*
- *Atomic Structure - Composition of Materials*
- *Food Processing*
- *Food Quality and Safety*
- *Nanofabrication for Optoelectronic Applications*
- *Nanomedicine*
- *Nanostructured Materials*
- *Water Quality*

2017

Co-organization of MNE2017, held at INL;

ISO 9001:2015 Certification;

Creation of the following Research Groups:

- *Atomic Manipulation for Quantum Nanotechnology*
- *Precision Medicines Engineering*

2018

Creation of the following Research Groups:

- *Electrodynamics of 2D materials*
- *Medical Devices*
- *Natural and Artificial Photonic Structures and Devices*

INL RESEARCH

22 Research Groups

+250 Researchers

RESEARCH DEPARTMENTS
and Research Groups

Advanced Electron Microscopy, Imaging & Spectroscopy

The ***Advanced Electron Microscopy, Imaging and Spectroscopy department*** performs true atomic/nano-resolution electron imaging combined with atomic/nano-resolution chemical analysis, in order to achieve a fundamental understanding of the chemical/physical phenomena at the atomic/nano level in real material systems.

ATOMIC STRUCTURE - COMPOSITION OF MATERIALS
Group Leader: **Paulo Ferreira** | paulo.ferreira@inl.int

NANOSTRUCTURED MATERIALS
Group Leader: **Leonard Francis** | leonard.francis@inl.int

Life Sciences

The ***Life Sciences department*** focuses its activities in the fields of food, health, and environment, particularly in: i) Nanoencapsulation technologies for smart and controlled drug/gens delivery and for enhancing bioavailability and functional properties of bioactives; ii) biosensors, microfluidic-based devices and integrated lab-on-a-chip solutions for food and water quality and safety as well as diagnostic and prognostic purposes; iii) advanced functionalities and applications of tailor-made nanostructured materials in combination with novel biomarkers and studies on biointerfaces.

Nano4Environment Unit

WATER QUALITY
Group Leader: **Begoña Espiña** | begona.espina@inl.int

Nano4Food Unit

FOOD PROCESSING
Group Leader: **Lorenzo Pastrana** | lorenzo.pastrana@inl.int

FOOD QUALITY AND SAFETY
Group Leader: **Marta Prado** | marta.prado@inl.int

Nano4Health Unit

NANOMEDICINE
Group Leader: **Manuel Bañobre** | manuel.banobre@inl.int

MEDICAL DEVICES
Group Leader: **Lorena Diéguez** | lorena.dieguez@inl.int

Micro & Nanofabrication

The ***Micro and Nanofabrication department*** explores both bottom-up and top-down approaches to the micro and nanofabrication aspects of materials, surfaces and devices, running a cleanroom with more than 50 systems. Main research activities include: i) processes for MEMS/NEMS, sensors, microfluidics, energy storage, conversion and adaptive optical devices, lithography and advanced packaging, rapid prototyping and cleanroom processes integration; ii) bottom-up catalysis, synthesis and research of materials, and nanofabrication and characterization of optoelectronic materials and devices in rigid and iii) flexible substrates, and incorporation of nanotechnology into thin film solar cells.

MICROFABRICATION AND EXPLORATORY NANOTECHNOLOGY
Group Leader: **João Gaspar** | joao.gaspar@inl.int

NANOCHEMISTRY
Group Leader: **Yury Kolenko** | yury.kolenko@inl.int

NANOFABRICATION FOR OPTOELECTRONIC APPLICATIONS
Group Leader: **Pedro Salomé** | pedro.salome@inl.int

Nanoelectronics Engineering

The ***Nanoelectronics Engineering department*** brings together four areas of activity at INL: systems engineering, spintronics, nanodevices and precision medicine engineering; addressing major challenges in industrial sensing, RF communications, biosensors and biomedical devices, agri-food and environmental monitoring applications.

SPINTRONICS
Group Leader: **Ricardo Ferreira** | ricardo.ferreira@inl.int

SYSTEM ENGINEERING
Group Leader: **João Piteira** | joao.piteira@inl.int

NANODEVICES
Group Leader: **Paulo Freitas** | paulo.freitas@inl.int

PRECISION MEDICINE ENGINEERING
Group Leader: **Peng Weng Kung** | weng.kung@inl.int

Nanophotonics

The ***Nanophotonics department*** aims to carry out top fundamental and applied research in areas such as biophotonics, photonic nanomagnetometry, plasmonics & materials, Bloch surface wave engineering and the design and application of photonic crystals.

ULTRAFAST BIO AND NANOPHOTONICS
Group Leader: **Jana B. Nieder** | jana.nieder@inl.int

NATURAL AND ARTIFICIAL PHOTONIC STRUCTURES AND DEVICES
Group Leader: **Martin López-Garcia** | martin.lopez@inl.int

Quantum & Energy Materials

The Quantum and Energy Materials department works on fundmantal and applied material science with strong efforts in quantum materials, e.g. 2D materials, both experimentally and theoretically, and energy materials covering the topics of energy generation and storage with strong efforts in catalysis, fuel cells, batteries, and photovoltaics.

Energy Materials Unit

NANOSTRUCTURED SOLAR CELLS
Group Leader: **Sascha Sadewasser** | sascha.sadewasser@inl.int

NANOMATERIALS FOR ENERGY STORAGE AND CONVERSION
Group Leader: **Lifeng Liu** | lifeng.liu@inl.int

Theory Unit

THEORY OF QUANTUM NANOSTRUCTURES
Group Leader: **Joaquín Fernández-Rossier** | joaquin.fernandez-rossier@inl.int

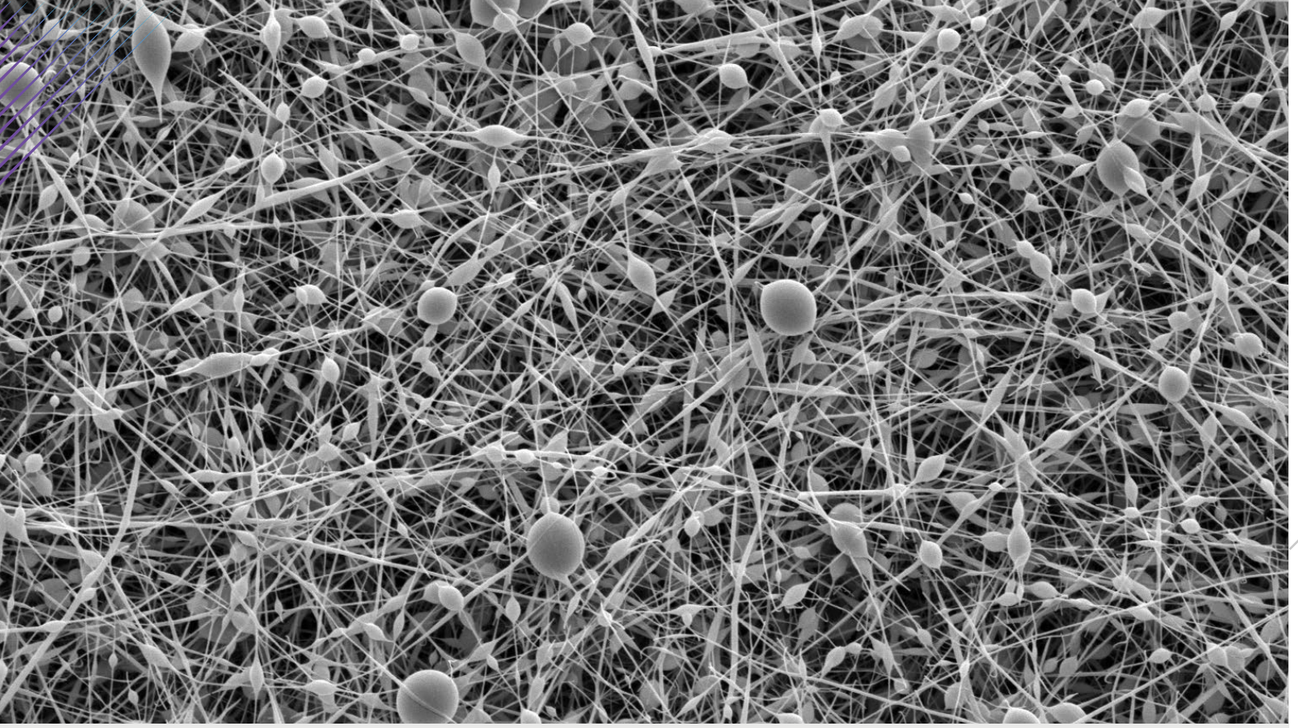
ELECTRODYNAMICS OF 2D MATERIALS
Group Leader: **Nuno Peres** | nuno.peres@inl.int

2D Materials Unit

2D MATERIALS AND DEVICES
Group Leader: **Pedro Alpuim** | pedro.alpuim.us@inl.int

ATOMIC MANIPULATION FOR QUANTUM NANOTECHNOLOGY
Group Leader: **Zhongchang Wang** | zhongchang.wang@inl.int

https://inl.int/research-groups/



"The conflict!", Electrospun beaded nanofibers. Authors: Miguel Cerqueira and Enrique Carbo. *

* This image was taken from the final selection of the INL 2017 scientific Photo Contest.

AEMIS

Advanced Electron Microscopy, Imaging and Spectroscopy

Clean energy technologies, microelectronics/optics and health/pharmaceuticals are essential for the future of our planet. However, their widespread implementation and truly transformational breakthroughs are only possible if a fundamental understanding of the relationship between the chemical/physical phenomena at the atomic/nano level in real materials systems is achieved. To reach these goals, it has become absolutely critical to perform true atomic/nano resolution imaging and chemical analysis. This is solely possible with sophisticated transmission and scanning-transmission electron microscopes (TEM/STEMs), scanning electron microscopes (SEMs), focused ion beams (FIBs) and X-ray photoelectron spectrometers (XPS). In some cases, these instruments can be coupled with spectroscopy tools, such as electron energy loss spectroscopy (EELS), energy dispersive spectroscopy (EDS) and advanced in-situ sample holders, in which the environment (for example heating, cooling, gas, light, electric biasing) is controlled to match near-realistic conditions of operation and the behavior of the sample is recorded dynamically in real time.

During 2018, the department focused on materials science, development of novel techniques and instrumentation, as well as providing training, technical support and consultation in the areas of electron microscopy and spectroscopy. The department has strong funding from national and international entities. It has built a strong research programme, with 25 publications in high-ranked journals, 2 conference proceeding, 1 book chapter and 1 edited book. Participation in top conferences and seminars included invited talks (18) and contributing talks/posters (30) and include the organization of 3 conferences/work-shops at INL.

Research Groups

Atomic Structure - Composition of Materials

Nanostructured Materials

AEMIS

Atomic Structure - Composition of Materials - ASCM

The ASCM group focuses on the study of the atomic structure, atomic composition, and defect behaviour of nanomaterials, through in-situ TEM, high-resolution TEM, aberration-corrected TEM/STEM, precession microscopy and EELS/EDS techniques. In particular, the group is interested in understanding the relationships between the atomic structure, composition and the properties of nanomaterials, and the fundamental underlying mechanisms of structural and property changes induced by crystalline defects. The material systems of interest include Lithium-ion oxides for batteries, proton exchange membranes fuel cells, 2D materials, catalyst nanoparticles and nanoscale particles, wires, and thin films. The team members include four postdoctoral researchers, eight PhD students, and one Masters student, along with their group leader **Paulo Ferreira**.

Proton exchange membrane fuel cells (PEMFCs) have enormous potential to transform the transportation and energy markets. Yet, its widespread application is currently hindered by a number of different factors, among these being both, the efficiency of the sluggish oxygen reduction reaction (ORR) kinetics, which is catalysed by Platinum-based (Pt) nanoparticles (NPs), and the instability of the Pt NPs during fuel cell operation. Using identical location TEM, the group has focused on the analysis of Platinum-Nickel (Pt−Ni) NPs, during the different stages of voltage cycling, in order to gain a deeper understanding of the prevailing degradation mechanisms and the changes in the atomic structure and composition of these NPs, which are able to enhance ORR kinetics compared to Pt alone, thus improving efficiency and lowering the cost of these systems. Their study provides a unique insight into the mechanisms of degradation in PEMFCs.

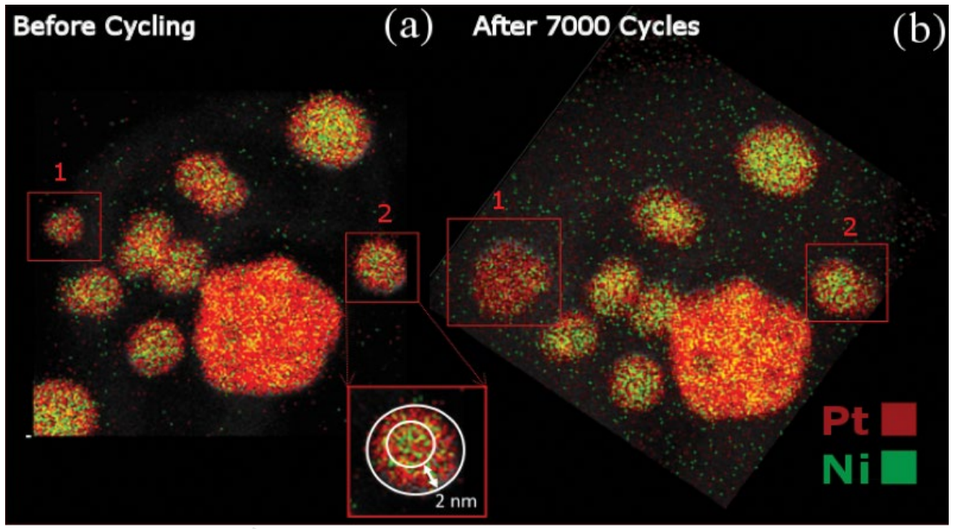


Figure 1. EDS mapping of Pt−Ni NPs (a) before cycling and (b) after 7000 cycles, showing the heterogeneous deposition of Pt on particles 1 and 2.

AEMIS

Nanostructured Materials - NM

The NM group is involved in investigating fundamental aspects and dynamic phenomena 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. The current and ongoing research topics include: (i) Metal Nanoparticles and Clusters; (ii) Nanocatalysts, (iii) Novel Phases and (iv) In-Situ Atomic Scale Observation of Interfacial Dynamics: Nucleation, Growth, Coalescence, and Phase Transformations. The team members include three postdoctoral researchers, one Masters student, and one summer student, along with their group leader **Leonard Francis**. The group had two visiting scientists during 2018.

Melting and freezing are considerably fundamental and practically important first-order phase transitions in condensed-matter physics, material science, and cli- mate change, yet a clear understanding of their kinetic pathways is still evolving. In situ atomic scale studies carried out by the group using a heating holder usingBismuth (bi) as a model system within an aberration-corrected scanning/transmission electron microscope revealed that it is possible to obtain direct evidence to show that pre-nucleation in either melting or freezing takes places via a multiple barrier-crossing pathway involving the formation and migration of domain boundaries (shown in the figure below), dislocations, and the ordering of interface and surface at the atomic scale. The findings in the present study demonstrate that melting/crystallization processes cannot be viewed as a simple single barrier-crossing event but rather as a complex multiple intermediate state phenomenon, which enhances our general understanding of nucleation and growth, melting/crystallization phenomena, phase transformations and helps to clarify atomic origins of temperature dependent behaviours in other nanomaterials and thin films.

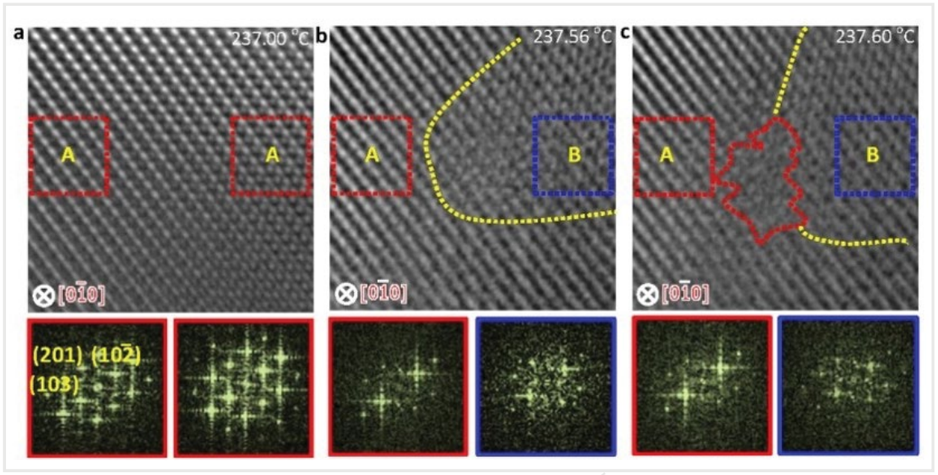
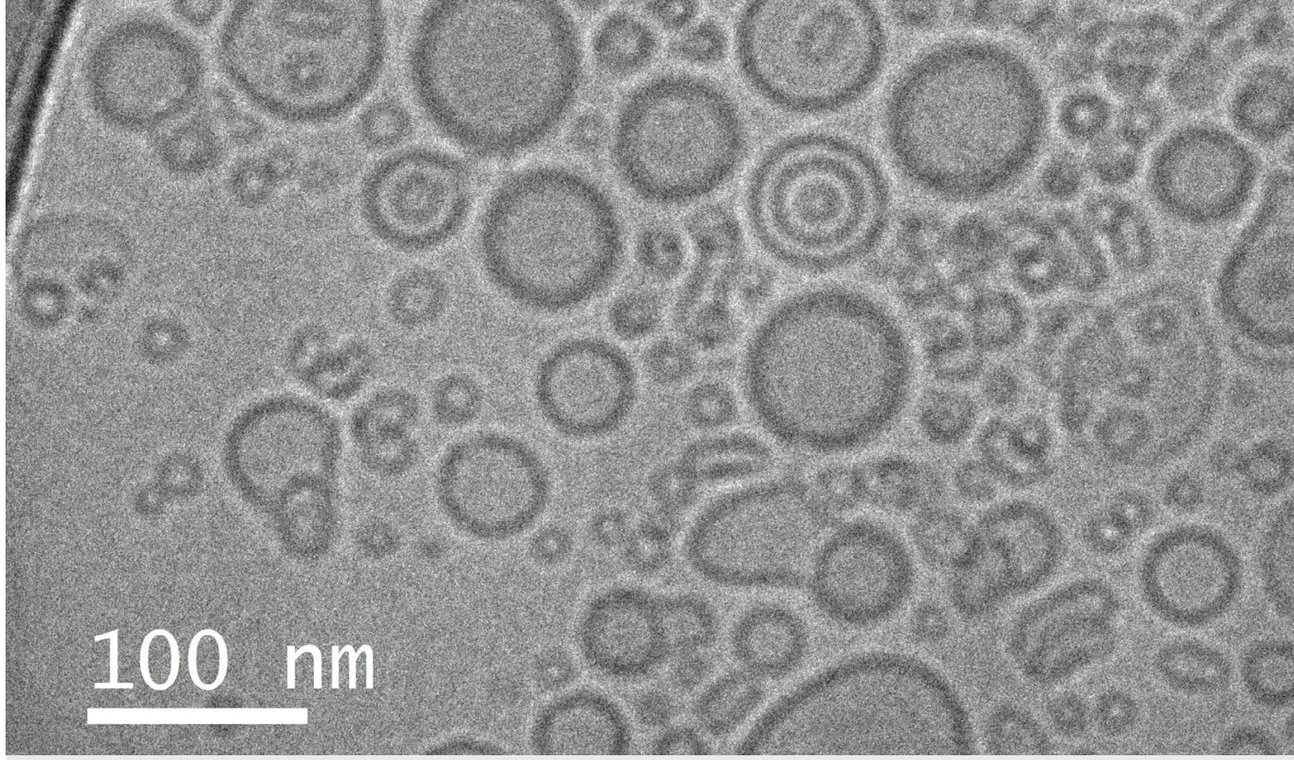


Figure 2. HRTEM images showing pre-melting at grain boundary (J. Phys. Chem. Lett., 2018, 9, 961–969).



"Lipoplex party", Bruno Silva and Daniel Stroppa. Cationic Liposome – DNA complexes imaged 2h after preparation using the conventional assembly method (in bulk). In some cases, complete multilayer particles can be observed, whereas in other cases, a diffuse dark interface (often not complete) that we attribute to DNA is seen around the liposomes.*

* This image was taken from the final selection of the INL 2017 scientific Photo Contest.

LIFE SCIENCES

The Department of Life Sciences (DLS) aims to improve the wellbeing and health of citizens by generating knowledge and developing applications of nanotechnologies in the fields of food, health, and environment.

The research at DLS is market-oriented and focused on the diagnosis and treatment of ageing-related diseases, as well as the monitoring and improvement of water and food quality, safety, and authenticity. The development of advanced nano-bio-engineered solutions for biomedical devices (including microfluidics), and food packaging and processing are also objectives of the DLS.

To achieve these goals, DLS develops sensors, lab-on-a-chip solutions, new biomarkers and bio interfaces, and tailored nanostructures and materials.

The DLS is structured into three units with five research groups overall, focusing the research activity to achieve critical mass enough to face new challenges, create internal synergies, and increase the external visibility of our activity. These are:

Research Groups

Nano4Environment Unit:

Water Quality

Nano4Food Unit:

Food Processing
Food Quality and Safety

Nano4Health Unit:

Medical Devices
Nanomedicine

LIFE SCIENCES

Nano for Environment Unit

Water Quality - WQ

The vision of the WQ is to bring new nanotechnology-based solutions to society for a safe and sustainable use of water resources. The group focuses in three main research lines:

- *Nanotech-based sensors for water quality monitoring:* They fully develop portable and/or unassisted biosensors for water biological and chemical contaminants.
- *Nanomaterials for water remediation:* They design, fabricate, and test nanomaterials for the selective capture or degradation of water chemical contaminants and water disinfection.
- *(Eco)nanotoxicology*: They evaluate the nanomaterials' fate, bioaccumulation, and toxicity, paying special attention in implementing the safe-by-design concept to the in-house produced nanomaterials.

During 2018, the WQ team members included one staff researcher, three postdoctoral research fellows, two research laboratory assistants, one PhD student, two master students, and one research associate, along with the group leader **Begoña Espiña**. The group hosted three visiting scientists during 2018. At a glance WQ published 9 original research articles, one PhD thesis was defended, and ran six externally funded projects.

One of the research highlights of WQ for 2018 was a paper-based sensor for the detection of sulfide in water using mercapto-tetrazine protected fluorescent gold nanodots. In this work, they demonstrated the development of a highly sensitive method to detect and quantify sulfide ions (S^{2-}) in water samples. The fluorescence of synthesized 6-mercapto-s-triazolo(4,3-b)-s-tetrazine-gold nanodots (MTT-AuNDs) was significantly and dose-dependently quenched by the addition of S^{2-} in solution. The detection limit was found to be 2 nM. Based on this principle, they developed a cost-effective and viable paper-based easy-to-use sensor for environmental monitoring.

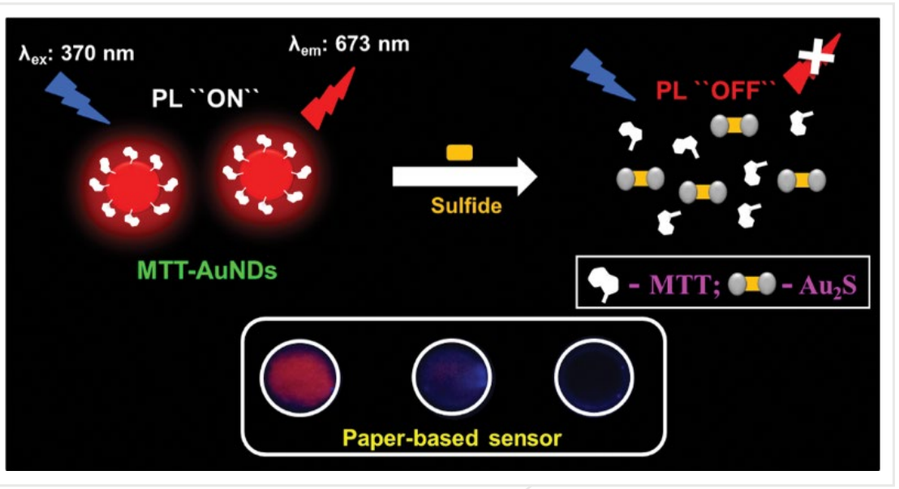


Figure 3. Concept of the sulfide paper-based sensor. From: ACS Appl. Mater. Interfaces, 2018, 10 (2), pp 1634–1645. doi: 10.1021/acsami.7b11769

LIFE SCIENCES

Nano for Food Unit

Food Processing - FP

The research activity of the FP is focused on developing nanotechnology applications to face big challenges in health (diet-related diseases), sustainability (food waste, plastic food packaging) and ageing & urbanization (convenience, personalization, emotion), by setting up a solid portfolio of technologies and solutions for the food industry in the fields of active and intelligent food packaging as well as in functional food nanostructures to obtain new rheological properties (for 3D printing) and encapsulation (to enhance bioactivity of food components).

Currently the FP is composed of four Staff researchers, nine postdoctoral researchers and engineers/lab assistants, nine associate researchers, five PhD students, along with the group leader **Lorenzo Pastrana**.

At a glance FP in 2018 has had 15 publications (58 since 2016), 22 externally-funded projects and contracts since 2016, one license agreement with a new company, and onePhD thesis defended and five ongoing, as well as onestart-up called "Salty Sensations".

Among the main research outcomes in 2018, the group has made considerable impact in the solutions to **reduce food loses and waste;** by developing edible films and coatings to extend produce shelf-life; by implementing antimicrobial bio-degradable polymers and cellulose films using electrospun nanofibers for food packaging, or with biodegradable ion-exchangers to recover high value-added products. The group has also developed novel ways to make **healthier and safer foods**, such as by replacing fat with emulgel for food fortification, using structured vegetable oils on meat-based products, and incorporating bio-based active nanoparticles for packaging applications. More recently, FP has moved towards *nutrition* by studying the modulation of gut-brain axes and the interaction between nanomaterials with gut cells.

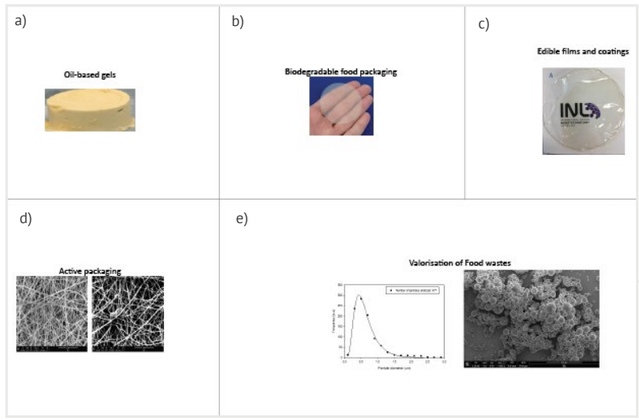


Figure 4. a) Omega 3 oleogel to replace saturated fats. b) and c) biodegradable, editable film containing an antioxidant essential oil nano-emulsion. d) cellulose-based multilayer film functionalised with chitosar nanofibers.

LIFE SCIENCES
Nano for Food Unit

Food Quality and Safety - FQ&S

The work of the FQ&S is designed towards the development of analytical approaches based on the combination of molecular biology and nano- and microfabrication technology in order to provide reliable tools for food quality and safety analysis. Our methodology is based on working on very specific analytical needs and on using a modular approach for each step of the process. Our research lines include: Novel strategies for sample preparation, Alternative DNA amplification methods, and Nanoparticle-assisted target detection.

The team is comprised of one staff researcher, three postdoctoral researchers, five PhD students and technicians, along with the group leader **Marta Prado**. Four visitors were also hosted this year by the FQ&S group: from Ocupharm Diagnostics SL. (Spain), IRTA (Spain), Forest Research Institute (India), and from Universidad Juárez Autónoma de Tabasco (Mexico).

During 2018, the FQ&S group published seven research articles, and one book chapter entitled *"The Use of Multiplex Real-Time PCR for the Simultaneous Detection of Foodborne Bacterial Pathogens"*. FQ&S is currently working on five externally-funded projects, two national, and three international, focused on the development of faster, innovative, and miniaturized analytical approaches for food safety, quality, and authenticity, together with one large cooperation agreement, one service contract with a diagnostics company, and four ongoing PhD thesis.

One of the group's research highlights was the development of a washable and reusable miniaturized device for DNA purification based on microscale solid phase extraction (μSPE). A biochemical protocol and a pre-treatment method were developed, optimised, and further tested with olive oil samples for DNA purification, showing better performance than commercially available kits, making this method a very promising sample preparation approach for olive oil and other samples with minute DNA content. This step is of high importance to ensure reliable results and to obtain enough target to be detected in further steps of analysis.

Figure 5. Experimental set up for DNA extraction experiments and average DNA concentration of elution samples obtained from extra virgin olive oil (EVOO) samples DNA-spiked and non-spiked with the commercial NucleoSpin® kit versus the results obtained in our prototype from the same samples. From: *Anal. Chim. Acta*. 1020 (2018) 30–40. doi:10.1016/j.aca.2018.02.079).

LIFE SCIENCES
Nano for Health Unit

Medical Devices - MD

The research of the *Medical Devices group* is focused on the development of technologies for the understanding and diagnosis of diseases. MD works in close collaboration with the clinic to enable translational medical research towards the realisation of precision medicine. To this aim, MD works in three main research lines: development of optical technology contributing to answer outstanding questions in the life sciences, engineering of microfluidic biosensors to study and evaluate disease biomarkers for diagnosis, and construction of biomimetic 3D organ-on-a-chip systems to model processes in disease evolution and treatment.

In 2018 the MD group, led by **Lorena Dieguez**, was composed of three staff researchers, five postdoctoral researchers, two research engineers, one PhD student, four Master students, and three technical visitors.

The newly created MD group has started two new national research projects as coordinators, on "Simultaneous Advanced Microscopies" and "Innovative Microfluidic Platform for Analysis of myeloid Leukemia blasts", and was awarded 2 European projects as partners that will start in 2019.

This year 2018 left them with 12 new peer reviewed publications, and the first spin-off company of INL, RUBYnanomed, incorporated in Portugal.

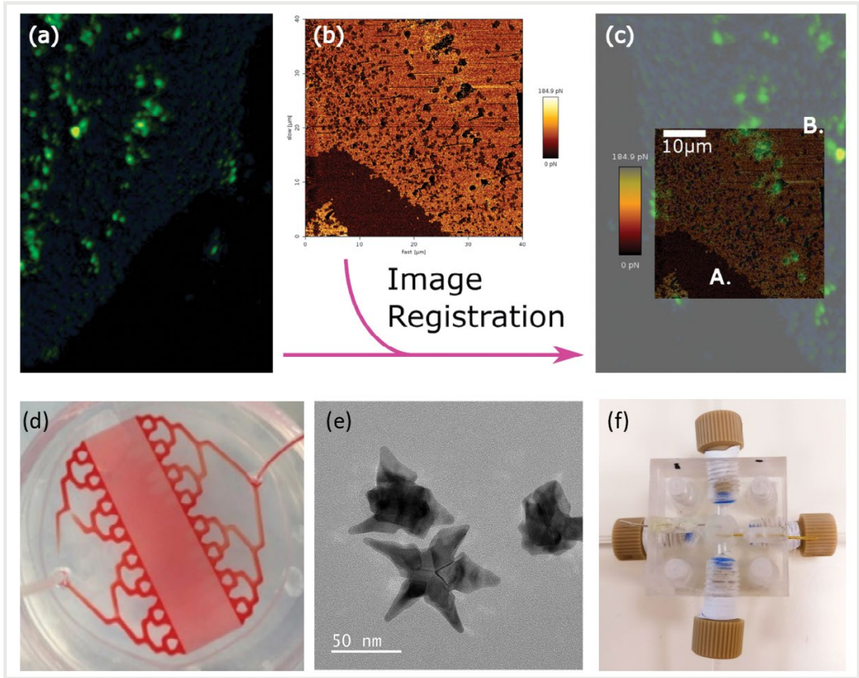


Figure 6. The newly developed combined microscopy system is able to record simultaneously a fluorescence optical sectioning image and an atomic force map (a, b,c). Microfluidic systems (d) are combined with sensors based on plasmonic nanoparticles (e) for early diagnosis of diseases. Biomimetic systems are developed for advanced 3D in vitro tests, including tissue engineering with continuous sample monitoring (f).

LIFE SCIENCES

Nano for Health Unit

Nanomedicine

Nanomedicine's research focuses on the development of diagnostic and therapeutic approaches towards an early and unequivocal diagnosis and treatment of cancer, inflammatory and neurological diseases. To this aim, *Nanomedicine* covers from fundamental research on the identification and validation of diseases' biomarkers and cellular interactions, to a more applied cross-disciplinary research focused on the development of technologies and nanostructures (inorganic, organic, hybrid) for precision disease diagnosis, therapy and theranostics, ranging from low to medium-high technology readiness levels (TRL).

In 2018, the *Nanomedicine* group, led by **Manuel Bañobre**, was constituted by five staff researchers, seven postdoctoral researchers, four PhD students, eight MSc students, eight short-stay visitors (>3 months) and two summer students.

The project portfolio was mainly constituted by one european, three regional and one national project. In addition, the group was awarded with ten national projects, four of them as coordinators. As a result of the developed research and the stablished worldwide scientific collaboration, the group published 25 papers in international peer-reviewed journals. As highlight achievements, highly biocompatible paramagnetic (Mn_xO_y) and superparamagnetic (hybrid organic-inorganic Fe_3O_4-based) nanoparticles have been developed as (responsive)-MRI contrast agents (CAs) that showed record T_1 and T_2 signal-to-noise ratios, respectively. In the particular case of T_1-CAs, the group has investigated what are the manganese oxides available, what kind of shapes can be produced and how the material-shape combination impacts their behaviour as MRI contrast agent (classic non-responsive vs. redox-responsive contrast agent). We have found that unique MnO_2 nanourchins greatly enhance the redox-responsiveness of the nanostructure and this has been validated *in vitro,* aiming at an early and accurate diagnosis of cancer.

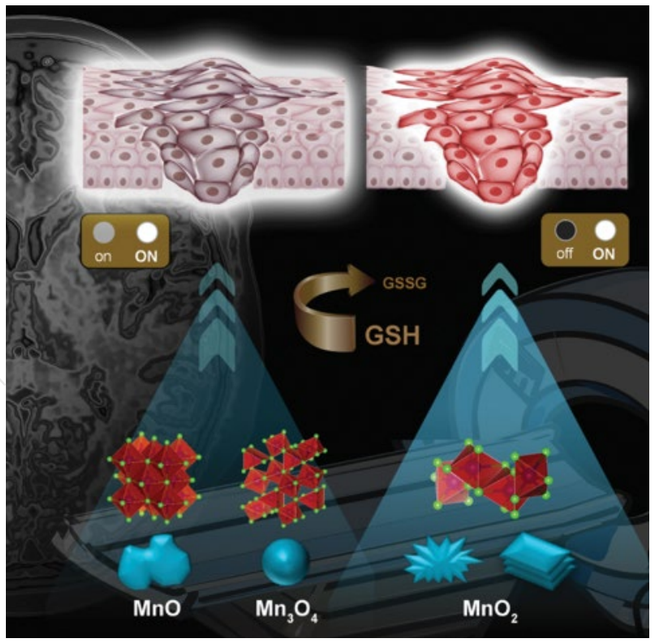
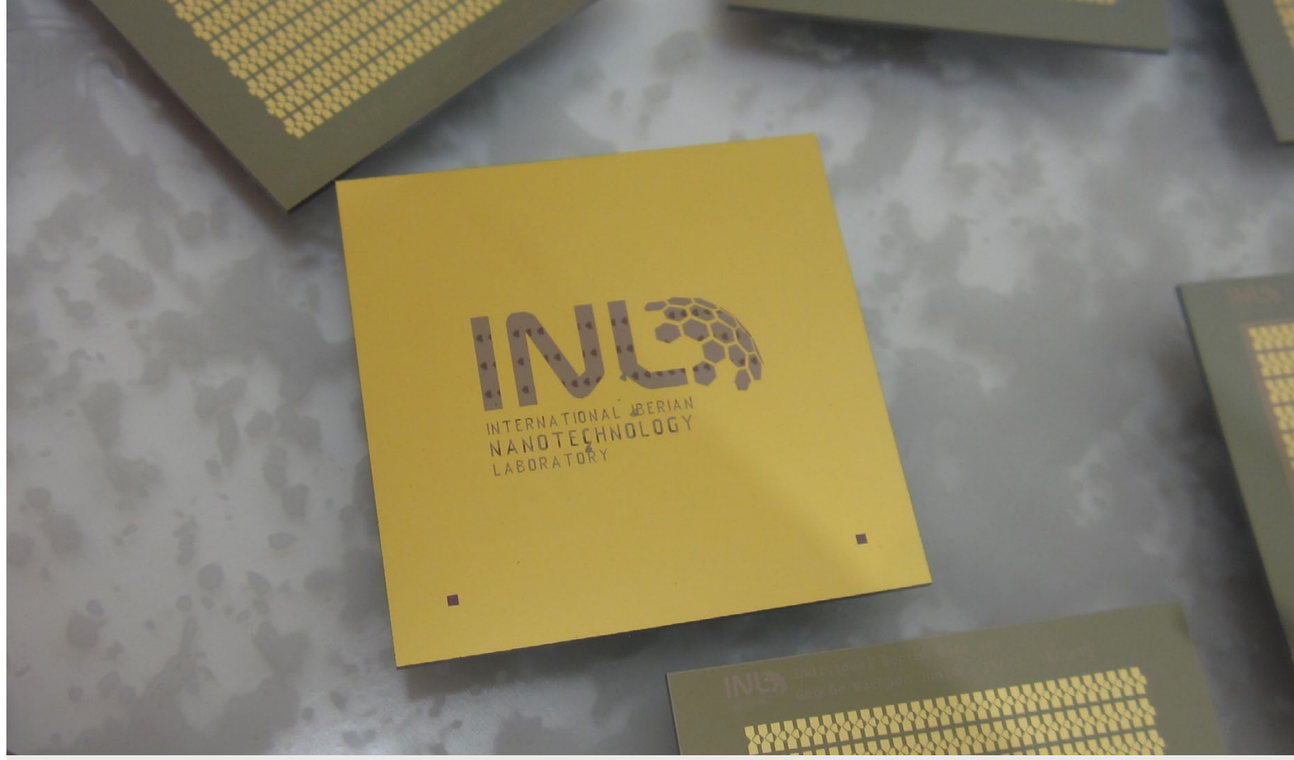


Figure 7. Front Cover image (Chem. Eur. J. 6/2018) highlighting their findings published in Chem. Eur. J. 2018, 24, 1295–1303 regarding the tunable performance of manganese oxide nanostructures as MRI contrast agents.



"INL factory ". FET substrate - 200 mm wafer cut. Author: Claudia Coelho and George Machado Jr. *

* This image was taken from the final selection of the INL 2017 scientific Photo Contest.

MICRO & NANOFABRICATION

This department explores both bottom-up and top-down approaches of micro and nanofabrication aspects for materials, surfaces and devices, being composed by three research groups:

Microfabrication and Exploratory Nanotechnology – Dedicated to fabrication processes for MEMS and NEMS, sensors and flexible devices, microfluidics, carbon-based and thin film semiconductors, energy storage, conversion and optical devices, lithography and advanced packaging;

Nanochemistry – Committed to bottom-up catalysis, synthesis and research of materials - catalytic, adsorption, thermoelectric and electronic, applications such as electrodes for water electrolysis, novel magnetic nanoparticles for biomedical area and inexpensive photovoltaic modules for clean energy, to name a few;

Nanofabrication for Optoelectronic Applications – Working on top-down nanofabrication and characterization of optoelectronic materials and devices in rigid and flexible substrates, and incorporation of nanotechnology into thin film solar cells (ultrathin architectures and materials) for increased efficiency.

Research Groups

- Microfabrication and Exploratory Nanotechnology
- Nanochemistry
- Nanofabrication of optoelectronic applications

Microfabrication and Exploratory Nanotechnology - MEN

The MEN group, lead by **João Gaspar**, is composed by 23 staff researchers and engineers, exploring and deploying micro- and nanofabrication solutions to INL, its partners and clients on technologies involving advanced machining, MEMS and NEMS, sensors and hybrid devices, fluidics, graphene and 2D materials, thin-film silicon electronics, nanostructuring methods for surface modification, flexible substrate systems, laser microstructuring, and interconnects and packaging. It also acts as a facility and expertise group providing support for internal and external cleanroom users, multi-project wafer runs, rapid prototyping and integration. Operating transversally in several fields while still pushing the science of technology for each individual technique, it serves application areas such as Internet of Things (IOT), medicine and health, automotive and environmental monitoring, which led to a strong engagement with industrial partners during 2018 in (a) micro/nanomechanical accelerometers and magnenotometers used in space, (b) Si-nanowire chips for explosives detection, the very same devices also used for biological applications, (c) Lidar components for autonomous driving and (d) carbon nanotubes (CNT)-based devices for artificial lungs, to name a few. The group has published nine peer-reviewed papers, had over 25 contributions to conferences and workshops and filed two patents in 2018.

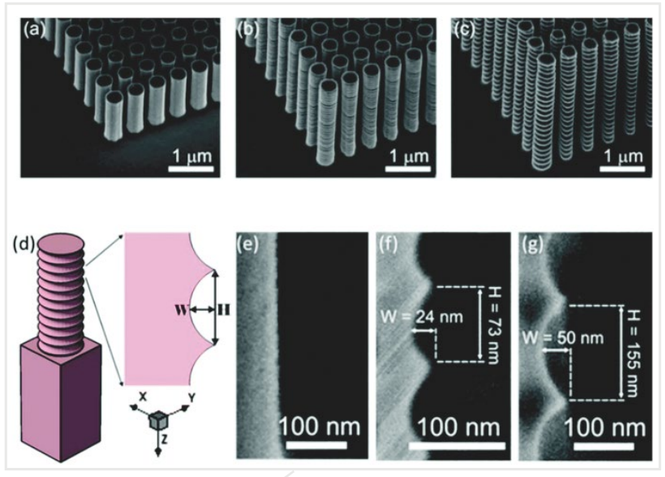


Figure 8. Machined silicon nanopillar arrays for efficient light trapping and broadband absorption of solar radiation (DOI: 10.1039/C8NR06210B (Paper) Nanoscale, 2018, 10, 18613-18621)

MICRO & NANOFABRICATION

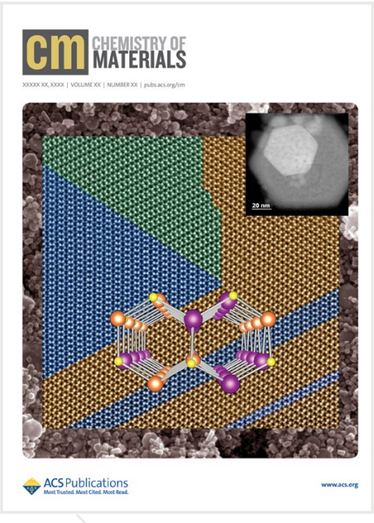
Nanochemistry

The group, led by **Yuri Kolen'Ko**, has 17 enthusiastic researchers merging together chemistry, materials science and nanotechnology within four experimental laboratories at INL. Their mission is to develop and realize creative and interdisciplinary concepts in the area of nanomaterials, focusing on the development of materials by pushing the following strategy CSI: Catalysis, Synthesis, and Investigation.

Chemical synthesis is the "work engine" of the group that has revealed unconventional nanocrystals, innovative covalent organic frameworks, and multifunctional nanocoatings. Sustainable solutions give rise to a number of collaborations with academia and industry, thus maximizing the impact of their work.

- Scientific achievements and output of their group members pinpoint their rapid personal and professional growth.
- Combining chemistry knowledge with interesting applications led to eight publications in 2018, two patent applications and several invited talks. In addition, their work was highlighted in Portuguese media.
- Their efforts in basic research and innovation bring several interesting national and international projects, with currently 13 ongoing.
- Their discoveries in catalysis, nanocrystal science, covalent organic frameworks, water research, and nanocoatings may enable the research and industry communities to advance R&D toward solving real-world energy and environmental problems.

https://onlinelibrary.wiley.com/doi/full/10.1002/chem.201801649



https://pubs.acs.org/doi/10.1021/acs.chemmater.8b04368

http://nanochemgroup.org

https://inl.int/micro-nanofabrication/nanochemistry/

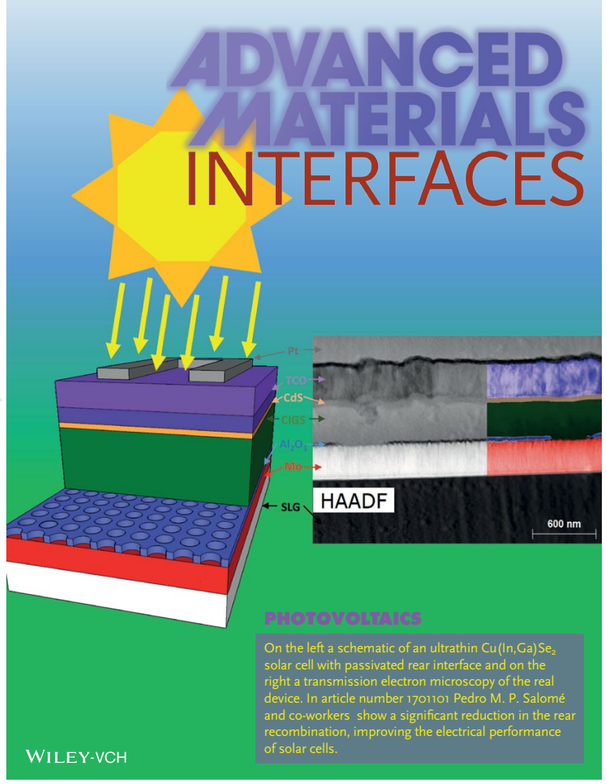
MICRO & NANOFABRICATION

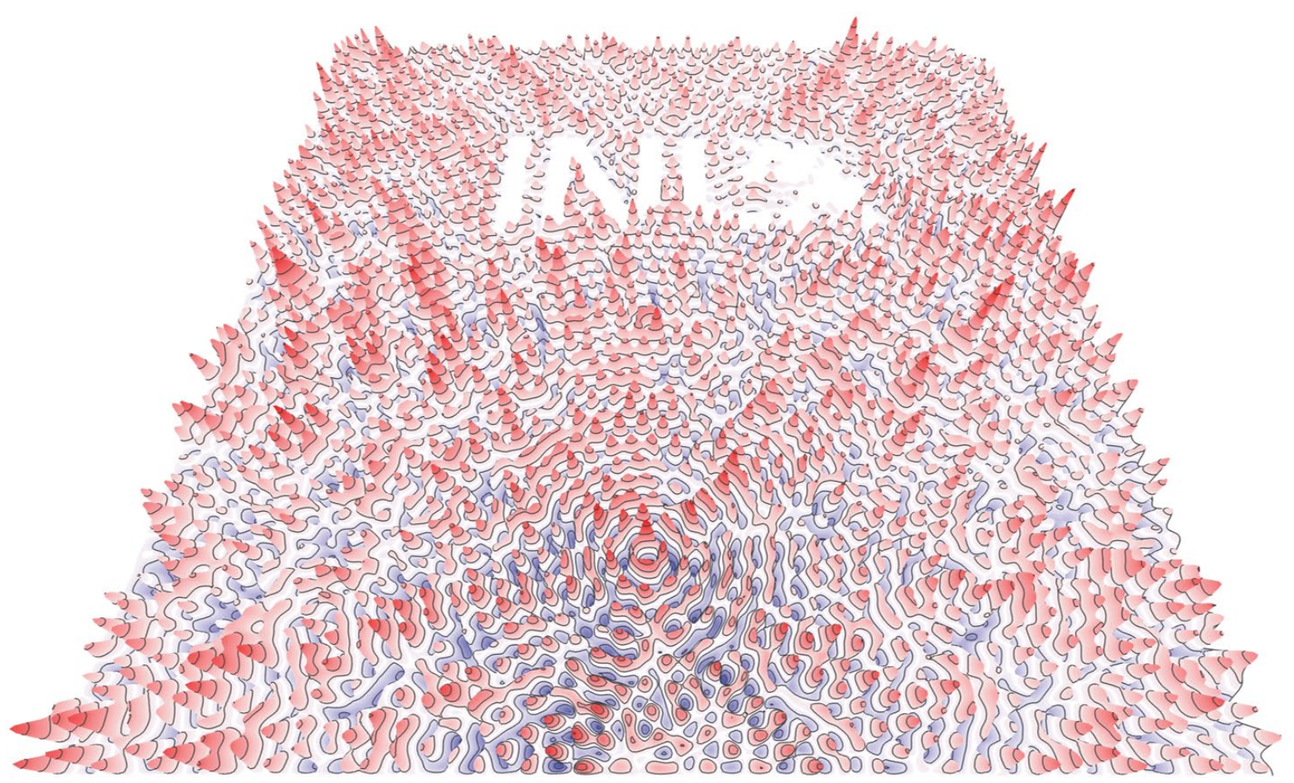
NanoFabrication for Optoelectronic Applications - NOA

The NOA group, led by **Pedro Salomé**, focuses on the incorporation of nanotechnology in optoelectronic devices. The core competences of the group are bottom-up nanofabrication and characterization of optoelectronic materials and devices. NOA´s nanofabrication cornerstone is INL´s cutting-edge cleanroom facilities while the vast experience of the group members in semiconductor materials is the backbone of the characterization capacities. The conjugation of both of these competences is the stepping stones that allows the NOA group to collaborate with both industrial and academic partners in: developing novel technology, prototyping, validating fabrication processes, products, among others.

Year 2018 was a consolidation year with offices, laboratory, and open space to start being used in exclusivity. With two new projects and partnerships with universities, the team headcount grew from three (in 2017) to nine (excluding students) at the end of 2018 - all funded externally. With 10 publications and three scientific inventions internally submitted as potential patents on their solar cell research line, the group is now complementing these activities with custom-made coatings in glass substrates which resulted in an RTD proposal offer with a private company.

Figure 9. “Image: Frontpiece in Advanced Materials Interface”





“Making Waves @ INL”, Micromagnetic simulations in a ferromagnetic material showing spin waves generated by an electrical point contact . author: Alex Jenkins. *

* This image was taken from the final selection of the INL 2017 scientific Photo Contest.

NANOELECTRONICS ENGINEERING

The NanoElectronics and NanoEgineering Department is focused on the development of devices with novel nano-electronic functionalities and in the integration of such devices at system level towards the execution of tasks that are relevant in a context of information gathering (sensing), information processing, communications, environmental monitoring, precision farming and novel medical tools.

The department aggregates 25 researchers and engineers distributed among four research groups. This is a strongly application-oriented department with a good record of deployment of research results in applications.

About 41% of the department activity is connected to research and innovation contracts established with Industrial partners. There is a good balance between science and applications with technologies and devices explored within a wide range of TRL levels: from disruptive devices that try to anticipate emerging needs up to devices that are ready to be integrated in commercial solutions. The Department is strongly collaborative, with 78% of the papers produced being co-authored with external partners from a network focused in Europe, but extending to the USA, Asia, and South America. In total, the department is participating in 26 research projects which resulted in 18 publications during 2018.

Research Groups

- Nanodevices
- Precision Medicine Engineering
- Spintronics
- System Engineering

Nanodevices

The Nanodevices group, led by **Paulo Freitas**, is an interdisciplinary group with transversal research lines, having projects in five domains: health, agri-food/sensor systems, micro/nano materials, and spintronics. In the spintronics area, activity covers magnetic tunnel junction (MTJ)-based sensor development in RTD industrial projects, together with the Spintronics group. Our multidisciplinary and transversal vision allows research collaborations internally at INL, with industry partners, RTO laboratories, hospitals and universities.

In health, the group works closely with hospitals for the diagnostic of different pathologies (e.g. colorectal cancer, peritoneal fibrosis, stroke and sepsis) using spintronics technology, previously developed at INESC-MN, and microfluidics. An integrated inter-ocular eye pressure monitoring system is being developed (together with Systems Engineering and NanoFab groups). In agrifood/sensor area, the team has a project in collaboration with the Systems Engineering group, related to grape maturation monitoring using a low-cost, stand-alone and integrated optical unit. The group has also expertise and collaborations on detection of foodborne pathogens by coupling bacteriophages to different sensing/microfluidic platforms. In the materials area, low RA (resistance area) graphene micro coils are being developed for compact power generators. Industrial collaborations started with ceramics companies for improved performance tableware (thermal and wear resistant coatings), with mould/plastic companies for dental implant technology (wear resistant coatings). The group is also working in capacitive sensor arrays for hand-motion-driven control. In the spintronics area, and in cooperation with the Spintronics group, industrial projects focus on MTJ sensor/system development and low volume device wafer prototyping.

Figure 10. Monitoring grape maturation and vine hydric stress with an integrated microspectrometer/IoT device. One of the first integrated optical microspectometers being placed in the grape bunch, Douro region, circa July 2018. It includes CMOS, photodiodes, interference filters, and on-chip LEDs. Partners collaborating on this project include INESC-MN, IMTek U Friburg (micro-optics, U Milan (optical properties of grapes), and Automation/FR.
Patent: J Piteira and P P Freitas, PCT/EP2018/056036

NANOELECTRONICS ENGINEERING

Precision Medicine Engineering - PME

Genetic contribution to different diseases were found to be varies and often very little, with non-genetic factors (e.g., environmental hazards, microbiome) having much greater attributable risks, and thereby producing a large phenotypic pool. The key goal to understanding human health and disease is to access the 'genotype-phenotype' correlogram, and the success of translating technological innovations (e.g., molecular medicine, molecular imaging) into clinical settings.

The PME team´s main interest focuses on developing and translating technological innovations (e.g., nuclear magnetic resonance, electron spin resonance) for the rapid molecular phenotyping into clinical point-of-care system.

The team, led by **Peng Weng Kung**, developed a new methodology for rapid, label-free molecular phenotyping of biological fluids (e.g., blood). By decomposing the multiple proton relaxation reservoirs arising from the direct and indirect water-protein interactions, they show that highly detailed and specific two-dimensional molecular fingerprintting of blood microenvironment can be rapidly typed using the two-dimensional Nuclear Magnetic Resonance T_1-T_2 correlational spectroscopy. The clinical utility of this technique was demonstrated through the analysis of whole blood in various physiological (e.g., oxygenation states) and pathological (e.g., hemoglobinopathies) conditions. This system was shown to be highly time- and patient-specific, delivering information that is potentially useful for medical diagnostic and monitoring purposes at point of use setting.

Weng Kung was invited to be the Guest Editor for Journal of Personalized Medicine.

https://www.mdpi.com/journal/jpm/special_issues/emerging_technologies

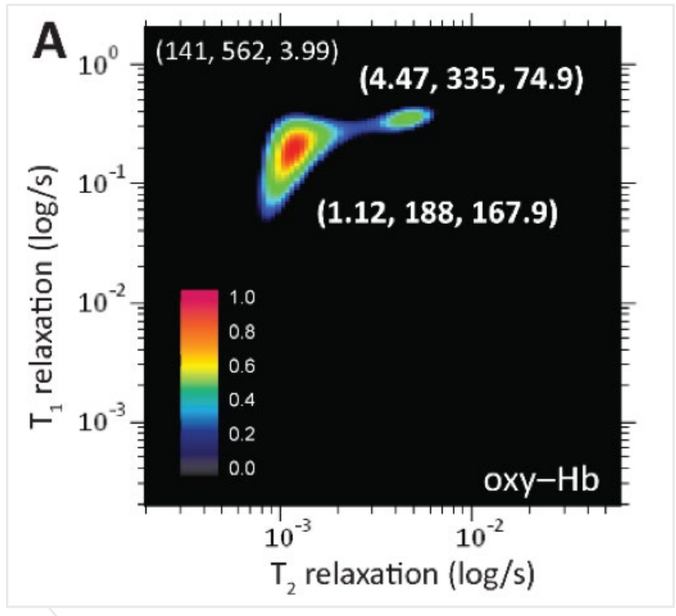


Figure 11. Genotype–Phenotype correlation: The NMR T_1-T_2 correlational spectrum of blood microenvironment in hemoglobin variants in (a) HbE, (b) HbD, and (c) beta thalassemia variant. The zoom-in details of decomposed relaxation reservoirs for (bulk water molecules, hydration layer, water-bound macromolecules). Peng, W.K., *et. al.*, "Two-dimensional T_1-T_2 Correlational Spectroscopy for Rapid and Label-free Molecular Phenotyping of Hemoglobinopathies" (submission, 2018).

Spintronics

The Spintronics research group, led by **Ricardo Ferreira**, is focused on the production of state-of-the-art CoFeB/MgO/CoFeB magnetic tunnel junctions (MTJ) tailored and optimized to fit demanding requirements of several specific applications. On the high TRL end of the scale, the group is producing ultrasensitive MTJ sensors aiming at applications in anti-counterfeiting technologies, electrical grid monitoring, industrial control, and automotive applications. On a more exploratory phase, the group is developing spin transfer nano-oscillators (homogeneous, vortex, spin hall), making an effort to push these devices up in the TRL scale and approaching the demands for novel IoT communication schemes and neuromorphic data processing. On the most fundamental level, spincaloritronics effects have been explored as possible tools for ultra-sensitive heat transfer and temperature sensors.

An interesting highlight from 2018 for the Spintronics group was their work on Spin-transfer torque nano-oscillators (STNO), which are important candidates for several applications based on ultra-tunable microwave generation and detection. The microwave dynamics in these STNOs are induced by spin currents that are typically generated either by spin polarization in an adjacent ferromagnetic layer or through the spin Hall effect. For the first time, a 3-terminal STNO based on an MTJ was excited by both of these spin injection mechanisms. The combination of these two mechanisms excites the free layer into dynamic regimes beyond what can be achieved by each excitation mechanism individually, resulting in enhanced output powers, a key figure of merit for device performance. The system response can be coherently quantified as a function of the total injected spin current density. This work was published in Communications Physics.

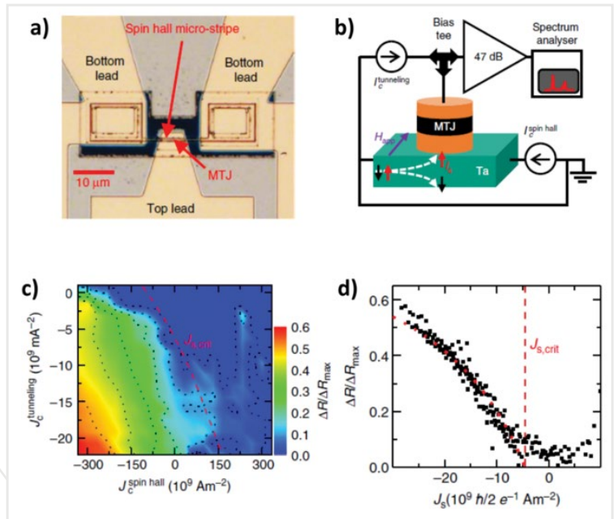


Figure 12. a) Sample overview. Optical microscope image of the final device. b) Schematic representation of the microwave emission measurement circuit setup for spin-polarized current-induced nano-oscillator devices. c) Color map of the normalized auto-oscillation amplitude ratio (ΔR/ΔRmax). Notice that the highest amplitudes are reached when the two excitation mechanisms are combined. d) The ratio ΔR/ΔRmax versus the total spin current (Js). The system can be modelled quantitatively considering the generalized spin current density that can be made from a combination of a spin polarized tunnel current and a pure spin current injected into the free layer from an adjacent hall line.

NANOELECTRONICS ENGINEERING

Systems Engineering

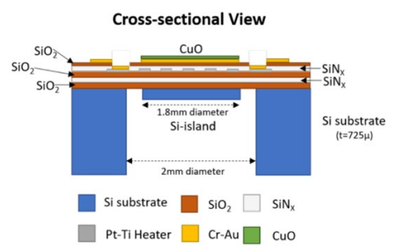
The focus of Systems Engineering group, led by **João Piteira**, is to bring nanotechnology developed at INL into form-factors compatible with applications in the areas of ICT, health, agri-food and environment. The high levels of integration and miniaturization required for such applications can be often achieved via custom-designed microelectronics solutions, in particular CMOS technologies that enable both high-performance and mainstream adoption of the resulting devices. The group's main mission is to use electronics and microelectronics combined with nanotechnology to solve challenges within the above areas designing and implementing hardware applications that are power, size and cost efficient. We are focusing in system integration of advanced sensing and actuating technologies while optimizing 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.

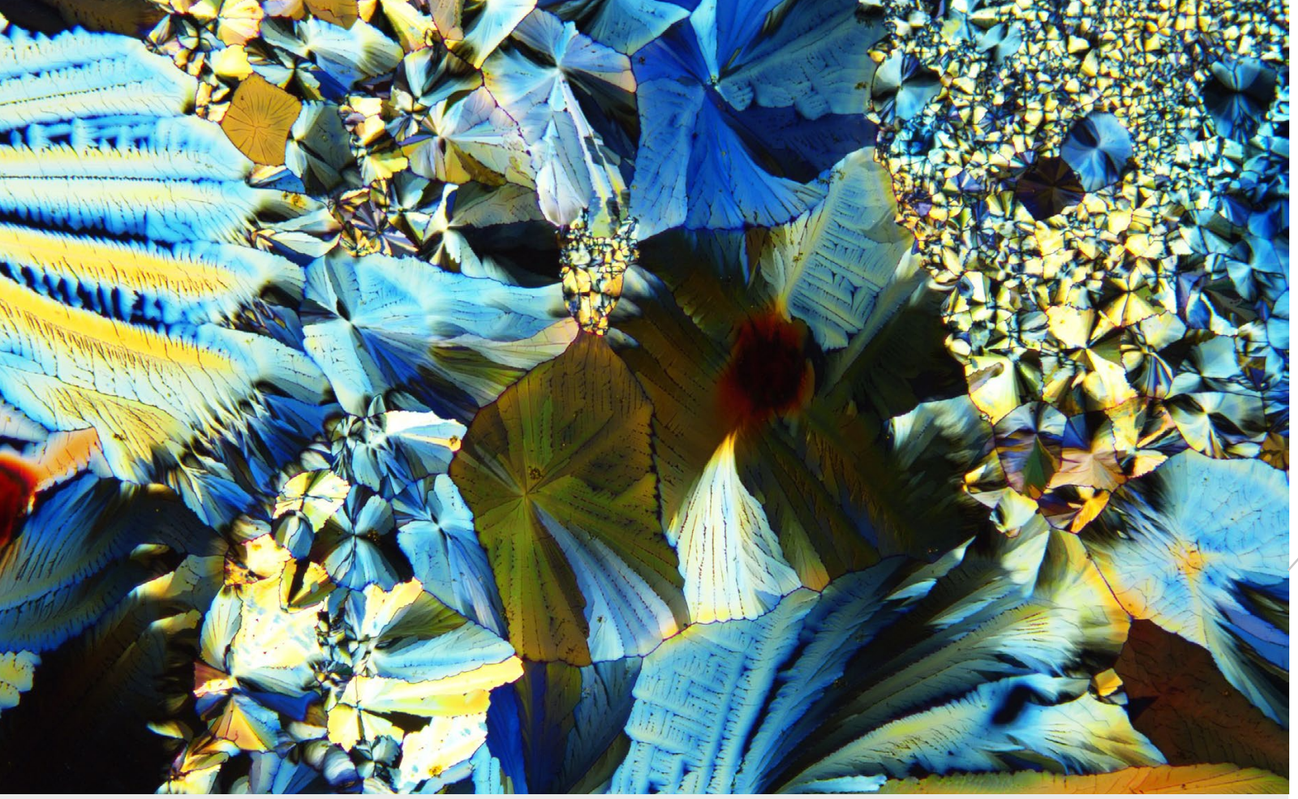
In the Advanced CMOS Hybrid devices research line we have successfully tested and characterized a magnetic image sensor fabricated with a monolithically integrated CMOS (AMS 0.35µm) and TMR (INL Spintronics group) processes. Another mixed-signal analogue IC design was completed and sent to fabrication (TSMC 0.18µm) as part of an implantable system for Intra-Ocular Pressure monitoring. The pressure sensor was designed and fabricated in a flexible polyimide process at INL (Nanodevices and Microfabrication groups).

Figure 13. Layout view of hybrid CMOS/TMR image sensor

Fig 14. Third generation of portable Potentiostat.Collaborations with the Water Quality Group , for the development of a portable device able to readout electrochemical sensors (designed and fabricated at INL). Automated Impedance measurements were made in river basin using this platform for Microcystin detection. A portable potentiostatic system has also been deployed through several collaborations within the frame of FCT funded projects. Improvements have been specified into the 3rd generation of this system targeting a true low cost and high performance Potentiostat device (to be launched in 2019).

Fig 15. Cross section of CO2 gas sensor: A major highlight within the System Integration research line is the development of an air quality sensor (CO2) for environmental monitoring. A new Copper Oxide sensor aiming at rapid response time, low power consumption and reliability is under fabrication for air quality IoT applications (Build Braga, NanoBiosensor and Ultra Low-power sensors with low power RF comms).





"Mosaic", Porphyrin crystals viewed using Polarized Optical Microscopy. Author: Carlos Rodrigues. *

* This image was taken from the final selection of the INL 2017 scientific Photo Contest.

NANOPHOTONICS

The Nanophotonics department at INL performs cutting-edge research and innovation in photonics aiming at improving our understanding of life at the molecular scale for the advancement and wellbeing of society.

It is composed of an interdisciplinary team of researchers working in the fields of non-invasive photonics-based spectroscopy and imaging technologies for materials science, biology and nanomedicine. They study natural photonic structures and develop artificial ones with unique light-matter properties creating innovation solutions, ranging from super-resolution, (bio-) sensing, hight.emitting devices, drug delivery, solar cells to quantum sensing and information technologies.

Based on European and national funding in 2018, their activities have grown forming two research groups, hiring five postdoctoral and two junior researchers widening their technological profile and strengthening the interaction with other INL departments and external collaborators.

Research Groups

Natural and Artificial Photonic Structures and Devices

Ultrafast Bio and Nanophotonics

NANOPHOTONICS

Natural and Artificial Photonic Structures and Devices - NAPSD

The NAPSD group, founded in March 2018 and led by **Martin López-Garcia**, has as main goal to develop new methods for the control of light-matter interactions towards novel scattering, emission, and absorption properties of nanostructured systems, following two strategies: (a) Discovery and biomimetics of natural photonic structures for green and inexpensive nanotechnology, and (b) Micro- and nanophotonic structures and devices integrable with current nanofabrication technologies.

The team is currently formed by four researchers with different backgrounds, such as biology, material science, and applied physics, which creates a very creative and multidisciplinary environment, with active collaboration with other groups at INL and worldwide. During 2018 the NAPSD group also hosted researchers and students from universities worldwide.

The first highlight of 2018 for NAPSD group was, in collaboration with the University of Bristol and published in Science Advances, the demonstration of algae that present intracellular nanospheres that reflect light at selective colours, depending on the light environment. This is the first time that a complex 3D photonic structure found on photosynthetic organisms.

A second highlight was the kick off of a new project to investigate how plants manipulate light at nanoscale to enhance photosynthesis. The group expects that both highlights, the published discoveries and the new project will allow them to develop new biomimetic approaches to green energy harvesting technologies during 2019.

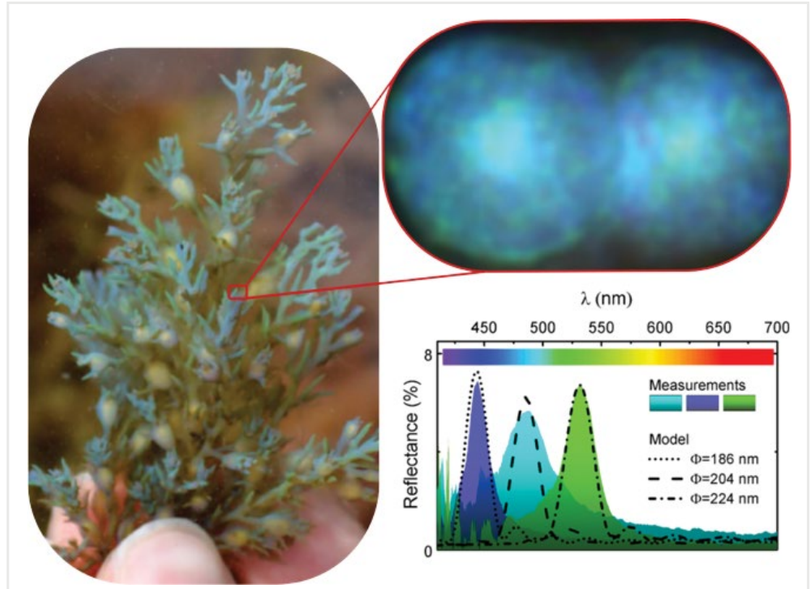


Figure 16: Brown algae Cystoseira Tamariscifolia showing the characteristic structural colour due to the presence of intracellular photonic crystals (inset) as described in M. Lopez-Garcia et al. Science Advances, 4, eaan8917 (2018).

NANOPHOTONICS

Ultrafast Bio- and Nanophotonics - UBNP

The UBNP group is devoted to the study of light-matter interactions and their use to develop technologies for *in vitro* diagnostics, advanced (bio)-imaging, quantum technologies as well as light-based computing. The current research lines relate to:

- Using advanced photonic tools to study drug delivery systems and their interaction with cells;
- Luminescent intracellular nanothermometers;
- Photonics nanoscale biosensors e.g. for DNA analysis;
- Super-resolution microscopy methods;
- Direct writing of 3D free-form microstructures;
- Single quantum emitters and their use in photonic devices, quantum metrology, and bioimaging;
- Novel light sources, such as quantum and plasmonic LEDs.

The UBNP interdisciplinary team, led by **Jana B. Nieder**, is currently composed of six physicists, two bioengineers, a chemist, and a physics engineer.

Highlights for the year 2018 include published research results on novel photonic ways to track the effect of drug delivery systems (see Figure below), develop a nanothermometer, or obtain activatable plasmonic structures for next generation displays. Those findings and technologies were partly developed with internal, national, and international collaborators. Other achievements for the year were the full development of Quantum-Material-based Light Emitting Devices, and a patent application (in collaboration with FemtoLab at U Porto/Sphere Ultrafast Photonics). National funding was awarded for the research on super-resolution microscopy and nanoscale sensing, and quantum metrology. For novel light sources, funding via a FETOpen project is being led by Bruno Romeira, for the development of photonic technologies for artificial intelligence hardware.

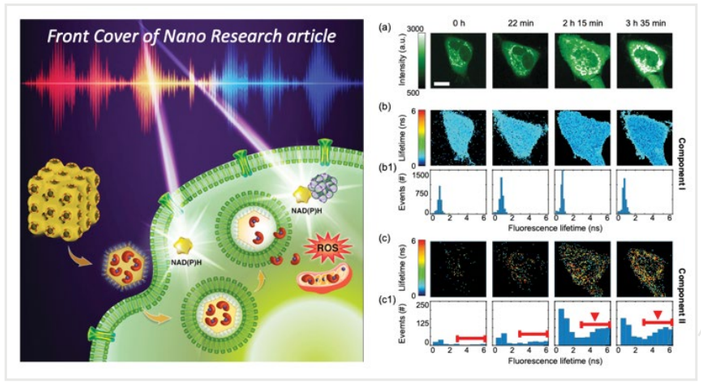
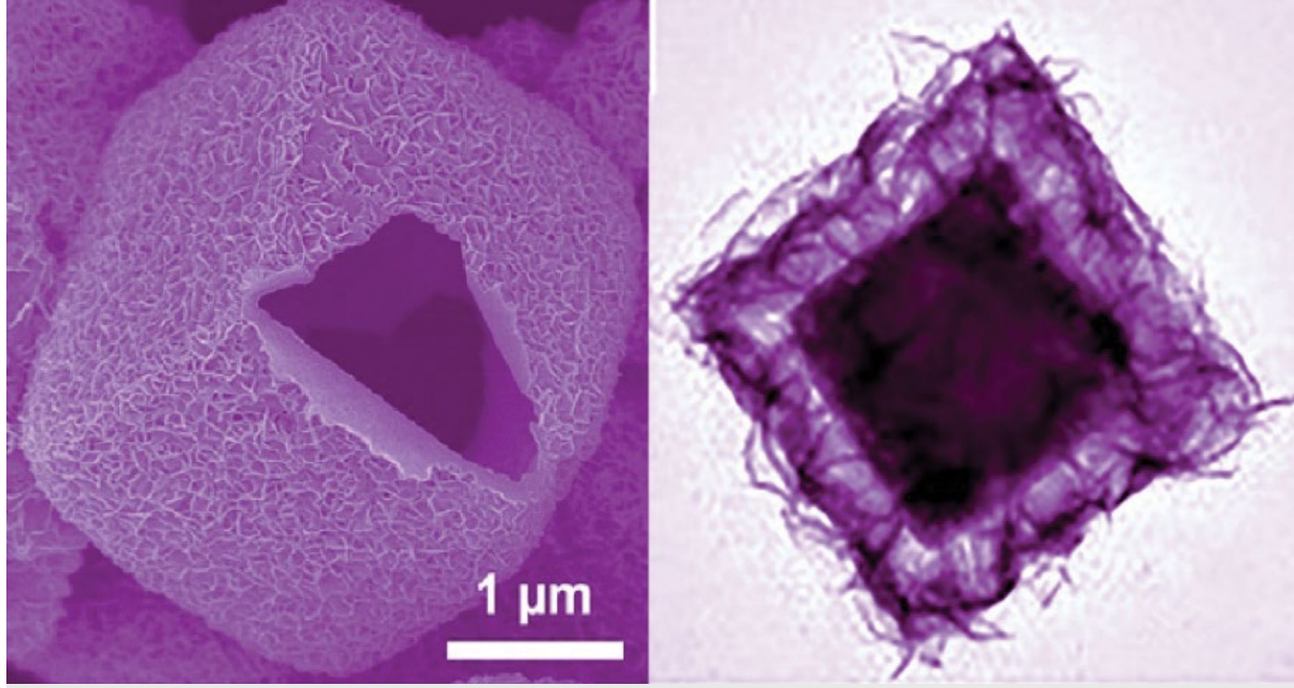


Figure 17: Research Highlight 2018: Nanophotonics for Medicine. Front cover of Nano Research illustrating the role of photonics to track the bioenergetic response of a drug delivery system. In the experimental results one can see the evolution of signal associated to endogenous NAD(P)H markers during the duration of the treatment.



"What's inside the box? A sugar cube". CoSe nanosheets-assembled hollow box contains a cobalt precursor nano-cube. Author: Wei Li. *
* This image was taken from the final selection of the INL 2017 scientific Photo Contest.

QUANTUM & ENERGY MATERIALS

The Department for Quantum and Energy Materials (QEM) focuses on fundamental and applied materials science with promising applications in quantum and energy technologies. On the quantum materials the emphasis is mainly on 2D materials where research is performed both experimentally and theoretically. Energy materials cover the topics energy generation and storage with strong efforts in catalysis, fuel cells, batteries, and photovoltaics.

Activities include experimental and theoretical research and development of 2D materials (graphene, transition metal di-chalcogenides, boron nitride, magnetic 2D materials, quantum spin Hall insulators, etc.), fabrication of devices based on 2D materials (e.g. biosensors and photodetectors), atomic scale electronics, functional point defects in 2D materials for quantum technologies, photovoltaic materials for advanced thin film solar cells (Cu(In,-Ga)Se_2, etc.), materials for solar-to-hydrogen conversion and batteries, etc.

The department is structured in three units, where each unit currently consists of two research groups:

Research Groups

2D Materials Unit:

2D Materials and Devices group – 2DMD

Atomic Manipulation for Quantum Nanotechnology – AMQN

Energy Materials Unit:

Laboratory for Nanostructured Solar Cells – NSC

Nanomaterials for Energy Storage and Conversion – NESC

Theory Unit:

Electrodynamics of 2D Materials Group – E2DM

Theory of Quantum Nanostructures Group - TQN

QUANTUM & ENERGY MATERIALS
2D Materials Unit

2D Materials and Devices - 2DMD

In 2018, the 2DMD group continued to study the growth of graphene and h-BN (hexagonal-Boron Nitride) on Cu cooper) and Mo (Molybdenum) catalysts by chemical vapour deposition (CVD), and started CVD of transition-metal di-chalcogenides ($MoSe_2$, MoS_2…). As for devices, their label-free biosensors based on graphene were further developed, giving new steps towards sensor integration and portability. A microfluidic chamber was coupled to the graphene chip. They started the fabrication of photodetectors based on Van der Waals stacks of 2D materials.

This year, the 2DMD group received a new postdoctoral researcher, a PhD student, and five MSc students, and also had others moving on to other challenges: a postdoctoral researcher and a PhD student who defended thesis on July 24th 2018. Other current members are: the group leader, **Pedro Alpuim** (also affiliated to the Physics Department of University of Minho (UM), an INL staff researcher, an associated researcher from UM, a CoFund postdoctoral researcher, and two PhD students. The group hosted one visiting scientist from the USA and a summer student from India.

In 2018, the 2DMD group achieved growth of millimeter-sized graphene single crystals followed by a clean way to transfer them onto Si/SiO_2 substrates, and obtained record limit-of-detection values of DNA 25-mer oligonucleotides using their electrolyte-gated functionalized graphene field-effect transistors. They will be participating in many new projects approved in collaboration with groups from both INL and other institutions, namely: on biosensing based on graphene plasmonics (with the University of Porto and the UM), another for DNA detection using graphene liquid-gate transistors (with INL Food Quality & Safety Research Group), another for developing RF graphene transistors and circuits (with UM), and one project with industry to develop graphene inks and pastes for inkjet and screen printing.

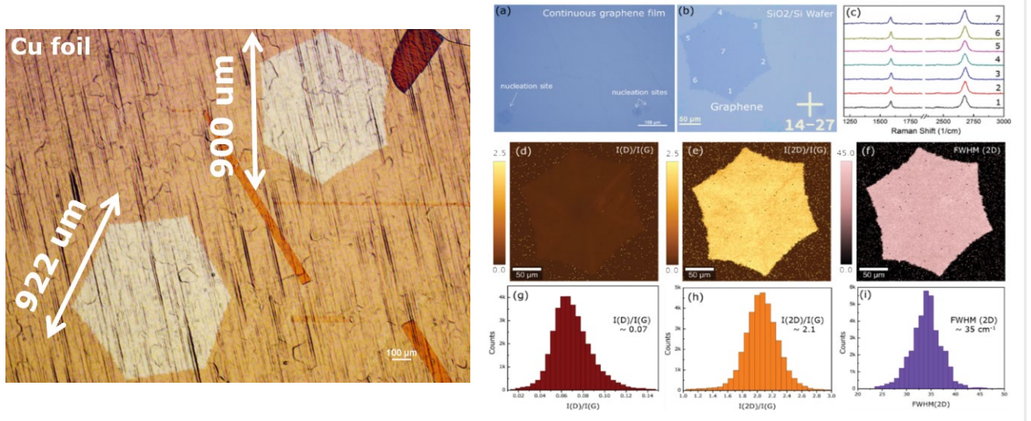


Figure 18. (Left) Graphene mm-sized single crystals as grown on Cu foil. (Right) The representative Raman signatures in (c) enable local characterization of layer number, structural defects, and quality of the as-transferred graphene. The spectral consistency of Raman-scattering signals measured from seven selected positions (b) indicates the uniformity of the as-grown graphene. The relative intensities of G (~1585 cm^{-1}) and 2D (~2700 cm^{-1}) bands are in accordance with those of monolayer graphene. Considering the negligible D-band intensity at ~1350 cm^{-1}, the defect density is minimal. The Raman mapping in (d) – (i) provides whole examination of the spatial uniformity over the selected graphene crystal. In (d) – (e) and (g) – (h), the intensity of D and 2D bands were normalized by G band intensity. The corresponding statistics in (h) extracted from the mapping of I(2D)/I(G) in (e) shows that over 95% of the as-transferred graphene has 2D band intensity higher than 1.6 times the intensity of G band, with a I(2D)/I(G) average of 2.1 ± 0.3, implying the high-quality monolayer CVD-grown graphene. Judging from the mapping of I(D)/I(G) and its corresponding statistics in (d) and (g), the intensity of D band is as low as 3.5% of 2D band intensity, i.e., no apparent defects were introduced over the whole mapping area. According to the results of (f) and (i), FWHM (2D) of 34.2 ± 3.0 cm^{-1} can further support the uniformity and the quality of the as-transferred graphene.

QUANTUM & ENERGY MATERIALS
2D Materials Unit

Atomic Manipulation for Quantum Nanotechnology - AMQN

The AMQN group was established in 2017, having 17 group members during 2018. The team is led by **Zhongchang Wang**. Main research lines and team members respectively working on these are:

1) Synthesis, property measurement and device fabrication of new two-dimensional materials for ferroelectric and ferromagnetic applications (eight postdoctoral researchers)
2) Atomic-scale structure characterization of ferroelectric and ferromagnetic two-dimensional materials (two postdoctoral researchers and one student)
3) Structure and property prediction and atomistic mechanism clarification based on first-principles methodology (one postdoctoral researcher and two students on this research line)
4) Heterostructures of multiple two-dimensional materials for multifunctional applications (four postdoctoral researchers will be assigned to this research line)
5) Two-dimensional materials for energy applications (one postdoctoral researcher and one student on this research line).

In the past two years, they developed three chemical vapor deposition (CVD) systems and a chemical vapor transport (CVT) system, aimed to develop new 2D material systems for ferroelectric and ferromagnetic devices. A highlight from 2018 was their report on the formation of stable free-standing 1D indium selenide (InSe) atomic chains obtained from 2D-InSe layered materials by directly heating at specific temperature, demonstrating that indium selenide (InSe) layered material experiences a transformation from 2D zig-zag edge structure to 1D atom chains, which is a bottom-up production of 1D atomic chains that provides the opportunity to propel the device channel forward to individual atom-chain level, and can have a crucial impact on the chain-based electronic devices and existing nanotechnologies.

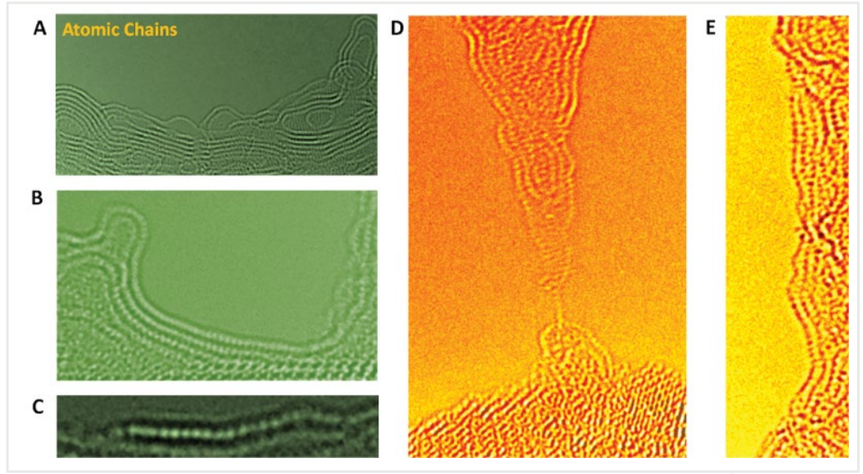


Figure 19: TEM Characterization of one-dimensional atom chains from two-dimensional InSe material. High-resolution TEM images of (A) bundles of curling atom chains in parallel arrangement, (B) several chains derived from InSe layered material (C) enlarged image showing a single chain of single atom limit. High-resolution bright-field TEM (HRTEM) images of (D) a single atom chain and a mass of atomic chains (E). In (A) to (D), atoms appear bright (overfocus); In (E), atoms appear dark (underfocus).

QUANTUM & ENERGY MATERIALS
Energy Materials Unit

Nanostructured Solar Cells – NSC

The NSC group develops nano- and micro-structures for and of chalcopyrite-type semiconductors ($Cu(In,Ga)Se_2$) for application in photovoltaic energy conversion, following four research lines:

- Development of growth methods for chalcopyrite nanostructures i.e. quantum dots and nanowires. The goal is to combine the excellent light absorbing properties with quantum properties, providing a pathway for increased power conversion efficiencies.
- Development of advanced thin film solar cells by the implementation of micro- and nanostructures.
- Development and application of scanning probe microscopy techniques for the characterization of solar cell materials and light-induced phenomena at the nanometer scale.
- Development of 2D materials for optoelectronic applications.

The team is led by **Sascha Sadewasser**, and consists of one staff researcher, one research engineer, two postdoctoral researchers, two PhD students, and two Masters students.

In collaboration with the group of N. Barreau (University of Nantes, France), the group analyzed the impact of a KF post-deposition treatment (PDT) on the aging of the $Cu(In,Ga)Se_2$ (CIGSe) surface. In the recent years, alkali-fluoride PDTs have led to a significant efficiency increase in CIGSe solar cells, which now reach up to 22.9%. Combining Kelvin probe force microscopy and photoelectron spectroscopy of treated and untreated samples with and without a thin CdS buffer layer, the groups could show that a stable In-oxide compound forms at the surface of KF-PDT CIGSe, making the treated samples stable against further oxidation. The results provide an explanation for previous phenomenological observations and demonstrate additional beneficial aspects for the introduction of the alkali-fluoride PDT in industrial processing.

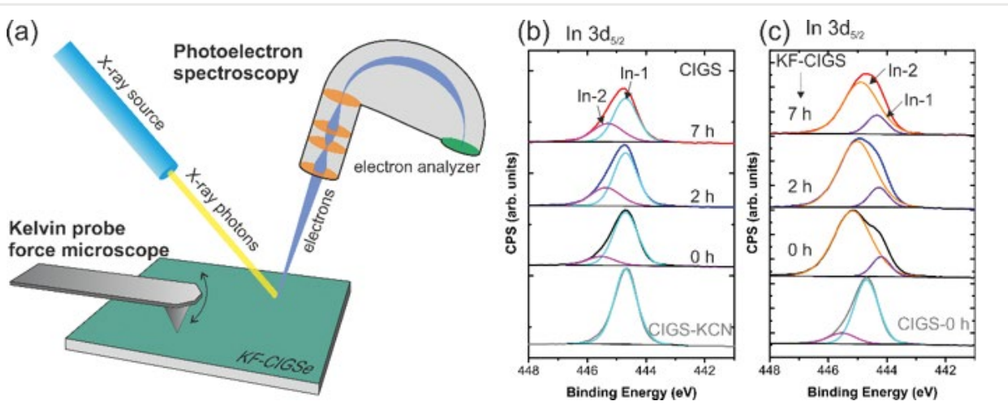


Figure 20: (a) Schematic illustration of Kelvin probe force microscopy and photoelectron spectroscopy (PES) measurements performed on KF-PDT CIGSe and PES spectra of the In $3d_{5/2}$ peak for (b) untreated and (c) KF-PDT CIGSe showing a clear difference in the surface chemistry.

QUANTUM & ENERGY MATERIALS
Energy Materials Unit

Nanomaterials for Energy Storage and Conversion – NESC

The NESC group conducts both fundamental and applied research about new nanostructured materials that can be used in electrochemical energy storage and conversion devices such as water electrolyzers, fuel cells, photoelectrochemical cells, rechargeable batteries and supercapacitors. Currently, the group has three research lines, including (1) advanced electrocatalysts for use in hydrogen and oxygen evolution, oxygen reduction and CO_2 electro-reduction reactions; (2) solar fuel production; (3) electrode materials for electrochemical energy storage. The group is now constituted of one staff researcher, five postdoctoral researchers, and seven associated researchers.

Currently, the group has one European and seven national projects ongoing. The group published nine papers in international peer-reviewed journals (in seven of which INL is the leading institution) and delivered five keynote/invited talks at international conferences. The research on metal phosphide catalysts published in Chemical Science (2018, 9, 3470) and Energy & Environmental Science (2018, 11, 1819) were highlighted by X-MOL research platform (https://www.x-mol.com/news/13126; https://www.x-mol.com/news/13441). Additionally, the group organized two international conferences (COST action HERALD Summit and Solar Fuel Production Workshop). The group leader, **Lifeng Liu**, was awarded the "Scientist Medal" by the International Association of Advanced Materials (IAAM).

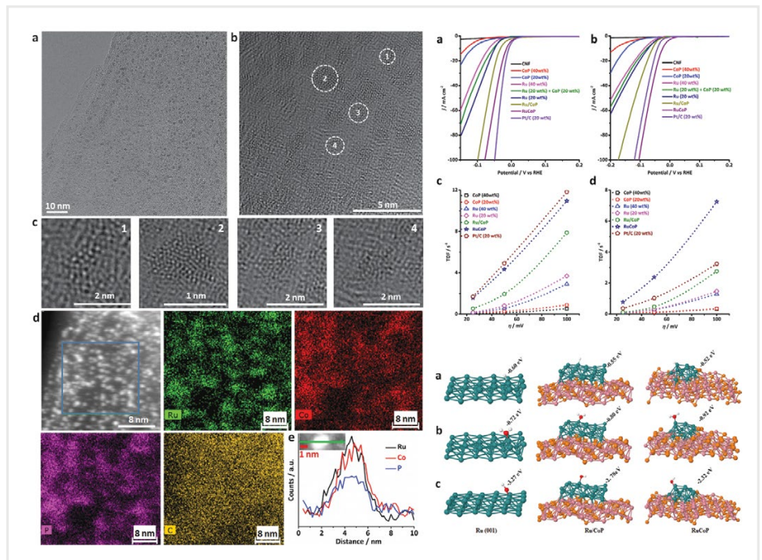


Figure 21. (a) TEM characterization of the RuCoP hybrid hydrogen evolution performance. (b) Electrocatalytic performance of Ru/CoP and RuCoP catalysts for the hydrogen evolution reaction tested in both acidic and alkaline solutions. (c) Model catalysts used to calculate the binding energy values of protons, water molecules and hydroxyl ions.

QUANTUM & ENERGY MATERIALS
Theory Unit

Electrodynamics of 2D Materials - E2DM

The E2DM group is a newly created group at INL during the last quarter of 2018. It is composed of three senior researchers, with double affiliation (University of Minho and INL), a PhD student, three master students, and the group leader, Prof. Nuno Peres. The team has a strong background in topics related to plasmonics in graphene and in Ab-initio calculations of the optical properties of 2D materials, including the use of the Bethe-Salpeter equation.

The goals for 2019 are:

- Strong interactions within other research groups and departments at INL. Outside the Department of Quantum and Energy Materials, the group envisions strong collaboration with others such as with the Natural and Artificial Photonic Structures and Devices group (NAPSD) and the Atomic Structure-Composition of Materials group (ASCM)
- Application to an INT network in the field of functional 2D materials
- Publishing in top notch scientific journals

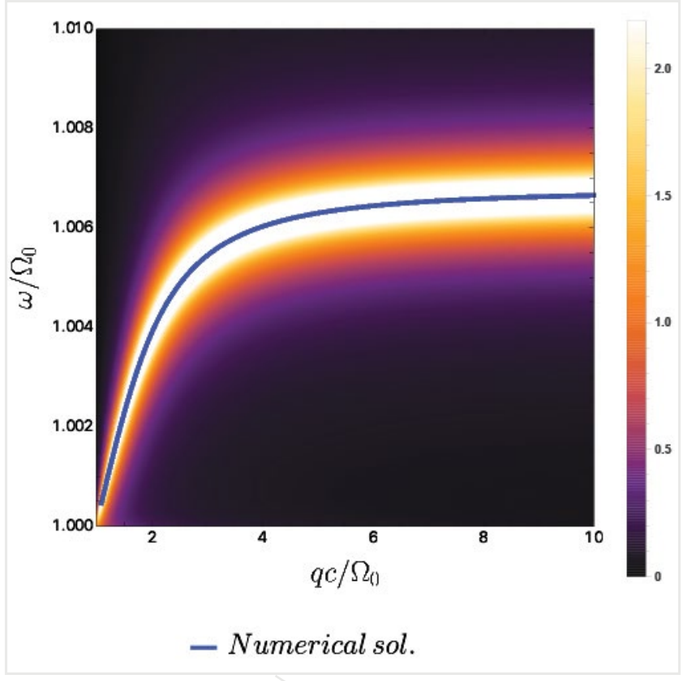


Figure 22. Surface wave at the interface between an antiferromagnet and a dielectric. The Spectral range of the surface wave lies in the terahertz.

QUANTUM & ENERGY MATERIALS
Theory Unit

Theory of Quantum Nanostructures - TQN

In 2018, the research of the TQN group has focused mainly on two systems:

1) Heterostructures of vertically-stacked two-dimensional ferromagnetic crystals, such as CrI_3
2) The understanding of electrically-driven spin resonance of individual atoms on surfaces, probed with scanning tunnelling microscopy.

The group is particularly interested in two types of questions: (1) how to probe spin physics at the atomic scale, and (2) how the spin properties of these atomic scale systems are different from bulk, due to the emergence of quantum phenomena. Their methods include both density functional based calculations as well as Hamiltonian models. In 2018, they have started a new research line on applied Quantum Computing. During 2018, the team, led by **Joaquín Fernández Rossier**, consisted of two postdoctoral researchers, three PhD students, two Masters students, and two summer students.

The group has published eight major high impact publications in 2018: two papers in Science, one in Nature Nanotechnology, one in Science Advances and one in Physical Review Letters that was highlighted as the cover of the journal. The most outstanding research output of 2018 has been the proposal of a new type of in-plane transport spin valve, based on spin proximity caused by ferromagnetic insulators in conducting two dimensional crystals, such as graphene bilayer. This work, carried out 100% at INL, has been highlighted at the cover of Physical Review Letters.

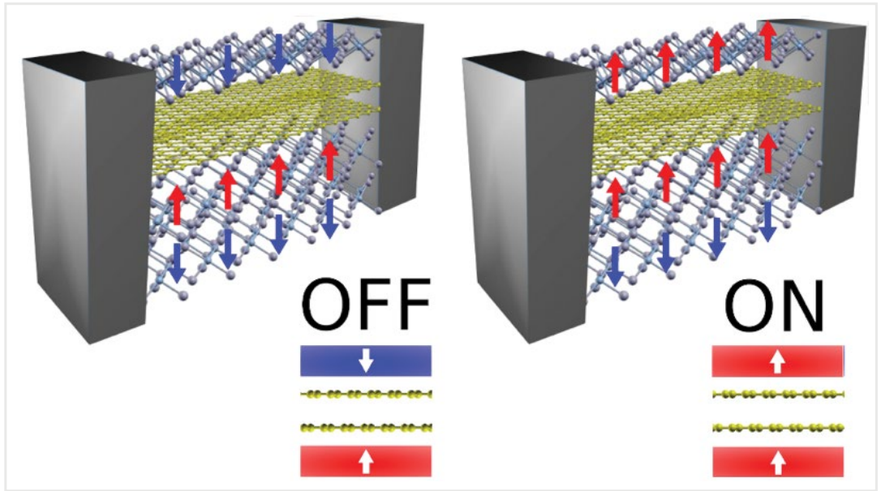


Figure 23. Scheme of Van der Waals Spin Valve. In plane conductance is switch on and off depending on the relative orientation of the ferromagnets. From C. Cardoso, D. Soriano. N. García-Martínez, J. Fernández-Rossier, Physical Review Letters 121, 067701 (2018), Cover of the journal.

BUSINESS & INNOVATION

BSR

Established to be a reference point for cutting-edge, interdisciplinary and collaborative research in nanotechnology and nanoscience, the business and innovation strategy of INL is based on the vision that INL will be recognized internationally as a research-intensive institution that is distinguished by its focus on the translation of knowledge into societal and economic benefits. The main pillars for this business and innovation strategy are:

- Becoming a trusted partner in the development of nanotechnology- and nanoscience-based solutions for major societal problems (health and ageing, environment and food-quality control, energy, ICT);

- A new approach to **creating value from research,** in collaboration with regional, national, and international stakeholders (e.g., universities, RTD centres, industry, and public/social organizations);

- A **knowledge-transfer corporate office,** positioning INL as a partner of choice for industry and business, supporting access to intellectual property, and providing knowledge-based services to companies;

- A new approach to **research & training with a focus on innovation.**

The role of the Business Strategic Relations (BSR) department is to lead and support INL in all its business operations. The activities of the BSR department spans over a wide range of matters such as initiating and maintaining external contacts with industry, hands-on project management and handling of grant proposals and contractual agreements.

The BSR department is, moreover, responsible for handling the commercialization and intellectual property pertaining to the research activities at INL or conducted with its partners.

The business operations at INL can, in general terms, be divided into two logical areas: one being centered on funding logics and the other on business logics. The funding logics area of INL relates to acquiring funding from public and private stakeholders to carry out research that will generate new knowledge and understanding for the benefit of society. For the business logics, INL is mainly based on services that are linked to micro- and nanofabrication requests, as well as various levels of characterization such as microscopy and spectroscopy services. INL further offers contracted R&D engaging with a company (or a set of companies) to assist their own development work. INL may further act as the extended arm of a company´s own R&D department. Main achievements of INL during 2018 are exemplified in the following sections.

INL is constantly exploring new ways to foster a higher level of industry involvement in its research activities, particularly leveraging its competitiveness in terms of bridging the gap between basic and applied RTD.

Model 1

INDUSTRY PUSH

Company approaches INL to:

- Get to know our capabilities & infrastructure.
- Request support in addressing specific R&D challenges.

Model 2

TRUST-BASED

Based on existing relationships (e.g. funded projects, provider, etc.), collaborations are initiated between INL and a specific company.

INL

Model 3

INDUSTRY PULL

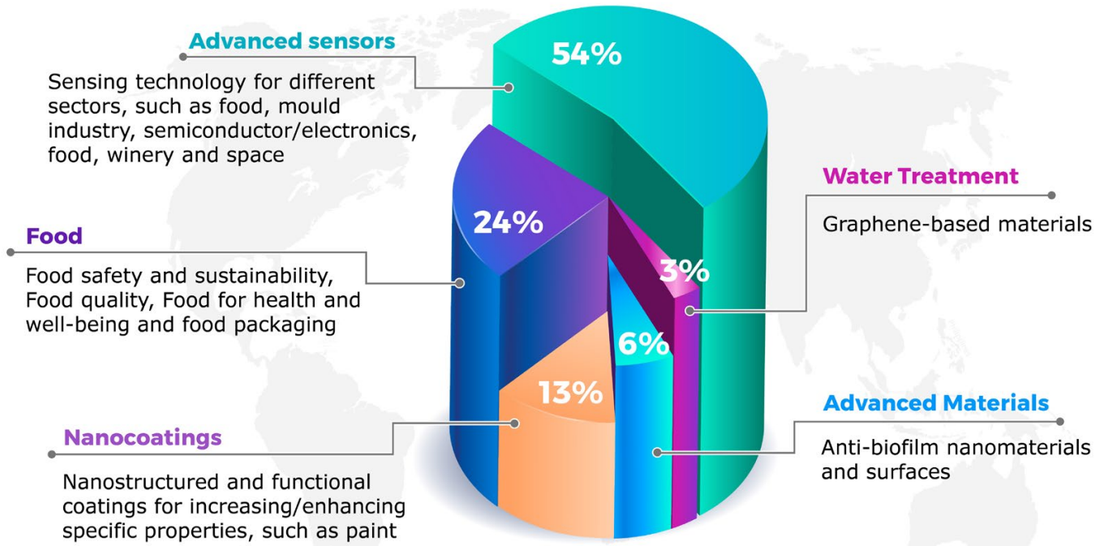
INL approaches companies to start a collaboration within a funded project or a RTD service agreement.

Ongoing funded projects with the industry

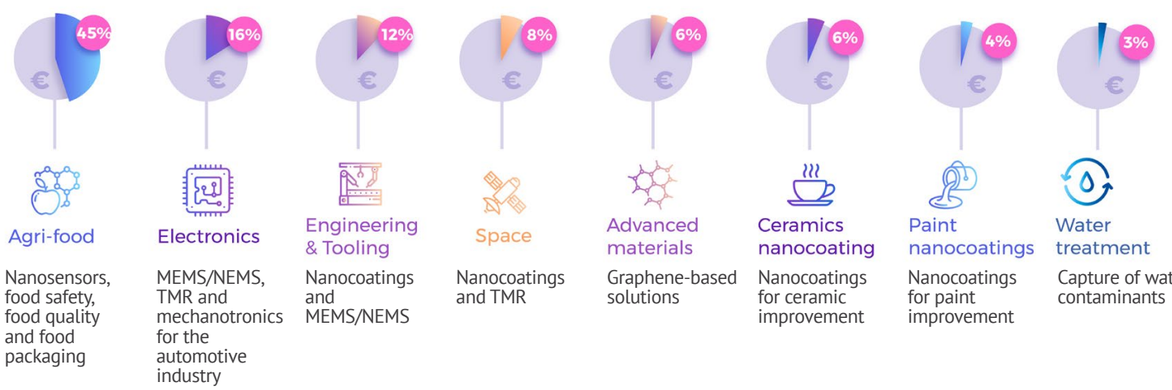
INL aims to play a leading role, at international level, in facilitating and coordinating the implementation of nanotechnology-based research programmes and projects that generate valuable compounded knowledge, products and services for the benefit of industry and society.

Until December 2018, INL had 17 ongoing funded high TRL projects with industry.

Breakdown of ongoing projects per Activity Area



Breakdown of ongoing projects per Sector

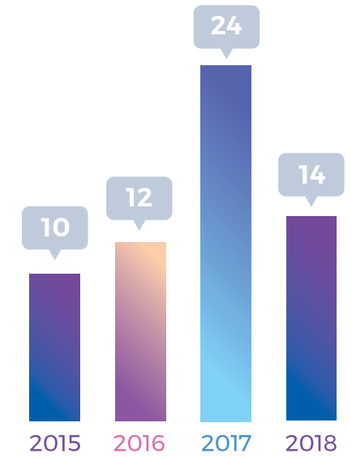


INTELLECTUAL PROPERTY

Patents

INL treats intellectual property (IP) with utmost care. Proper IP management is essential for building trust and for enabling successful collaboration with industry, academic institutions and other partners. INL continuously monitors intellectual assets and ownership to offer suitable IP protection strategies for efficient commercial exploitation. This is performed without jeopardizing the important open dissemination of research results and the exchange of information among academic scholars.

Number of patent applications filed by INL per year



An illustration of the active filing strategy at INL for protecting inventive concepts derived from its outstanding scientific competence.

Bartolomeu de Gusmão Award 2018

INL has been very active in exploring innovative concepts resulting from the excellent research activities at INL, with the goal of generating business opportunities and successful deployment of nanotechnology in society. The efforts have also been recognized externally. In 2018, INL was one of the entities awarded by the Portuguese Government with the **Bartolomeu de Gusmão Award**[1] ***(Prémio Bartolomeu de Gusmão)*** in its first edition. INL was awarded in the "Technological Innovation" category for its consistent strategy of protecting innovation and for being repeatedly the organization located in Portugal that files most patent applications every year at the European Patent Office. The graph above illustrates the number of filed patent applications by INL the last four years, corresponding to more than twenty pending patent families.

Bartolomeu de Gusmão Award 2018, INL Director-General, Prof. Lars Montelius, gratefully received the award "on behalf of the 300 people from 32 nationalities who work at INL".

[1] This Prize was created by Portuguese Ministry of Justice and INPI, the National Institute for Industrial Property, to award the organizations, companies and individuals who have excelled in protecting the Innovation they developed, and to make them an example to others.

WORLDWIDE CONNECTIVITY

Overall International Collaboration

Science is global and INL is engaged in relations with numerous institutional partners worldwide. Besides coordinating and managing several strategic projects in partnership with entities from all Europe, INL's Business and Strategic Relations team is also a facilitator for the interactions between INL and industry, in managing INL's IP portfolio and giving support to more than **105 research and innovation funded projects,** which are listed in "Funded Projects" section 3.5.

105 Projects
306 Partners
25 Countries

Breakdown of projects per funding programme:

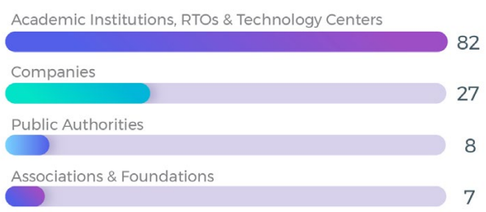
80 National
13 Horizon 2020
12 Interregional

Institutional Level Agreements

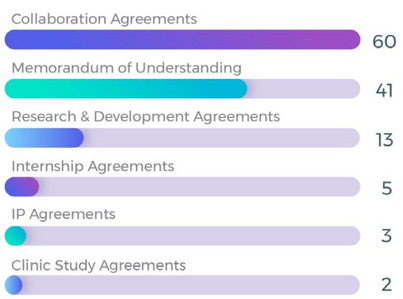
INL has, until December 2018, accomplished 124 Institutional Level Agreements, with 17 different countries. These numbers have been increasing in the latest years and demonstrate the maximisation of the innovation and collaborative work between INL and Research Institutions, Academia, Companies, Associations, Foundations and Public Authorities worldwide. It is of great importance to strengthen the collaborations with institutions worldwide to be able to achieve our Mission and Vision.

124 Institutional Agreements in force

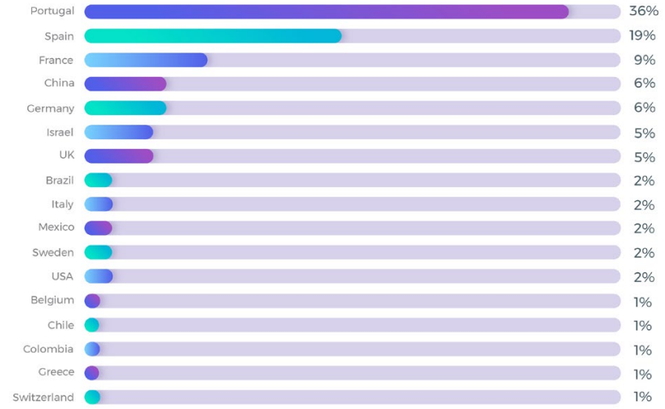
Institutional Agreements per Institution Type



Institutional Agreements per Agreement Type



Institutional Agreements spread over 17 countries



Partnerships and collaborations with companies and private stakeholders are among the top priorities within INL in order to accelerate innovative technology transfer and to develop new nanotechnology-based solutions for grand societal challenges

BSR Coordination and Support Action Projects

During 2017 and 2018 the BSR department had 18 ongoing coordination and support action projects:

18 Projects
80 Partners
18 Countries

Breakdown of projects per funding programme:

7 National Projects
3 Horizon 2020 Projects
8 Interregional Collaboration Projects

SELECTED BSR PROJECTS: EUROPEAN PROJECTS

EPPN

European Network for Pilot Production Projects and Innovation Hubs

Start Date: 01 June 2017 | **End Date:** 31 May 2020 (36 months)
Funding Programme: Horizon 2020
Budget Total: € 997.625,00 | **Budget INL:** € 300.625,00
Website: eppn.eu

EPPN
European Network for Pilot Production Projects and Innovation Hubs

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 768661.

EPPN aims at exploiting the European pilot lines, prototyping production facilities and Open Innovation Test Beds (OITB) and their associated ecosystem in the area of nanotechnology and advanced materials. EPPN digital platform is a marketplace acting as single entry point, connecting Pilot Lines and OITB with its users: SMEs, Startups, Large Enterprises, Policy makers, Investors and other actors in the ecosystem along industrial value chains.

Clusternanoroad

Driving Europe's NMBP economy – Cross-cluster innovation and value creation through validated NMBP collaborative strategies and roadmap

Start Date: 01 September 2016 | **End Date:** 28 February 2019 (30 months)
Funding Programme: Horizon 2020
Budget Total: € 499.168,75 | **Budget INL:** € 105.437,50
Website: clusternanoroad.eu

CLUSTERNANOROAD has the aim to stimulate the uptake of Key Enabling Technologies (KETs) including nanotechnology, advanced materials, biotechnology and advanced manufacturing into multiple sectors across Europe. The project has been focused on clusters as the portal for enabling technologies to boost economic growth through smart specialisation. Clusters within sectors.

Ket4CleanProduction

Pan-European Access for manufacturing SME on technology services for clean production through a Network of premier KET Technology Centres with one-stop shop access including EEN and discourse with policy makers on RIS3

Start Date: 01 January 2018 | **End Date:** 30 December 2020 (36 months)
Funding Programme: Horizon 2020
Budget Total: € 4.898.510,00 | **Budget INL:** € 125.218,75
Website: ket4sme.eu

KET4CleanProduction is developing a sustainable platform and ecosystem by addressing the needs of SMEs by delivering a portfolio of KET available to be used creating win-win situations between manufacturing SMEs and technology service providers. The main objective is to foster the use of advanced manufacturing technologies and related key enabling technologies by SMEs to upgrade their production processes towards resource- and energy efficiency and sustainability.

SELECTED BSR PROJECTS: INTERREGIONAL PROJECTS

Nanogateway

Crossborder Platform for the Promotion of RTD+I in Nanotechnology

Start Date: 01 October 2016 | **End Date:** 30 September 2019 (36 months)
Funding Programme: INTERREG V-A España-Portugal (POCTEP) 2014-2020
Budget Total: €1.013.028,79 | **Budget INL:** €1.013.028,79
Website: nanogateway.eu

NANOGATEWAY aims to implement a strategy and action plan to unlock the potential of nanotechnology-base research by creating new collaborative approaches among the stakeholder in the value chain. INL, together with regional institutions, intends to strengthen the capacity to develop excellence in RTD+I and motivate academic institutions and research centers to develop collaborative RTD projects and to guide their projects in the search for solutions and nanotech based products.

Atlantic KET Med

Establishing a transnational advanced pilot manufacturing ecosystem for future biomedical products

Start Date: 01 November 2017 | **End Date:** 31 October 2020 (36 months)
Funding Programme: Interreg Atlantic Area
Budget Total: 2,768,040.46€ | **Budget INL:** 470,983.67€
Website: atlantic-ketmed.eu

Atlantic KET Med is a project coordinated by the National University of Ireland Galway involving six other partners from the EU Atlantic Area, including INL. Atlantic KET Med is bringing new, high tech, pilot production capacity to the EU Atlantic Area in support of SMEs and Start-ups using the Key Enabling Technologies (KETs) to produce Next Generation medical devices. The initiative offers direct support to companies to enhance their: Innova

KETmaritime

Transfer of Key Enabling Technologies (KETs) to the Maritime Industries

Start Date: 01 November 2017 | **End Date:** 29 February 2020 (36 months)
Funding Programme: Interreg Atlantic Area
Budget Total: 988.510,40€ | **Budget INL:** 224.000,00€
Website: ketmaritime.eu

KETmaritime aims to build a cooperative network and strengthen the KETs transfer of innovation results to facilitate the emergence of new products, services and processes across the Atlantic Area. KETmaritime network intends to increase knowledge, identify and exchange good practices and sustainable solutions based on KETs for the marine economy and resources, in order to improve the socioeconomic situation through innovation and transnational cooperation.

Nanoeaters

Valorization and transfer of NANOtechnologies to EArly adopTERS of the Euroregion Galicia-Norte Portugal

Start Date: 01 January 2017 | **End Date:** 31 December 2019 (36 months)
Funding Programme: INTERREG V-A España-Portugal (POCTEP) 2014-2020
Budget Total: €4.255.750,69 | **Budget INL:** €1.471.852,35

NANOEATERS aims to encourage synergic cooperation between crossborder RTD centers and universities from Galicia and Norte de Portugal. The final goal is to improve the connection between RTD centers and companies, so that results from RTD can be commercially exploited. NANOEATERS results from a network of Research Centers coordinated by GAIN - Galician Innovation Agency (Spain) and supports the Euroregional "early adopters" companies in the application of new nanotechnology-based solutions. Companies, Universities and Technology Centers will work together with INL in the definition of new nanobased commercially available products and services.

Códigomáis

Foundation of a Cross-border Innovation Ecosystem in the Health Sector

Start Date: 01 January 2016 | **End Date:** 31 December 2019 (36 months)
Funding Programme: INTERREG V-A España-Portugal (POCTEP) 2014-2020
Budget Total: €2.258.893,06 | **Budget INL:** €229.162,15

website: codigomais.eu

CÓDIGOMÁIS is an initiative coordinated by ACIS – Axencia Galega para Xestion do Coñecemento en Saude – Servicio Gallego de Salud (Spain) aiming at promoting the cooperation in the health sector in the regions of Galicia and North of Portuga. The project pursues three main goals: improve the cooperation between the research centers, regional administration, companies and end-users; increase market-oriented RTD; and promote the internationalisation of the Galicia-Norte de Portugal Health Ecosystem.

NMP-REG

Delivering NMP to Regional manufacturing

Start Date: 01 April 2016 | **End Date:** 31 March 2021 (60 months)
Funding Programme: Interreg Europe
Budget Total: €1.622.195,00 | **Budget INL:** €143.968,75
website: interregeurope.eu/nmp-reg/

NMP-REG is a project led by ASEV – Agency for the development of the Empolese Valdelsa (Italy) and groups partners from five regions, who want to face the challenge of ensuring that innovation actors cooperate to deliver research results to the manufacturing sector, with subsequent benefits for regional growth. The overall objective of NMP-REG is to improve regional policies for delivery of innovation in NMP to manufacturing. The initiative focuses on policy actions that can support innovation delivery, using coordinated action from key players.

CT-BIO: Transregional Cluster on Biotechnology

Increase the Growth and competitiveness of the cross-border biotechnology sector

Start Date: 30 March 2017 | **End Date:** 30 September 2019 (30 months)
Funding Programme: INTERREG V-A España-Portugal (POCTEP) 2014-2020
Budget Total: €1.839.305,00 | **Budget INL:** €209.544,18
website: ct-bio.org

The main goal of the CT-BIO project is to improve the business competitiveness and the consolidation of the biotech and life sciences sector in the cross-border region of Galicia and Norte de Portugal with a joint plan based on collaboration between agents and companies on both sides of the border.

The core mission of the project is to promote the cooperation and integration of the biotech sector in the trans-border region through the boost of the Iberian Biotech Cluster.

SELECTED BSR PROJECTS: NATIONAL PROJECTS

Nanotech@NortePT

Promote Nanotechnology in the Industry of North Portugal

Start Date: 01 June 2016 | **End Date:** 31 May 2018 (24 months)
Funding Programme: Norte2020
Budget Total: € 207.562,50 | **Budget INL:** € 144.340,00
Website: nanotechnorte.pt

Nanotech@NortePT project aims to promote scientific and technological knowledge transfer in the field of nanotechnology in order to increase cooperation, companies' investment in R&D and to promote the North Portugal region as a supplier of knowledge and technology in the field of nanotechnology. The initiative is coordinated by CeNTI – Centre for Nanotechnology and Smart Materials (Portugal) in collaboration with INL. Supported by nanotechnology based knowledge and by the advanced critical mass in the region, the project intends to identify, develop and create new business projects that globally distinguished.

Nourish

A Portuguese Rapid Prototyping Open Digital Innovation Hub for Nanotechnology and Advanced Materials

Start Date: 1 September 2017 | **End Date:** 31 August 2019 (24 months)
Funding Programme: COMPETE 2020
Budget Total: € 723 372 | **Budget INL:** € 723 372
Website: nourish.inl.int

Nourish project aims to setup a Rapid Prototyping Open Digital Innovation Hub. This initiative is instrumental in supporting the SME's and entrepreneurs in the Nanotechnology and Advanced Materials to overcome the so-called "valley-of-death" between the research activities and the market roll-out of innovation products or services. Hence, NOuRIsh has two main strategic objectives: promote the economic exploitation of R&D results emerging from the nanotechnology innovation and research system; boost the transfer of scientific and technological knowledge on nanotechnology to the business sector.

Micro&NanoFabs@PT

Network of Micro and Nano Fabrication Research Facilities in Portugal

Start Date: 01 October 2017 | **End Date:** 30 September 2020 (36 months)
Funding Programme: COMPETE2020; NORTE2020
Budget Total: € 6.036.528,22 | **Budget INL:** € 2.920.792,00

Micro&NanoFabs@PT is part of the National Road Map of Strategic Interest Research Infrastructures. It integrates large infrastructures of micro- and nanofabrication with clean rooms properly equipped for the manufacture and characterization of micro- and nanodevice technologies, as well as laboratories with microfabrication, design and characterization capabilities.The project presents itself as an infrastructure with high international penetration capability that benefits from the existence of a joint business plan and a governance model able to integrate the three national nodes (INL, INESC-MN and CMEMS-UMinho). Micro&NanoFabs@PT provides advanced services to industry and scientific community and simultaneously creating an advanced training offer, providing technology transfer services and promoting the incubation of new startups in need of access to advanced services micro- and nanofabrication and design.

WORLDWIDE CONNECTIVITY

Overall International Collaboration

The internationalization of research is essential for the development of high-quality science and innovation. The collaboration with leading research entities and companies, both national and international, offers not only a fruitful exchange of ideas, but also to identify synergies and potentialities of collaboration among the various research centres and infrastructures.

The INL has been since its creation in constant and intense collaboration with many entities at international level. Currently, INL researchers collaborate regularly with universities and other research centers from all around the world INL also participates actively in several **national, European and international associations, networks and platforms**, namely:

- **IBM-Q Network,** a community of Fortune 500 companies, academic institutions, start-ups and national research labs working with IBM to advance Quantum Computing.
- **Bio Based industry European Technology Platform;**
- **EARTO** – European Association of Research and Technology Organisations;
- **ARTEMIS-IA** Industry Association :
    - **ECSEL JU** - Joint Undertaking on Electronic Components and Systems for European Leadership;
    - **ENIAC JU** - Joint Undertaking on Nanoelectronics;
- **ECSITE**-European Network of Science Centers & Museums
- **EUMAT** - European Technology Platform for Advanced Engineering Materials and Technologies;
- **ETPN** - The European Technology Platform for Nanomedicine;
- **EPPN** - European Pilot Production Network **(Coordinated by INL)**;
- **NanoGateway** Platform for Research and Innovation in Nanotechnology **(Powered by INL)**;
- **NANOfutures** - European initiative for sustainable development by Nanotechnologies;
- **NIA** - Nanotechnology Industries Association;
- **EuroNanoLab** - a collaborative network formed by the research infrastructures for micro- and nanofabrication of France (RENATECH), Czech Republic (CEITEC), Italy (CNR), the Netherlands (NanoLab NL), Norway (NorFab), Sweden (Myfab), Portugal and Spain (both represented by INL);
- **S3P Agrifood T&BD, Thematic Partnership on Traceability and Big Data in the Agrifood Value Chain,** under the S3 Platform on Agri-Food, Coordinated by Junta de Andalucía;
- **Health Cluster Portugal;**
- **Health Cluster Galicia ;**
- **Produtech Cluster Portugal.**

INL also participates in steering committees, international advisory boards and scientific advisory committees, as:

- Member of the **EC Executive High Level Group (HLG) at DG NMPB;**
- **Board member** and **Working Group Chair** of the two European Technology Platforms **NANOFutures** (www.nanofutures.eu) and **EuMat** (http://eumat.eu/);
- Presidence of the **IUVSTA**: The International Union for Vacuum Science, Technique and Applications www.iuvsta-us.org.

ENTREPRENEURSHIP

The INL's Entrepreneurship Support Programme provides more than incubation facilities. It offers acceleration programmes, access to an international network of mentors (business, financial, legal and communication areas), or even a Venture Fund (SBS Fund) where companies can have access to a first round of investment.

The Entrepreneurship Programme combines services and resources to support new businesses around the world in a range of areas where nanotechnology can be applied as a KET, namely in the fields of Health, Food & Environment, ICT and Energy.

We are dedicated to supporting ideas that can range from early-stage investment to in-depth research with the vision to "Help entrepreneurs around the world to bring great nanotech ideas into life".

In partnership with several institutions, namely Startup Braga, we help new nanotech-based start-ups with global ambitions to grow, providing:

- Incubation Services
- Acceleration Programmes
- Open Access / User Facilities

ACCELERATION PROGRAMMES

Over the last few years INL has launched and implemented six Acceleration Programmes:

- **FUEL:** Future Entrepreneurs' League
- **StartUP.nano:** Dynamization of Nanotechnology-Based Entrepreneurship in the Northern Region of Portugal
- **CTBio:** Cross-border Cluster on Biotechnology
- **Código Máis:** Creation of a Cross-Border Health Innovation Ecosystem
- **Enhance Micro Algae:** High added-value industrial opportunities for microalgae in the Atlantic Area
- **NouRISH:** NanOtechnology Rapid Prototyping Innovation Hub

ENTREPRENEURSHIP
ACCELERATION PROGRAMMES

Acceleration Programmes: Facts & Figures

70
Applications
received

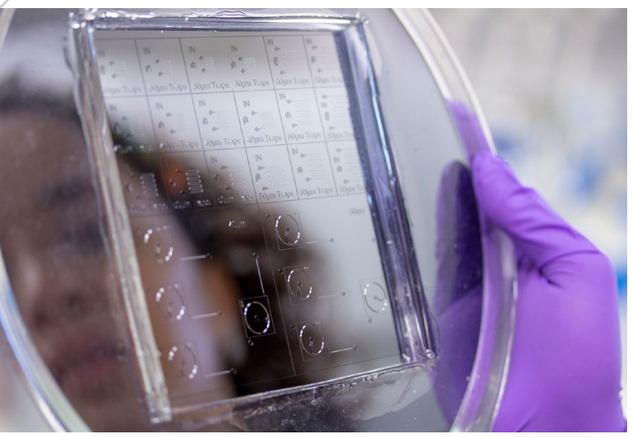
49
Teams/Entrepreneurial
projects supported

33
Teams
working together on consolidation of their Business Models

14
Start-ups
formally created

6
Start-ups
incubated at INL's facilities

INL Spin-Off



In 2018, INL released the first INL Spinoff, called RUBYnanomed, where INL has a head of terms agreeing to be co-founder with 10% of the company by transferring to RUBYnanomed the exclusive license of a patent application assigned to INL.
RUBYnanomed focuses its activities on proving solutions for non-invasive cancer progression monitoring.

RUBY nanomed

INL USER FACILITIES

USER FACILITIES

The INL User Facilities – the Micro and Nanofabrication, the Advanced Electron Microscopy, Imaging and Spectroscopy (AEMIS) and the Nanophotonics & Bioimaging flagships – are designed to be an open facility for researchers and technologists from academia and the industrial sector, allowing access not only to the infrastructure and systems in a self-service mode but also to skilled experts in microsystems and nanotechnology.

The user facilities provide support throughout the entire research and development chain in cleanroom processes as well as in advanced microscopy, spectroscopic, imaging and photonic techniques. Another impacting factor is the heterogeneous set of techniques available under the same roof, leading to competitive integration of different technologies and rapid prototyping, thus paving the way to methods and devices with performances out of reach for a given single technology.

2018 was marked by the certification of the three INL User Facilities according to ISO 9001:2015 standard, becoming one of the very few RTO achieving this recognition.

INL User Facilities in numbers

FACILITY	Usage Hours	N° of bookings	N° of users	N° of serviced groups	N° of Licenses	External users/services
MICRO AND NANOFABRICATION	23 690	13 620	150	20	857	134
AEMIS	14 753	2 241	164	20	207	46
NANOPHOTONICS & BIOIMAGING	6 749	2 329	122	19	334	3

USER FACILITIES

Advanced Electron Microscopy Imaging and Spectroscopy

The AEMIS facility is a core multi-user facility that features cutting-edge instrumentation, techniques and expertise required for the characterization of samples in the physical and life sciences. The facility focuses on materials and biological research, development of novel techniques and instrumentation, as well as providing training, technical support and consultation in the areas of electron microscopy and spectroscopy. The centre facility houses several electron microscopes that can probe the physical, electronic and chemical structure of matter down to the atomic scale. These instruments are coupled with advanced in-situ holders, in which the environment is controlled to match near-realistic conditions of operation, dynamically recording the behaviour of the sample in real time. State-of-the-art support facilities also are available including standard specimen preparation equipment and an image analysis laboratory.

In 2018, a great effort was made to further develop the Advanced Electron Microscopy facility with the aim to increase the service offer and provide full services for a wide range of products characterization. 3 expert facility managers were hired, a sample preparation room was set-up and standard operating procedures developed for all instruments.

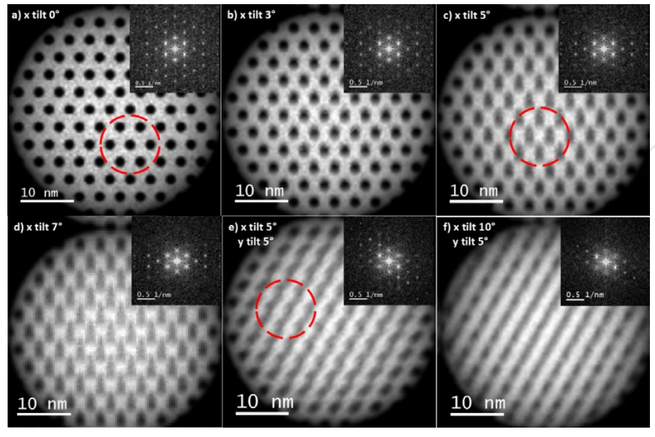


Figure 24 – Aberration corrected STEM tilt series of mesoporous silica nanoparticles.

Available instrumentation:

- Aberration-Corrected Scanning-Transmission Electron Microscopy (STEM)
- Aberration-Corrected Transmission Electron Microscopy (TEM)
- Conventional TEM/STEM
- Environmental Scanning Electron Microscopy (SEM)
- In Situ TEM Heating/Bias Holder
- Dual Beam FIB-SEM
- X-Ray Photo Electron Spectroscopy (XPS)
- Cryo TEM Holders
- Ion Milling
- Vitrobot
- Cryo Microtome
- Plasma Cleaner
- Critical Point Dryer

Latest updates:

Differential Phase Contrast (DPC) has been developed to image individual light atoms and probe the electrical-magnetic field at the atomic scale. In addition various protocols were developed for air-sensitive samples.

Equipment acquired:

- Gatan PIPS Ion Milling
- Gatan Dimpler
- RMS Cryo Microtome
- Gatan Ultrasonic Cutter

List of equipment available at
https://inl.int/competence-units-advanced-electron-microscopy/

USER FACILITIES
Micro & Nanofabrication

The 1000m^2 controlled class 100 and 1000 Cleanroom facility offers micro- and nanofabrication solutions on substrates from 200-mm-diameter wafers down to samples below 10 mm in size to both internal and external users.

This open-access user facility provides support throughout all the development chain in cleanroom processes: device modelling and design, process integration and device fabrication, packaging and testing.

In 2018, the Micro and Nanofabrication Facility has reinforced its technology transfer activities and strengthen its ties with companies worldwide, offering consultancy services, expert support and prototyping, resulting in 134 external services and an occupancy of 20657 person/hours.

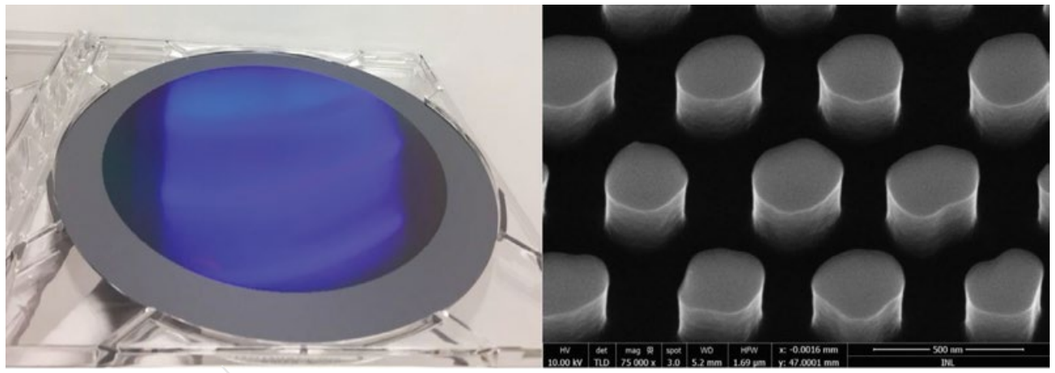


Figure 25. Highly-dense 200-mm-diameter master with sub-µm pitch, sub-µm diameter pillars for high-throughput NIL replication and nanopatterning of LED's in sapphire substrates (PSS).

Available technologies:

- Advanced Si micromachining
- MEMS and NEMS
- Processes for spintronics, sensors and hybrid devices, microfluidics
- Techniques involving graphene, carbon nanotubes (CNTs) and 2D materials
- Thin-film silicon electronics
- Nanostructuring methods for solar cells and other devices
- Fabrication of flexible substrate systems
- Laser microstructuring, interconnects and packaging

Latest Updates:

- E-beam lithography of dense patterns covering large areas
- Wafer scale replication of microfluidic features;
- Micro-nano machining of masters for lenses (etching and grayscale lithography);
- Nanowires;
- CMOS integration of devices for LiDAR.

Equipment acquired:

- Laminator and optical microscope
- Ordering of nanoimprint system, additional ICP etcher tool and cluster upgrade of multiple plasma tools

List of equipment available at
https://inl.int/competence-units-micro-and-nanofabrication/

USER FACILITIES
Nanophotonics & Bioimaging

The INL Nanophotonics & Bioimaging Flagship Facility provides a comprehensive set of high-end commercial solutions for imaging and optical spectroscopy suited for the characterization of biological samples and the characterization of new materials.

Besides performing frontier research in photonics, the aim is to become an innovation partner in the photonics technologies sector collaborating with research groups and innovative photonics companies.

During 2018, we have striven to integrate the various advanced light optical microscopy and spectroscopy solutions into a dedicated user facility with a clear technology portfolio, a unified booking system and a user training programme, empowering INL researchers and external collaborators with an open access platform and fostering interdisciplinary use of the equipment. Furthermore, during this year, a dedicated fulltime facility manager was hired with the aim to expand the services provided and reach new users inside and outside INL. The latest plans target that our facility will join national and international research infrastructure networks in the fields of microscopy and bioimaging.

Available techniques:

- Advanced High Resolution Fluorescence Microscopy
- Raman Microscopy
- Photonics-enabled techniques
- Unique combined imaging techniques
- Optical Spectroscopy techniques

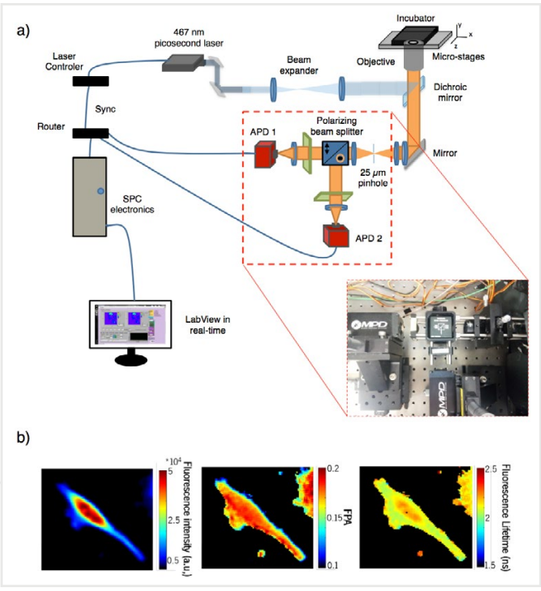


Figure 26 – a) Scheme of the FLIM-FPA setup, inset in the dash red line shows photo of the detection part b) Example of simultaneous recordings of intensity, FPA and FLIM images taken on a GFP labelled HeLA live cell.

Latest Updates:

xzz

New Fluorescence polarization anisotropy imaging implementation in the FLIM setup.

During 2018 and in collaboration with the Ultrafast Bio- and Nanophotonics research group, our facility has implemented a setup that combines Fluorescence Polarization Anisotropy (FPA) imaging and Fluorescence Lifetime Imaging Microscopy (FLIM). This new FLIM-FPA setup allows simultaneous recording of the lifetime and FPA data of the analysed sample. The system is even suitable for live cells as a top stage incubator can be used. FPA methods are widely used in the medical, biomedical and biochemical fields. The most popular applications of the FPA include ligand binding, luminescence nanothermometry, immunoassays and assays related to drug discovery.

In our new FPA-FLIM system, the sample is excited with linearly polarized picosecond pulses laser light and the emission is separated into parallel and perpendicular components and measured simultaneously with avalanche photodiodes (APD 1 and APD2). After the signal is sent to router that allows up to 8 channel detection for only one time correlated single photon counting (TCSPC) unit.
Our configuration allows Hanbury-Brown-Twiss (HBT) detection e.g. for the study of single quantum emitters.

List of equipment available at
https://inl.int/competence-units-nanophotonics/

HEALTH, ENVIRONMENT & SAFETY

Safety at Work,
Healthy Employees,
Environment Protection

HEALTH, ENVIRONMENT & SAFETY

Safety at Work

Safety Policy and Programme

Promoting a work environment that provides the necessary safety conditions, ensures the well-being of all the employees and collaborators, and minimizes the environmental risks, within the frame of INL's commitment with social and environmental sustainability.

Employee Involvement

- **Safety Committee:**

Regular monthly meetings of the Safety Committee took place during 2018, resulting:

1 Document produced

22 Measures approved

12 Measures implemented

- **Emergency teams:**

Emergency teams were updated to ensure an efficient support in an emergency situation. There are three team categories:

33 people
First Aid Teams

18 people
First Intervention Teams

19 people
Evacuation Teams

Trainings

252 Fire Extinguishers & Hose Reels

160 Health & Safety Induction

79 Hazardous Waste Management

28 First Aid Course

12 AED Course

6 Paediatric First Aid Course

Emergency

During 2018, several key actions were undertaken towards the review and improvement of INL emergency procedures:

- Establishment of Safety Training Programme – fire extinguishers and hose reel hands-on training provided every month. Training on the internal emergency plan auto-protective measures provided to all emergency team members;
- Assignment of dedicated internal phone number to report emergency situations;
- Implementation of task cards for emergency team members;
- Annual fire drill successfully performed – relevant improvement measures identified and action plan defined and under implementation;
- New class D fire extinguishers supplied to all laboratories that manipulate combustible metals/compounds;
- Regular Inspection by Portuguese National Authority for Civil Protection (ANPC) resulted in a positive evaluation.

HEALTH, ENVIRONMENT & SAFETY
Safety at Work

Audits

INL Health, Environment and Safety Management is implemented within the scope of INL Quality Management System, and certified as compliant with the requirements of ISO 9001:2015. The HE&S process has therefore successfully passed an external audit by SGS in September 2018.

Internal audits are also an essential tool to ensure all preparatory actions towards a solid and reliable system are implemented. The HE&S process was subject to two specific audits with positive evaluation.

Healthy Employees

Occupational Health Programme

A safe and positive work environment plays a crucial role on the health of employees, and having healthy and well- motivated staff is a priority for INL.

INL has established an Occupational Health Programme with medical exams being performed by the time of admission of Members of the Personnel and periodically repeated.
Certain functions and activities may present an increased degree of risk to the people involved. In this sense, reviews of the functions which require ongoing medical screening are carried out in consultation with INL occupational health services provider.

In 2018, the admission exams were extended to Associated Members of Personnel (MPA) whose period of stay at INL is longer than 6 months.

Exams performed in 2018:

Admission	95
Regular	28
Other	5
End of Contract	15
Maternity	4

Fitness and Outdoor Activities

INL social facilities include a Fitness Centre equipped with a gym and shower rooms. Fitness classes – Pilates, Functional Training and Low Pressure Fitness - and occasional workshops can be attended in this space upon prior enrolment with the INL Social Committee.

The INL Social Committee is very active in promoting outdoor activities like hiking and participation in trails and has recently created the INL Running Community open to all INLers.

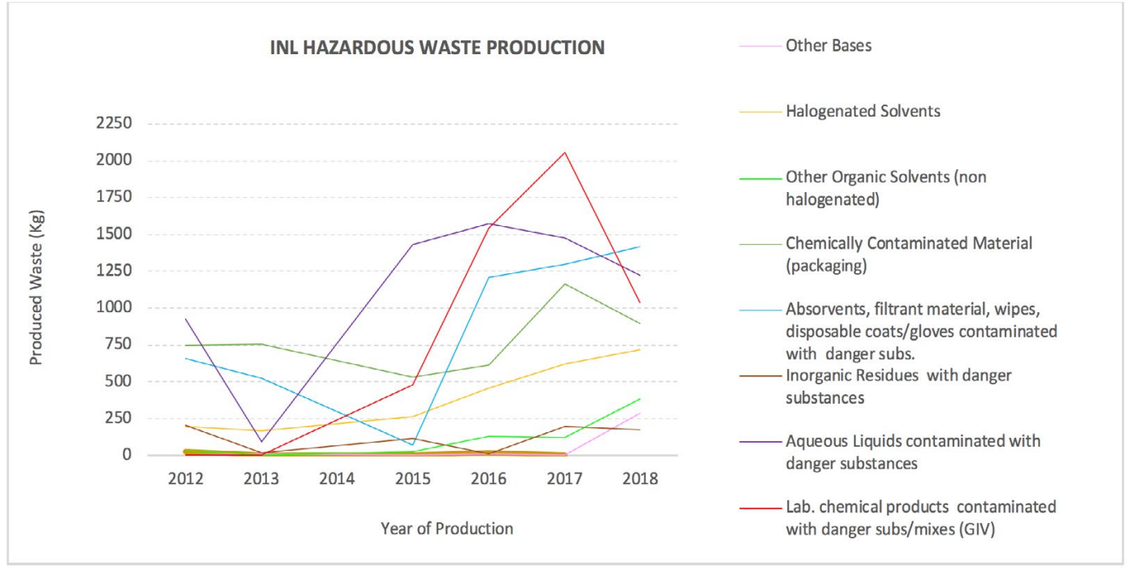
HEALTH, ENVIRONMENT & SAFETY
Environment Protection

Hazardous Waste

INL takes particular care with the hazardous waste that is produced during the regular performance of its activities. The first principle is waste minimization with strong focus on the prevention of production of pollutants at the source.

Hazardous wastes produced (solids and liquids, biological and chemical) are disposed of in accordance with internal procedures defined, and properly collected and treated by an external entity. INL follows the EU & Portuguese Regulations in the classification of the produced wastes.

Hazardous Waste Production Comparison



Non-hazardous waste separation for recycling is a general practice at INL, in line with the guidelines established within the Scale Zero programme.

Indoor air quality is monitored on a regular basis throughout the whole campus to ensure the health and comfort of building occupants.

QUALITY MANAGEMENT SYSTEM

Quality Statement

The Quality Management System (QMS) is planned and defined in a manner that meets INL's strategic orientation, Quality Policy and defined Objectives and in compliance with all the requirements of applicable standards and regulations.
INL's approach to quality assurance and continuous improvement is to learn from best practice. Therefore, the QMS sets requirements for process management and customer service quality that strive to meet and exceed the highest standards.
We recognize that INL quality is a concern of each and every one of our staff members, who are deeply involved in the deployment of INL quality culture and continuous improvement in order to achieve Operational Excellence.

To this end, INL is fully committed to:

- Becoming a worldwide reference on R&D oriented towards Nanoscience;
- Deploying knowledge to the business world and for the benefit of society;
- Ensuring continuous improvement of its operational performance;
- Fostering creativity and orientation to market;
- Assuring compliance with rules and regulations.

Quality Roadmap

2016

First steps towards the building of a quality culture at INL

Implementation of quality control methodologies to the microfabrication processes developed in the cleanroom facility of INL.

Definition and establishment of a Quality Management System with the focus on the development of micro and nanofabrication services.

2017

Full implementation of INL QMS and ISO 9001 Certification Award

September: Certification audit successfully concluded – INL assessed and certified as meeting the requirements of ISO 9001:2015 to the following activities: Training, Self-service Processing, Process Research and Development, Design and Consulting Services in the field of Micro and Nanofabrication.

December: Decision to extend the certification scope to the Advanced Electron Microscopy and the Nanophotonics facilities.

2018

Extension of QMS Scope and Recertification

September: Surveillance audit and extension of certification scope to all INL User Facilities: Micro and Nanofabrication, Advanced Electron Microscopy and Nanophotonics – Access, Training and Use of Equipment for Research, Technology Development and Technology Transfer Services.

2019

New Horizons

Decision to work towards the implementation of two other management standards (NP4457 – Research, Development and Innovation - and ISO 13485 – Medical Devices), leading to the establishment of an integrated management system.

QUALITY IN NUMBERS

17 Processes

161 Occurrences reported/treated

108 Quality Trainings

80.1 % Operational KPI achieved

77.4 % Strategic KPI achieved

129 Improvement Opportunities

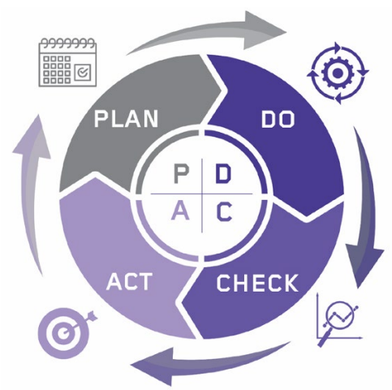
Quality Working Group

INL follows a process management model and our commitment with Quality naturally involves all process owners who, among other responsibilities and competences, are in charge of:

- Raising awareness of process performance improvement;
- Coordinating the preparation of documents and promoting their implementation;
- Action driving for continuous improvement;
- Promoting the optimisation of resources;
- Ensuring internal communication and dissemination of the results obtained;
- Implementing the necessary actions to achieve the objectives;
- Adopting a risk management approach.

The progress of all quality processes, both core and support, is periodically reported by Process Owners during the Process Performance Review Meeting, which is held quarterly with the objective of continuously analysing results, identifying gaps and areas for improvement and discussing strategies to address them.

Continuous Improvement Programme



Our goal is to promote the establishment of improvement objectives at all levels of the organisation and deploy effective processes.

Following a Plan-Do-Check-Act cycle model, our continuous improvement programme enables the organization to identify, measure, control and improve the various business processes that ultimately lead to Operational Excellence.

QUALITY MANAGEMENT SYSTEM

Success stories

Security System & Digitalization of Process to Access INL

IMPROVEMENT:
- Real-time information of who is in the premises;
- Check-out procedure at emergency meeting points;
- Digitalization of access request workflow;
- Definition of access profiles, areas, duration and requirements.

RESULTS:
Increased reliability of emergency system;
Optimization and standardization of access process.

Implementation of a Stock Management System

IMPROVEMENT:
- Implementation of barcode reading system;
- Definition of minimum stock levels and reorder points;
- Automatic notification system of purchase needs;
- Creation of dedicated warehouses.

RESULTS:
- Real time tracking of stock levels;
- Optimization of purchasing and logistics flow;
- Optimization of supply chain avoiding stock rupture and impact on research activities;
- Reduction of paperwork.

Implementation of a Lab Coat Management System

IMPROVEMENT:
- Creation of a warehouse for lab coats in use;
- Acquisition of dedicated washing machines;
- Implementation of labelling system to assign lab coats to cost centers.

RESULTS:
- Separation of lab coats in use from new lab coats, avoiding double purchase;
- Lab coats properly returned to their cost centers after washing.

INL SOCIAL FOOTPRINT

School Visits
Scale Travels
Scale Zero

SOCIAL FOOTPRINT
School Visits

Summary

In order to foster public engagement and improve the organisation's outreach effort at local and national level, the INL hosts regular School Visits to its premises, designed for students of elementary and high schools.

The School Visits aim to:
- Increase and foster public engagement
- Communicate science to students
- Promote INL work/research
- Increase INL reputation

Session details and requirements

Normal visits take up to 30 participants (students and teachers/supervisors) and the estimated time for each visit is around 1h30/2h. The tour visit starts with a presentation at INL auditorium given by the Communication Unit, and after they start the tour by our facilities with one volunteer from the research area or from the BSR department (according with the area of study of the schools / institution / university / company).

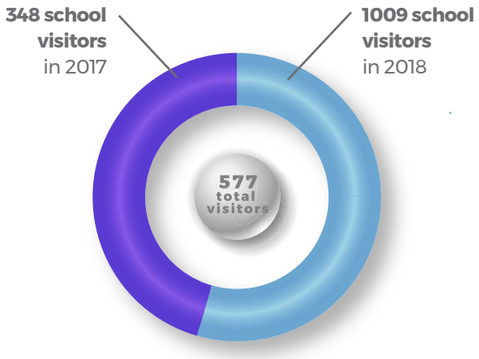
Evaluation and references

HIGHLIGHTS
- Positive feedback from teachers and students;
- Elaboration of work/group papers in the classroom about the visit, which improves what they learned in the visit;
- Sharing of personal and educational experiences;
- Demystification of stereotypes (scientists, what is nanotechnology, what it is for and how it is used).

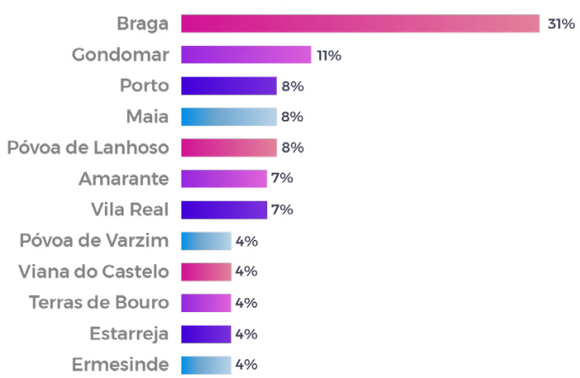
PITFALLS AND SOLUTIONS
- Difficulty in getting enough volunteers to respond to the number of requests for visits, but with persistence, it was possible to cover them.
- Language barrier: only those who speak Portuguese are considered for volunteering. The solution to this involves proposing to the schools to have the visit in English, that give an opportunity to the foreign scientists.
- Conflict of the visit with external/internal events. The solution is based on the State office providing an alternative to another room and ensuring the necessary conditions for the normal completion of the visit.

PROCESSING | TO IMPROVE
- Better organization of visits with events. A more up-to-date schedule could expedite the process of marking visits to avoid conflict.
- Promote visits given in English and not only in Portuguese.
- Satisfaction survey for a qualitative analysis of visits.

Numbers and figures



Percentage of visitors per region from April 2017 to June 2018:



SOCIAL FOOTPRINT
Scale Travels

A JOURNEY FOR ARTISTS AND NANOTECH EXPERTS

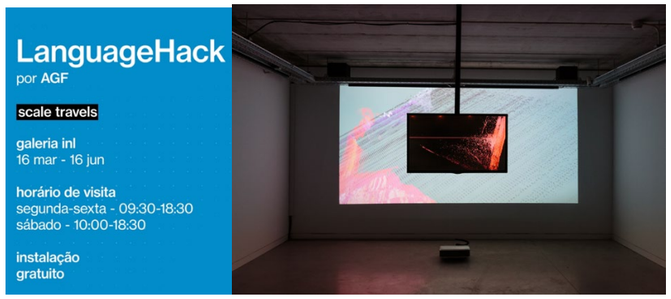
Scale.Travels is the INL initiative that aims at fostering a multidisciplinary and hybrid approach between science, technology and arts to innovate through creativity in nanotechnology.

Goals
- Spark the discussion about the social, cultural and ethical impact of nanotechnology through media arts;
- Promote collaborations between INL and other organisations and initiatives within the scope of science and media arts;
- Create novel media and digital objects based on nanotechnology leading to original experiences and unexpected products, processes and services;
- Create a critical approach to research and technological development fostering competitiveness based on knowledge and creativity

Within the **Scale.Travels**, INL hosts **two distinct programmes of residences**:
- **Scale.Travels Residencies** - programme resulting from a partnership with gnration, a creative hub located in Braga, Portugal.

Launched in 2015, the **Scale.Travels Residence** programme aims at bringing media artists and researchers into convergence embedded in a real laboratory environment inside INL's unique facilities for a 1 to 2 weeks period.

The initiative has been producing several works in collaboration with renowned artists like Ryoichi Kurokawa, Tarik Barri or Pierce Warneck; all exhibited over the time at the INL Gallery in gnration.



STARTS Residence – under the framework of the Horizon 2020 research and innovation programme promoted by the European Commission, this initiative supports longer creative collaborations.

In 2018, INL welcomed two residencies that brought together nanotech experts and international artists like João Martinho Moura and HeHe.

SCALE.TRAVELS IN NUMBERS:

SOCIAL FOOTPRINT
Scale Zero

WHY INL IS GOING SCALE ZERO?

As an intergovernmental research organization dedicated to delivering the best possible solutions based on science and key enabling technologies for the benefit of society, INL must act according to this essential principle, and this means making choices with the least impact possible.

Scale Zero is an internal initiative that comprises concrete actions towards the goal of having a 100% sustainable INL with zero-waste generation. Although in some cases it may be very difficult to get there, the daily objective since 2018 – the year **Scale Zero** was implemented – is to get as close as possible to that objective.

To start, the use of plastic water bottles and was banned at INL and each member of the personnel got his/her own mug with the **Scale Zero** logo on it. In the same line, plastic cups were replaced by glass ones. INL Summit 2018, the major event promoted by INL, had the paper consumption reduced to a minimum and plastic was also kept out of the initiative.

To promote sustainable commuting from and to INL, it was created a “Share-a-Ride” platform where every INLer can offer and request rides.

We believe that steps like the above mentioned, which may seem small but had already have a significant impact, will start to have a spillover effect in every INLer, their families, their friends, our suppliers, our clients and, ultimately, in each person that gets in touch with INL.

INL AS AN INTERNATIONAL ORGANISATION
Nationalities

INL’s main characteristic is the fact of being an International Organization, and this is clear to those who have been visiting us through this 10 years of history, but the numbers can speak for themselves. In 2018 the 213 employees came from 32 different nationalities. Being Portugal the country with more representation, Spain, India and China are also in a good number among the full list followed by Brazil, Germany and Italy.

32
Nationalities

213
R&D Staff

1	Algerian	1	Iranian
2	American	5	Italian
1	Bangladeshi	1	Japanese
1	Belgian	1	Malaysian
4	British	1	New Zealander
6	Brazilian	1	Nigerian
1	Chilean	3	Polish
10	Chinese	104	Portuguese
2	Colombian	1	Puerto Rican
1	Danish	2	Romanian
1	Estonian	2	Russian
1	Finnish	1	Slovenian
3	French	29	Spanish
6	German	2	Swedish
1	Hungarian	1	Taiwanese
15	Indian	2	Ukrainian

INL AS AN INTERNATIONAL ORGANISATION
Learning Organisation Plan

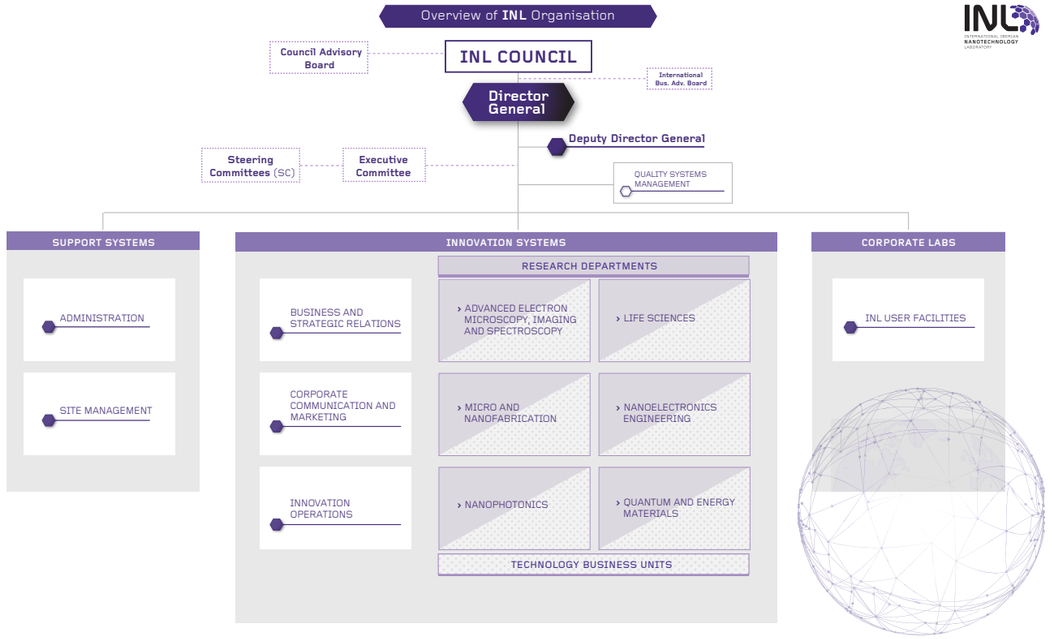
It's commonly understood that learning is a key differentiator for organisational growth to increase its overall innovation capacity. In that regard we have launched a strategic initiative around the role of learning with the aim to foster the development of INL as a Learning Organisation. Important milestones are building up excellence as a learning organization, to identify key strengths and emerging opportunities, to sharpen and display areas of excellence, and to enter new forms of partnerships. Specifically, we aim within this strategic initiative to establish activities that will address leadership and excellence in three interconnected areas:

Internal Professional Development, i.e. to assure that we, the INL community, improve our knowledge and will be empowered to identify, tackle and quickly resolve workplace-based problems; building up group dynamics; enhance cooperation; initiate change; build up the INL-Learning Model that establishes advanced learning as the new normal at INL; nurture and build a culture inherent to Learning Organisations.

External Commissioned Education Offerings:
Here we aim to develop state-of-the-art and advanced commissioned education offerings making use of science driven and research-based methods. Commissioned Education Offerings aim to be developed in areas of interest to INL, such as subjects concerned with how exponential technologies affect society/enterprises, and should be built in partnership with global leading education providers to maximise uptake and impact. Of special importance is to address the by digitalization driven increased needs for re-skilling and life-long learning and education.

Communicating Science and Outreach activities: Learning and knowledge creation in connection with Society relying on the wider perspectives contained within the newly articulated Science Capital perspectives (a conceptual tool related to individuals exposure and knowledge of science). One objective is to seek and realize synergies in between the learning and knowledge building dimensions in Communicating Science and outreach activities and the Internal Professional Development and External Commissioned Education Offerings. This initiative has a clear relation to Communicating Science and Outreach activities, such as, but not limited to, the Science Centre; the development of the S.E.N.S.E. building project; INL Scale Travel activities, etc.

INL AS AN INTERNATIONAL ORGANISATION
Organisational Chart



INL IN FIGURES

PUBLICATIONS
and highlights

902
Total Publications
(2010 - April 2019)

47
h-index
(April 2019)

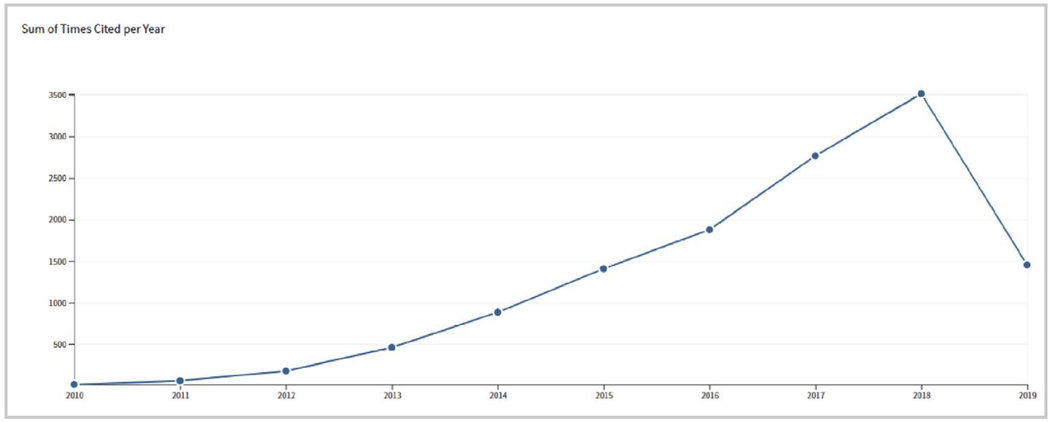
13.97
Average citations per item

12,603
Sum of Times Cited
(2010 - April 2019)

11,615
Without self citations

10,093
Citing Articles
(2010 - April 2019)

9,692
Without self citations



INL accumulated h-index over the years is **47**

Number of citations 12,603 at the time of publication of the report, cited in 10,093 articles over the years. Specifically for last year, we were cited in 541 articles during year 2018.

223 publications in 2018

PHD VIVAS 2017–2018

Vânia Vilas-Boas
PhD defended on 2017
University of Porto
"Targeting CXCR4 with immune-modified iron oxide nanoparticles for cancer treatment with magnetically-induced hyperthermia. An in vitro approach"

Charles Amos
PhD defended on 2017
University of Texas at Austin
"Effect of Chemical Treatment and Trivalent Doping on the Surface Structure and Surface Chemistry of Li1-xNi0.5-yMn1.5+yO4"

José Diego Teixeira Barbosa Costa
PhD defended on 2017
University of Porto
"Spin Transfer Torque Nano Oscillators: Fabrication, Characterization, and Dynamics"

George Luiz Machado Júnior
PhD defended on 2018
University of Minho
"Microfabrication of graphene field-effect transistors for biosensing applications"

José Alexandre de Nóbrega Chícharo
PhD defended on 2018
Instituto Superior Técnico (IST) University of Lisboa
"Design and optimization of a magnetic microcytometer for cell detection and enumeration"

Kang Yu
PhD defended on 2018
University of Texas at Austin
"Understanding PEMFCs by 3D-Identical Location TEM and EELS"

Eligenes Sampaio
PhD defended on 2018
Federal University of Ceará
"All-cellulose films based on bacterial cellulose"

Helder Levi
PhD defended on 2018
Federal University of Ceará
"Antioxidant Bacterial Cellulose Edible Films incorporating gelatin hydrolysate from tilapia skin"

Diana Noriega
PhD defended on 2018
University of Vigo (Spain)
"Development of extraction methods to obtain high value-added products from industrial processing wastes of illex argentinus and cynara scolymus"

Mohamad Tarequzzaman
PhD defended on 2018
Instituto Superior Técnico (IST) University of Lisboa
"Tunneling and Spin Hall Current Induced Nano-Oscillators"

MSC VIVAS 2017–2018

Cindy Leonor Alves Dias
MSc defended on 2017
University of Minho
"Nanotoxicity of fruit based carbon-dots using in vitro and in vivo models"

Gema Puertas Hernando
MSc defended on 2017
Universidad de Santiago de Compostela (SPAIN)
"DNA extraction and purification from olive oil samples by microscale solid phase extraction (μSPE) and microfluidics"

Miguel Amaral
MSc defended on 2017
University ofPorto, Physics
"Integrated platforms for magnetic particle manipulation"

Ana Maria Gomes Vieira
MSc defended on 2018
University of Santiago de Compostela
"Functionalization of nano-liposomes for delivery of marine toxins as anti-cancer agents"

Sharath Kumar Manjeshwar Sathyanath
MSc defended on 2018
University of Minho
"Electron Microscopy and Spectroscopy Study of Modified Titanate Nanowires and Nanotubes"

Pedro Miguel Cruz
MSc defended on 2018
University of Porto
"Digital Quantum Simulation of Few-body Hamiltonians on a Noisy Quantum Computer"

Ricardo Bernardino Silva
MSc defended on 2018
University Nova de Lisboa
"Optical lithography for sub-micrometre point contact structures in thin film solar cells"

Filipa Marlene Carvalho Freitas
MSc defended on 2018
University of Minho
"Production and characterization of lignin nanoparticles derived from lignocellulosic biomass"

Tomás Sousa Lopes
MSc defended on 2018
University Nova de Lisboa
"Metal layer for enhancing optical reflection in passivation layers in thin film solar cells"

Nélson Vasco Dias Ferreira Martins
MSc defended on 2017
University of Beira Interior (Portugal)
"Aplicação em Química Medicinal da simulação Computacional 3D de Nanomateriais Poliméricos para os desenvolvimento de "Drug Delivery systems"

Beatriz D'Avó Pereira
MSc defended on 2018
University of Minho
"Development and characterization of biopolymeric nanostructures for bioactive compounds encapsulation by nanospray dryer"

Luís Filipe Alves Passos
MSc defended on 2018
University of Minho
"Development of bacteriophage-loaded micro/nanostructures using microfluidics"

Marina do Carmo Alves
MSc defended on 2018
University of Minho
"Cu(In,Ga)Se2 thin film solar cells by magnetron sputtering"

Marco Zutter
MSc defended on 2018
University of Basel
"Zn(O,S) Buffer Layers for Cu(In,Ga)Se2 Thin Film Solar Cells by Magnetron Sputtering"

Rodrigo Ferreira
MSc defended on 2018
DFA-FCUP, University ofPorto
"Few-cycle laser for real-time nanomedicine research"

Pedro Lima da Silva
MSc defended on 2018
Universidade University of Minho
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FUNDED PROJECTS

Funded projects Partnerships

Countries we have projects with to mark on the map (25 countries):

Algeria	Israel
Austria	Italy
Belgium	United Kingdom
Bulgaria	Latvia
Croatia	Macedonia
Czech Republic	Netherlands
Denmark	Portugal
Finland	Slovakia
France	Slovenia
Germany	Spain
Greece	Sweden
Hungary	United Kingdom
Ireland	USA

List of Funded projects in force until 31-12-2018: (107 Projects)

Acronym	Project Name	Framework
2DMS	Two dimensional magnetic semiconductors	FCT
3D NEONET	Drug Discovery and Delivery NEtwork for ONcology and Eye Therapeutics	HORIZON 2020
ACTinRING	Uncovering the mechanistic assembly and function of actin ring networks in axonal biology and pathology	PORTUGAL 2020
ARCIGS-M	Advanced aRchitectures for ultra-thin high-efficiency CIGS solar cells with high Manufacturability	HORIZON 2020
ARMA4VESPA	Armadilhas e iscos seletivos para eliminação da Vespa velutina	IFAP (National Funding)
ATLANTIC-KET-MED	Establishing a transnational inter-regional advanced pilot manufacturing line / ecosystem for future biomedical products	INTERREG Atlantic
BIOMPHO2	Towards biomimetic photosynthetic photonics	PORTUGAL 2020
BIOSENSOR4FETUS	Development of a biosensor for fetal well-being monitoring	PORTUGAL 2020
CANCER	ADVANCING CANCER RESEARCH: FROM BASIC KNOWLEDGE TO APPLICATION	NORTE 2020
CAPTURE	Mechano-dependent capture of Circulating Tumour Cells: a cell-ECM based approach coupled with cancer specific glycomarkers	PORTUGAL 2020

FUNDED PROJECTS

Acronym	Project Name	Framework
CASOLEM	Correlated Analysis of Inorganic Solar Cells in and outside an Electron Microscope	PORTUGAL 2020
CaTCh	Pre-clinical evaluation of novel chemical compounds for cancer treatment: tackling unmet clinical needs	PORTUGAL 2020
CECs(Bio)Sensing	(Bio)sensors for assessment of contaminants of emerging concern in fishery commodities	PORTUGAL 2020
CleanTumor	Electromagnetic probe for optimized complete tumor resection	PORTUGAL 2020
CLUSTERNANOROAD	Driving Europe's NMBP economy - Cross-cluster innovation and value creation through validated NMBP collaborative strategies and roadmap	HORIZON 2020
CODIGOMAIS	Creación de un Ecosistema Transfronterizo de Innovación en Salud	INTERREG POCTEP
CritCat	Towards Replacement of Critical Catalyst Materials by Improved Nanoparticle Control and Rational Design	HORIZON 2020
CritMag	REEs-free high-performance permanent magnets based on exchange-spring and high anisotropy phases	PORTUGAL 2020
CTB	Cluster Transfronteirizo Biotecnologico	INTERREG POCTEP
CVMar +i	Inovação industrial através de colaborações específicas entre empresas e centros de investigação no contexto de valorização biotecnológica marinha	INTERREG POCTEP
EnhanceMicroAlgae	High added-value industrial opportunities for microalgae in the Atlantic Area	INTERREG Atlantic
EPPN	European Network for Pilot Projects and Innovation Hubs	HORIZON 2020
FIM4STROKE	A Fully Integrated Magnetoresistive Biochip Platform for Stroke Patient Stratification	PORTUGAL 2020
Fishbiosensing	Portable electrochemical (bio)sensing devices for safety and quality assessment of fishery products	PORTUGAL 2020
FLASH	FLASH sintering of lead free functional oxides towards sustainable processing of materials for energy and related applications.	PORTUGAL 2020
FODIAC	Foods for diabetes and cognition	HORIZON 2020
FROnTHERA	Frontiers of technology for theranostics of cancer, metabolic and neurodegenerative diseases	NORTE 2020
Frulact - Nanobiosensor	NanoBioSensor – desenvolvimento de nanosensores para avaliação da qualidade microbiológica de produtos à base de fruta	PORTUGAL 2020
FuEL	Future Entrepreneurs' League	PORTUGAL 2020
GNESIS	Graphenest's New Engineered System and its Implementation Solutions	PORTUGAL 2020
Graphene-qbits	Grafeno funcionalizado para tecnologias quânticas	PORTUGAL 2020

FUNDED PROJECTS

Acronym	Project Name	Framework
GRAPHSENS	Mid- and far-infrared plasmonic biosensing with graphene	PORTUGAL 2020
HEALTHYDENT	Design of new antimicrobial osseointegrated dental implants	PORTUGAL 2020
i-GRAPE	Integrated, Low-Cost and Stand-Alone Micro-Optical System for Grape Maturation and Vine Hydric Stress Monitoring	HORIZON 2020
I-MECH	Intelligent Motion Control Platform for Smart Mechatronic Systems	HORIZON 2020
IMPAct-L	Innovative Microfluidic Platform for Analysis of myeloid Leukemia blasts mielóide	PORTUGAL 2020
INFANTE	Satélite para aplicações marítimas e comunicações a partir de constelações	PORTUGAL 2020
INL 2020	Dinamização da participação do INL em programas de financiamento do Horizonte 2020	NORTE 2020
InNPeC	Nano tools for rare giants: an innovative blood-based screening for prostate cancer	PORTUGAL 2020
InovSolarCells	Development of innovative nanostructured dielectric materials for interface passivation in thin film solar cells	PORTUGAL 2020
INSENSE	Nova Geração de Tecnologias de Integração e Encapsulamento de Sensores	PORTUGAL 2020
IPValue@INL	IPValue@INL .: Turning Knowledge into Value thought IP Protection at INL	PORTUGAL 2020
KET4CleanProduction	Pan-European Access for man. SME on tech. services for clean production through a Network of premier KET Technology Centres with one stop shop access incl. EEN and discourse with policy makers on RIS3	HORIZON 2020
KETmaritime	Transfer of Key Enabling Technologies (KETs) to the Maritime Industries	INTERREG Atlantic
LA2D	Large area two dimensional heterostructures for photodetectors	PORTUGAL 2020
MAGLINE	Desenvolvimento e Validação Industrial do Processo de Fabricação de Sensores TMR	PORTUGAL 2020
MagTargetON	Local specific treatment of triple-negative-breast-cancer through externally triggered target-less drug carriers	PORTUGAL 2020
MePhEES	Nanostructured transition Metal Phosphides for Electrochemical Energy Storage	FCT
MiconCell	Micro-concentrator thin film solar cells	PORTUGAL 2020
Micro&NanoFabs@PT	Network of Micro and Nano Fabrication Research Facilities in Portugal	PORTUGAL 2020
MICRODIGEST	Micro-device for human gastrointestinal tract simulation	PORTUGAL 2020
MicrofluidicGeneTherapy	Microfluidic Layer-by-layer Assembly of Cationic Liposome - Nucleic Acid Nanoparticles for Gene Delivery	PORTUGAL 2020

FUNDED PROJECTS

Acronym	Project Name	Framework
MicroPhotOGen	Microfluidic photoelectrochemical devices for blood oxygenation	PORTUGAL 2020
MicroTreat	Biomimetic microenvironment for the study and development of targeted therapies in hematological malignancies	PORTUGAL 2020
MobFood	MOBILIZAÇÃO DE CONHECIMENTO CIENTÍFICO E TECNOLÓGICO EM RESPOSTA AOS DESAFIOS DO MERCADO AGROALIMENTAR	PORTUGAL 2020
msCORE	Multiscale methodology with model order reduction for advanced materials and processes	PORTUGAL 2020
MusclEng	Development of advanced strategies and solutions for muscle tissue engineering based on electromechanical microenvironments	PORTUGAL 2020
NANOCULTURE	Risk assessment and mitigation of the presence of engineered NANOmaterials in Atlantic aquaCULTURE	INTERREG Atlantic
NanoDesk	Herramientas web avanzadas para la promoción de la aplicación de la nanotecnología y el uso seguro de nanomateriales en el sector del plástico	INTERREG SUDOE
NANOEATERS	Transferencia y valorización de nanotecnologías a PYMES innovadoras (early adopters) de la Eurorregión	INTERREG POCTEP
nanoGateway	Plataforma Transfronteiriça para a promoção da I&DT+i em nanotecnologia	INTERREG POCTEP
Nano-MINENV	MINERALS OF ENVIRONMENTAL RELEVANCE IN ACID MINE DRAINAGE CONTAMINATED SYSTEMS: PROPERTIES AND REACTIVITY AT THE NANOSCALE	PORTUGAL 2020
Nanotech@NortePT	Promover a nanotecnologia no tecido industrial na região norte de Portugal	NORTE 2020
NANOTHER	TAMs-targeted and externally controlled nanotheranostics of triple-negative-breast-cancer	FCT
NanoTRAINforGrowthII	INL Fellowship programme in nanotechnologies for nanomedicine, energy, ICT, food and environment applications	HORIZON 2020
NANOXYPACK	Nano-sized oxygen scavenger for new active food packaging	PORTUGAL 2020
NBSF	Nanotechnology based functional solutions	NORTE 2020
NFsCoolingSystem	An advanced microCooling System based on inovative NanoFluids and acoustic streaming	PORTUGAL 2020
NIMAS	New Active Medical Implants	PORTUGAL 2020
NMP-REG	Delivering NMP to REGional manufacturing	INTERREG Europe
NOuRIsH	NanOtechnology Rapid Prototyping Innovation Hub	PORTUGAL 2020

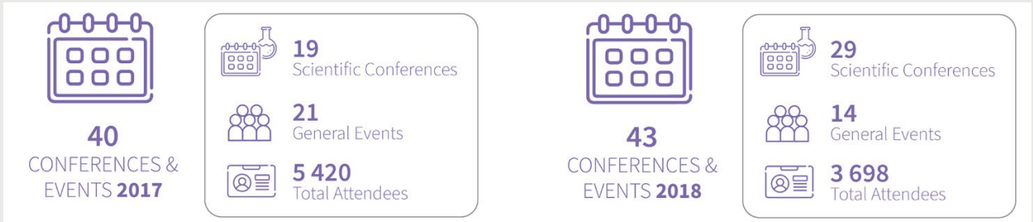
FUNDED PROJECTS

Acronym	Project Name	Framework
NovaCell	Development of novel Ultrathin solar cell architectures for low-light, low-cost and flexible opto-electronic devices	PORTUGAL 2020
NOVAMAG	Novel magnetic textures in heavy metal/ferromagnet multi-layers	PORTUGAL 2020
OCIDIAGNOSE	Occult Hepatitis C in Different Clinical Settings: Detection, Characterization and Diagnostic Tools	PORTUGAL 2020
ON4SupremeSens	Graphene and novel thin films for super resolution microsco-py and bio-sensing	PORTUGAL 2020
OPTIMA	Optical monitoring of environmental emissions of ammonia by an integrated and autonomous membrane-based fluo-rescence platform	PORTUGAL 2020
PACKTERIOPHAGE	Bacteriophage-releasing nanoestructured smart packaging materials for the control of food-borne pathogens	PORTUGAL 2020
PANA	PROMOTING ACTIVE AGEING: FUNCTIONAL NANO-STRUCTURES FOR ALZHEIMER'S DISEASE AT UL-TRA-EARLY STAGES	HORIZON 2020
pBio4.0	pBio4.0 - Prevenir o Biofouling em Sistemas de membranas	PORTUGAL 2020
Phages-on-chip	An integrated phage-based microdevice for multiplex detec-tion of bloodstream infections	PORTUGAL 2020
PhageSTEC	Encapsulated bacteriophages for pre-slaughter interven-tions to reduce to Shiga toxinproducing E. coli (STEC) in ruminants	PORTUGAL 2020
PORTGRAPHE	Control of Port and Douro Wines authenticity using graphene DNA sensors	PORTUGAL 2020
PREMICER	Premium Porcelain Hotelware Products	PORTUGAL 2020
PrintPV	Impressão em larga escala de novos sistemas fotovoltaicos baseados na calcopirite Cu(In,Ga)Se2	PORTUGAL 2020
Product In Touch	Development and Industrial Validation of a Multimodal Virtu-al Prototyping for In-Car Design	PORTUGAL 2020
Produtech SIF	Soluções para a Indústria de Futuro	PORTUGAL 2020
PT-DZ	Magnetic nanocomposite hydrogels from biopolymers as smart delivery systems	FCT
QUA-ND-O	Intracellular Quantum Sensing Techniques for Personalized Medicines of Neurodegenerative Diseases	PORTUGAL 2020
RTChip4Theranostics	Real time Liver-on-a-chip platform with integrated micro(bio) sensors for preclinical validation of graphene-based magnet-ic nanocarriers towards cancer theranostics	PORTUGAL 2020
SAM	Simultaneous Advanced Microscopies	PORTUGAL 2020

FUNDED PROJECTS

Acronym	Project Name	Framework
ScienceWars	ScienceWars - May Science be with you!	HORIZON 2020
Seafood Age	Smart and eco-innovative SEAFOOD processes and prod-ucts for healthy AGEing	INTERREG Atlantic
SELF-i	Self-reporting immunostimulating formulation for on-demand cancer therapy with realtime treatment response monitoring	PORTUGAL 2020
SIMPLIFIED	Easy Tooth Abutment	PORTUGAL 2020
SiTMP4SolarH2	Produção de hidrogénio assistida pelo Sol baseada em fo-tocátodos de silício revestidos por novos nanocatalisadores de fosforetos de metal de transição abundantes	PORTUGAL 2020
SofTE	Combining soft electronics and tissue engineering as a strat-egy for establishing reliable implantable biosensing	PORTUGAL 2020
STARTUP.NANO	Dinamização do Empreendedorismo de base Nanotec-nológica na Região Norte de Portugal	NORTE 2020
Strip2Sense	Test strips for biomarker screening of venous thromboembo-lism in oncology	PORTUGAL 2020
TACIT	Tandem Solar Cells Improved Optically	PORTUGAL 2020
ThermalBuffer	The buffering effects of upwelling and geomorphology on coastal warming	PORTUGAL 2020
Tintas Lacca	NanoLACCA - Development of nano-polimeric opaque and translucent top coats to increase material protection and paint performance	PORTUGAL 2020
uMEMS	MEMS de filme fino de silício em electrónica para apli-cações de sensôres pervasivas	FCT
USECoIN	Understanding the Structure Evolution of Seedless Copper Interconnects for Nanoelectronics	PORTUGAL 2020
UT-BORN-PT	Unconventional Thermoelectrics Based on Self-Organized Binary Nanocrystal Superlatices	FCT
YPACK	HIGH PERFORMANCE POLYHYDROXYALKANOATES (PHB) BASED PACKAGING TO MINIMISE FOOD WASTE	HORIZON 2020
USECoIN	PTDC/CTM-CTM/31953/2017 (USECoIN)	PORTUGAL 2020
UT-BORN-PT	UTAP-EXPL/CTE/0050/2017 (UT-BORN-PT)	FCT
WaterNanoEnv	WATERNANOENV	GAIN - Agencia Gallega de Innovación
YPACK	H2020 Ypack	HORIZON 2020

EVENTS



Events and Conferences are an integral part of the collaboration spirit that moves INL forward.

The number and quality of scientific meetings has been increasing at a consistent pace, to the point that INL is now recognized as an entity that excels in the organization and delivery of remarkable conference experiences, particularly in the highly demanding area of science and research events.

The years of 2017 and 2018 were a good example of that, with two events standing out – MNE17 and INL Summit 2018. MNE is the main international conference dedicated to Micro and Nano Engineering, and the 2017 edition organized by INL managed to attract almost 800 participants to Braga, in Portugal, from all over the world.

INL Summit in its 2018 edition reached a record number of participants – over 600 – and established a new standard in terms of the sessions' quality and relevance, not only regarding its scientific output but also in the way they were able to involve a wider audience.

EVENTS 2017

Date	Event Name	Number of attendees	Type of event
19 January 2017	S34Growth	22	Scientific
20 January 2017	Gala 2017	22	General
24/ 25 January 2017	NMP-REG : Meeting	12	Scientific
02 February 2017	Nano world Cancer day 2017	92	General
06 February 2017	Water Nano	18	Scientific
08 March 2017	Nebaum	18	General
20 March until 24 2017	Electron microscopy course	29	Scientific
29 March 2017	Nano Cluster	8	Scientific
10 April 2017	National Meetings of Biochemists	59	Scientific
13 April 2017	RoadShow Tritec	9	General
20/21 April 2017	H2020-PANA meeting	17	Scientific
26 April 2017	Hackathon INL-ICVS	18	Scientific

EVENTS

Date	Event Name	Number of attendees	Type of event
26 April 2017	Urban Innovatie Actions	30	General
15 May 2017	XI Plenário da Comunidade de Trabalho GNP	154	General
17 May 2017	Research Policy Working Group (RPWG)	10	Scientific
27 June 2017	Kit Saúde	18	Scientific
14 July 2017	1st Workshop (Startup nano)	75	Scientific
8 September	Nanofika	36	General
8 September	Nanotecnologias e sociedade	39	General
12 &13 september	QuantaLab Worshop	33	Scientific
18 to 22 september	MNE	660	Scientific
24 & 25 september	Open House	3100	General
25 september	NANOeaters	16	Scientific
25 september	Bioweek	78	Scientific
27 september	Hackathon Kick off ceremony	12	General
13 october	Mikta	9	General
17 october	Nanodesk coordinatiom meeting	10	Scientific
18 october	Comité inovação #38	23	General
18 october	Idea to the market	45	General
18 october	NANOdesk	33	Scientific
19 & 20 october	INL Summit 2017	500	General
24 october	Student class / Jana Nieder	16	Scientific
26 october	NewCo Event	13	General
28 & 29 October	Startup Nano Launchpad Bootcamp	24	General
10 november	Commitee CPLP (Community of portuguese language countries)	5	General
23 november	Thanksgiving Event 2017	13	General
24 november	Certification Cerimony	8	General
4 & 5 december	KETmaritime project kick-off	19	Scientific
12 december	NANO Bootcamp	13	General
13 december	Nanotechnology in Portugal Science, Business, Society	104	General
		5420	

EVENTS

EVENTS 2018

Date	Event Name	Number of attendees	Type of event
Jan-05	Startup Nano: Final Pitch	62	General
January 17-18	EuroNanolab Meeting	11	Scientific
Jan-26	Nanoeaters	68	Scientific
Feb-02	Nanoworld cancer day	140	General
February 8-9	3D-Neonet meeting	63	Scientific
Mar-03	RGDP	200	Scientific
April 11-13	Jornadas FCCN	400	Scientific
Apr-10	Industry at INL	182	General
Apr-13	FODIAC	25	Scientific
Apr-21	AEMIS Workshop	110	Scientific
Apr-26	Curso técnico de gestão e programação	33	General
May 2-3	KET MED Project Meeting	10	Scientific
May-04	Electron Microscopy Workshop	78	Scientific
May-05	Nano-BioEngineering / Nanogateway school	60	Scientific
May-16	Health Days	43	General
05-Jul	Fuel Workshop	24	Scientific
10-12 Jul	SMETS	46	Scientific
11-Jul	NanoGateway H2020 Workshop	30	General
24-Jul	NanoGateway H2020 Workshop	30	General
27-Jul	IEEE R8 SYP Congress	119	General
27-Jul	NanoGateway Summer school	55	Scientific
Sep-04	Fuel Workshop	22	Scientific
September 5/6	BINA Workshop	15	General
September 6/7	Cost Action	35	Scientific
September 10/11	AHRMIO	90	General
September 18/20	NNT	90	Scientific
September 25/28	Herald Summit	75	Scientific
01-Oct	Fuel Workshop	22	Scientific
November 14/15	1st INL Annual Research Symposium	200	Scientific
October 15/16	INL Summit 2018	590	General
Oct-17	NanoGateway Mision 10000	260	Scientific
18-Oct	NanoGateway H2020 Workshop	9	General

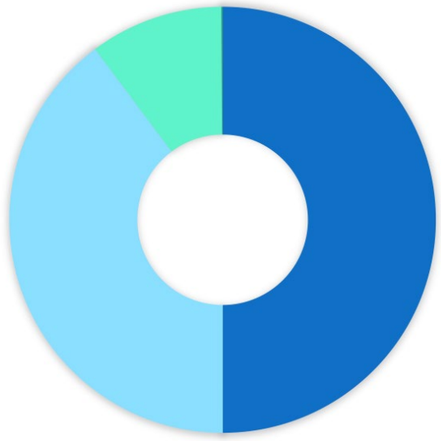
EVENTS

24-Oct	EU-OSHA	116	General; External event
24-Oct	NanoGateway IBM Quantalab	94	Scientific
November 8/9	Combined Microscopy	61	Scientific
Nov-19	Fuel Workshop	20	Scientific
November 29/30	Solar Fuel Workshop	70	Scientific
November 29/30	ARCIGS-M project meeting	27	Scientific
Nov-19	Fuel Workshop	20	Scientific
Nov-22	Fuel Workshop	22	Scientific
Nov-26	NanoGateway H2020 workshop	31	General
December 6/7	EuroNanolab	20	Scientific
December 6/7	I-GRAPE Kick-off Meeting	20	Scientific
		3698	

FINANCIAL REPORT

Income in 2018

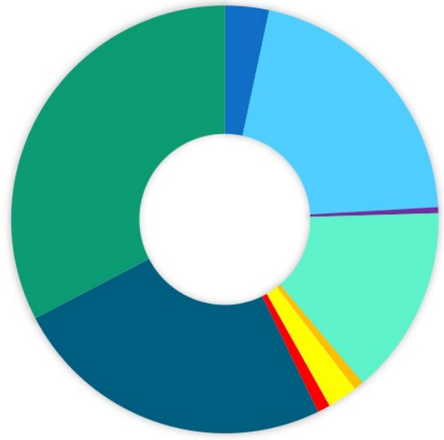
€ 14 MILLION



50,0% Member State Contributions
39,8% External grant funding
10,1% Other external funding*
0,1% Other receipts**

External Grant Funding in 2018

€ 5,6 MILLION



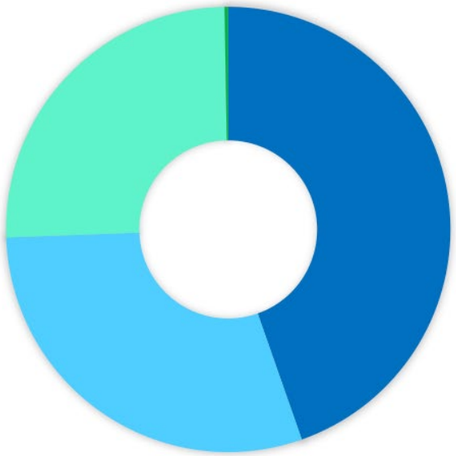
3,3% FCT
20,8% HORIZON 2020
0,5% INTERREG Europe
14,3% INTERREG POCTEP
0,7% INTERREG SUDOE
2,3% INTERRREG Atlantic
1,0% NATIONAL FUNDS
24,5% NORTE 2020
32,6% PORTUGAL 2020

** Includes income from services to private and public institutions, training courses and conference fees.*

*** Includes interest earned and extraordinary incomes.*

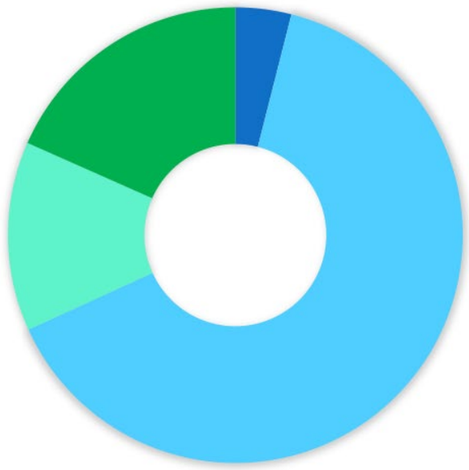
Expenditure in 2018

€ 20,5 MILLION



44,6%	Personnel Costs
29,8%	Operating costs
25,3%	Deprecitions
0,3%	Other costs*

Expenditure by Area



4,0%	Direction General
64,2%	Innovation Systems
13,4%	Support Systems
18,4%	Corporate Labs

** Includes financing costs and extraordinary expenditure.*