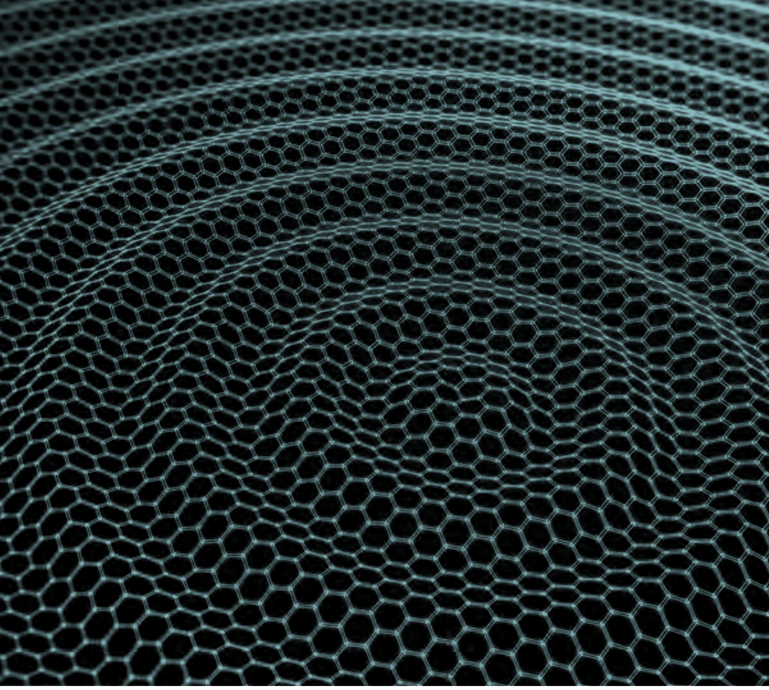

ACTIVITY REPORT

2017 **2018**

CIC nanoGUNE

ACTIVITY REPORT

2017 **2018**

CIC nanoGUNE

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ORGANIZATION & FUNDING

NANOGUNE IN NUMBERS 2017-2018

Our mission is to perform world-class nanoscience research for the competitive growth of the Basque Country

203 ISI publications

7 004 Citations

8.4 Average impact factor

19 PhD theses accomplished

33 PhD theses ongoing*

97 Grants in place

10 Research groups

108 Employees*

44 Students and Guests*

4 Patents submitted

74 Seminars

133 Invited talks

10 Conferences and workshops organized

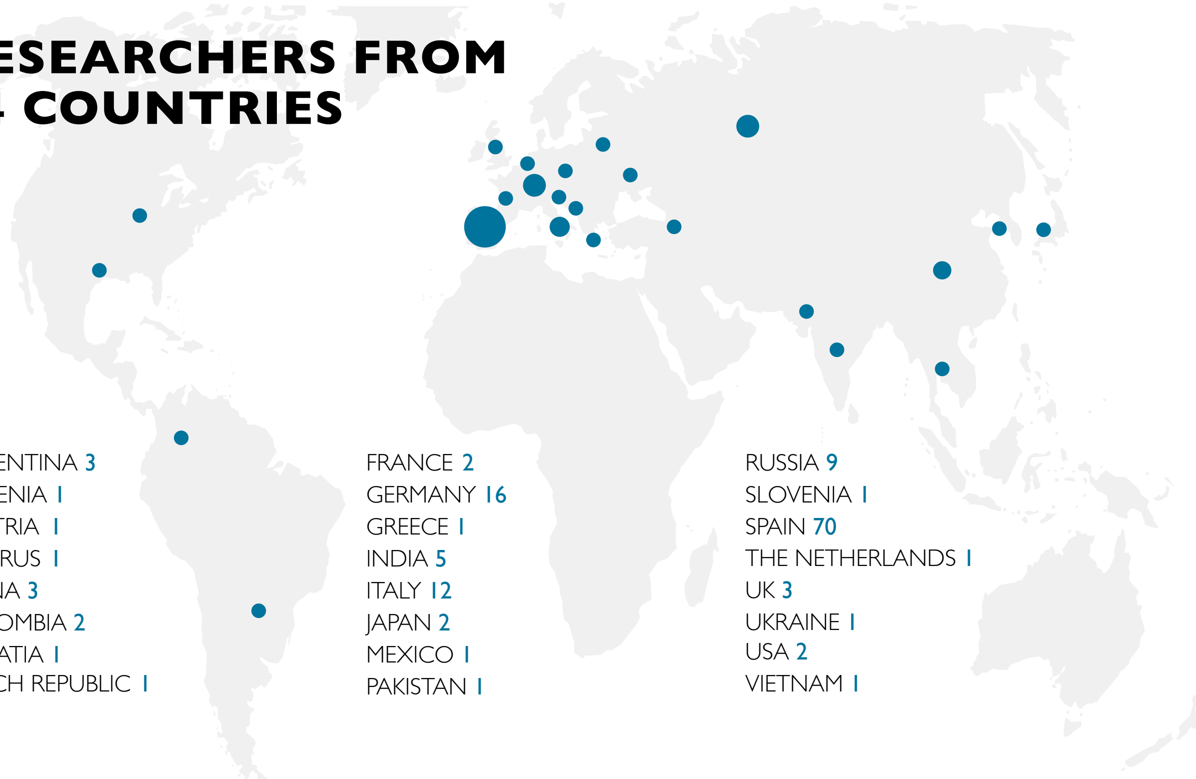
5 Startups

649 Times in the media

332 Visitors from high school and universities

* On 31 December 2018

RESEARCHERS FROM 24 COUNTRIES

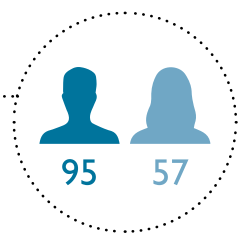


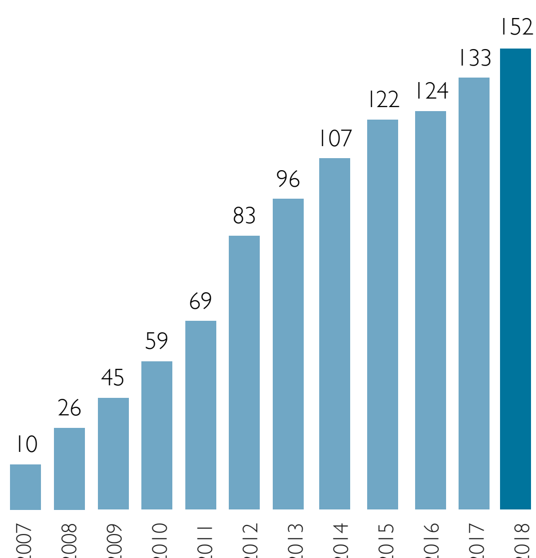
ARGENTINA **3**
ARMENIA **1**
AUSTRIA **1**
BELARUS **1**
CHINA **3**
COLOMBIA **2**
CROATIA **1**
CZECH REPUBLIC **1**

FRANCE **2**
GERMANY **16**
GREECE **1**
INDIA **5**
ITALY **12**
JAPAN **2**
MEXICO **1**
PAKISTAN **1**

RUSSIA **9**
SLOVENIA **1**
SPAIN **70**
THE NETHERLANDS **1**
UK **3**
UKRAINE **1**
USA **2**
VIETNAM **1**

NANOPEOPLE





Senior Scientists **12**
Research Fellows **5**
Post-docs **32**
Pre-docs **31**
Specialists **4**
Technical Team **13**
Management & Services **11**
Master Students **2**
Undergraduates **9**
Guest Researchers **33**

nanoGUNE personnel on 31 December 2018

MESSAGE FROM THE DIRECTOR

"We are combining world-class nanoscience research with a focus on knowledge and technology transfer activities"

Since the opening of nanoGUNE in 2009, we have been working hard with the aim of building up a research center and infrastructure that combine world-class nanoscience research with a focus on knowledge and technology transfer activities. Now, ten years later, we have succeeded in putting together an international team of outstanding scientists and a number of startup companies that we have been launching for the development of nanotechnology in the Basque Country and worldwide, thanks to the continuous support of a good number of individuals, public institutions, especially the Basque Government, and our International Advisory Committee. The creation of the center was partially funded in the framework of the Spanish Consolider program, aimed at big projects at the frontiers of science performed by consolidated research groups that were expected to lead Spanish science in a given field, and in the period 2017-2018 we have been recognized as a Maria de Maeztu center of excellence, a recognition given to centers that stand out for the international impact of their research activity. During the last two years, we have intensified our knowledge and technology transfer activities, specifically in the three areas (manufacturing, energy, and health) that have been taken by the Basque Government to be strategic in the framework of the research and innovation smart specialization strategy (RIS3) of the European Commission; in this period of time, we have also succeeded in the certification of our innovation management system to the UNE 166.002:2014 standard.

In the period 2017-2018, a platform for industrial research and experimental development has been launched, thus complementing our external-services department with new specialists working in the fields of nanooptics, electrospinning, and electron microscopy. Our team is now composed of nearly 100 researchers (including graduate students and post-docs) and technicians, coming from 24 different countries worldwide, in addition to a few undergraduates and master students and a good number of guests. This team has been making outstanding contributions to the fields of nanomagnetism, nanooptics, self-assembly, nanobiomechanics, nanodevices, electron microscopy, theory, nanomaterials, nanoimaging, and nanoengineering.

José M. Pitarke
Director

As for our startup companies, Graphenea's new laboratories have been inaugurated at Miramon's Technological Park. Our younger spin-off companies Simune, Ctech-nano, Evolgene, and Prospero Biosciences are still in a startup phase, thus sharing our laboratories at nanoGUNE; and during the last year we have participated, with our knowledge and infrastructure, in the creation of a new company, Biotech Foods, with the aim of producing and commercializing cultured meat. Highlights of our industrial activity also include the launching of new contract research with international leading companies like Intel, BASF, and Infineon, among others.

In our effort to be pioneers, to discover new worlds, to become the first to exploit certain niches offered by the global advance of nanoscience and nanotechnology, we must continue to explore those routes whose destiny is still unknown and unimaginable. We need to be there, at the forefront. Being a small center in a small country we will keep doing our best in the search of innovation, with the expectation that we will always find a niche for us to offer something different. This is the big challenge of the small.

José M. Pitarke
Director

Donostia - San Sebastian, December 2018

I

RESEARCHERS IN ACTION

10 RESEARCH GROUPS
97 RESEARCHERS

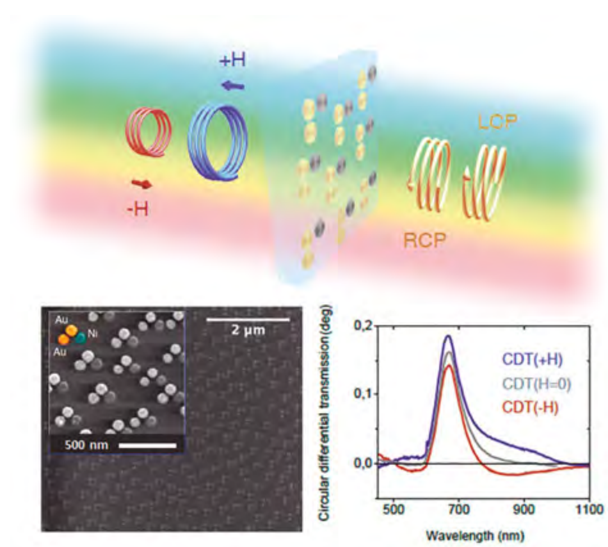
NANOMAGNETISM

The Nanomagnetism group conducts world-class fundamental and applied research in nanomagnetism and related characterization techniques. The group has accomplished an internationally leading role in investigations of advanced magneto-optical and magneto-plasmonic effects and their utilization for fundamental and applied purposes, including tool and device designs. Furthermore, the group has broad expertise in the fields of thin-film and multilayer growth, nanostructure fabrication and magnetic materials characterization, as well as in the development of theoretical and computational models for quantitative descriptions of magnetic and optical properties at the nanoscale.

During the 2017-18 period, work of the Nanomagnetism group and its collaborators from around the globe has led to numerous key achievements. For instance, group members demonstrated that the paramagnetic dynamic state of a ferromagnet is far more complex than its thermodynamic counterpart and exhibits anomalous meta-magnetic tendencies. Another key achievement, accomplished jointly with collaborators from NIST in the US, was the demonstration that thermodynamic properties of non-uniform materials can be accurately described by means of local properties, including a "local" Curie temperature down to the 1 – 3 nm length scale. In the field of magneto-plasmonic metamaterials, group members designed and developed in collaboration with the University of Gothenburg ultra-thin chiroptical meta-surfaces built on two-dimensional chiral meta-atoms (trimers of optically interacting Au and Ni nanodisks), in which the circularly polarized light transmission can be controlled by an externally applied magnetic field (see image).

In terms of more applied work, the Nanomagnetism group in collaboration with CEIT has developed a novel tool for the detection of transverse magneto-optical Kerr effects (T-MOKE). In addition, the group successfully continued its activities on magneto-optical ellipsometry with a particular emphasis on utilizing this unique methodology for relevant materials research topics. In collaboration with researchers from ICN2, the Nanomagnetism group demonstrated a new integrated magneto-chromic simultaneous nano-heating/thermometry concept for biomedical applications (e.g., light induced hyperthermia for cancer treatment). The concept is based on the innovative local photo-induced heating and opto-magnetic detection of tiny viscosity variations around magneto-plasmonic (Co/Au and Fe/Au) nanodomes in solution. The technological interest arises because of the extreme simplicity of the temperature detection scheme, as well as of the low-cost and scalability of the nanofabrication process of the nanodomes.

Furthermore, Dr. Berger and Dr. Vavassori contributed in 2017 to an influential Magnetism-Roadmap article that serves as a key reference for major developments in magnetism today.



Magnetic-field tunable plasmonic chiroptical surfaces (concept illustrated in the upper panel, where RCP and LCP stand for right and left circular polarization of light). The tuned parameter is the transmission of circularly polarized light (CDT in the bottom-right panel) of desired handedness at designed wavelengths (illustrated in the bottom-right panel), and the tuning is enabled by the meta-atom design that accommodates ferromagnetic plasmonic elements as shown in the SEM image (Ni nanodisks blue-colored in the inset).

TEAM

Andreas Berger
Research Director
Group Leader
PhD in Physics 1993
RWTH Aachen University (Germany)

Paolo Vavassori
Ikerbasque Research Professor
Group Coleader
PhD in Physics 1994
Politecnico di Milano (Italy)

Master Student
Mikel Quintana, UPV/EHU

Technicians
Eneko Iriarte
César Rufo

Pre-doctoral Researchers
Adrián Crespo, DEPCL Fellow (until 28/08/2017), *Study and control of spatial correlation and dynamics of magnetization in nanostructured metamaterials with magnetic frustration*
Lorenzo Fallarino, PFPI Fellow (until 30/04/2017), *Fabrication and characterization of magnetic thin films and multilayers*
Matteo Pancaldi, FPI Fellow (until 30/11/2018), *Study of geometrical frustration and thermal activation in arrays of magnetic nanostructures*
Patricia Riego, La Caixa Fellow, *Study of magnetization dynamics in thin films*
Ramon Weber, MdM Fellow, *Magneto-optical response modification in metallic interfaces and their application in magneto-plasmonics*

Post-doctoral Researchers
Eleftheria Diamanti, Elkartek Fellow
Naëmi Leo, MdM Fellow
Alberto López-Ortega, Juan de la Cierva Fellow
Eva Oblak, Elkartek Fellow
Mario Zapata, H2020 Fellow

Guest Researchers
One-month stay minimum
Nikolaos Barmpatsalos, University of York (UK)
Juan Marcos Marín, University of Antioquia (Colombia)
Tomomi Suwa, NAIST (Japan)

Undergraduates
Sara Arias, UAB (until 31/08/2018)
Alessio Gabbani, University of Pisa
Aitor Garcia, UPV/EHU (until 28/02/2018)
Mikel García, UPV/EHU
Beñat Monfort, UPV/EHU (until 11/08/2017)

FPI, predoctoral grant of the Spanish Government
PFPI, predoctoral grant of the Basque Government
DEPCL, Basque Department of Education
MdM, María de Maeztu Excellence Unit

NANOOPTICS

The Nanooptics group performs experimental and theoretical research in nanooptics and nanophotonics, covering both fundamental and applied aspects. Essentially, near-field nanoscopy (scattering-type Scanning Near-field Optical Microscopy, s-SNOM) and infrared nanospectroscopy (Fourier transform infrared nanospectroscopy, nano-FTIR) are being developed and applied in various areas of science and technology.

Near-field nanoscopy and nanospectroscopy offer a wavelength-independent spatial resolution of about 10 to 20 nm at visible, infrared, and terahertz frequencies, thus beating the conventional resolution (diffraction) limit by a factor of up to 1 000.

During the last two years, we have kept working on instrumental development of near-field microscopy, in order to push its spatial resolution towards the single-molecule level, to enable three-dimensional infrared-spectroscopic nanoimaging, and to enable novel imaging modalities.

Further, near-field microscopy has been applied to study plasmons in metal and graphene nanostructures, as well as phonons in polar crystals, for the development of ultracompact nanophotonic devices and their application. Infrared nanospectroscopy has also been used for the nanoscale mapping of the chemical composition of polymers, the secondary structure of proteins, the carrier distribution in semiconductor nanowires, and the optoelectronic properties of novel two-dimensional (2D) materials.

We have also been developing and applying theory (i) for describing the propagation and scattering of waves/surface waves in natural, artificial, and 2D materials, (ii) for near-field spectroscopy, and (iii) for the reconstruction of materials properties from near-field data.

During the 2017-2018 period, the group has also initiated industry-related projects (e.g. with Infineon) and has promoted the creation of a new characterization service offering s-SNOM and nano-FTIR analysis.

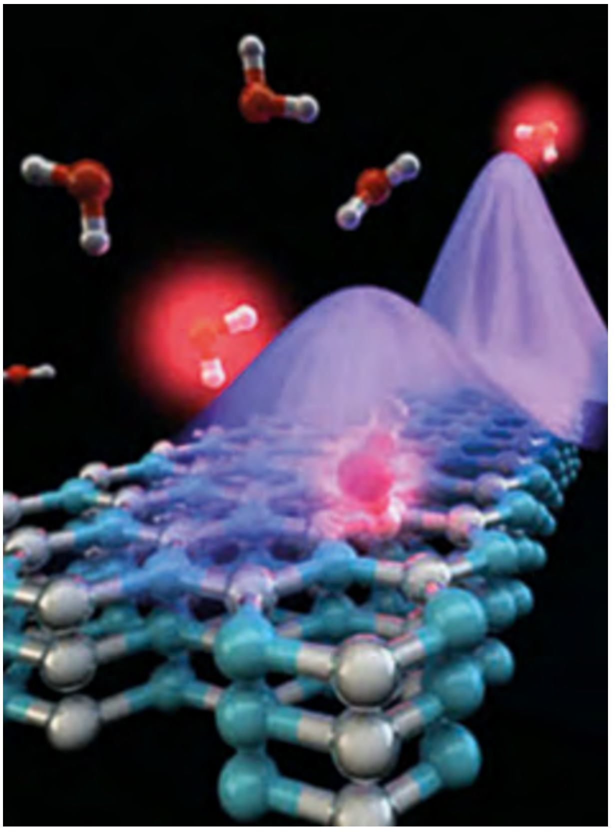


Illustration of the interaction between molecular vibrations and phonon polaritons in a boron-nitride nanoresonator.

TEAM

Rainer Hillenbrand
Ikerbasque Research Professor
Group Leader
PhD in Physics 2001
Technical University of Munich (Germany)

Research Fellow
Alexey Nikitin, Ikerbasque Research Fellow (until 31/12/2017)

Technician
Carlos Crespo

Specialist
Iban Amenabar

Master Student
Gonzalo Álvarez, UPV/EHU (until 31/08/2018)

Guest Researchers
One-month stay minimum
Pablo Alonso-González, University of Oviedo (Spain)
Andrea Konecna, CFM (Spain)
Malin Kück, Humboldt University of Berlin (Germany)
Weiliang Ma, Soochow University (China)
Daena Madhi, DTU (Denmark)
Paulo Sarriugarte, UPV/EHU (Spain)
Peter Schmidt, ICFO (Spain)

Pre-doctoral Researchers
Francisco J. Alfaro, FPI Fellow, *Low-dimensional nanophotonics with hyperbolic polaritons*
Irene Dolado, PFPI Fellow, *Optoelectronic nanosensors based on hyperbolic polaritons in 2D materials*
Carlos A. Maciel, nanoGUNE Fellow, *Theoretical description of low-loss electron energy loss spectroscopy of nanophotonic materials and devices*
Stefan Mastel, Flagship Fellow (until 14/05/2018), *Enhancing resolutions, efficiency, and understanding IR and THz near-field microscopy*
Lars Mester, ITN Fellow, *Subsurface chemical mapping based on infrared near-field spectroscopy*
Divya Virmani, ITN Fellow, *Enhanced chemical-sensitive infrared scattering scanning near-field optical microscopy*

Undergraduates
Leire Alegría, UPV/EHU (until 26/08/2017)
Iker Castrillo, UAB (until 14/09/2018)
Iker Lasa, UPV/EHU (until 27/03/2018)

Post-doctoral Researchers
Marta Autore, Flagship Fellow
Shu Chen, H2020 Fellow
Peining Li, Marie-Curie Fellow
Monika Goikoetxea, nanoGUNE Fellow
Alexander Govyadinov, H2020 Fellow
Curdin Maissen, H2020 Fellow
Martin Schnell, Marie-Curie Fellow

FPI, predoctoral grant of the Spanish Government
PFPI, predoctoral grant of the Basque Government

SELF-ASSEMBLY

The self-assembly of molecules is a natural and synthetic method to create complex nanoscale structures. We use it specifically for proteins, in a combined biochemistry, chemistry, and physics approach. Our group studies and controls the self-assembly of biological (peptides, proteins, and viruses), organic (polyelectrolytes), and inorganic (nanoparticles) building blocks. The assembly systems are applied to the development of novel nanoscale and microscale devices.

Our research group is interested in one-dimensional structures built from proteins, such as the tobacco mosaic virus, the textbook example for the self-assembly of proteins. We have worked on additional assembly strategies, such as constructing ultrathin metal and oxide wires, e.g. for virus-based ferrofluids. Our chemical tools are molecular linkers.

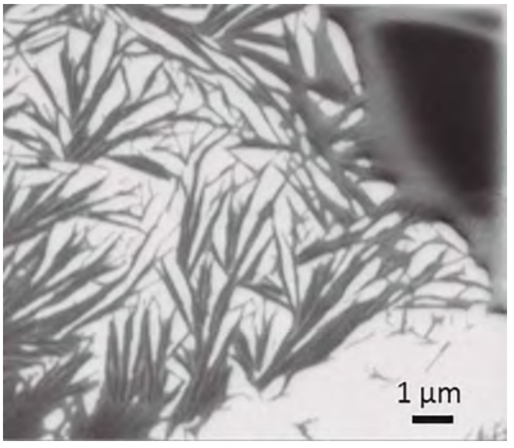
In our electrospinning projects, we steer the assembly of proteins, peptides, and other biomolecules by electrospinning to micro and nanofibers, with diameters down to single-molecule sizes. We elucidate the assembly mechanisms with rheometry, Raman spectromicroscopy, S(T)EM, infrared spectroscopy, and high-speed videomicroscopy.

We investigate fluids and wetting of soft matter on the nanoscale, with a special focus on the interaction of water with viruses and other biosurfaces. Our methods comprise AFM and S(T)EM in water vapor. These studies can have wide-ranging consequences, because the humidity influences virus transmission, for plant and for human viruses.

In a project related to bionano self-assembly, we have established self-assembly systems of peptide, protein, and/or DNA for the development of a wide range of applications from electrical devices to drug-delivery systems. This project uses many types of biological, chemical, and physical techniques to fabricate and analyze assembled structures and devices.

Our protein biomineralization research is focused on studying the biomineralization phenomena of assembled proteins and virus capsids at the nanoscale. Our techniques are based on synchrotron X-ray diffraction and S(T)EM, also in liquids.

During the period 2017-2018, the Self-Assembly group has expanded its collaborations to various centers such as the University of Grenoble (France), CIC biomaGUNE, and CFM CSIC-UPV/EHU. These collaborations translate into a more pronounced (bio)chemical synthesis branch.



Electron-microscopy image of a microdroplet of the ionic liquid hexyl-methyl-imidazolium iodide (top right), wetting 20 nm wide Tobacco Mosaic Virus rods without structural changes.

TEAM

Alexander Bittner
Ikerbasque Research Professor
Group Leader
PhD in Chemistry 1996
Free University of Berlin
(Germany)

Research Fellow
Mitsuhiro Okuda,
Ikerbasque Research Fellow

Technicians
Aitziber Eleta
Gabriela Pretre

Visiting Professor
Sylvie Morin,
York University Toronto
(Canada)

Guest Researchers
One-month stay minimum
Saioa Cobo,
Grenoble Alpes University (France)
Jorge H. Melillo, CFM (Spain)

Pre-doctoral Researcher
Maiara Iriarte, nanoGUNE Fellow,
Nanoscale water and ice

Undergraduates
Natali Constante, UB (until 13/09/2018)
Elena Esteban, UPV/EHU
Silvia Locarno, University of Milan (until 31/10/2017)
Joseba López, UPV/EHU (until 31/08/2018)
Ryo Kobayashi, Nagaoka University of Technology (Japan)
Irene Ortega, UPV/EHU (until 18/09/2017)

Post-doctoral Researchers
José M. Alonso, Elkartek Fellow (until 31/12/2017)
María Cascajo, Elkartek Fellow (until 30/11/2018)
Elizaveta Nikulina, Elkartek Fellow
Irma Pérez, nanoGUNE Fellow (until 31/12/2017)

NANOBIOMECHANICS

Proteins are the building blocks of living organisms. Proteins are also essential in most biochemical processes necessary for life. Understanding how proteins work provides crucial information for understanding biological systems. The Nanobiomechanics group is aimed at the understanding of the function of proteins in living organisms and how these proteins can also be useful in our everyday life.

Our approach to study proteins is based on the concept of mechanobiology, which focusses on the application of mechanical perturbations to proteins. These mechanical perturbations are indeed natural in living organisms. Our skin, our muscles, and our bones are all designed to resist and function under mechanical force. We are able to walk because our muscles generate mechanical forces; our heart pumps blood creating a shear stress in vessels and arteries. Almost any biological process is related somehow to the existence of mechanical interactions. Unfortunately, this also includes diseases and disorders such as inflammation, tumor spread, heart failure, injuries, arthritis, etc. In addition, bacterial and viral infections occur with the interplay of mechanical forces at the molecular level.

The Nanobiomechanics group employs state-of-the-art techniques to investigate how mechanical forces impact the proteins that form living cells. In our laboratory, proteins are captured individually and studied in detail. From bacteria to animals and viruses, our group investigates biological processes that occur under force and that are crucial for life, using single-molecule force spectroscopy. This allows us to observe how the conformation of proteins changes under force and how forces can also trigger biochemical reactions. We believe that studying the mechanics of proteins is essential to understand the development of many diseases. In particular, we investigate proteins involved in viral and bacterial infections. Our research provides new aspects of microbial infections that could lead to new methodologies for treatment and prevention of microbial diseases.

The interest of the Nanobiomechanics group is not limited to the understanding of the function of proteins; we are also interested in transforming and designing that function. In this sense, the group employs protein engineering techniques based on the reconstruction of ancestral sequences to alter the function of proteins and enzymes based on the principles of evolution. The group is leader in the reconstruction of ancestral enzymes, and outstanding properties have been demonstrated that make them suitable candidates for biotechnological applications. Our research covers a wide range of enzymatic functions, from cellular oxidation processes to the industrial generation of nanocellulose, a biomaterial with numerous potential applications.

Artistic representation of an experiment performed with an Atomic Force Microscope (AFM) in which a multimodular protein is held and stretched by a cantilever tip. (Image by Antonio Reifs).

Raúl Pérez-Jiménez
Ikerbasque Research Professor
Group Leader

TEAM

Raúl Pérez-Jiménez
Ikerbasque Research Professor
Group Leader
PhD in Physical Chemistry 2005
University of Granada (Spain)

Research Fellow
David De Sancho, Ikerbasque Research Fellow (until 28/02/2018)

Technicians
Wilmer A. Pardo
Marie Fertin (until 08/04/2018)

Master Students
Anne Aguirre, UPV/EHU (until 10/07/2017)
Leire Aldazabal, UPV/EHU (until 19/05/2017)

Guest Researchers
One-month stay minimum
Bárbara Rodríguez, UPV/EHU (Spain)
Rajendra Sharma, IMDEA (Spain)

Pre-doctoral Researchers
Álvaro Alonso, PFPI Fellow (until 31/12/2017), *Nanomechanics of pathogenic attachment: uropathogenic escherichia coli and human immunodeficiency virus*
Borja Alonso, Elkartek Fellow, *Ancestral cellulases for degradation of lignocellulosic materials*
Leyre Barandiaran, Elkartek Fellow, *Ancestral enzymes for degradation of lignocellulosic biomass*
Aitor Manteca, nanoGUNE Fellow (until 31/07/2017), *Mechanochemical evolution of the giant muscle protein titin as inferred from resurrected proteins*
Antonio Reifs, FPI Fellow, *Control of the nanomechanics of viral infections, from bacteria to cells.*
Susana Revilla, FP7 Fellow (until 28/02/2017), *Design of molecular force sensors based on fluorescence to reveal the nanomechanics of viral infections at the cellular level*

Undergraduates
Jon Iriarte, UPV/EHU (until 15/08/2017)
Amaia Ochandorena, UPV/EHU (until 17/08/2018)
Ion Ander Yusta, Don Bosco (until 31/05/2017)

Post-doctoral Researchers
José Luis Adrio, nanoGUNE Fellow
Nerea Barruetabeña, Elkartek Fellow
Patricia García, Elkartek Fellow (until 31/12/2017)
Ana I. Platero, DFG Fellow (until 31/03/2018)
Joerg Schönfelder, DFG Fellow (until 14/09/2018)

FPI, predoctoral grant of the Spanish Government
PFPI, predoctoral grant of the Basque Government
DFG, Regional Council of Gipuzkoa

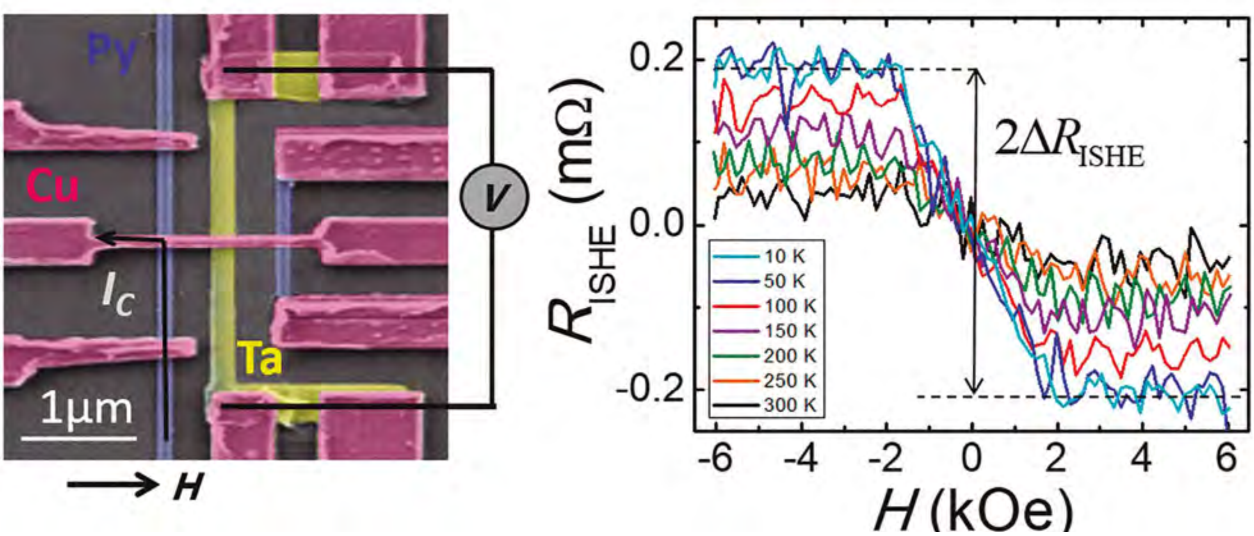
NANODEVICES

A major challenge faced nowadays by the electronics industry is to find suitable materials and devices that allow us to continue with the increase in computing resources together with reduced power consumption. In this context, the general aim of the Nanodevices group is to study the electronic properties of materials at the nanoscale. Some of these materials are potential candidates for future logic devices; but they are also interesting for electronic memories, photovoltaics, and many other gadgets. For this, advanced nanofabrication methods are used and we measure the electron transport of materials under extreme conditions, such as low temperatures and high magnetic fields. We are currently working on three main research lines.

In the first place, we are working on spintronics with organic molecules, two-dimensional (2D) materials, and metals. Spintronics is a field based on the use of the spin of the electron, a purely quantum mechanical entity, to transmit and process information. It works as a substitute of the role of the electron charge in standard electronics, aiming at reaching lower power consumption in devices. We can create, transport, and manipulate pure spin currents, both as an alternative and as a complement to conventional electronics.

In the standard electronics front, we use organic and 2D materials as building blocks for novel (opto-)electronic devices. We are particularly interested in merging materials with different dimensionalities for pushing effects such as light collection and emission as well as sensing.

In the third place, we are interested in magnetism and superconductivity in correlated materials. This type of materials, for example some rare-earth oxides, have an indicated interplay among different degrees of freedom such as the electronic carriers, the lattice vibrations, and the magnetic interactions. Understanding these materials provides useful knowledge for the understanding of how matter works at the nanoscale and how to manipulate it for creating, for example, supercurrents flow without heat dissipation.



UNVEILING THE MECHANISMS OF THE SPIN HALL EFFECT

Future development in spintronic devices requires interconversion between charge currents and spin currents, which can be achieved with effects based on spin-orbit coupling, such as the spin Hall effect. The Nanodevices group uses multiterminal nanodevices, as the one shown in this false-colored scanning electron micrograph (left panel), in order to quantify this effect by purely electrical measurements (right panel).

TEAM

Luis E. Hueso
Ikerbasque Research Professor
Group Leader
PhD in Physics 2002
University of Santiago de Compostela (Spain)

Fèlix Casanova
Ikerbasque Research Professor
PhD in Physics 2003
University of Barcelona (Spain)

Research Fellows

Santiago Blanco-Canosa, Ikerbasque Research Fellow (until 31/05/2018)
Catalina Mansilla, Gipuzkoa Fellow
Pablo Stoliar, Ramón y Cajal Fellow (until 31/03/2018)

Technicians

Xabier Carballo (until 31/07/2018)
Julen Echavarri (until 02/01/2017)
Roger Llopis
José Ramón Suárez (06/07/2018)

Guest Researchers

One-month stay minimum

Yuichiro Ando, Kyoto University (Japan)
Marco Gobbi, CFM (Spain)
Federico Golmar, CONICET (Argentina)
Stephen McMillan, University of Iowa (USA)
Vahagn Mkhitaryan, ICFO (Spain)
Koichi Oyanagi, Tohoku University (Japan)
Elías Torres, Graphenea (Spain)

Pre-doctoral Researchers

Coline Adda, ANR Fellow (until 31/10/2018), *Neuromorphic devices with Mott insulators*
Ainhoa Atxabal, PFPI Fellow (until 30/11/2018), *In-device spectroscopy at metal/organic semiconductor interfaces*
María Barra, MdM Fellow, *Extreme nanofabrication of spintronic and plasmonic devices*
Francesco Calavalle, ITN Fellow, *Advanced hybrid organic based devices*
Inge Groen, SRC Fellow, *Optimization of spin-to-charge current conversion in a lateral device using spin-orbit effects*
Juan Manuel Gómez, FPI Fellow, *Electrical excitation and transport of magnons in magnetic-insulator-based lateral nanostructures*
Franz Herling, H2020 Fellow, *Spin-to-charge conversion in strong spin-orbit coupling systems*
Josu López, PFPI Fellow (until 15/06/2018), *Noncollinear magnets for spintronics*
Mário Ribeiro, ITN Fellow (until 28/02/2017), *Electronic and spintronic devices using two-dimensional materials*
Edurne Sagasta, FPU Fellow, *Towards efficient spin-to-charge current conversions in spin orbitronics*
Elisabetta Zuccatti, nanoGUNE Fellow, *Design and optimization of organic field-effect transistors*

Undergraduates

Julen Arruabarrena, Don Bosco (until 16/07/2018)
Luis Esteban, UNIZAR (until 18/08/2017)
Ainhoa Fernández, UPV/EHU (until 11/08/2017)
Beñat García, UPV/EHU (until 31/07/2017)
David García, UAB
Elena Hernández, UPV/EHU
Andoni Ugartemendia, UPV/EHU (until 11/08/2017)

Post-doctoral Researchers

Kaushik Bairagi, H2020 Fellow
Sara Catalano, SNSF Fellow
Safeer Chenattukuzhiyil, MCIU Fellow
Josep Ingla-Aynés, MdM Fellow
Maider Ormaza, Marie-Curie Fellow
Subir Parui, H2020 Fellow (until 30/09/2017)
Van Tuong Pham, H2020 Fellow
Saúl Vélez, DFG Fellow (until 31/08/2017)
Wenjing Yan, ITN Fellow (until 20/08/2017)

ANR, Agence National de la Recherche (France)
FPI, predoctoral grant of the Spanish Government
FPU, predoctoral grant of the Spanish Government
PFPI, predoctoral grant of the Basque Government
MdM, María de Maeztu Excellence Unit
SRC, Semiconductor Research Corporation
MCIU, Spanish Ministry of Science, Innovation, and Universities.
SNSF, Swiss National Science Foundation

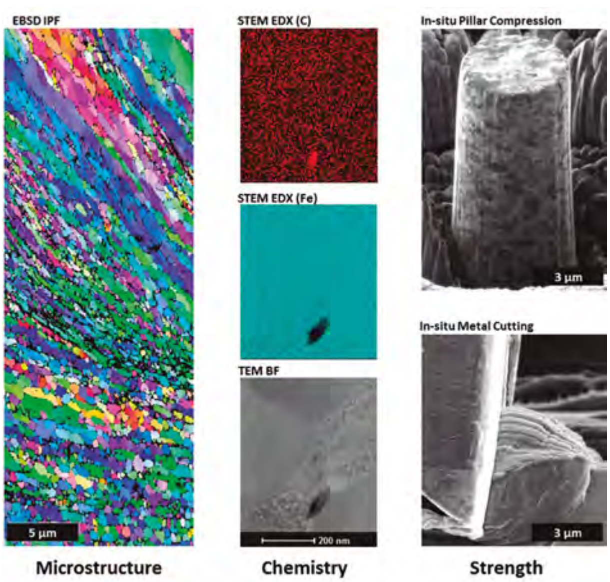
ELECTRON MICROSCOPY

Having information about the structure and composition of materials is of key importance for the basic understanding of their properties and of the functioning of nanodevices. Moreover, our ability to characterize and understand these structures is critical for revealing the quality issues of existing products, providing answers for problems currently faced by industry. The Electron-Microscopy group provides a high-level electron-microscopy support to the local scientific community in order to face these challenges.

Our laboratory is specialized in high-resolution Transmission-Electron Microscopy (TEM) imaging and structure analysis, local analysis of the composition of materials, prototyping of metal plasmonic structures, and the study of plasmonic resonances by electron energy-loss spectroscopy (EELS), the visualization of magnetic fields by electron holography and Lorentz microscopy, nanofabrication using focused ion beams (FIB) and electron beams, 3D imaging by electron tomography and FIB slicing, as well as electron microscopy of wet and liquid materials.

In the last years, we have developed a research line dealing with nanostructures and micro-mechanical properties of metals. In particular, a study of peculiar microstructures formed in the chips during high-speed machining of industrial steels has provided a basic understanding of plasticity mechanisms involved in tool/metal interaction.

We maintain a broad collaboration with many other institutes in the Basque Country and worldwide.



Nanostructured metals produced by large plastic deformation show extreme mechanical properties. An example of such nanostructures is depicted in the left-hand side of the figure (SEM-EBSD-IPF technique), which demonstrates ultra-fine grain sizes. This and similar nanostructured metal-materials were structurally and mechanically investigated, giving a full picture of structure-composition-properties relationships. Such alloys have undergone strains greater than 1 000%, refining the grain structure down to nanometers. We found, through STEM-EDX analysis, that most of the material is chemically homogeneous with no phase separation and no segregation in the grain boundaries, indicating an average carbon content over the theoretical saturation limit. This has led to extraordinary mechanical properties, which have been tested by micro-pillar milling and subsequent compression revealing remarkable mechanical properties in case of some steels of up to three times the strength of the original material. The mechanical energy needed for processing a cut has been investigated by *in-situ* SEM cutting, and atomistic details of the process were studied by molecular dynamics. This defines a full characterization range from a basic atomistic level to industrial scale process parameters.

TEAM

Andrey Chuvilin
Ikerbasque Research Professor
PhD in Physics and Mathematics 1998
Siberian Branch of the Russian Academy of Sciences, Novosibirsk (Russia)

Specialist
Eugenii Modin

Technician
Christopher Tollan

Guest Researchers
One-month stay minimum
Iurii Ivanov, University of Cambridge (UK)
Maria Kazakova, Novosibirsk State University (Russia)
Joscha Kruse, DIPC (Spain)
Sergei Lopatin, FEI (The Netherlands)
Dimitry Melnikau, CFM (Spain)

Pre-doctoral Researchers
Stefan Merkens, nanoGUNE Fellow, *In-situ studies of nanoparticles growth and self-assembly using liquid cell transmission electron microscopy*

Post-doctoral Researchers
Bentejui Medina, Elkartek Fellow

THEORY

In the Theory group we do theoretical simulations of matter at the nanoscale. Starting from the fundamental equations of quantum physics, which are the ones describing the behavior of electrons and nuclei, we do "virtual reality" simulations of materials, nanoparticles, liquids, and their interfaces at the atomic scale, thereby gaining a very detailed view of their structure and dynamics, as well as predicting properties of interest for such systems.

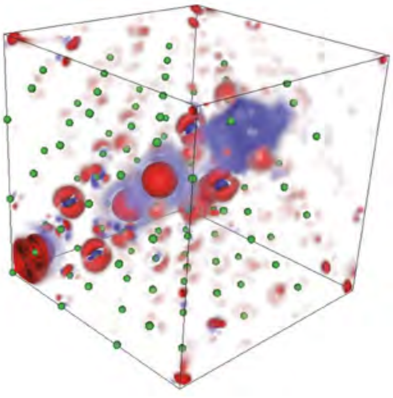
Part of our work is in the development and improvement of simulation methods, allowing a more effective simulation of systems of increasing complexity. Such developments are based on progress in the theoretical physics of solids and liquids, in a project called SIESTA that involves scientists in Spain (Barcelona, Madrid, San Sebastian, Santander), the USA (Stanford), and Australia (Perth). The Siesta method is used by thousands of scientists worldwide. In its 20th anniversary, SIESTA was converted to a free open-source license (GPL) after years of open source for academics only. The article describing the method was within the twelve papers recently selected as most prominent of the fifty years of life of the Journal of Physics Condensed Matter of the Institute of Physics of the UK. The papers associated to the method have around 12 000 citations.

A prominent line of research in our group explores the behavior of water and wet systems at the atomic scale, including nanoscale wetting and nanoconfined water and biomolecules in water. We collaborate in this with scientists at the University of Stony Brook (USA) and the Autonomous University of Madrid (Spain). Understanding water confined at the nanoscale is extremely important for understanding the inner workings of cells. A few years back we found that in narrow confinement (around 1 nm) water transits from a very complex behavior related to its molecular structure to suddenly behaving as a simple ideal two-dimensional (2D) liquid of spherical particles, a consequence of the oxygen atoms in water slowing in their motion within the liquid, while the hydrogen atoms keep moving rather quickly.

Further research into the topic (Phys. Rev. E **93**, 062137 (2016)) led to our prediction that the dielectric response of nanoconfined water would be anomalously low, around 30 times lower than in the bulk, quite a record value in many respects. This prediction has been confirmed experimentally in a recent paper in Science (Science **360**, 1339 (2018)), who found a value that was even lower than our prediction. This could have important implications in understanding the way water works among the constituents of a living cell.

Another important line of research is the study of radiation damage in materials, relevant to the treatment of cancer by ion therapy, for instance. When a charged particle shoots through a material or biological tissue, electronic excitation processes take place, which we try to understand with time-dependent (non-equilibrium) theories. This we do in collaboration with top players in the field: DIPC and CFM, both at the same campus as nanoGUNE, and several USA National Laboratories (Argonne, Los Alamos, and Livermore).

In a recent work (Phys. Rev. Lett. **121**, 116401 (2018)), we found a completely unexpected effect in radiation damage. The core electrons increase the energy dissipation of a nickel-atom projectile when flapping around the stationary stopping regime, in a process analogous to the flapping of a flag in the wind. Electronic stopping of projectiles were considered quasi-stationary for over a century; but, once proposed, that instability makes a lot of sense, especially in the context of the recently proposed time crystals (Phys. Rev. Lett. **109**, 160401(2012)), systems in which the continuum time invariance is broken developing a pulsating periodicity.



Excess (blue) and defect (red) particle density in bulk nickel when a nickel-ion projectile is shooting through it at a velocity that is 1.3% of the speed of light. (Image by R. Ullah and A. Correa).

Emilio Artacho
Ikerbasque Research Professor
Group Leader

TEAM

Emilio Artacho
Ikerbasque Research Professor
Group Leader
PhD in Physics 1990
Autonomous University of Madrid (Spain)

Research Fellow

Adriá Gil,
Gipuzkoa Fellow

Pre-doctoral Researchers

Iker Ortiz de Luzuriaga, nanoGUNE Fellow, *Computational studies on the interaction of metallic complexes containing derivates of phenanthroline with G-quadruplex*
Ernesto Ruiz, FPI Fellow (until 31/05/2018)
Rafi Ullah, FPI Fellow (until 28/02/2018), *Non-adiabatic processes in the radiation damage of materials from first principles*
Jon Zubeltzu, FPI Fellow (until 05/06/2017), *Theoretical simulations of nanoconfined water*

Undergraduates

Maitane Muñoz, UPV/EHU (until 30/06/2017)

Guest Researchers

One-month stay minimum

Pablo Aguado, DIPC (Spain)
Alfredo Correa, DIPC (Spain)
Eleanor Green, ETH Zurich (Switzerland)
Joas S. Grossi, National University of Cuyo (Argentina)
Jorge Kohanoff, QUB (UK)
Etienne Plésiat, ECAM (France)
Elleuchi Sawssen, University of Sfax (Tunisia)
Aleksandr V. Terentjev, DIPC (Spain)

Post-doctoral Researchers

Anna Kimmel, Marie-Curie Fellow
Natalia Koval, H2020 Fellow
Petr Koval, nanoGUNE Fellow
David López-Durán, MCIU Fellow
Daniel Muñoz, Marie-Curie Fellow

FPI, predoctoral grant of the Spanish Government
MCIU, Spanish Ministry of Science, Innovation, and Universities

NANOMATERIALS

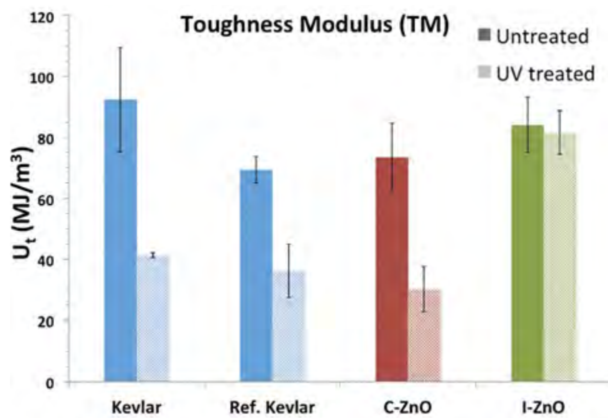
Working with materials at the nanoscale allows for enhancing functionalities or even introducing completely new properties that are not present at the macroscopic shape of the materials. The Nanomaterials group covers wide ranges of functionalization of materials. We aim at improving existing materials compositions and introducing novel materials for the improvement of the efficiency of a variety of devices and applications. For this, we consider hybrid materials, that is, blends of inorganic and organic materials, as utmost important for future applications as they can combine benefits from polymers with the benefits of solids in a best possible way.

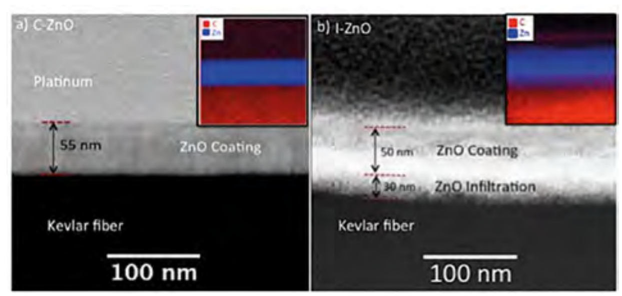
To achieve our objectives, the group operates in various research lines, including corrosion protection, functionalization of polymeric fibers for next generation textile, energy storage, enzymatic catalysis, as well as a social science aspect, the approach towards responsible research and innovation (RRI).

We have started a Innovative training network (ITN, HYCOAT), which integrates most of the groups in Europe that work in thin-film technologies for hybrid materials with a strong emphasis on developing the next generation of experts in the field.

We have developed a new strategy for improving the electrical conductivity of some polymers by doping the polymers with metals from the vapor phase. The approach was published in three consecutive publications: J. Mater. Chem. C **5**, 2686 (2017); Adv. Mater. Interfaces **4**, 1600806 (2017); and ACS Appl. Mater. Interfaces **9**, 27964 (2017).

We have shown a new approach towards improving polymeric fibers, making them resistant against degradation through sunlight and improving their mechanical strength. The polymeric fibers consist of Kevlar, a polymer used for personal protection in bulletproof vests and in sports equipment. The improvement strategy was published in Chem. Mater. **29**, 10068 (2017), and a specific aspect of the process has been submitted as patent application (EP18382552.0).





TEM images of cross-sections of a) a Kevlar fiber coated with ZnO and b) a Kevlar fiber infiltrated with ZnO, a process developed at nanoGUNE. Insets show EDS color maps with the carbon signal coded red and the zinc signal coded blue. In the infiltrated case the ZnO diffused into the Kevlar polymer, rather than just coating the surface, thereby creating a hybrid material in the polymer. Lower panel: Modulus of toughness of original Kevlar, heat treated Kevlar (Ref. Kevlar), coated Kevlar, and infiltrated Kevlar before and after irradiation with UV light. It shows the clear benefit of the infiltration process for the mechanical properties of Kevlar both with and without irradiation with UV light. (Images taken from: Chem. Mater. **29**, 10068 (2017)).

TEAM

Mato Knez
Ikerbasque Research Professor
Group Leader
PhD in Physical Chemistry 2003
Max Planck Institute
of Solid State Research,
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Research Fellow
Ana Beloqui, Gipuzkoa Fellow

Technician
Mikel Beltrán

Pre-doctoral Researchers
Karina Ashurbekova, ITN Fellow, *(Bio) functionalized gas permeation barriers through vapor phase infiltration and spatial MLD*
Itxasne Azpitarte, PFPI Fellow, *Vapour phase modification of kevlar fibres*
Gabriele Botta, MdM Fellow, *Functionalization of 2D materials by ALD*
Unai Carmona, PFPI Fellow (until 30/06/2018), *Ferritin-based hybrid nanocomposites for enzyme-mimetic catalytic activity*
Sarai García, nanoGUNE Fellow, *Functionalization of nanoparticles for energy storage*
Oksana Iurkevich, ITN Fellow, *Electronic functionalization of packaging materials*
Andoni Rodríguez, MCIU Fellow, *Magneto-optic functionalization of 2D materials*
Weike Wang, ITN Fellow (until 30/11/2017), *Vapor phase infiltration (VPI) and doping of conducting polymers*

Guest Researchers
One-month stay minimum
Iva Saric, University of Rijeka (Croatia)
Susana Velasco, biomaGUNE (Spain)

Post-doctoral Researchers
Jaime DuMont, Marie-Curie Fellow
Nagore Ibarra, H2020 Fellow
Victor Koroteev, MdM Fellow
Fan Yang, nanoGUNE Fellow (until 30/09/2017)

Undergraduates
Josu Arano, UPV/EHU (until 17/08/2018)
Josune Díaz, Don Bosco (until 13/06/2017)
Manuel Knez, St. Stephan Grammar School (until 09/06/2017)

PFPI, predoctoral grant of the Basque Government
MdM, María de Maeztu Excellence Unit
MCIU, Spanish Ministry of Science, Innovation, and Universities.

NANOIMAGING

Nature behaves differently at the scale of atoms. The Nanoimaging group studies the quantum behavior of small objects, just formed by a small number of atoms or molecules, using scanning probe microscopies. We search for effects related to their optical, magnetic, or electronic properties, which could help us to understand the fundamentals of quantum processes and to construct models explaining their peculiar behavior. The guideline of our research is to turn quantum phenomena relevant for novel materials.

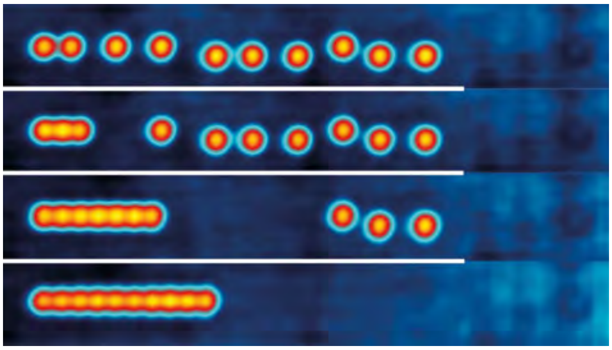
Our experiments use local probe microscopies to study materials down to the scale of atoms and molecules. But beyond "seeing", our group is fundamentally experienced in spectroscopy. Scanning Probe Spectroscopies "measure" forces, electrons, photons, and spins at the nanometer-length scale.

A major field of research in our group is the physics and chemistry of molecular nanostructures. We fabricate these structures by inducing controlled chemical reactions of a metal surface. If we mix different types of molecular precursors, hybrid structures such as magnetic porphyrins connected to graphene nanoribbons can be created. The chemical strategies utilized for the formation of this molecular LEGO allows us to fabricate molecular systems with pre-selected properties. In this way, we explore the emergence of novel phenomena in carbon-based materials.

We are also interested in correlated phenomena of quantum materials, such as superconductivity and magnetism. Superconductivity is a quantum phenomenon in macroscopic length scales. Little is known about its behavior when the dimensions of the material are reduced below its characteristic coherence length scale. We study how superconductivity evolves in the limit of two dimensions and also the effect of local magnetic fields and distortions at interfaces and atomic impurities. In combination with the atomic manipulation capability of our Scanning Tunneling Microscope (STM), we can fabricate artificial atomic structures like the one in the figure and we can study novel states of matter with unique quantum properties, which could be the basis of future technology.

Within the field of novel materials, we are particularly interested in investigating the growth and atomic-scale properties of transition metal dichalcogenides, a family of two-dimensional (layered) materials that can behave as a semiconductor, metal, or superconductor simply by modifying its composition. The two-dimensional (2D) character of these materials favors the creation of very clean and atomically perfect interfaces, facilitating charge transport. Our goal is to create ideal optoelectronic devices performing efficiently in comparison with current heterostructures.

Our research fields are established in collaboration with various groups at nanoGUNE and with university groups in Berlin, Zaragoza, Santiago de Compostela, and the Basque Country, as well as with research institutes such as ICN2 in Barcelona.



Sequence of STM images showing different steps in the fabrication of an atomic chain of manganese atoms on the surface of the superconducting surface of ß-Bi_2Pd.

TEAM

Jose Ignacio Pascual
Ikerbasque Research Professor
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PhD in Physics 1998
Autonomous University of Madrid
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Research Fellows

Reyes Calvo,
Gipuzkoa Fellow
Miguel Moreno-Ugeda,
Ikerbasque Research Fellow
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Technician

David Arias

Master Student

José Manuel Pereira , UPV/EHU

Guest Researchers

One-month stay minimum

Kim A. C. Akius, Leiden University (The Netherlands)
Martina Corso, CFM (Spain)
Paul Dreher, DIPC (Spain)
Dimas Garcia de Oteyza, DIPC (Spain)
Guowen Kuang, Hong Kong University (China)
Wolfgang Kuch, Freie University Berlin (Gremany)
Néstor Merino, DIPC (Spain)
Alexander D. Neef, University of Regensburg (Germany)
Wen Wan, Xiamen University (China)
Lei Xie, Tongji University (China)

Pre-doctoral Researchers

Eduard Carbonell, nanoGUNE Fellow (until 31/08/2017), *Electronic tailoring of graphene nanosctructures via on-surface synthesis*
Niklas Friedrich, FPI Fellow, *Towards a graphene based single-molecule OLED*
Nieves Morquillas, FP7 Fellow (until 31/07/2018), *Optoelectronic properties in heterostructures of two-dimensional materials*
Nerea Ontoso, FPI Fellow, *Graphene nanostructures for spin-based devices with topological materials*
Carmen Rubio, nanoGUNE Fellow, *The atomic-scale limits of magnetism and superconductivity explored by electronic excitations in tunneling spectroscopy*
Stefano Trivini, MdM Fellow, *Atomic scale superconductivity of novel materials*
Javier Zaldivar, nanoGUNE Fellow, *Local probe studies on superconducting nanomaterials*

Undergraduates

Asier Alonso, UPV/EHU (until 11/08/2017)
Robert Berghaus, Darmstadt University of Technology (until 30/04/2017)
Bruno Candelas, UPV/EHU (until 11/08/2017)
Asier Garmendia, UPV/EHU
Rubén Ibarrondo, UPV/EHU (until 34/08/2018)

Post-doctoral Researchers

Deung Jang Choi, Marie-Curie Fellow (until 30/04/2018)
Jingcheng Li, DFG Fellow
Anil Rajapitamahuni, MdM Fellow

FPI, predoctoral grant of the Spanish Government
MdM, María de Maeztu Excellence Unit
DFG, Regional Council of Gipuzkoa

NANOENGINEERING

The Nanoengineering group aligns its research and technology development according to industrial and clinical needs and incorporates market-driven needs and real-life applications from the very beginning into the research programs. The aim is to bridge the gap between basic research and industrial as well as clinical applications by introducing nanotechnology and photonic approaches to finally gain added value for novel methods, devices, and instrumentation. Our current research is reflected in subsequently outlined five research lines, which include photonic and plasmonic sensing for biomedical applications, food control, environmental monitoring, and materials science.

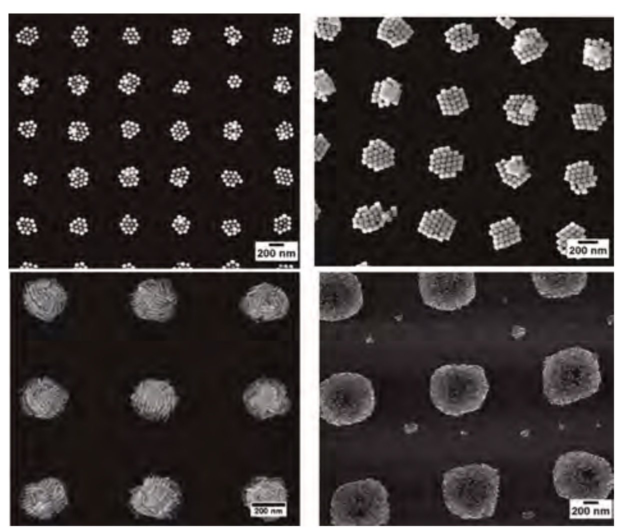
One research line focuses on plasmonic detection of biomarkers. This research line aims at developing a highly sensitive liquid biopsy based on propagating and localized surface-plasmon resonances. Additionally, the method will be employed for food control and the measurement of environmental conditions.

In a second research line, we are building up a nanoplasmonic sensor platform based on self-assembled Au nanoparticles (NP) with ultrahigh resolution and limit of detection. A universal self-assembly process of Au nanoparticles could be established. The chemically controlled process allows for a regular and homogeneous self-assembly of nanoparticles with different shapes and various sizes over several square millimeters. The process was demonstrated for spheres, octopods, rods, triangles, and cubes. The nanoparticle arrays will be employed in plasmonic biosensing chips featuring localized surface plasmons (LSP) and propagating surface-plasmon resonances (SPR) as well as surface-enhanced Raman spectroscopy (SERS).

In a third research line, we are developing a new platform that combines Raman and FTIR (Fourier transform infrared) spectroscopy to be applied to the early detection of Alzheimer's disease. Our main objective is to develop a combined spectroscopy platform that integrates the spectral information from both techniques and helps in building multivariate analyses-based robust prediction algorithms for the early diagnosis of Alzheimer's disease. The method will be used for food control and environmental monitoring, too.

Photonic monitoring of physiology, our fourth research line, pursues the superior goal of implementing optical systems and fiber-based probes for measuring various parameters, as for example lactate, pH, hemoglobin derivatives, or oxygenation. The idea is to establish non-invasive or minimally invasive rapid methods instead of standard biochemistry that takes hours or even days. Typical pathological cases are hypoxia, ischemia, or sepsis.

Furthermore, the Nanoengineering group has been working on a compact solution for a photoplethysmograph for pulse wave analysis and blood oxygen saturation that can be integrated with other sensors for multiparameter monitoring and allows access to raw data. A special focus lies on solutions that are portable, non-invasive, and comfortable to wear for the patient. Another objective of this fifth research line is to reliably extract information from corrupted data caused by movement artifacts and further interferences.



Self-assembled regular clusters of Au nanoparticles with different shapes:
a) Nanospheres: 65 nm diameter.
b) Nanooctopods: 55 nm size.
c) Nanorods: 70 nm length, 15 nm width.
d) Nanotriangles: 50 nm size.

TEAM

Andreas Seifert
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Group Leader
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University of Freiburg
(Germany)

Master Students
Leire Fernández, UPV/EHU
(until 30/09/2018)
Aitor Jaunarena, Tecnun
(until 09/04/2018)

Technician
Eneko López

Pre-doctoral Researchers
Mathias Charconnet, nanoGUNE Fellow, *Nanofabrication of plasmonics supercrystals for surface enhanced spectroscopy*
Ion Olaetxea, PFPI Fellow, *Non-invasive sensing of pH and lactate in newborns during delivery*

Guest Researchers
One-month stay minimum
Antoine Canova, Grenoble INP (France)
Christian Kuttner, biomaGUNE (Spain)
Odei Vegas, BTI (Spain)
Constança Vieira, University of Lisbon (Portugal)
Vished Vished, biomaGUNE (Spain)

Undergraduates
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Marina Echave, Tecnun
Pablo García, Tecnun (38/07/2017)
María Larburu, Tecnun
Xabier Morales, Tecnun (until 11/08/2017)
Carlos Rodríguez, UPV/EHU

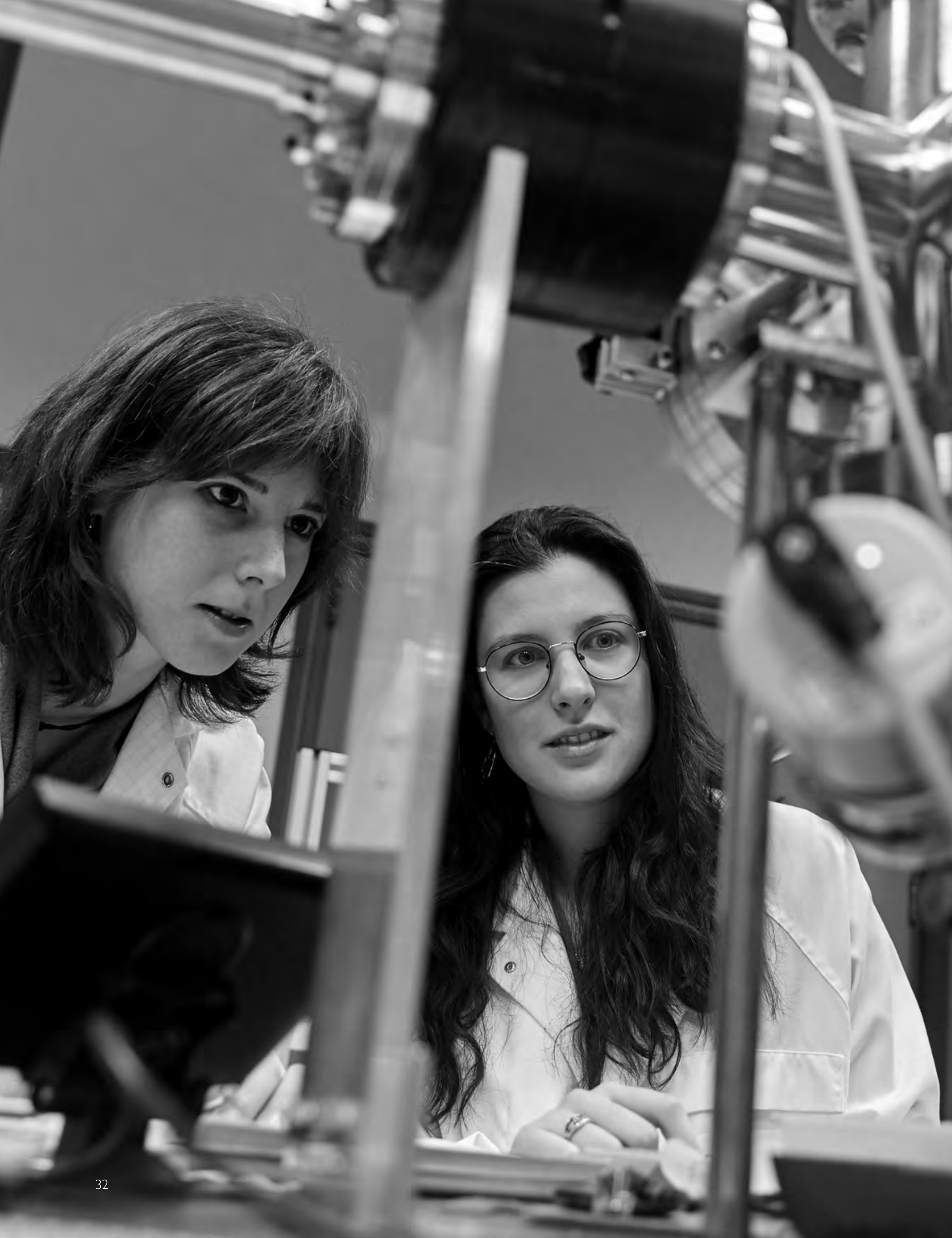
Post-doctoral Researchers
Olga Antonova, Elkartek Fellow
Jaione Etxebarria, Elkartek Fellow
Maria C. Morant, Elkartek Fellow (31/05/2018)
Gajendra Singh, Elkartek Fellow (31/08/2018)
Ana Valero, GV Fellow

PFPI, predoctoral grant of the Basque Government
GV, Basque Government

2

RESEARCH OUTPUTS

203 ISI PUBLICATIONS
7 004 CITATIONS
133 INVITED TALKS



HIGHLIGHTED PUBLICATIONS

Acoustic terahertz graphene plasmons revealed by photocurrent nanoscopy
Nature Nanotechnology **12**, 31–35 (2017)

Metamagnetic anomalies near dynamic phase transitions
Physical Review Letters **118**, 117202 (2017)

Size effect and scaling power-law for superelasticity in shape-memory alloys at the nanoscale
Nature Nanotechnology **12**, 790–796 (2017)

Mechanochemical evolution of the giant muscle protein titin as inferred from resurrected proteins
Nature Structural & Molecular Biology **24**, 652–657 (2017)

A molecular spin-photovoltaic device
Science **357**, 677-680 (2017)

Survival of spin state in magnetic porphyrins contacted by graphene nanoribbons
Science Advances **4**, eaaq0582 (2018)

Infrared hyperbolic metasurface based on nanostructured van der Waals materials
Science **359**, 892-896 (2018)

Mechanical architecture and folding of E. coli type 1 pilus domains
Nature Communications **9**, 2758 (2018)

Imidazole grafted nanogels for the fabrication of organic-inorganic protein hybrids
Advanced Functional Materials **28**, 1803115 (2018)

In-plane anisotropic and ultra-low-loss polaritons in a natural van der Waals crystal
Nature **562**, 557–562 (2018)

Acoustic terahertz graphene plasmons revealed by photocurrent nanoscopy

Nature Nanotechnology **12**, 31–35 (2017)

P. Alonso-González, **A. Y. Nikitin**, Y. Gao, A. Woessner, M. B. Lundeberg, A. Principi, N. Forcellini, **W. Yan**, **S. Vélez**, A. J. Huber, K. Watanabe, T. Taniguchi, **F. Casanova**, **L. E. Hueso**, M. Polini, J. Hone, F. H. L. Koppens, and **R. Hillenbrand**

We developed a technique for imaging THz photocurrents with nanoscale resolution, and applied it to visualize strongly compressed THz waves (plasmons) in a graphene photodetector. The extremely short wavelengths and highly concentrated fields of these plasmons open new venues for the development of miniaturized optoelectronic THz devices.

Radiation in the terahertz (THz) frequency range is attracting large interest because of its manifold application potential for non-destructive imaging, next-generation wireless communications, or sensing. But still, the generation, detection, and control of THz radiation faces numerous technological challenges. Particularly, the relatively long wavelengths (from 30 to 300 μm) of THz radiation require solutions for nanoscale integration of THz devices or for nanoscale sensing and imaging applications.

In recent years, graphene plasmonics has become a highly promising platform for shrinking THz waves. It is based on the interaction of light with collective electron oscillations in graphene, giving rise to electromagnetic waves that are called plasmons. Graphene plasmons propagate with a strongly reduced wavelength and can concentrate THz fields to subwavelength-scale dimensions, while the plasmons themselves can be controlled electrically.

In this study, strongly compressed and confined THz plasmons were visualized in a room-temperature THz detector based on graphene. To see the plasmons, we recorded a nanoscale map of the photocurrent that the detector produced while a sharp metal tip was scanned across it. The tip had the function to focus the THz illumination to a spot size of about 50 nm, which is about 2 000 times smaller than the illumination wavelength. This new imaging technique, named THz photocurrent nanoscopy, provides unprecedented possibilities for characterizing optoelectronic properties at THz frequencies.

Specifically, we recorded photocurrent images of the graphene detector while it was illuminated with THz radiation of around 100 µm wavelength. The images showed photocurrent oscillations revealing that THz plasmons with a more than 50 times reduced wavelength were propagating in the device while producing a photocurrent.

At the beginning we were quite surprised about the extremely short plasmon wavelength, as THz graphene plasmons are typically much less compressed. We managed to solve the puzzle by theoretical studies, which showed that the plasmons couple with the metal gate below the graphene. This coupling leads to an additional compression of the plasmons and an extreme field confinement, which could open the door towards various detector and sensor applications. The plasmons also show a linear dispersion – i.e., their energy is proportional to the momentum - which could be beneficial for information and communication technologies. We also analyzed the lifetime of the THz plasmons, which showed that the damping of THz plasmons is determined by the impurities in the graphene.

THz photocurrent nanoscopy relies on a strong photo-thermoelectric effect in graphene, which transforms heat generated by THz fields, including that of THz plasmons, into a current. In the future, the strong thermoelectric effect could also be applied for on-chip THz plasmon detection in graphene plasmonic circuits. The technique of THz photocurrent nanoimaging could find further application potential beyond plasmon imaging, for example, for studying the local THz optoelectronic properties of other 2D materials, classical 2D electron gases, or semiconductor nanostructures.

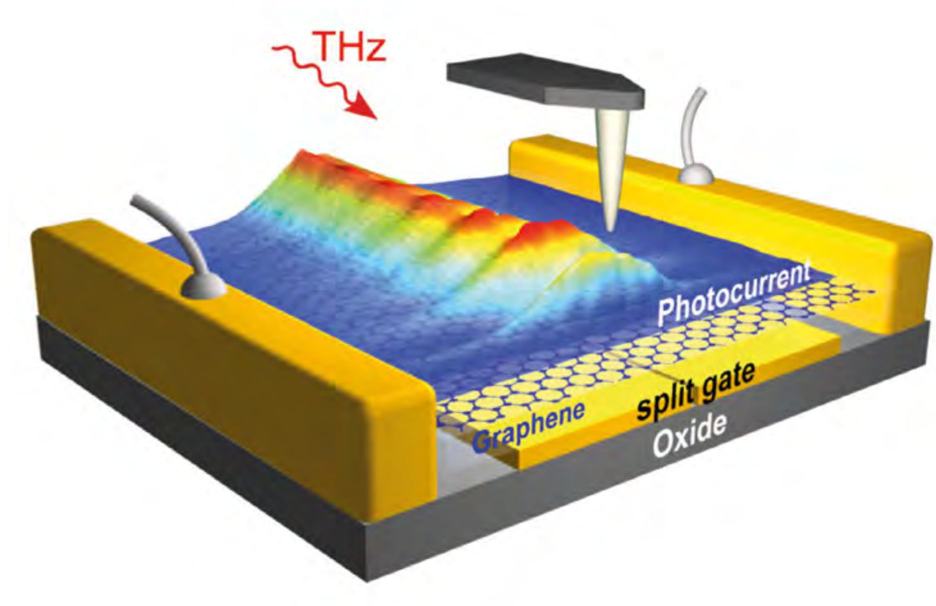


Figure: THz plasmons of extremely short wavelength propagating along the graphene sheet of a THz detector, as visualized with photocurrent images obtained by scanning probe microscopy.

2

Metamagnetic anomalies near dynamic phase transitions

Physical Review Letters **118**, 117202 (2017)

P. Riego, P. Vavassori, and **A. Berger**

The study of dynamic behavior and kinetic pattern formation in interacting systems is a crucially important aspect of science, given that they are present in such diverse areas as laser emission, the formation of sand dunes, or brain activity.

The study of non-equilibrium dynamic phenomena is of utmost importance, and its detailed understanding crucially relies on appropriate models. One of these models is the widely used kinetic Ising Model (kIM), which can exhibit qualitatively different types of dynamic behavior, including dynamic phase transitions (DPTs), despite its simplicity. After more than two decades of research using kIM, consensus emerged that the properties of DPTs are truly analogous to those of thermodynamic phase transitions (TPTs). Our work, however, revealed that these similarities between dynamic and thermodynamic phase transitions are far more limited than previously thought.

Surprisingly, our study demonstrated most significant deviations to occur when the dynamics is slow. This is unexpected, because slow dynamics is generally understood to approach thermodynamic behavior and most experimental studies of equilibrium properties are in fact slow dynamics studies, in which the external parameters are changed so slowly that the system can be presumed to be arbitrarily close to thermodynamic equilibrium conditions. However, our new work shows that slow DPTs are very different from conventional TPTs, whereas fast DPTs exhibit the previously postulated full equivalency to TPTs.

We studied, by means of experiments and computations, the detailed behavior of a ferromagnetic system that mimics kIM upon being subjected to a combination of an oscillatory magnetic field of amplitude H_0 and period P, and a time-independent bias field H_b. When the oscillatory field is swept fast, the magnetization M of the system cannot follow the field reversal and thus exhibits a nonzero cycle-averaged magnetization value Q=<M>, which is the order parameter of the dynamic state. So far, $Q(P,H_b)$ diagrams of DPTs were assumed to be equivalent to the M(T,H) diagrams for TPTs with T and H being the temperature and applied field, respectively. Concomitantly, the susceptibility diagrams, i.e. the susceptibility versus period P and bias field H_b, were understood to be identical exhibiting a single sharp peak due to the susceptibility divergence at the critical point. However, our detailed study revealed that there are anomalous additional features occurring for DPTs in cases of slow dynamic phase transitions, which appear as susceptibility side-bands in the paramagnetic state, and for which no equivalency exists in TPTs. Only for fast DPTs the equivalency to TPTs actually exists.

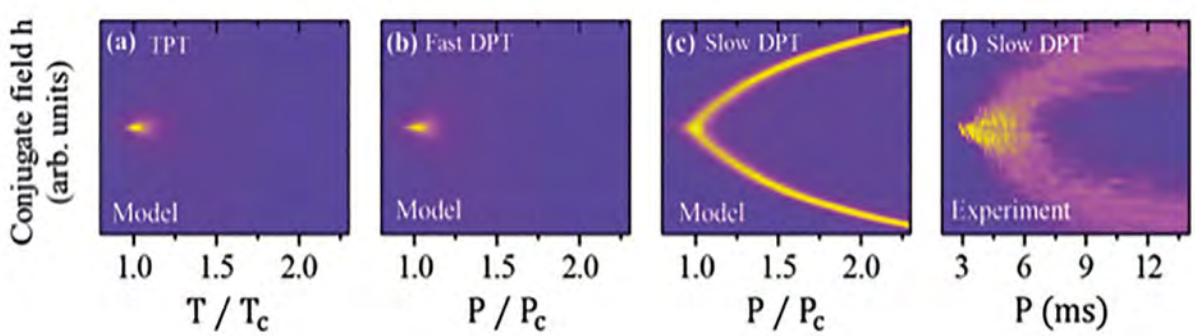


Figure: Susceptibility diagrams for model calculations in (a-c) and experiments in (d). The TPT in (a) and the fast DPT in (b) are analogous, while the slow DPTs in (c) and (d) show sidebands that are absent in the TPT. The conjugate field is the external applied field H in (a) and the bias field H_b in (b-d). [The experimental data in (d) represent fluctuations rather than susceptibility measurements. Both quantities are found to behave in an identical manner, but fluctuations show better noise performance in our experiments].

3

Size effect and scaling power-law for superelasticity in shape-memory alloys at the nanoscale

Nature Nanotechnology **12**, 790–796 (2017)

J. F. Gómez-Cortés, M. L. Nó, I. López-Ferreno, J. Hernández-Saz, S. I. Molina, **A. Chuvilin,** and J. M. San Juan

We have explored superelasticity properties on a nanometric scale based on shearing an alloy's pillars down to the nanoscale. We have found that below one micron in diameter the material behaves differently and requires much higher stress for it to be deformed. This superelastic behaviour is opening up new channels in the application of microsystems involving flexible electronics and microsystems that can be implanted into the human body.

Superelasticity is a physical property by which it is possible to deform a material to a considerable extent, up to 10%, which is much higher than in the case of elasticity. When stress is applied to a straight rod the rod can form a U-shape, and when the applied stress is removed the rod fully regains its original shape. Although this has been amply proven in macroscopic materials, until now no one had been able to explore these superelasticity properties at the microscale and at the nanoscale.

We have managed to see that the superelastic effect is maintained in really small devices in a copper-aluminium-nickel alloy. This is an alloy with shape memory on which we have been working for over 20 years at a macroscopic level: Cu-Al-Ni, an alloy that displays superelasticity in ambient temperature.

By using a Focused Ion Beam, an ion cannon that acts as a kind of atomic knife shearing the material, micropillars and nanopillars of this alloy have been built with diameters ranging between 2 μm and 260 nm. To these pillars a stress has been applied using a nanoindenter and their behavior has been measured.

We have for the first time confirmed and quantified that in diameters of less than a micrometer there is a considerable change in the properties relating to the critical stress for superelasticity. The material starts to behave differently and needs a much higher stress for superelasticity to take place. The alloy continues to display superelasticity; but for a much higher stress. We have also proposed an atomic model that allows one to understand why and how the atomic structure of these pillars changes when a stress is applied.

This discovery opens up new channels in the design of strategies for applying alloys with shape memory to develop flexible microsystems and electromechanical nanosystems.

Flexible electronics is very much present on today's market; it is being increasingly used in garments, sports footwear, and displays. All this is also of crucial importance in developing smart healthcare devices of the lab-on-a-chip type that can be implanted into the human body. It will be possible to build tiny micropumps or microactuators that can be implanted on a chip, and which will allow a substance to be released and regulated inside the human body for a range of medical treatments.

This is a discovery that is expected to have great scientific and technological repercussions and offers the potential to revolutionize various aspects in related fields.

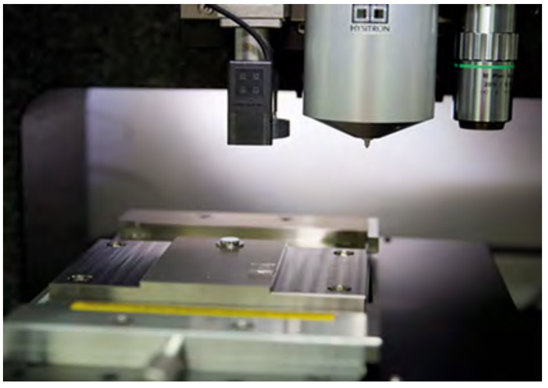


Figure: Pillars were built using a Cu-Al-Ni alloy, each pillar with a diameter measuring about 500 nm. (Image by Jose M. San Juan, UPV/EHU).

4

Mechanochemical evolution of the giant muscle protein titin as inferred from resurrected proteins

Nature Structural & Molecular Biology **24**, 652–657 (2017)

A. Manteca, J. Schönfelder, A. Alonso-Caballero, M. J. Fertin, N. Barruetabeña, B. F Faria, E. Herrero-Galán, J. Alegre-Cebollada, **D. De Sancho**, and **R. Perez-Jimenez**

The sarcomere-based structure of muscles is conserved among vertebrates; however, vertebrate muscle physiology is extremely diverse. A molecular explanation for this muscle diversity and its evolution has not been proposed. We use phylogenetic analysis and single-molecule force spectroscopy (smFS) to investigate the mechanochemical evolution of titin, a giant protein responsible for the elasticity of muscle filaments.

Titin is one of the proteins that make up the muscles of all vertebrates; it is an elastic protein that acts as a spring by refolding and returning to its original state. Protein evolution has been studied from many points of view: its thermal stability, function, and structure; but no one had ever studied the evolution of the mechanical properties of a protein. For titin this is a particularly appropriate approach given its function.

For this research, we selected over thirty animals from different taxonomic groups and of different sizes. The complete genome of many animals was already available, so the first thing we did was to build a phylogenetic tree with the titin sequences of around thirty tetrapods. This tree enabled us to calculate the most probable sequences of the protein titin of four common ancestors of the taxonomic groups to which these animals belong: placental mammals, dating back about 100 million years; all mammals, dating back 170-180 million years; the common ancestor of the sauropsids, including all birds, reptiles, and also dinosaurs, and which lived about 280 million years ago; and the common ancestor of all the animals we have studied, which would be the common ancestor of the tetrapods, dating back about 350 million years.

Once we had the sequences, we synthesized the most elastic fragment of the proteins in the laboratory, and using an atomic-force microscope we were able to measure the mechanical resistance of each of the proteins. This instrument allows one, literally, to take a protein, stretch it, and unfold it mechanically using force, which is something similar to what happens to titin in the muscle. In this way, we were able to compare the resistance or stability of all the titins under study. In this study, we realized that the mechanochemical stability of the proteins depends on the number of disulfide bridges displayed by the titin, which are sulfur-sulfur bonds between two cysteine residues.

We were able to see that the ancestral proteins were more resistant than those of today's animals, and they had more disulfide bridges than the modern ones. Yet this difference was not so big compared with a small animal such as a finch. This fact led us to think that there could be a link between the mechanochemical properties of titin and the size of the animals. We saw a pretty good correlation: the larger animals had less stable proteins and the smaller ones more stable proteins. This observation enabled us to predict the size of the ancestral animals.

Once we had inferred the size of the common ancestors, we compared them with fossil records and the scientific literature available in this respect. We were able to see that there was substantial agreement; the ancestors of mammals, birds, and tetrapods in general were really small, weighing less than 100 g, although we do of course have a margin of error inherent in the techniques themselves. This may not be surprising, because one could consider that this is information that was already known; but what is new here is that we did not use a fossil, but started from a reconstructed protein, a purely molecular piece of information.

The interesting point here is that we have tracked the mechanochemical evolution, how titin gradually changed throughout evolution, and we have been able to reconstruct the mechanical history of titin.

Figure: **Titin is one of the proteins that make up the muscles of all vertebrates; it is an elastic protein that acts as a spring by refolding and returning to its original state.**

5

A molecular spin-photovoltaic device

Science **357**, 677-680 (2017)

X. Sun, **S. Vélez, A. Atxabal**, A. Bedoya-Pinto, **S. Parui**, X. Zhu, **R. Llopis, F. Casanova,** and **L. E. Hueso**

A photovoltaic cell in which magnetic materials such as electrodes are used for the first time to provide current opens up a new channel for converting light into electrical power more efficiently.

Electronic spin currents can be measured with a spin valve—a device that injects charge carriers from one ferromagnetic electrode to another through a semiconductor layer. Some organic semiconductors can have long spin-carrier lifetimes and can also generate charge carriers through the photovoltaic effect. A spin valve based on C_{60} shows that the spin current could be modulated by the photocurrent.

The device is simply a photovoltaic cell manufactured from an organic material —fullerene C_{60}— and fitted with cobalt and nickel magnetic electrodes. Fullerene C_{60}, known as Buckyball, is a ball-shaped molecule comprising C_{60} carbon atoms. What is more, the magnetic electrodes produce current with an added property known as spin. The combination of both is no coincidence, since fullerene is known to be a photovoltaic material that could allow the spin direction to be controlled. The proper use and control of this property allows the efficiency of the solar cell to be increased, thus making it capable of generating a bigger current. The spins of the usual solar cells are 'disordered' but thanks to magnetism we have managed to 'order' them so that a bigger current can be collected. We have confirmed that the use of electrodes of this type increases the photovoltaic efficiency of the device by 14%.

The device has another added advantage, an it has been found to be capable of directly generating an alternating current which is much more useful in applications than the direct current generated by the usual solar cells, as transformers no longer need to be used. The reversal of the current takes place in the device itself when the electrons created by the light interact with the magnetic contacts, whose spins have been 'ordered'.

Even though it is true that we have demonstrated that the use of magnetic electrodes allows the efficiency of the photovoltaic cells to be increased, we insist that we are still a long way from obtaining an optimum photovoltaic cell. With this aim in mind we are working on building similar devices using organic materials which have already shown themselves to be more efficient than fullerene. In the future, it will be possible to build a commercial device that acts as a solar module and produces alternating current directly.

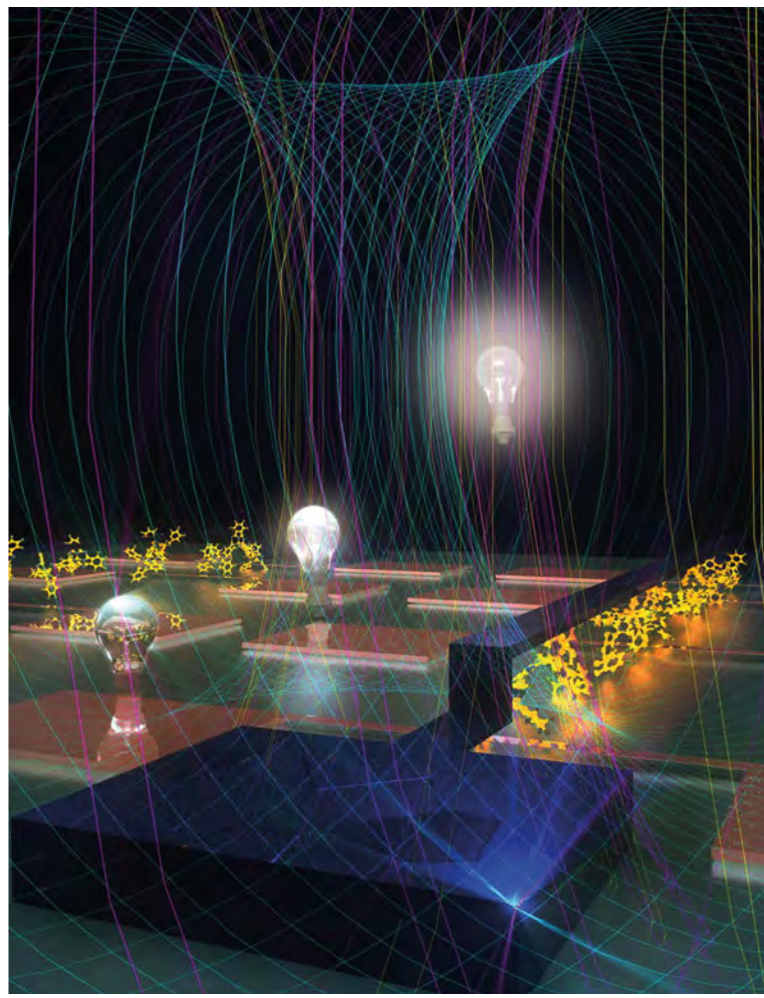


Figure: Artistic representation of organic spin valves, in which the molecular layers are sandwiched between magnetic films. The electrical response of these devices changes with both the magnetic field and the collected light, opening the way of creating multifunctional devices that can create power more efficiently than existing ones.

6

Survival of spin state in magnetic porphyrins contacted by graphene nanoribbons

Science Advances **4**, eaaq0582 (2018)

J. Li, N. Merino-Díez, **E. Carbonell-Sanromà**, M. Vilas-Varela, D. G. de Oteyza, D. Peña, M. Corso, and **J. I. Pascual**

A single molecule can behave as the smallest electronic component of an electronic system. With this premise in mind, we have brought closer the long-awaited objective of using molecules as electronic components.

The idea is fascinating: to store information into a single molecule and read it. We have known for a long time how to make molecules with precision, but until now we have not been able to wire them into a circuit. To achieve this goal, we have developed graphene narrow stripes with the aim of using them as electrical wires.

Graphene and graphene nanoribbons (GNRs) are ideal systems for wiring functional molecules, due to their extraordinary electron mobility and structural stability under high currents. For doing the molecule-wire connection covalent Carbon–Carbon bonds are ideal, because they make a stable system with robust electrical and mechanical connections. Thus, a synthetic method called on-surface synthesis was utilized to precisely contact the molecule at predefined places. We designed and synthetized molecular building blocks with 'glue-like' chemical terminations at the points where contacts are to be created; from then on, nature does the rest of the job for us. Using a simple metaphor to illustrate this process, we realized a molecular LEGO. And this was done after many previous studies learning how to use nature's laws for assembling molecules into more complex nanostructures.

To demonstrate the working function of the molecular device, we used Scanning Tunneling Microscopy (STM) for the visualization of atoms and molecules, and for measuring their behavior. By means of this tool, we were able to confirm under which conditions the magnetic information stored in the molecule could survive to the contact.

Combining precise measurements of the behavior of the molecular device with atomically resolved images, we found that the way the contact to the molecule was made crucially impacts on the behavior of the molecular device. These results open a new way to develop novel materials for efficient electronics.

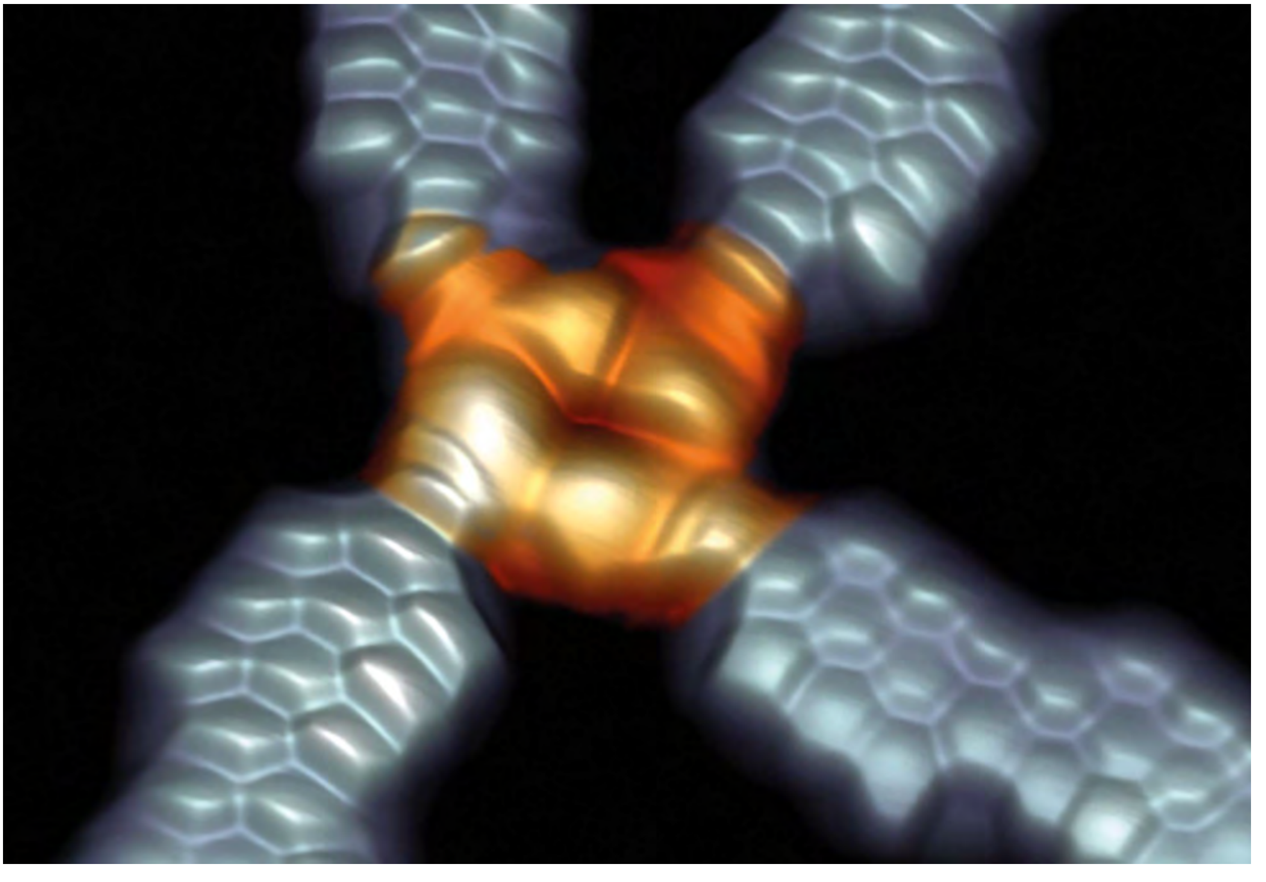


Figure: STM image of the new molecular device and its contacts made of graphene nanoribbons.

7

Infrared hyperbolic metasurface based on nanostructured van der Waals materials

Science **359**, 892-896 (2018)

P. Li, I. Dolado, F. J. Alfaro-Mozaz, F. Casanova, L. E. Hueso, S. Liu, J. H. Edgar, A.Y. Nikitin, **S. Vélez**, and **R. Hillenbrand**

Metasurfaces with strongly anisotropic optical properties can support deep subwavelength-scale confined electromagnetic waves (polaritons), which promise opportunities for controlling light in photonic and optoelectronic applications. We developed a mid-infrared hyperbolic metasurface by nanostructuring a thin layer of hexagonal boron nitride that supports deep subwavelength-scale phonon polaritons propagating with in-plane hyperbolic dispersion.

Optical waves propagating away from a point source typically exhibit circular (convex) wavefronts, like waves on a water surface when a stone is dropped. The reason for this circular propagation is that the medium through which light travels is typically homogenous and isotropic, i.e. uniform in all directions. Scientists had already theoretically predicted that specifically structured surfaces can turn the wavefronts of light upside down when it propagates along them. On such surfaces, called hyberbolic metasurfaces, the waves emitted from a point source propagate only in certain directions and with open (concave) wavefronts. These unusual waves are called hyperbolic surface polaritons. Because they propagate only in certain directions, and with wavelengths that are much smaller than that of light in free space or standard waveguides, they could help to miniaturize optical devices for sensing and signal processing.

In this work, we developed a metasurface for infrared light. It is based on boron nitride, a graphene-like two-dimensional (2D) material selected because of its capability to manipulate infrared light on extremely small length scales, which could be applied for the development of miniaturized chemical sensors or for heat management in nanoscale optoelectronic devices. On the other hand, we succeeded to directly observe the concave wavefronts with a special optical microscope, which have been elusive so far.

Hyperbolic metasurfaces are challenging to fabricate, because an extremely precise structuring on the nanometer scale is required. We mastered this challenge by electron beam lithography and etching of thin flakes of high-quality boron nitride provided by Kansas State University. After several optimization steps, we achieved the required precision and obtained grating structures with gap sizes as small as 25 nm. The same fabrication methods can be applied to other materials, which could pave the way to realize artificial metasurface structures with custom-made optical properties.

To see how the waves propagate along the metasurface, we used a state-of the-art infrared nanoimaging technique. We first placed an infrared gold nanorod onto the metasurface. It plays the role of a stone dropped into water. The nanorod concentrates incident infrared light into a tiny spot, which launches waves that then propagate along the metasurface. With the help of a scattering-type scanning near-field microscope (s-SNOM) we imaged the waves. The images indeed showed the concave curvature of the wavefronts that were propagating away from the gold nanorod, exactly as predicted by theory.

The results promise nanostructured 2D materials to become a novel platform for hyberbolic metasurface devices and circuits, and further demonstrate how near-field microscopy can be applied to unveil exotic optical phenomena in anisotropic materials and for verifying new metasurface design principles.

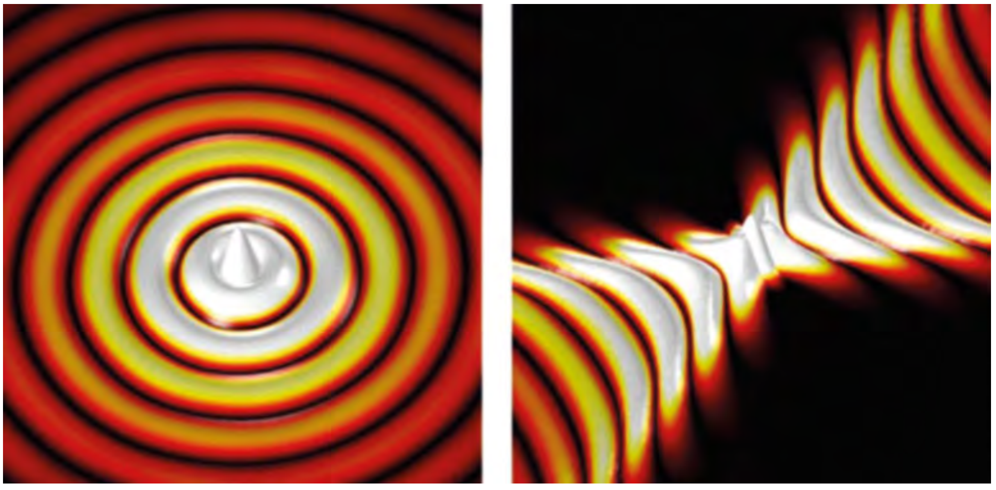


Figure: Illustration of waves propagating away from a point-like source. Left: Regular wave propagation. Right: Wave propagation on a hyperbolic metasurface.

8

Mechanical architecture and folding of *E. coli* type 1 pilus domains

Nature Communications **9**, 2758 (2018)

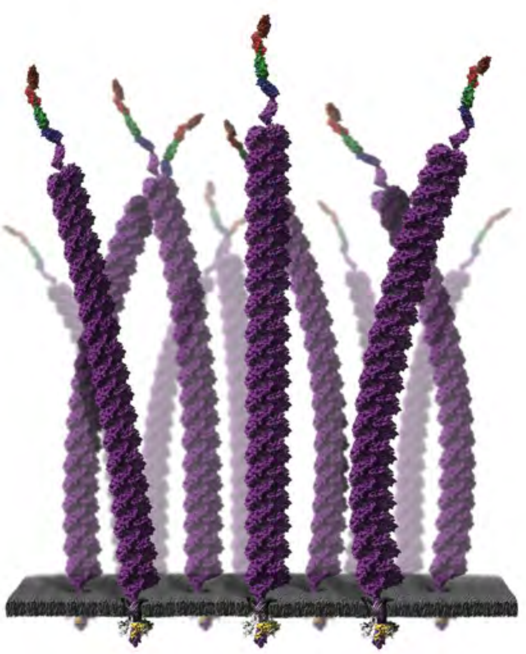
A. Alonso-Caballero, J. Schonfelder, S. Poly, F. Corsetti, D. De Sancho**, E. Artacho,** and **R. Perez-Jimenez**

Uropathogenic *Escherichia coli* (UPEC) are bacteria that cause urinary tract infection (UTI), which is one of the most common and recurrent infections worldwide. Virtually every person in the world will suffer UTI at least once in his/her life. Although the disease can be easily treated, in some situations can lead to permanent kidney damage. For infection, UPEC needs to attach to the urethra and resist the extreme shear forces of the urine flow. This is possible thanks to thousands of appendages that each bacterium has in its surface, called pili type-1, and that uses to stick to the tissue and start infection.

In this work, we have studied the mechanical resistance of the pilus and each one of its four different constituents, the domains FimA, FimF, FimG, and FimH. These domains are assembled following a very precise structure. First, thousands of FimA domains form a A helical rod that acts as a spring. Domains FimF-FimG-FimH form the so-called tip fibrillum, with the very last domain, FimH, as ultimate responsible for binding to the D-mannose molecules at the surface of the tissue. The resistance of the whole chain is essential for the attachment and survival of the bacterium.

In order to study these domains, we have used protein engineering techniques to isolate each domain and study them using single-molecule force spectroscopy. This technique allows for the investigation of individual proteins to which a very precise mechanical force can be applied. Thus, it is possible to have a detailed description of the architecture and mechanical resistance of each domain individually and all of them together.

We have discovered a mechanical hierarchy within the domains that explains the spring-like behaviour and resistance of the pilus. The study represents the first mechanical map of the pilus. In addition, the study reveals the complex mechanochemical process of pilus assembly in the bacterial periplasms involving several enzymes in a perfectly orchestrated process. All in all, the study sheds light into the very first step of bacterial attachment prior infection and points towards several molecular events that could be potentially targeted to combat infection.



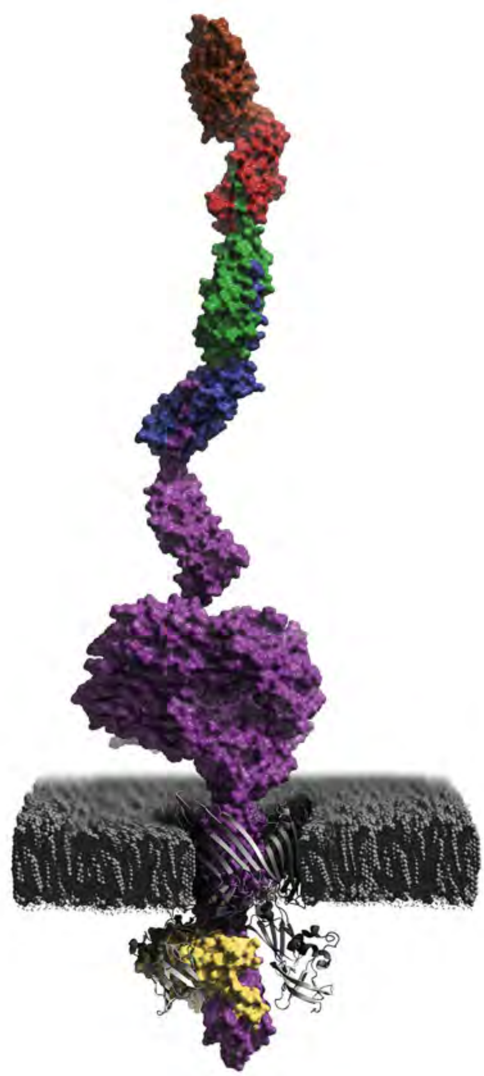


Figure: Representation of the UPEC pilus type 1 and its domains. Thousands of pili are used by each bacterium to attach to the urethra and the bladder epithelium and start infection.

9

Imidazole grafted nanogels for the fabrication of organic-inorganic protein hybrids

Advanced Functional Materials **28**, 1803115 (2018)

A. Rodriguez-Abetxuko, M. C. Morant-Miñana, L. Yate, F. López-Gallego**, A. Seifert, M. Knez,** and **A. Beloqui**

In this work, we provide a platform for the development of highly responsive organic-inorganic enzyme hybrids. A full characterization of our new composites reveals the first reported example in which the assembly mechanism is triggered by the sum of Cu(II)-imidazole interaction and $Cu_3(PO_4)_2$ inorganic salt formation.

The embedment of enzymes, and proteins in general, within (in)organic materials results in a chemical and physical stabilization and the consequent enhancement of its catalytic activity, as it has been proven for protein nanoflowers or enzymes encapsulated inside Metal Organic Frameworks (MOFs). Due to the remarkable features of these biohybrids, they have gained attention for their application potential in the field of sensing, drug delivery, or biotransformations.

In this work, we provide a platform for the fast synthesis of a new sort of organic-inorganic protein hybrids. The successful fabrication of these materials requires the encapsulation of proteins inside porous nanogels, which are grafted with imidazole molecules. As an example, we fabricate and characterize a Cu(II)-based organic-inorganic peroxidase. This revealed the first reported example in which the assembly mechanism is triggered by the sum of Cu(II)-imidazole interaction and $Cu_3(PO_4)_2$ inorganic salt formation. Also, we demonstrate that the imidazole-organic component of our hybrid provides a favorable spatial distribution for the enzyme. This results in enhanced conversion rates, robustness of the composite at low pH values, and a remarkable thermal stability at 65°C, exhibiting 400% of the activity of the mineralized enzyme lacking the organic constituent.

Importantly, unlike in previous studies on biohybrid fabrication, we show that the assembly of the imidazole modified nanogels can be triggered by a broad number of transition metallic cations (including mono-, di-, and trivalent cations). Thus, we open the scope to the on-demand selection of the more suitable metallic cation for the fabrication of the biohybrid, according to a particular application.

We have discovered a mechanical hierarchy within the domains that explains the spring-like behaviour and resistance of the pilus. The study represents the first mechanical map of the pilus. In addition, the study reveals the complex mechanochemical process of pilus assembly in the bacterial periplasms involving several enzymes in a perfectly orchestrated process. All in all, the study sheds light into the very first step of bacterial attachment prior infection and points towards several molecular events that could be potentially targeted to combat infection.

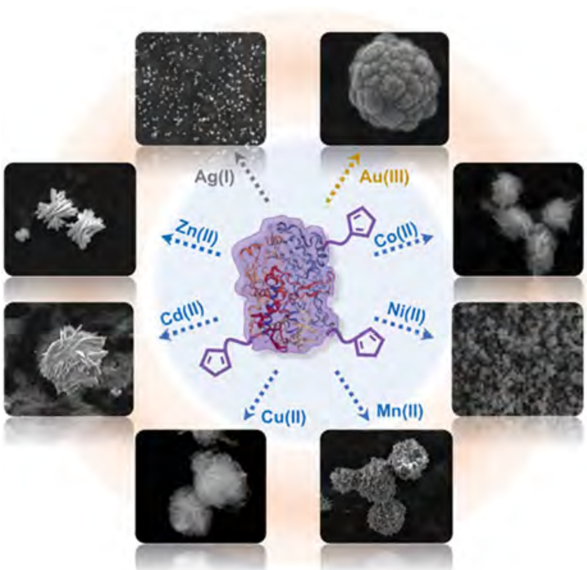


Figure: A new platform for the assembly of organic-inorganic protein hybrids based on imidazole-grafted enzyme nanogels. The ability of the imidazole nanogels to mimic the biomineralization mechanism with a broad number of metallic salts allows for the fabrication of protein hybrids on demand. Particularly, the use of enzyme nanogels lead to highly active, robust, and thermostable heterogeneous catalysts.

10

In-plane anisotropic and ultra-low-loss polaritons in a natural van der Waals crystal

Nature **562**, 557–562 (2018)

W. Ma, P. Alonso-González, S. Li, A. Y. Nikitin, J. Yuan, J. Martín-Sánchez, J. Taboada-Gutiérrez, **I. Amenabar**, **P. Li, S. Vélez, C. Tollan**, Z. Dai, Y. Zhang, S. Sriram, K. Kalantar-Zadeh, S.-T. Lee, **R. Hillenbrand**, and Q. Bao

We discovered nanoscale confined phonon polaritons (electromagnetic modes formed by the coupling of lattice vibrations and light) that propagate only in specific directions along thin slabs of molybdenum trioxide – a natural anisotropic two-dimensional (2D) material. Besides their unique directional character, these polaritons live for an exceptionally long time, and thus could find applications in signal processing, sensing, or heat management at the nanoscale.

Future information and communication technologies will rely on the manipulation not only of electrons but also of light at the nanometer scale. Squeezing (confining) light to such a small size has been a major goal in nanophotonics for many years. A successful strategy is the use of polaritons, which are electromagnetic waves resulting from the coupling of light and matter. Particularly strong light squeezing can be achieved with polaritons at infrared frequencies in 2D materials, such as graphene and hexagonal boron nitride. However, although extraordinary polaritonic properties - such as electrical tuning of graphene polaritons - have been recently achieved with these materials, the polaritons have always been found to propagate along all directions of the material surface, thereby losing energy quite fast, which limits their application potential.

Recently, it was predicted that polaritons can propagate "anisotropically" along the surface of 2D materials in which the electronic or structural properties are different along different directions. In this case, the velocity and wavelength of the polaritons strongly depend on the direction in which they propagate. This property could lead to a highly directional polariton propagation in the form of nanoscale confined rays, which could find future applications in the fields of sensing, heat management, or maybe even quantum computing.

Until now, the directional propagation of polaritons has been observed experimentally only in artificially structured materials, where the ultimate polariton confinement is much more difficult to achieve than in natural materials. Now, we have discovered ultra-confined infrared polaritons that propagate only in specific directions along thin slabs of the natural 2D material molybdenum trioxide (a-MoO_3).

Apart from directional propagation, our study also revealed that the polaritons on α-MoO_3 can have an extraordinarily long lifetime. Our measurements show that polaritons on α-MoO_3 live up to 20 picoseconds, which is 40 times larger than the best-possible polariton lifetime in high-quality graphene at room temperature.

Because the wavelength of the polaritons is much smaller than that of light, we had to use a near-field optical microscope (s-SNOM) in order to image them. The establishment of this technique coincided perfectly with the emergence of novel van der Waals materials, enabling the imaging of a variety of unique and even unexpected polaritons during the past years.

For a better understanding of the experimental results, we developed a theory that allowed us to extract the relation between the momentum of polaritons in α-MoO_3 with their energy. We have realized that phonon polaritons in α-MoO_3 can become "in plane hyperbolic" making their energy and wavefronts to propagate in different directions along the surface, which can lead to interesting exotic optical effects (such as e.g. negative refraction or "superlensing").

This work is just the beginning of a series of studies focused on the directional control and manipulation of light with the help of ultra-low-loss polaritons at the nanoscale, which could benefit the development of more efficient nanophotonic devices for optical sensing, signal processing, or heat management.

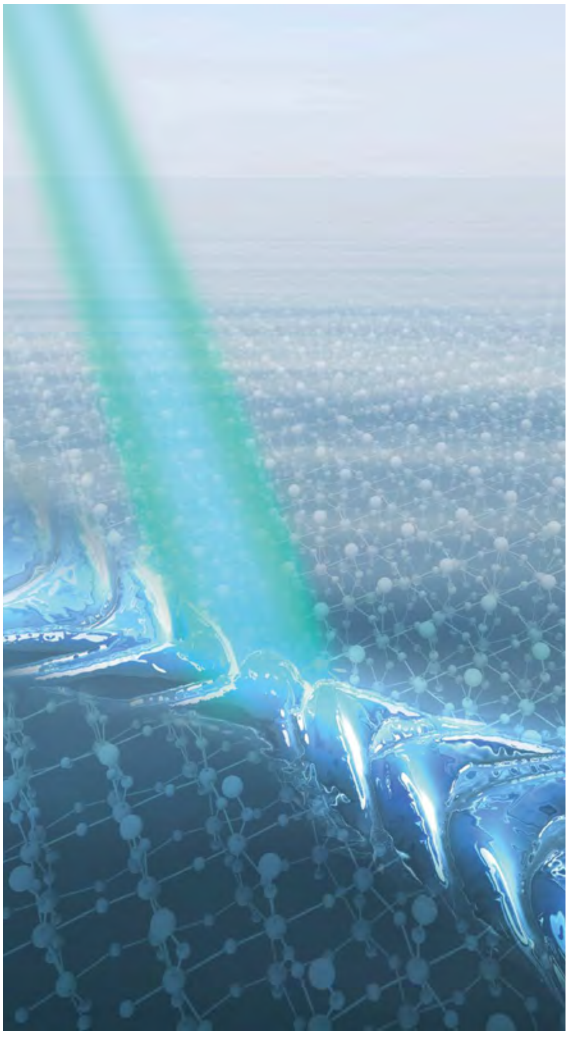


Figure: Illustration of directional phonon polaritons propagating along a thin layer of molybdenum trioxide.

HIGHLIGHTED GRANTS

GRAPHENE FLAGSHIP

GRAPHENE CORE 1

Start-date: 01/04/2016
End-date: 31/03/2018
Partners: 150 academics and companies
Total funding: 89 000 000 €
Contribution to nanoGUNE: 368 000 €

This project is the second in the series of EC-financed parts of the Graphene Flagship. The Graphene Flagship is a 10-year research and innovation endeavour with a total project cost of 1 000 million euros, funded jointly by the European Commission, member states and associated countries. The first part of the Flagship was a 30-month Collaborative Project, Coordination and Support Action (CP-CSA) under the 7th framework program (2013-2016), while this and the following parts are implemented as Core Projects under the Horizon- -2020 framework. The mission of the Graphene Flagship is to take graphene and related layered materials from a state of raw potential to a point where they can revolutionize multiple industries. This will bring a new dimension to future technology – a faster, thinner, stronger, flexible, and broadband revolution. Our program will put Europe firmly at the heart of the process, with a manifold return on the EU investment, in terms of both technological innovation and economic growth.

To realize this vision, we have brought together a large European consortium with about 150 partners in 23 countries. The partners represent academia, research institutes, and industries working closely together in 15 technical work packages and five supporting work packages covering the entire value chain from materials to components and systems. As time progresses, the center of gravity of the Flagship moves towards applications, which is reflected in the increasing importance of the higher levels of the value chain. In this first core project, the main focus is on components and initial system level tasks. The first core project is divided into 4 divisions, which in turn comprise 3 to 5 work packages on related topics. A fifth external division acts as a link to the parts of the Flagship that are funded by the member states and associated countries or by other funding sources. This creates a collaborative framework for the entire Flagship.

GRAPHENE CORE 2

Start-date: 01/04/2018

End-date: 31/03/2020

Partners: 130 academics and companies

Total Funding: 88 000 000 €

Contribution to nanoGUNE: 220 800 €

This proposal describes the third stage of the EC-funded part of the Graphene Flagship. It builds upon the results achieved in the ramp-up phase (2013 - 2016) and the first core project (2016 - 2018).

The progress of the Flagship follows the general plans set out in the Framework Partnership Agreement, the second core project representing an additional step towards higher technology and manufacturing readiness levels. The Flagship is built upon the concept of value chains, one of which is along the axis of materials-components-systems; the ramp-up phase placed substantial resources on the development of materials production technologies, the first core project moved to emphasize components, and the second core project will move further towards integrating components in larger systems.

This evolution is manifested, e.g., in the introduction of six market-motivated spearhead projects during this Core 2 project.

FET OPEN

2D INK

Start-date: 01/01/2016

End-date: 31/12/2018

Partners: 8 academics and one company

Total funding: 2 962 661 €

Contribution to nanoGUNE: 297 600 €

2D-INK is targeted at developing inks of novel 2D semiconducting materials for low-cost large-area fabrication processes on insulating substrates through a new methodology, which will exceed the properties of state-of-the-art graphene and graphene- -oxide based inks.

Achieving this will represent an important step forward in the processing of 2D semiconducting materials and will provide the key parameters for fabricating the next generation of ultrathin electronic appliances and exploring their potential over other scientific and technological disciplines, such as sensing, photonics, energy storage and conversion, and spintronics.

FEMTOTERABYTE

Start-date: 01/03/2017

End-date: 29/02/2020

Partners: 8 academics and 2 companies

Total funding: 3 712 833 €

Contribution to nanoGUNE: 316 616 €

The project aims to elucidate the fundamentals of the emergence and manipulation of light's orbital and spin angular momenta to achieve a non-thermal momentum-transfer-driven ultrafast switching process and to demonstrate its practical realization, and will map its suitability for future upscaling towards industrial device implementation. Here we are developing the conceptually new paradigm for ultra-dense and ultrafast magnetic storage that will exceed the current technology by two orders of magnitude in storage density (going from terabit/inch^2 to tens of terabytes/inch^2) and by about four orders of magnitude in operation speed (going from low GHz to THz for read/write). This will be achieved in an all-optical platform that allows deterministic, non-thermal, low-energy, ultrafast magnetization switching at few nanometers and potentially down to a molecular length-scale. The main building block of the envisioned memory unit in this new paradigm is an spinoptical nanoplasmonic antenna that concentrates pulsed polarized light at the nanometer length-scale and enables non-thermal spin-orbit mediated transfer of the light's angular momentum (orbital and/or spin) to the nanoscale magnetic architectures. In this way, fs-pulsed light, assisted by the plasmonic optical spin-selective antenna and the local electromagnetic field enhancement, allows for the precise control of the magnetic state of nanometer sized molecular magnetic structures.

PETER

Start-date: 01/01/2018

End-date: 31/12/2020

Partners: 3 academics and one company

Total funding: 2 898 684 €

Contribution to nanoGUNE: 613 353 €

Here we propose to establish Plasmon-enhanced Terahertz Electron Paramagnetic Resonance spectroscopy and scanning microscopy as a unique Electron Paramagnetic Resonance (EPR) platform for high-sensitivity local analysis of paramagnetic organic and inorganic species and materials. Here, we will deliver novel hardware and infrastructure providing groundbreaking innovation in the magnetic sensing and imaging. The platform is conceptually based on incorporating THz plasmonic antennas onto surfaces (spectroscopy) and scanning probe tips (microscopy), resulting in a strong, local enhancement (about two orders of magnitude) of the magnetic sensing field. Extending to the THz region enables effective utilization of plasmonic structures resulting in a radical improvement of EPR sensitivity (about four orders of magnitude) and spatial resolution going beyond the diffraction limit, and thus the introduction of a scanning probe microscopic regime into this field. This will make possible to map the sample over its area and so to localize its properties with unprecedented resolution (below 1 micrometre). Such a significant enhancement of the EPR performance will open new ways in magnetic sensing technologies, enabling for instance to study *in situ* functional centers in a wide variety of materials and, generally, set a new direction in the development of the EPR-employing industry. EPR finds its applications in many scientific areas covering chemistry, biology, medicine, materials science, physics, etc. Hence, introducing this new method would have a profound impact on scientific, technological, and societal stakeholders in many research and industrial communities.

INNOVATIVE TRAINING NETWORKS (ITN)

SPINOGRAPH

Start-date: 01/09/2013

End-date: 31/08/2017

Partners: 3 academics and 2 companies

Total funding: 3 783 986 €

Contribution to nanoGUNE: 458 863 €

Spintronics stands for electronics based on the electron spin degree of freedom. The huge success of spintronics in metals, which started from the pioneering discovery of Giant Magnetoresistance (GMR), has revolutionized the magnetoelectronics industry. The exploration of spin effects in other types of materials is leading to an array of fascinating physical phenomena and holds the promise of future breakthroughs. The discovery of graphene, the first truly two dimensional crystal, together with the remarkable progress in the fabrication of graphene devices, has naturally led to the exploration of hybrid graphene/ferromagnetic devices to explore spintronics in graphene.

THINFACE

Start-date: 01/09/2013

End-date: 31/10/2017

Partners: 7 academics and one company

Total funding: 3 873 668 €

Contribution to nanoGUNE: 467 938 €

Our main goal here is to push forward new ideas and techniques within the field of hybrid thin films for new energy devices. The approach focuses on sustainable energy solutions, thus meeting one of our most challenging societal issues. The consortium includes experimental and theoretical groups working in physics, chemistry, and materials science, which offers a broad range of possibilities for early stage researchers to gain knowledge and experience in exploring, fabricating, and characterizing materials of relevance for future applications in electronics and energy storage.

SPM2.0

Start-date: 01/01/2017

End-date: 31/12/2020

Partners: 7 academics and 3 companies

Total funding: 3 593 489 €

Contribution to nanoGUNE: 495 746 €

Advanced-Microscopy techniques are widely recognized as one of the pillars onto which the research and manufacture of nanotechnology-based products is sustained. At present, the greatest challenge faced by these techniques is the realization of fast and non-destructive tomographic images with chemical composition sensitivity and with sub-10 nm spatial resolution, in both organic and inorganic materials, and in all environmental conditions. Scanning Probe Microscopes are currently the Advanced-Microscopy techniques experiencing the fastest evolution and innovation towards solving this challenge. Scanning Probe Microscopes have crossed fundamental barriers, and novel systems exist that show potential unparalleled performance in terms of three-dimensional (3D) nanoscale imaging capabilities, imaging speed, and chemical sensitivity mapping. The objective of this Innovative Training Network is to train a new generation of researchers in the science and technology of these novel Scanning Probe Microscopes, in which Europe is currently in a leading position, in order to enforce its further development and its quick and wide commercialization and implementation in public and private research centers and industrial and metrology institutions. The researchers of the network will acquire a solid state-of-the-art multidisciplinary scientific training in this field of research, covering from basic science to industrial applications, which should enable them to generate new scientific knowledge of the highest impact. In addition, they will receive a practical training on transferable skills in order to increase their employability perspectives and to qualify them to access to responsibility job positions in the private and public sectors. The final aim of the network is to consolidate Europe as the world leader in Scanning Probe Microscopy technologies and its emerging applications in key sectors like Materials, Microelectronics, Biology, and Medicine.

QuESTech

Start-date: 01/01/2018

End-date: 31/12/2021

Partners: 7 academics and 2 companies

Total funding: 3 884 019 €

Contribution to nanoGUNE: 445 698 €

Quantum Electronics provides a challenging and innovative multidisciplinary framework for training young researchers with excellent prospects for a career either industry or in academia. In this promising area, the "Quantum Electronics Science and Technology" training project, with acronym QuESTech, will create a

European network of experts providing state-of-the-art training for young researchers in the general field of experimental, applied, and theoretical Quantum Electronics.

The overarching science and technology goal of our research program is to build, study, and qualify quantum electronic devices. QuESTech will train 15 PhD students through research in the sub-fields of spintronics, single-electronics, quantum dots, and quantum thermodynamics. The individual research projects will include technological developments in terms of nanomaterials growth, nanostructuring, near-field microscopies, transport measurements under extreme conditions, and theoretical calculations. Several QuESTech results are already identified to be of commercial interest for the emerging Quantum-Electronics industry.

Systematic secondments will be organized, including (for every researcher) a secondment of two months to a partner of the private sector. QuESTech will organize three sessions of the European School On Nanosciences and Nanotechnologies (ESONN) devoted to Quantum Nanoelectronics, combining theoretical and practical training, which will be open to young researchers outside the consortium. By 2021, we aim to have prepared a new generation of young researchers able to address the emergence of "Beyond C-MOS" Nanoelectronics.

HYCOAT

Start-date: 01/01/2018

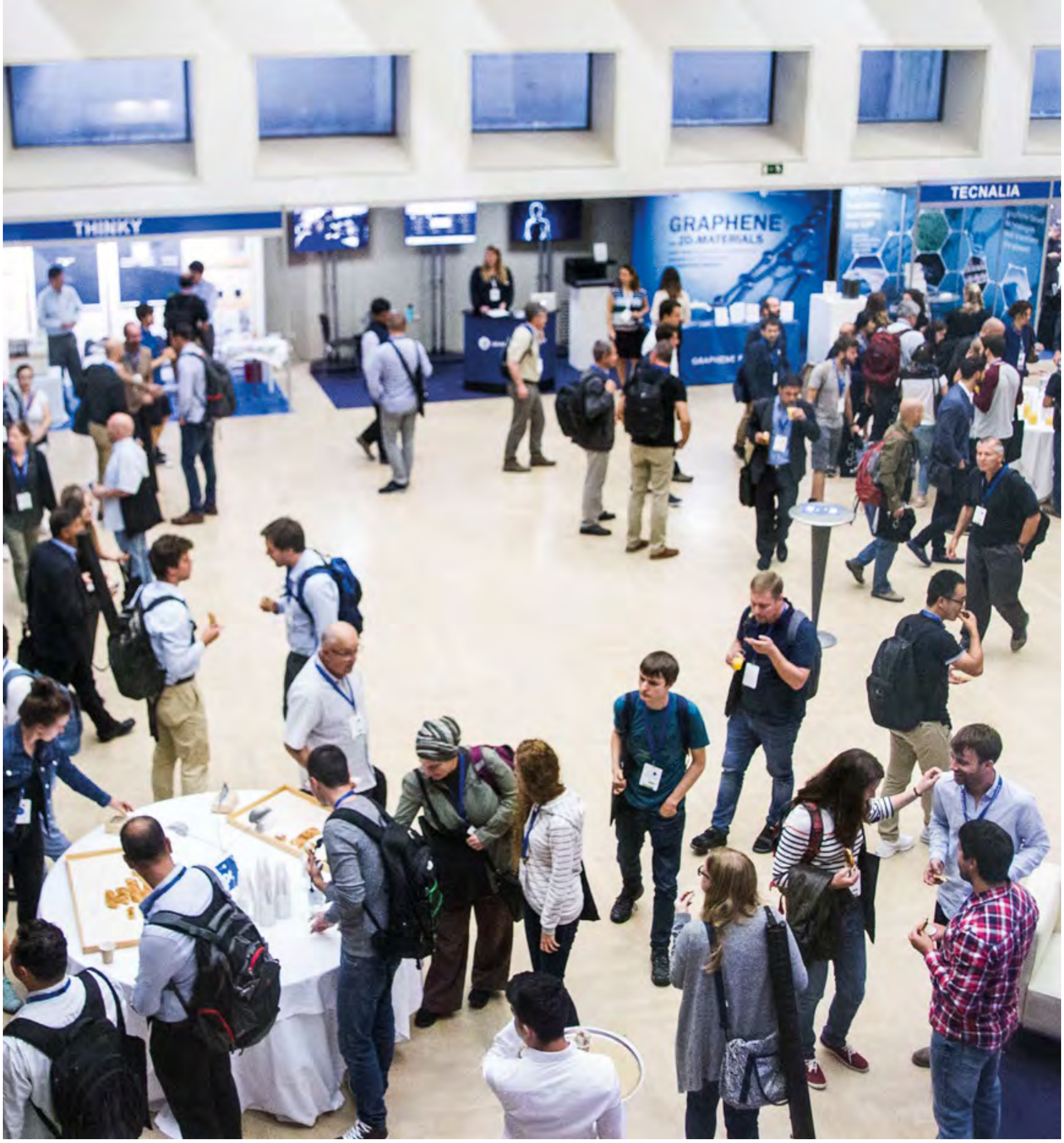
End-date: 31/12/2021

Partners: 10 academics

Total Funding: 3 898 798 €

Contribution to nanoGUNE: 430 946 €

HYCOAT is the first ITN at the intersection of chemistry, physics, materials science, and engineering dealing with the synthesis and applications of hybrid coatings grown by molecular layer deposition (MLD). With self-limiting binary reactions, MLD is the ideal ultra-thin film deposition technique, offering unique advantages for growing uniform, conformal hybrid films providing precise and flexible control over the film thickness and chemical composition at the molecular scale. This new field of MLD is pioneered at nanoscience laboratories across Europe. HYCOAT provides a European approach to facilitate an interdisciplinary and multi-environment platform for training a new generation of MLD researchers. A coordinated effort of 10 beneficiaries and 16 partner organizations from 7 European countries (Belgium, Finland, Germany, Ireland, The Netherlands, Norway, and Spain), HYCOAT targets the development of novel precursor chemistries, processes, characterization and modeling of MLD, and the demonstration of hybrid coatings in four key high-impact fields of application relevant for European Industries: packaging, biomedicine, electronics, and batteries. The understanding and engineering of hybrid coatings by MLD is essential for its wide range of applications, and the interaction with European high-tech industry is ensured through the active participation of 10 industries, 2 university hospitals, and a synchrotron facility. Training will take place through research projects, courses, and workshops, with emphasis on self-directed, hands-on, collaborative learning. This European knowledge alliance with an inter- and trans-disciplinary mobility and an intense collaboration between the private and public entities is needed to equip the next generation of researchers and extrapolate Europe's current pioneering role in the science of MLD towards a leadership in the economic and societal impact of innovations enabled by MLD.



CONFERENCES AND WORKSHOPS

2017

WATER SUSTAINABILITY WORKSHOP
13/01/2017
Workshop organized within the EU-funded project Marina – Marine knowledge sharing platform for federating responsible research and innovation communities.
Organizer: nanoGUNE
18 participants

WORKSHOP ON HYBRID MATERIALS BY ALD/MLD & IBERIAN ALD
23-25/01/2017
Organizers: nanoGUNE, Herald COST action, and CTECHnano
40 participants

2017 nanoGUNE PhD WORKSHOP
30/01/2017
Organizer: nanoGUNE
64 participants

SURFACES AND INTERFACES
20-23/06/2017
Summer school organized in the framework of a European collaborative network of doctorate programs in Physics and Chemistry of Advanced Materials (PCAM) and the European innovative training network THINFACE.
Organizers: nanoGUNE, DIPC, and CFM
59 participants

2018

2018 nanoGUNE PhD WORKSHOP

30/01/2018

Organizer: nanoGUNE

76 participants

ENERGÍA EÓLICA MARINA: ¿NUESTRO FUTURO?

Workshop organized within the EU-funded project Marina – Marine knowledge sharing platform for federating responsible research and innovation communities.

Organizer: nanoGUNE

12 participants

NUESTRO OCÉANO: FUENTE DE GRAN RIQUEZA

3/05/2018

Workshop organized to celebrate the European Maritime Day 2018 under the umbrella of the EU-funded project Marina – Marine knowledge sharing platform for federating responsible research and innovation communities.

Organizers: nanoGUNE, San Sebastian Aquarium, Plentzia Marine Station

30 participants

GRAPHENE WEEK 2018

10-14/09/2018

Main event of the Graphene Flagship initiative of the European Commission.

Organizer: nanoGUNE and the Graphene Flagship

659 participants

QuESTech TRAINING SESSIONS

02-04/10/2018

QuESTech - Quantum Electronics Science and Technology Training is a EU-H2020-ITN project.

Organizers: nanoGUNE & QuESTech

20 participants

IN-SITU ELECTRON MICROSCOPY WORKSHOP

15-16/11/2018

Organizers: nanoGUNE and Protochips

40 participants

A LOOK AT GRAPHENE WEEK 2018

Over 650 experts from 51 countries worldwide, including Nobel Laureate Andre Geim, joined us in San Sebastian from 10 to 14 September 2018 to learn about graphene and other two-dimensional (2D) materials at the 13th edition of the Graphene-Week Conference.

The Graphene Week is the main Conference of the Graphene Flagship, one of the biggest European research initiatives with over 150 members and a budget of 1 000 million euros. In 2018 the Graphene Week was held in Donostia - San Sebastian after having been hosted in previous editions in Athens, Warsaw, and Manchester, among other venues. "San Sebastian is one of the true centers of graphene research, not just in Europe but the world" said Graphene-Flagship Director Jari Kinaret. "While the scientific talks are important, the Graphene Week also provides a valuable opportunity to network and socialize with others in the graphene community", he added. Iñigo Urkullu, President of the Basque Government, stressed that "for us it is extraordinarily important that this Conference takes place here so that we can introduce to the world our industrial and technological culture. That is why we warmly welcome the research and exploration of the material of the future, graphene."

The aim of the Graphene Week international Conference was to report on the most significant advances that are taking place in the fields of graphene and other 2D materials. A tantalizing program was put in place, including 30 invited talks, 95 oral contributions, and more than 300 posters.

The Graphene Week 2018 also hosted various multidisciplinary sessions, such as the workshop entitled *Graphene for Human Space Exploration*, which explored the potential applications of graphene in space in the framework of a collaboration of the European Space Agency (ESA) and NATO; the *Graphene Innovation Forum*, which was focused on the commercial and industrial applications of graphene and other 2D materials; and the *EU-USA International Workshop* co-organized with the National Science Foundation (NSF) of the USA. The Graphene Week 2018 also included the initiative *Women in Graphene* set up to promote women in science and to create a more diverse scientific community.

The Kursaal Conference Center also hosted an industrial forum with 15 exhibitors with demonstrations of products that use graphene, as well as with inspiring success stories of companies and startups across Europe.


CIC nanoGUNE
NANOSCIENCE COOPERATIVE RESEARCH CENTER
Graphenea
#GrapheneWeek
GRAPHENE
WEEK
Gipuzkoako Foru Aldundia
Diputación Foral de Gipuzkoa
CIC Network
SCIENTIFIC REPORTS
CIC energiGUNE
GRAPHENE

INVITED TALKS

2017

Polariton mapping in 2D materials
07/01/2017, Rainer Hillenbrand
Nanometa 2017, Tirol (Austria)

A 2D field-effect spin transistor
25/01/2017, Luis Hueso
Nanolito 2017, Salamanca (Spain)

Nanoimaging and control of polaritons in 2D materials
02/02/2017, Rainer Hillenbrand
2017 nanoPorTugal Conference, Porto (Portugal)

SIESTA: experiences and thoughts for the future
02/02/2017, Emilio Artacho
Workshop on Scientific Software Integration in Chemistry and Materials, Berkeley (USA)

Infrared nanospectroscopy
22/02/2017, Rainer Hillenbrand
EU COST Action: Beyond Conventional Tissue Imaging, Bari (Italy)

Interaction effects in 2D materials
28/02/2017, Miguel M. Ugeda
RTG-QM3 Kick-off Workshop, Bremen (Germany)

Characterization of collective ground states in single-layer $NbSe_2$
08/03/2017, Miguel M. Ugeda
International Winter School on Electronic Properties of Novel Materials, Tirol (Austria)

A two-dimensional spin field-effect switch
14/03/2017, Felix Casanova
APS March Meeting, New Orleans (USA)

Nanoimaging and control of polaritons in 2D materials
20/03/2017, Rainer Hillenbrand
DPG-Frühjahrstagung, Dresden (Germany)

Manipulating the magnetic anisotropy of molecules
22/03/2017, Jose Ignacio Pascual
Physics Days 2017, Helsinki (Finland)

Plasmon-assisted thermal excitations of artificial spin ices
22/03/2017, Paolo Vavassori
DPG-Frühjahrstagung, Dresden (Germany)

Nanoimaging of IR and THz Polaritons in 2D Materials
19/04/2017, Rainer Hillenbrand
2017 MRS Spring Meeting, Phoenix (USA)

Nanophotonics in low dimensions
19/04/2017, Alexey Nikitin
International Conference on Nanophotonics and Nanooptoelectronics (ICNN), Yokohama (Japan)

Two-dimensional spin field-effect transistor
24/04/2017, Felix Casanova
IEEE International Magnetics Conference, Dublin (Ireland)

Magnetic micro- and nano-actuators and robots
26/04/2017, Paolo Vavassori
IEEE International Magnetics Conference, Dublin (Ireland)

Fabrication of individual devices on the nanometer scale
03/05/2017, Andreas Berger
IX International Conference in Education and Modeling in Basic Sciences, Medellin (Colombia)

Ellipsometry measurements and modeling for materials characterization
04/05/2017, Andreas Berger
IX International Conference in Education and Modeling in Basic Sciences, Medellin (Colombia)

Towards rare-earth-free permanent magnets: strongly exchange coupled core|shell nanoparticles
10/05/2017, Alberto Lopez-Ortega
International Conference on Small Science 2017, Donostia - San Sebastian (Spain)

Hybrid ribbons of graphene
11/05/2017, Jose Ignacio Pascual
10th European School on Molecular Nanoscience, Madrid (Spain)

Nanoimaging and control of polaritons in 2D materials
14/05/2017, Rainer Hillenbrand
Discussions on Nano & Mesoscopic Optics (DINAMO), Siglufjordur (Iceland)

Nanoscience in the Basque Country
18/05/2017, Andreas Seifert
PCAM (Physics and Chemistry of Advanced Materials) 2017 Workshop, Kraków (Poland)

Water and viruses: reciprocal control
25/05/2017, Alexander Bittner
Water Biophysics Conference 2017, Erice (Italy)

Towards an understanding of dynamic phase transitions
29/05/2017, Andreas Berger
11th Symposium on Hysteresis Modeling and Micromagnetics, Barcelona (Spain)

ECAM Materials simulations
01/06/2017, Emilio Artacho
Computational Materials: Challenges and Future Opportunities 2017, Paris (France)

Infrared and terahertz nanospectroscopy: an emerging analytical tool for science and technology
06/06/2017, Rainer Hillenbrand
Modern Trends in Solid State Quantum Physics, Klosterneuburg (Austria)

Graphene-based spintronic devices: from a 2D spin field-effect transistor to a spin-to-charge converter
05/06/2017, Felix Casanova
2017 Workshop on Spins, Valleys, and Topological States in 2D and Layered Materials, Columbus (Ohio)

Spin transport, spinterface, and spin photovoltaics in molecular films
05/06/2017, Luis Hueso
Trends in Nanotechnology International Conference, Dresden (Germany)

Elementary phenomena in hybrid graphene nanoribbons at metal surfaces
14/06/2017, Jose Ignacio Pascual
1st ELECMI International Workshop, Zaragoza (Spain)

Spin Hall effect in heavy metals: mechanisms and optimization
15/06/2017, Felix Casanova
Workshop on Spin Currents and Spin-Orbit Torques, Grenoble (France)

Accessing kinetics of structural rearrangements in graphene via direct atomic imaging
21/06/2017, Andrey Chuvilin
13th European Conference on Surface Crystallography and Dynamics, Donostia - San Sebastian (Spain)

Nanoimaging of IR and THz polaritons in 2D materials
21/06/2017, Rainer Hillenbrand
PCAM Summer School on Surfaces and Interfaces, Donostia - San Sebastian (Spain)

Towards plasmon-assisted thermal excitations of artificial spin ices
27/06/2017, Paolo Vavassori
Loch Lomond Workshop on Artificial Spin Ices, Glasgow (UK)

Infrared and terahertz s-SNOM and its applications to study polaritons in 2D materials
29/06/2017, Rainer Hillenbrand
Graphene Study 2017, Hindås/Gothenburg (Sweden)

Ice sublimation in dry weather: Earth vs. Mars
06/07/2017, Alexander Bittner
Waterspain 2017, Zaragoza (Spain)

Simulations of water nanoconfined by corrugated walls
06/07/2017, Emilio Artacho
Waterspain 2017, Zaragoza (Spain)

Tracking the 'quasi-liquid layer'
06/07/2017, Alexander Bittner
Waterspain 2017, Zaragoza (Spain)

Fabrication and functionalization of hybrid materials by ALD
10/07/2017, Mato Knez
Frontiers in Materials Processing Applications, Research, and Technology 2017, Bordeaux (France)

Spin Hall effect in heavy metals: mechanisms and optimization
19/07/2017, Felix Casanova
XXXVI Reunión Bienal de la Real Sociedad Española de Física, Santiago de Compostela (Spain)

Spin photovoltaic devices
19/07/2017, Luis Hueso
XXXVI Reunión Bienal de la Real Sociedad Española de Física, Santiago de Compostela (Spain)

Ellipsometric analysis of magneto-optical effects in thin films, nanostructures, and spin transport devices
25/07/2017, Andreas Berger
8th International Conference on Metamaterials, Photonic Crystals, and Plasmonics, Incheon - Seoul (South Korea)

Magneto-plasmonic nanostructures and crystals
25/07/2017, Paolo Vavassori
8th International Conference on Metamaterials, Photonic Crystals, and Plasmonics, Incheon - Seoul (South Korea)

Surface magnetization probed by spin Hall magnetoresistance
31/07/2017, Felix Casanova
Young Research Leaders Group Workshop: Insulator Spintronics – Strong-Coupling, Coherence and Entanglement 2017, Mainz (Germany)

Nanoimaging and control of polaritons in 2D materials
01/08/2017, Rainer Hillenbrand
Nanophotonics of 2D materials, Donostia - San Sebastian (Spain)

Kinetics of atomic rearrangements on the example of graphene
03/08/2017, Andrey Chuvilin
Second Russian Conference "Graphene: Molecule and 2D Crystal", Novosibirsk (Russia)

Novel applications of nanomagnetism to biomedicine
20/08/2017, Paolo Vavassori
International Baltic Conference on Magnetism 2017, Svetlogorsk (Russia)

Magnetic size-dependent properties of Co-ferrite nanoparticles and strongly exchange coupled core|shell nanoparticles with high magnetic anisotropy: a novel strategy towards rare-earth-free permanent magnets
27/08/2017, Alberto Lopez-Ortega
IUMRS-International Conference on Advanced Materials 2017, Kyoto (Japan)

Advances in IR and THz spectroscopic nanoimaging
30/08/2017, Rainer Hillenbrand
IRMMW-THz-2017, Cancun (Mexico)

Accessing reaction kinetics via direct imaging of atoms: the example of graphene
01/09/2017, Andrey Chuvilin
5th Dresden Nanoanalysis Symposium, Dresden (Germany)

Surface magnetization probed by spin Hall magnetoresistance
04/09/2017, Saül Vélez
Quantum Spintronics at Interfaces Workshop, Donostia - San Sebastian (Spain)

Interaction of magnetic atoms with superconducting materials
05/09/2017, Jose Ignacio Pascual
Quantum Spintronics at Interfaces Workshop, Donostia - San Sebastian (Spain)

IR and THz nanospectroscopy: an emerging analytical tool for science and technology
05/09/2017, Rainer Hillenbrand
International Conference on Enhanced Spectroscopies, Munich (Germany)

Hybrid materials by ALD-derived methods: opportunities for novel materials design
11/09/2017, Mato Knez
20th International Conference and Exhibition on Advanced Nanotechnology, Amsterdam (The Netherlands)

Molecular electronics
13/09/2017, Luis Hueso
European School on Nanosciences & Nanotechnologies 2017, Grenoble (France)

Surface-plasmon resonance platforms for diagnostics
18/09/2017, Maria Carmen Morant
E-MRS 2017 Fall Meeting, Warsaw (Poland)

Tunnel spectroscopy of atoms and molecules: exciting electrons, spins, and vibrations
22/09/2017, Jose Ignacio Pascual
Frontiers of Condensed Matter Physics School, Les Houches (France)

Graphene plasmon studies by infrared and terahertz nanoimaging
26/09/2017, Rainer Hillenbrand
Graphene Week 2017, Athens (Greece)

Hybrid materials by ALD-derived methods: opportunities for materials design
26/09/2017, Mato Knez
Russian ALD Conference, Saint-Petersburg (Russia)

Plasmon-assisted thermal excitation of artificial spin ices
02/10/2017, Paolo Vavassori
Italian National Conference on the Physics of Matter, Trieste (Italy)

Elementary phenomena in hybrid graphene nanoribbons at metal surfaces
04/10/2017, Jose Ignacio Pascual
RIVA-X Iberian Vacuum Conference 2017, Bilbao (Spain)

Water on viral surfaces
04/10/2017, Alexander Bittner
RIVA-X Iberian Vacuum Conference 2017, Bilbao (Spain)

Utilization of atomic layer deposition (ALD) for vapor phase infiltration and doping of conducting polymers
05/10/2017, Mato Knez
RIVA-X Iberian Vacuum Conference 2017, Bilbao (Spain)

Exciting electrons, spins, and vibrations in atoms and molecules, one at a time
11/10/2017, Jose Ignacio Pascual
2017 PIER Graduate Week, Hamburg (Germany)

Application of thin-film coating technologies beyond 2D films
12/10/2017, Mato Knez
Beyond! 2D Workshop, Kreuth (Germany)

Graphene-based spintronic devices: from a 2D spin field-effect transistor to a spin-to-charge converter
23/10/2017, Luis Hueso
Workshop Spain-Taiwan "2D Materials and Interfaces for Spintronics", Barcelona (Spain)

Photonic methods and devices in medical diagnosis
24/10/2017, Andreas Seifert
6th Global (NANJING) R&D Summit, Nanjing (China)

Nanoimaging and control of polaritons in 2D materials
25/10/2017, Rainer Hillenbrand
The 8th International Symposium on Surface Science, Tsukuba (Japan)

Novel innovations in photonic medical diagnosis
25/10/2017, Andreas Seifert
International Biomaterials Innovation Summit, Xuzhou (China)

Enzyme mimetic bio-inorganic nanoparticles based on ferritin
03/11/2017, Mato Knez
15th Chinese Biophysics Congress, Shanghai (China)

Merging spin and light in organic devices
06/11/2017, Luis Hueso
62nd Annual Conference on Magnetism and Magnetic Materials, Pittsburgh (USA)

Hybrid graphene nanoribbons on surfaces
20/11/2017, Jose Ignacio Pascual
5th Ito International Research Conference, RIKEN Centennial Anniversary & Surface and Interface Spectroscopy, Tokyo (Japan)

IR and THz nanoimaging and nanospectroscopy: emerging analytical tools for science and technology
23/11/2017, Rainer Hillenbrand
LNLS 27th Annual Users Meeting (RAU), Campinas (Brazil)

Infrared and Terahertz nanospectroscopy: an emerging analytical tool for science and technology
30/11/2017, Rainer Hillenbrand
MRS Fall Meeting & Exhibit 2017, Boston (USA)

2018

Applications of nanomagnetism to biosensing
28/01/2018, Paolo Vavassori
SPIE Photonics West Bios: Frontiers in Biological Detection, San Francisco (USA)

Graphene-based heterostructures as spintronic devices
08/02/2018, Felix Casanova
nanoPorTugal 2018, Lisbon (Portugal)

STM and nc-AFM for single-molecule imaging, spectroscopy, and manipulation
09/02/2018, Jose Ignacio Pascual
BIST Symposium on Microscopy, Nanoscopy, and Imaging Sciences, Barcelona (Spain)

Experiences in the application of Responsible Research and Innovation (RRI) through the MARINA project
18/02/2018, Nagore Ibarra
RRI in the Basque Country, Donostia – San Sebastian (Spain)

Inducing magnetism in graphene nanoribbons on surfaces
25/02/2018, Jose Ignacio Pascual
IInternational Conference on Novel 2D Materials Explored via Scanning probe Microscopy & Spectroscopy, Donostia – San Sebastian (Spain)

Materials structures I
05/03/2018, Mato Knez
SPIE Smart Structures + Nondestructive Evaluation 2018, Denver (USA)

Nanoimaging of polaritons in 2D materials
10/03/2018, Rainer Hillenbrand
Nanolight 2018, Benasque (Spain)

Boron-nitride nanoresonators for phonon-enhanced molecular vibrational spectroscopy at the strong coupling limit
11/03/2018, Marta Autore
DPG-Frühjahrstagung 2018, Berlin (Germany)

Elementary phenomena in hybrid graphene nanoribbons at surfaces
12/03/2018, Jose Ignacio Pascual
DPG-Frühjahrstagung 2018, Berlin (Germany)

Electron beam lithography: spintronics and nanooptics applications
13/03/2018, Felix Casanova
Imaginenano 2018, Bilbao (Spain)

Functional hybrid polymer-inorganic materials by vapor phase infiltration
14/03/2018, Mato Knez
TMS 2018 Annual Meeting & Exhibition, Phoenix (USA)

Elementary phenomena in hybrid graphene nanoribbons at surfaces
15/03/2018, Jingcheng Li
Nanospain 2018, Bilbao (Spain)

Hybrid materials by mimicking mineralization from the vapor phase
05/04/2018, Mato Knez
MRS Spring Meeting 2018, Phoenix (USA)

Graphene molecular devices
11/04/2018, Luis Hueso
Spanish Network for 2D Materials 2018, Madrid (Spain)

Microscopies on MoS_2/graphene battery materials
24/05/2018, Victor Koroteev
CIC energiGUNE's Workshop "Day on microscopies on energy-storage systems", Miñano (Spain)

Magnetic graphene nanostructures
24/05/2018, Jose Ignacio Pascual
11th European School on Molecular Nanoscience - 6th Workshop on 2D Materials, Puerto de Santiago (Spain)

Plasmon induced magneto-optical enhancement in metallic Ag/FeCo core/shell nanoparticles synthesized by colloidal chemistry
28/05/2018, Alberto Lopez-Ortega
Heyrovsky Discussions 2018, Prague (Czech Republic)

Infrared nanophotonics based on boron nitride
31/05/2018, Rainer Hillenbrand
International Conference on Physics of 2D Crystals, La Valletta (Malta)

Ultra-sensitive magneto-optical detection
01/06/2018, Andreas Berger
Global Center for Bio-Convergence Spin System - 2nd International Symposium, Daegu (South Korea)

Magneto-plasmonic nanostructures and crystals: applications to sensing
01/06/2018, Paolo Vavassori
Global Center for Bio-Convergence Spin System - 2nd International Symposium, Daegu (South Korea)

Biomedical applications of magnetic nanostructures
03/06/2018, Paolo Vavassori
5th International Conference of Asian Union of Magnetics Societies, Jeju (South Korea)

Investigations of magnetic materials with predefined exchange coupling strength profiles
04/06/2018, Andreas Berger
5th International Conference of Asian Union of Magnetics Societies, Jeju (South Korea)

Graphene-based spintronic devices: from a field-effect transistor to a spin-to-charge converter
05/06/2018, Luis Hueso
5th International Conference of Asian Union of Magnetics Societies, Jeju (South Korea)

Kinetics of stone-wales rotation in graphene via direct atomic imaging
11/06/2018, Andrey Chuvilin
2nd ELECMI International Workshop, Zaragoza (Spain)

Spin correlations of atomic chains on surfaces
13/06/2018, Deung Jang Choi
2nd ELECMI International Workshop, Zaragoza (Spain)

Strongly exchange coupled core|shell nanoparticles with high magnetic anisotropy: a strategy towards rare-earth-free permanent magnets
18/06/2018, Alberto Lopez-Ortega
E-MRS Spring Meeting 2018, Strasbourg (France)

Water and ice at proteins and viruses
20/06/2018, Alexander Bittner
Alp-tip 2018, Garmisch (Germany)

Basque nanoscience
21/06/2018, Andreas Seifert
6th Nano-Carbon Enhanced Materials Consortium, Munich-Freising (Germany)

Un enfoque práctico para co-construir ciencia y tecnología a través de la participación pública y la involucración de actores interesados para la anticipación: por qué y cómo
29/06/2018, Nagore Ibarra
Representación y Anticipación: Modelización Interventiva RRI en las Ciencias y Técnicas Emergentes (FFI2015-69792-R), Donostia – San Sebastian (Spain)

Magneto-plasmonic nanostructures and crystals
02/07/2018, Paolo Vavassori
11th International Conference on Nanophotonics, Wroclaw (Poland)

FEBID fabrication of individual magnetic nanostructures and nanoactuated-magneto-mechanical systems
10/07/2018, Paolo Vavassori
The 7th International Workshop on Focused Electron Beam-Induced Processing, Modena (Italy)

Photonics for medical diagnostics: from the lab to the market
12/07/2018, Andreas Seifert
Nanotech & Nanobiotechnology 2018, Paris (France)

Magneto-plasmonic nanostructures and crystals: principles and applications
16/07/2018, Paolo Vavassori
International Conference on Magnetism, San Francisco (USA)

Nanodevices based on 2D materials
17/07/2018, Luis Hueso
Basics and Applications of Nanolithography, Jaca (Spain)

ALD-induced blending of polymers with ceramics for novel functional hybrids
25/07/2018, Mato Knez
7th International Conference on Microelectronics and Plasma Technology, Songdo (South Korea)

Microscopía y espectroscopía con resolución nanoscópica: herramientas fundamentales para resolver los constituyentes de la materia
25/07/2018, Jose Ignacio Pascual
Universidad Internacional Menéndez Pelayo-Nanotecnología: Luces y Sombras del Control de la Materia a Escala Atómica, Santander (Spain)

Tuning the spin Hall effect in heavy metals
22/08/2018, Felix Casanova
SPIE NanoScience + Engineering 2018, San Diego (USA)

Magneto-plasmonic nanostructures and crystals: principles and applications
26/08/2018, Paolo Vavassori
The 15th International Conference on Near-Field Optics, Nanophotonics & Related Techniques, Troyes (France)

Difussion phenomena in ALD
27/08/2018, Mato Knez
HYCOAT Workshop "Hybrid Nanocoatings Through Molecular Layer Deposition", Ghent (Belgium)

Atomic kinetics rearrangement using the example of graphene
28/08/2018, Andrey Chuvilin
27th Conference on Electron Microscopy, Moscow (Russia)

Elementary phenomena in hybrid graphene nanoribbons on surfaces
28/08/2018, Jose Ignacio Pascual
34th European Conference on Surface Science, Aarhus (Denmark)

3D electron microscopy for nanomaterials investigation
28/08/2018, Evgenii Modin
27th Conference on Electron Microscopy, Chernogolovka (Russia)

Merging spin and light in organic devices
03/09/2018, Luis Hueso
Joint European Magnetic Symposia 2018, Mainz (Germany)

Spintronics with 2D-material-based heterostructures
11/09/2018, Felix Casanova
Graphene Week 2018, Donostia – San Sebastian (Spain)

Electronic transport in low-dimensional materials
13/09/2018, Luis Hueso
European School on Nanosciences & Nanotechnologies, Grenoble (France)

Ascensores espaciales, nanotubos de carbono, fibra y lo demás
15/09/2018, Nagore Ibarra
NAUKAS 2018, Bilbao (Spain)

Cuando la luz encuentra la materia
15/09/2018, Marta Autore
NAUKAS 2018, Bilbao (Spain)

Proteins from dry to wet
17/09/2018, Alexander Bittner
Bionano 2018, Krakow (Poland)

Protein crystals for nanospace design
17/09/2018, Mitsuhiro Okuda
Bionano 2018, Krakow (Poland)

Magneto-optics and magneto-plasmonics
23/09/2018, Paolo Vavassori
2018 European School on Magnetism, Krakow (Poland)

Advanced three-dimensional electron-microscopy characterization of nanomaterials
23/09/2018, Evgenii Modin
4th Asian School-Conference on Physics and Technology of Nanostructured Materials, Vladivostok (Russia)

Inducing magnetism in graphene nanoribbons on surfaces
24/09/2018, Jose Ignacio Pascual
On-Surface Synthesis 2018, Feliu de Guixols (Spain)

Magnetometry
24/09/2018, Paolo Vavassori
2018 European School on Magnetism, Krakow (Poland)

Hybrid materials by vapor phase infiltration of ceramics into polymers
26/09/2018, Mato Knez
MSE Congress 2018, Darmstadt (Germany)

Unveling the mechanisms of the spin Hall effect in heavy metals
01/10/2018, Felix Casanova
KITS Workshop on Collective Spin Dynamics in Nanostructures 2018, Beijing (China)

High-resolution EELS: from chemical analysis to phonons and back
17/10/2018, Andrey Chuvilin
State-of-the-Art Trends of Scientific Research of Artificial and Natural Nanoobjects, Moscow (Russia)

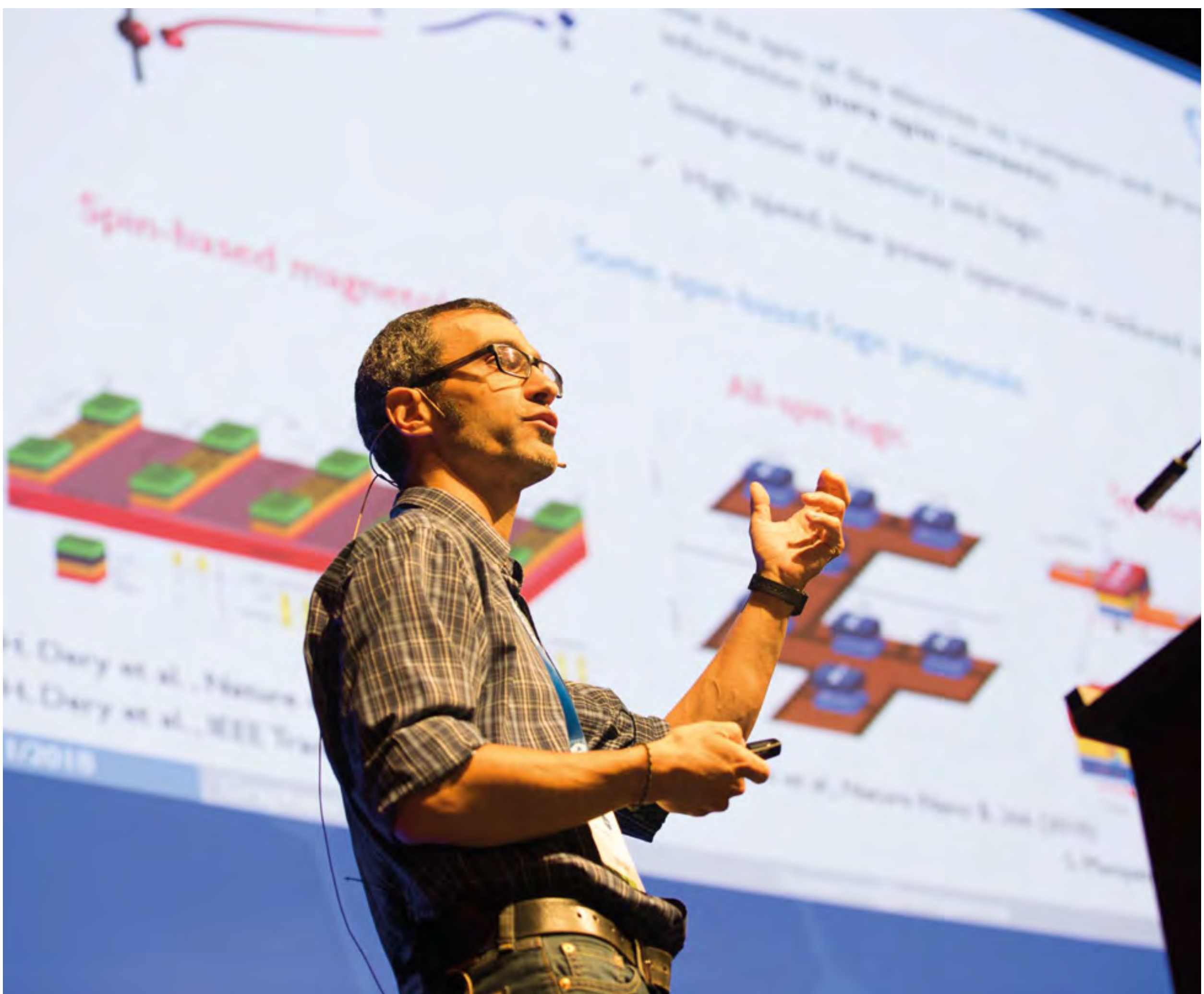
Why aberration correction in TEM is so good for carbon materials: from imaging atoms to measuring reaction kinetics
18/10/2018, Andrey Chuvilin
State-of-the-Art Trends of Scientific Research of Artificial and Natural Nanoobjects, Moscow (Russia)

Turning on magnetism in graphene nanostructures
23/10/2018, Jose Ignacio Pascual
2nd European Conference on Molecular Spintronics, Peñíscola (Spain)

Manipulating spin currents with graphene-based heterostructures
19/11/2018, Felix Casanova
3rd EU-Japan Flagship Workshop on Graphene and Related 2D Materials 2018, Sendai (Japan)

Spintronics with graphene-based heterostructures
22/11/2018, Felix Casanova
One-Day Symposium on Application of Graphene and Related 2D Materials, Tokyo (Japan)

Magneto-plasmonics: principles and applications
09/12/2018, Paolo Vavassori
International Conference on Magnetic Materials and Applications 2018, Bhubaneswar (India)



SEMINARS

NanoGUNE organizes research seminars to be given by both nanoGUNE personnel and external invited speakers. All these seminars take place at the nanoGUNE seminar room.

2017

Electrically-driven fluorescence of single-molecule junctions
13/01/2017, Michael Chong
University of Strasbourg (France)

NanoGUNE Colloquium: The magnetism of oxides
16/01/2017, Josep Fontcuberta
Instituto de Ciencia de Materiales de Barcelona (Spain)

Conversion of an ultrafast downhill folding protein into a slow two-state folder by mechanical force
13/02/2017, Jorg Schonfelder
nanoGUNE

Mid-PhD Seminar: Non-locality in CVD graphene / Enhancing the ultrafast THz-driven magnetization dynamics in magnetic nanostructures
20/02/2017, Mario Ribeiro / Matteo Pancaldi
nanoGUNE

Spin correlations of atomic structures on superconducting surfaces
27/02/2017, Deung Jang Choi
nanoGUNE

Nonlinear Terahertz phononics: a novel route to controlling matter
27/02/2017, Sebastian Mährlein
Fritz Haber Institute of the Max Planck Society (Germany)

Optical nanoimaging of hyperbolic surface polaritons at the edges of van der Waals materials
20/03/2017, Peining Li
nanoGUNE

NanoGUNE Colloquium: Artificial ferroic systems
27/03/2017, Laura Heydermann
ETH Zürich (Switzerland)

Electrochemical capacitors: electrode materials, mechanisms, and current R&D challenges
03/04/2017, Roman Mysyk
CIC energiGUNE (Spain)

A MML workshop: methodology and a practical example
10/04/2017, Nagore Ibarra
nanoGUNE

Spin current physics and applications
11/05/2017, Eiji Saitoh
Tohoku University (Japan)

Mid PhD Seminar: Towards efficient spin-to-charge current conversions in spin orbitronics / Generalized magneto-optical ellipsometry and its applications to materials analysis
15/05/2017, Edurne Sagasta / Patricia Riego
nanoGUNE

Role of an ultrathin MgO(001) interlayer in high-performance CuPc-based magnetic tunnel junctions
19/05/2017, Tae-Hee Kim
Ewha Womens University & IBS Center for Quantum Nanoscience (South Korea)

Science for industry: new concept on innovation
24/05/2017, Xiang Zhang
University of Cambridge (UK)

Fomento San Sebastián: promoting local innovation
29/05/2017, Ainhoa Aldasoro
Fomento San Sebastián (Spain)

Mid-PhD Seminar: Metal cutting, a scientific approach
12/06/2017, Bentejui Medina
nanoGUNE

NanoGUNE Colloquium: Magnets as enablers for renewable energy and resource efficiency
19/06/2017, Oliver Gutfleisch
TU Darmstadt (Germany)

Chiral interactions in thin-film magnets
20/06/2017, Chris Marrows
University of Leeds (UK)

Molecular switching at surfaces and interfaces
22/06/2017, Olaf Magnussen
University of Kiel (Germany)

Mid PhD Seminar: Superconductivity in layered materials / Exploring graphene nanoribbons on gold surfaces; synthesis and electronic structure characterization
26/06/2017, Javier Zaldivar / Nestor Merino
nanoGUNE

NanoGUNE Colloquium: Single-molecule conductance measurements
10/07/2017, Herre van der Zant
Delft University of Technology (The Netherlands)

Fundamentals and applications of organic electronics biosensors
13/07/2017, Fabio Biscarini
University of Modena (Italy)

The influence of aerosols and clouds on climate
18/07/2017, Ulrike Lohmann
ETH Zurich (Switzerland)

Mid-PhD Seminar: Magnon spin transport in yttrium iron garnet / Probing low-energy hyperbolic polaritons in van der Waals crystals with an electron microscope
24/07/2017, Juan Manuel Gomez / Andrea Konecna
nanoGUNE

ONYX graphene and 2D materials inspector
04/09/2017, Albert Redo-Sanchez
das-Nano (Spain)

Mid-PhD Seminar: Reconstruction of ancestral enzymes for biomass degradation / Ancestral cellulases for nanocellulose production
11/09/2017, Leyre Barandiaran / Borja Alonso
nanoGUNE

Self-assembly and sensor properties of noble metal nanoparticle composites
25/09/2017, Yvonne Joseph
TU Bergakademie Freiberg (Germany)

Single-atom and vibrational spectroscopies in the electron microscope
29/09/2017, Ondrej L. Krivanek
Arizona State University (USA)

Chemistry in nanoconfined water: from H^+/OH^- formation and diffusion to prebiotic peptide synthesis
02/10/2017, Daniel Muñoz-Santiburcio
nanoGUNE

Biological path to nanodevices: biological nanofabrication of devices by protein supramolecules?
09/10/2017, Ichiro Yamashita
Osaka University (Japan)

Phonon-enhanced molecular vibrational spectroscopy at the strong coupling limit
16/10/2017, Marta Autore
nanoGUNE

On-surface chemical reactions, single-molecule manipulations, and donor-acceptor properties studied by STM and AFM
09/10/2017, Tobias Meier
University of Basel (Switzerland)

Computational protein design: the computer as a virtual laboratory
13/11/2017, Ivan Coluzza
CIC biomaGUNE (Spain)

Photonics on healthcare
23/11/2017, Rajesh Kumar
Norwegian University of Science and Technology (Norway) & NASA (USA)

Optoelectronic properties in 2D junctions
27/11/2017, Nieves Morquillas
nanoGUNE

Theoretical and computational nanobiotechnology: medical nanobiosolutions *in silico*
04/12/2017, Adria Gil
nanoGUNE

Sensing with nanoelectronic quantum devices: measuring qubits, motion, and time
11/12/2017, Edward Laird
Oxford University (UK)

Tech transfer vs. scientific method transfer
18/12/2017, Xavi Marti
IGSresearch & Czech Academy of Sciences (Czech Republic)

2018

Templated assembly of plasmonic supercrystals
15/01/2018, Christoph Hanske
biomaGUNE (Spain)

Multiscale modelization in an icosahedral non-enveloped virus: capsid pH sensing and disassembly induced by alkaline pH
22/01/2018, Diego M. Guerin
University of the Basque Country (Spain)

Insights into nanoplasmonics from first-principles time-dependent density-functional simulations
12/02/2018, Daniel Sanchez-Portal
Materials Physics Center (Spain)

A multiscale approach to artificial spin ice thermal simulations
19/02/2018, Mateo Pancaldi
nanoGUNE

Novel electronic phases in 2D transition metal dichalcogenides
26/02/2018, Miguel M. Ugeda
nanoGUNE

When ferromagnetism goes 2D
05/03/2018, Efren Navarro-Moratalla
University of Valencia (Spain)

New materials characterization by TEM scanning precession electron diffraction in combination with e-PDF *in situ* analysis at the nanoscale
12/03/2018, Stavros Nicolopoulos
NanoMEGAS SPRL (Belgium)

Porosity, nanostructure, and asymmetry in oblique angle deposited thin films
19/03/2018, Agustin R. González-Elipe
Instituto de Ciencia de Materiales de Sevilla (Spain)

Determination of the Dzyaloshinskii-Moriya interaction and more
26/03/2018, Chun-Yeol You,
Daegu Institue of Science and Technology (South Korea)

Computational modeling for nanophotonic phenomena, components, and devices
09/04/2018, Jost Adam
University of Southern Denmark (Denmark)

Engineering exotic light wavefronts with nanostructured van der Waals materials
16/04/2018, Peining Li
nanoGUNE

Interplay of structure and magnetism during ultrafast optical excitations
20/04/2018, Eric Fullerton
University of California San Diego (USA)

118 years of magnetic recording: impact and challenges ahead
23/04/2018, Eric Fullerton
University of California San Diego (USA)

Topological insulators and Rashba interfaces as efficient converters of spin to charge current: towards low power consumption and energy harvesting
07/05/2018, Carlos Rojas-Sánchez
Institut Jean Lamour (France)

Visualizing the conformational dynamics of viral membrane fusion machines
11/05/2018, James Munro
Tufts University (USA)

NanoGUNE Colloquium: Antiferromagnetic spintronics
14/05/2018, Tomas Jugnwirth
Czech Academy of Sciences (Czech Republic) & University of Nottingham (UK)

Inside nature materials
21/05/2018, Maria Maragkou
Nature (UK)

Microscopies on MoS_2/graphene battery materials
28/05/2018, Victor Koroteev
nanoGUNE

About the low-temperature dynamics of water in different environments
11/06/2018, Silvina Cerveny
Materials Physics Center (Spain)

Terahertz-driven spin dynamics: towards ultrafast "ballistic" magnetization switching
19/06/2018, Stefano Bonetti
Stockholm University (Sweden)

Hybrid graphene nanoribbons
02/07/2018, Jingcheng Li
nanoGUNE

Ancestral sequence reconstruction: improving the catalytic efficiency of an endoglucanase
09/07/2018, Nerea Barruetabeña
nanoGUNE

Plasmonics in sensing: from nanoparticle assemblies to SERS analytics
23/07/2018, Christian Kuttner
CIC biomaGUNE (Spain)

Imaging interaction effects in semiconducting nanowires and their superconducting hybrids
03/09/2018, Haim Bedenkopf
Weizmann Institute of Science (Israel)

Record-small photonic crystal based on a van der Waals material
10/09/2018, Javier Alfaro
nanoGUNE

3D characterization of nanomaterials by electron microscopy
17/09/2018, Evgenii Modin
nanoGUNE

The need to move and adapt at the early stages of the academic career in the biomedical engineering field
24/09/2018, Jacobo Paredes
Tecnun (Spain)

When 2D materials meet molecules: molecular functions in hybrid van der Waals heterostructures
01/10/2018, Marco Gobbi
nanoGUNE

Insect-inspired capillary nanostamping
02/10/2018, Martin Steinhart
University of Osnabrück (Germany)

Modeling defects in functional materials
08/10/2018, Anna Kimmel
nanoGUNE

NanoGUNE Colloquium: Guiding principles for peptide nanotechnology
15/10/2018, Rein Ulijn
CUNY Advanced Science Research Center (USA)

Multimode plasmomechanics in surface-enhanced Raman scattering
29/10/2018, Stephanie Reich
Free University Berlin (Germany)

Optical properties of solids applying time-dependent density-functional theory with jellium-with-gap-model exchange-correlation kernels
05/11/2018, Aleksandr Terentjev
nanoGUNE

Recent develoments on doping and electronic properties of organic semiconductors
08/11/2018, Frank Ortmann
Dresden University of Technology (Germany)

NanoGUNE Colloquium: Engineering living (nano)materials
26/11/2018, Aranzazu Del Campo
INM-Leibniz Institute for New Materials (Germany)

Nanostructured (porous) silicon: growth strategies, surface modification, and biomedical applications
10/12/2018, Miguel Manso
Madrid Autonomous University (Spain)

PUBLICATIONS

2017

A. Manteca, A. Alonso-Caballero, M. Fertin, S. Poly, D. De Sancho, and R. Perez-Jimenez
European Biophysics Journal with Biophysics Letters **46**, 189 (2017)
The influence of disulfide bonds in the mechanical stability of proteins is context dependent

S. Chen, M. Autore, J. Li, P. Li, P. Alonso-Gonzalez, Z. Yang, L. Martin-Moreno, R. Hillenbrand, and A. Nikitin
ACS Photonics **4**, 3089 (2017)
Acoustic graphene plasmon nanoresonators for field-enhanced infrared molecular spectroscopy

N. Merino-Diez, A. Garcia-Lekue, E. Carbonell-Sanroma, J. Li, M. Corso, L. Colazzo, F. Sedona, D. Sanchez-Portal, J. I. Pascual, and D. de Oteyza
ACS Nano **11**, 11661 (2017)
Width-dependent band gap in armchair graphene nanoribbons reveals Fermi level pinning on Au(111)

S. Mastel, M. Lundeberg, P. Alonso-Gonzalez, Y. Gao, K. Watanabe, T. Taniguchi, J. Hone, F. Koppens, A. Nikitin, and R. Hillenbrand
Nano Letters **17**, 6526 (2017)
Terahertz nanofocusing with cantilevered terahertz-resonant antenna tips

K. Kinastowska, J. Barroso, L. Yate, V. Pavlov, A. Chuvilin, W. Bartkowiak, and M. Grzelczak
Photochemical & Photobiological Sciences **16**, 1771 (2017)
Cobalt oxide as a selective co-catalyst for water oxidation in the presence of an organic dye

R. Puttock, H. Corte-Leon, V. Neu, D. Cox, A. Manzin, V. Antonov, P. Vavassori, and O. Kazakova
IEEE Transactions on Magnetics **53**, 6500805 (2017)
V-shaped domain wall probes for calibrated magnetic force microscopy

V. Vanyukov, G. Mikheev, T. Mogileva, A. Puzyr, V. Bondar, D. Lyashenko, and A. Chuvilin
Journal of Nanophotonics **11**, 032506 (2017)
Saturable absorption in detonation nanodiamond dispersions

C. Rubio-Verdu, G. Saenz-Arce, J. Martinez-Asencio, D. Milan, M. Moaied, J. Palacios, M. Caturla, and C. Untiedt
Physical Chemistry Chemical Physics **19**, 8061 (2017)
Graphene flakes obtained by local electro-exfoliation of graphite with a STM tip

A. Kubas, C. Orain, D. De Sancho, L. Saujet, M. Sensi, C. Gauquelin, I. Meynial-Salles, P. Soucaille, H. Bottin, C. Baffert, V. Fourmond, R. Best, J. Blumberger, and C. Leger
Nature Chemistry **9**, 88 (2017)
Mechanism of O_2 diffusion and reduction in FeFe hydrogenases

A. Eleta-Lopez and A. Calo
Microscopy Research and Technique **80**, 18 (2017)
Key factors of scanning a plant virus with AFM in air and aqueous solution

F. Yang, M. Abadia, C. Chen, W. Wang, L. Li, L. Zhang, C. Rogero, A. Chuvilin, and M. Knez
Nano Research **10**, 97 (2017)
Design of active and stable oxygen reduction reaction catalysts by embedding Co_xO_y nanoparticles into nitrogen-doped carbon

P. Li, I. Dolado, F. J. Alfaro-Mozaz, A. Nikitin, F. Casanova, L. E. Hueso, S. Velez, and R. Hillenbrand
Nano Letters **17**, 228 (2017)
Optical nanoimaging of hyperbolic surface polaritons at the edges of van der Waals materials

L. Ugarte, A. Santamaria-Echart, S. Mastel, M. Autore, R. Hillenbrand, M. A. Corcuera, and A. Eceiza
Industrial Crops And Products **95**, 564 (2017)
An alternative approach for the incorporation of cellulose nanocrystals in flexible polyurethane foams based on renewably sourced polyols

P. Alonso-Gonzalez, A. Nikitin, Y. Gao, A. Woessner, M. B. Lundeberg, A. Principi, N. Forcellini, W. Yan, S. Velez, A. J. Huber, K. Watanabe, T. Taniguchi, F. Casanova, L. E. Hueso, M. Polini, J. Hone, F. H. L. Koppens, and R. Hillenbrand
Nature Nanotechnology **12**, 31 (2017)
Acoustic terahertz graphene plasmons revealed by photocurrent nanoscopy

M. B. Lundeberg, Y. Gao, A. Woessner, C. Tan, P. Alonso-Gonzalez, K. Watanabe, T. Taniguchi, J. Hone, R. Hillenbrand, and F. H. L. Koppens
Nature Materials **16**, 204 (2017)
Thermoelectric detection and imaging of propagating graphene plasmons

A. Schulman, A. Kitoh, P. Stoliar, and I. Inoue
Applied Physics Letters **110**, 013502 (2017)
Sign-changing non-monotonic voltage gain of HfO_2/Parylene-C/$SrTiO_3$ field-effect transistor due to percolative insulator to two-dimensional metal transition

E. Carbonell, P. Brandimarte, R. Balog, M. Corso, S. Kawai, A. Garcia-Lekue, S. Saito, S. Yamaguchi, E. Meyer, D. Sanchez-Portal, and J. I. Pascual
Nano Letters **17**, 50 (2017)
Quantum dots embedded in graphene nanoribbons by chemical substitution

J. A. Arregi, P. Riego, and A. Berger
Journal of Physics D: Applied Physics **50**, 03LT01 (2017)
What is the longitudinal magneto-optical Kerr effect?

K. Rodriguez, M. Hoffmann, F. Golmar, G. Pasquevich, P. Werner, W. Hergert, and C. Torres
Applied Surface Science **393**, 256 (2017)
Producing $ZnFe_2O_4$ thin films from ZnO/FeO multilayers

D. Villuendas, S. Velez, T. Tsutaoka, and J. Hernandez
New Journal of Physics **19**, 023031 (2017)
Multiphase magnetic deflagrations in a Nd_5Ge_3 single crystal

D. De Sancho and R. Best
Biophysical Journal **112**, 196 (2017)
Complex dynamics in single-molecule force spectroscopy from simple simulation models

J. Rivas-Pardo, Z. Martonfalvi, A. Manteca, E. Eckels, D. Echelman, M. Kellermayer, J. Alegre-Cebollada, W. Linke, and J. Fernandez
Biophysical Journal **112**, 167 (2017)
A multi-tool mouse model to study the elasticity of native titin

A. Alonso-Caballero and R. Perez-Jimenez
Biophysical Journal **112**, 490 (2017)
Mechanical architecture and genesis of bacterial pilus domains revealed by single-molecule force spectroscopy

A. Alonso-Caballero, J. Rivas-Pardo, C. Badilla, D. Echelman, and J. Fernandez
Biophysical Journal **112**, 300 (2017)
A lego toolbox for engineering proteins for single-molecule force spectroscopy

I. Amenabar, S. Poly, M. Goikoetxea, W. Nuansing, P. Lasch, and R. Hillenbrand
Nature Communications **8**, 14402 (2017)
Hyperspectral infrared nanoimaging of organic samples based on Fourier transform infrared nanospectroscopy

M. Kozina, M. Pancaldi, C. Bernhard, T. van Driel, J. Glownia, P. Marsik, M. Radovic, C. Vaz, D. Zhu, S. Bonetti, U. Staub, and M. Hoffmann
Applied Physics Letters **110**, 081106 (2017)
Local terahertz field enhancement for time-resolved X-ray diffraction

W. Wang, F. Yang, C. Chen, L. Zhang, Y. Qin, and M. Knez
Advanced Materials Interfaces **4**, 1600806 (2017)
Tuning the conductivity of polyaniline through doping by means of single precursor vapor phase infiltration

M. Zacharska, L. Bulusheva, A. Lisitsyn, S. Beloshapkin, Y. Guo, A. Chuvilin, E. Shlyakhova, O. Podyacheva, J. Leahy, A. Okotrub, and D. Bulushev
Chemsuschem **10**, 720 (2017)
Factors influencing the performance of Pd/C catalysts in the green production of hydrogen from formic acid

L. Li, L. Zhang, and M. Knez
Pharmacological Research **119**, 478 (2017)
Comparison of two endogenous delivery agents in cancer therapy: exosomes and ferritin

D. Melnikau, A. Govyadinov, A. Sanchez-Iglesias, M. Grzelczak, L. Liz-Marzan, and Y. Rakovich
Nano Letters **17**, 1808 (2017)
Strong magneto-optical response of nonmagnetic organic materials coupled to plasmonic nanostructures

D. Choi, P. Abufager, L. Limot, and N. Lorente
Journal of Chemical Physics **146**, 092309 (2017)
From tunneling to contact in a magnetic atom: the non-equilibrium Kondo effect

J. Kohanoff and E. Artacho
PLoS One **12**, e0171820 (2017)
Water radiolysis by low-energy carbon projectiles from first-principles molecular dynamics

J. Poumirol, P. Liu, T. Slipchenko, A. Nikitin, L. Martin-Moreno, J. Faist, and A. Kuzmenko
Nature Communications **8**, 14626 (2017)
Electrically controlled terahertz magneto-optical phenomena in continuous and patterned graphene

P. Riego, P. Vavassori, and A. Berger
Physical Review Letters **118**, 117202 (2017)
Metamagnetic anomalies near dynamic phase transitions

W. Wang, C. Chen, C. Tollan, F. Yang, Y. Qin, and M. Knez
Journal of Materials Chemistry C **5**, 2686 (2017)
Efficient and controllable vapor to solid doping of the polythiophene P3HT by low-temperature vapor--phase infiltration

P. Stoliar, J. Tranchant, B. Corraze, E. Janod, M. Besland, F. Tesler, M. Rozenberg, and L. Cario
Advanced Functional Materials **27**, 1604740 (2017)
A leaky-integrate-and-fire neuron analog realized with a mott insulator

A. Gouralnik, E. Pustovalov, K. Lin, A. Chuvilin, S. Chusovitina, S. Dotsenko, A. Cherednichenko, V. Plotnikov, V. Ivanov, V. Belokon, I. Tkachenko, and N. Galkin
Nanotechnology **28**, 115303 (2017)
An approach to growth of Fe-Si multilayers with controlled composition profile: a way to exchange coupled thin films

P. Kusch, S. Mastel, N. S. Mueller, N. Morquillas, S. Hegg, R. Gorbachev, F. Schedin, U. Huebner, J. I. Pascual, S. Reich, and R. Hillenbrand
Nano Letters **17**, 2667 (2017)
Dual-scattering near-field microscope for correlative nanoimaging of SERS and electromagnetic hotspots

E. Artacho and D. O'Regan
Physical Review B **95**, 115155 (2017)
Quantum mechanics in an evolving Hilbert space

I. Martinez, M. Ribeiro, P. Andres, L. E. Hueso, F. Casanova, and F. Aliev
Physical Review Applied **7**, 034034 (2017)
Photodoping-driven crossover in the low-frequency noise of MoS_2 transistors

C. Maissen, G. Scalari, M. Beck, and J. Faist
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3

BUSINESS CONNECTION

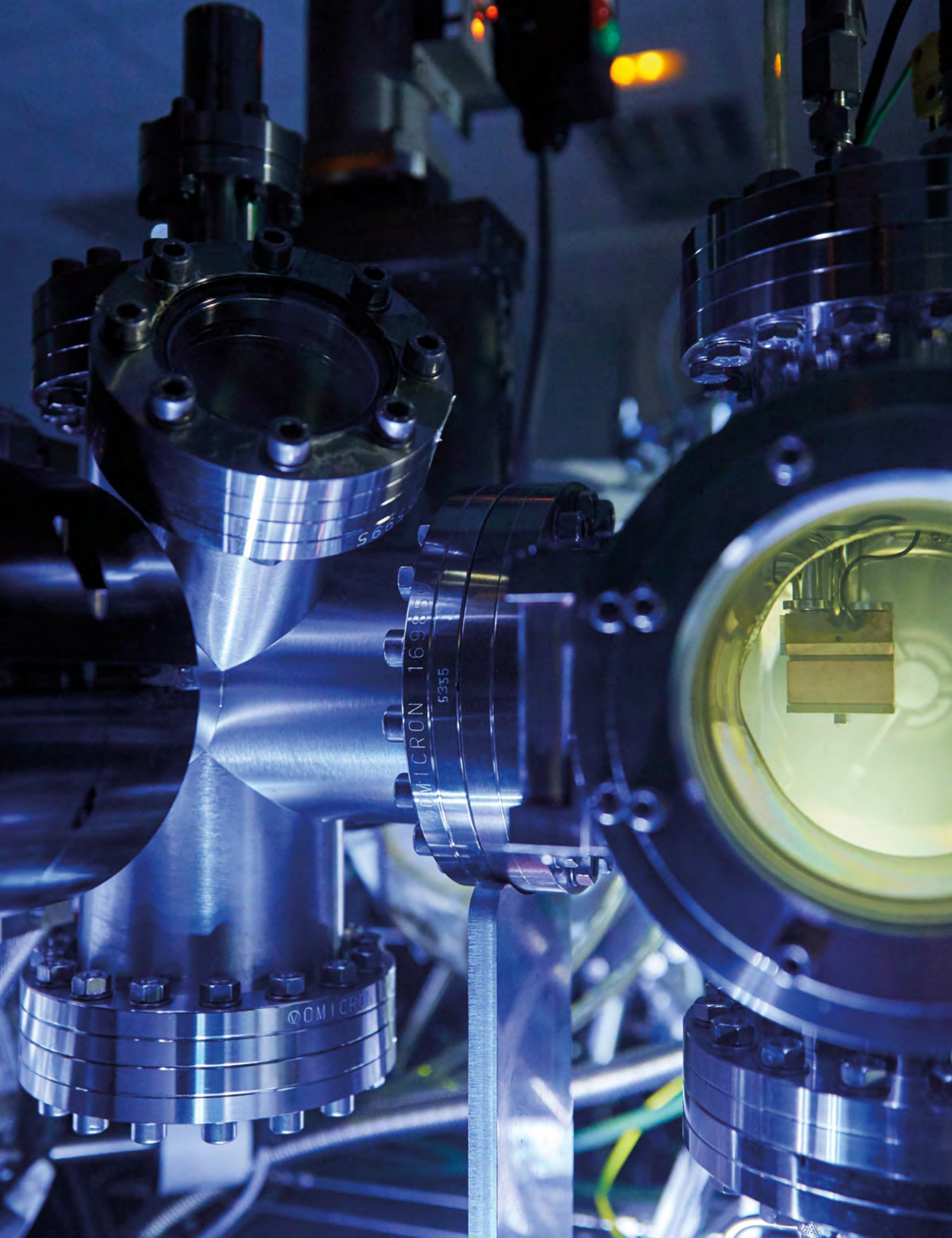
13 PATENTS
5 STARTUPS

TECHNOLOGY TRANSFER

The Basque Country counts with a solid industrial tradition that is already a reference in Europe. In the framework of the Science, Technology, and Innovation Plan (PCTI) Euskadi 2020 and its Research and Innovation Smart Specialization Strategy (RIS3), the Basque Government shows a clear commitment to strengthen the Basque industrial fabric and bets on strategic technologies on Manufacturing, Energy, and Health. The implementation of this strategy goes hand by hand with the right tools: cluster policies promoted by the Basque Society for a Competitiveness Transformation (SPRI) and Business Innovation Centers in Araba, Bizkaia, and Gipuzkoa. In this context, nanoGUNE, as a Cooperative Research Center, is well aligned with the general Basque strategy and has a clear aim to transversally incorporate nanotechnology into manufacturing processes and into marketed products.

At the same time, internationalization is one of nanoGUNE´s identification marks. NanoGUNE combines a state-of-the-art research infrastructure with top-class researchers producing high-quality research to be applied to various sectors. As a result, the transfer of our knowledge and technology is already a reality today. NanoGUNE provides services to an increasing amount of local and international companies, as nanotechnology is becoming part of the daily solutions to the problems that industry is facing nowadays.

In our local innovation hub, the Basque industry, driven by the PCTI Euskadi 2020 strategy, is becoming ready to absorb the highly innovative solutions nanotechnology can provide and is open to perceive the enhancement of some properties that can only be reached through advanced technologies such as nanotechnology. The promotion of a real collaboration between scientific and technological players, the shared used of infrastructures, and the mobility of our staff will also help to achieve an efficient technology-transfer mechanism with a market-driven research to be aligned with the needs of the industry.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EXTERNAL SERVICES

externalservices.nanogune.eu

Our External-Services department is designed with a double goal: (i) to contribute with our know-how to the innovation processes of industrial and technological companies, supporting their research and development strategy and their projects, and (ii) to open our facilities to external users from academia, technology centers, and companies, so that they all can benefit from nanoGUNE's unique infrastructure.

Our expertise is particularly strong in three specialization areas:

• Coatings for materials functionalization.

• Microscopy for the characterization and fabrication of materials and devices.

• Optics for the analysis and development of new optical materials features.

Our services can be contracted under a self-service mode or can be carried out by qualified specialists. In the first case, a large number of scientific tools is available for external academic and industrial users. To ensure the good use of our infrastructure, users need to certify their qualification to use our tools by receiving an initial training before starting their work. In the second case, our know-how serves to a wide range of technology centers and companies in order to improve the efficiency of their processes, add value to their products, or even create new ones.

The services we offer can be of interest for a wide range of industries and research fields: automotive industry, machine-tool manufacturers, materials science, and microscopy laboratories, among others.

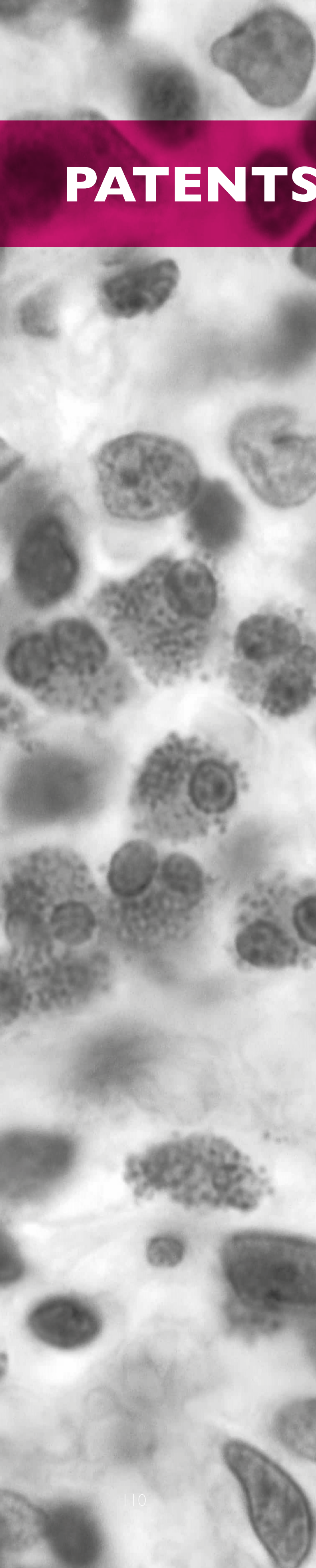
NOVASPIDER

A NEW RANGE OF TOOLS TO REVOLUTIONIZE THE WAY NANOFIBERS ARE PRODUCED

novaspider.com

NovaSpider is a three-dimensional (3D) electrospinning machine that allows users to produce advanced nanofibers in their own laboratory. NovaSpider enables the creation of hybrid nano and micro fiber composite structures at a competitive price. Developed by nanoGUNE, this tool is the result of a close engineering cooperation with expert engineers and experienced specialists in the 3D printing industry.

Our Industry 4.0 technology provides a highly-versatile and easy way to control all parameters involved in the electrospinning process. We provide all the scientific and technical support that is needed for installation, a very comprehensive documentation, and a personal customer service. A team of materials scientists and engineers is available to support the creation of nanofibers based on any material, offering electrospinning tools and processes for the nanofiber production.



PATENTS PORTFOLIO

HEALTH

Manipulation of magnetic particles in conduits for the propagation of domain walls

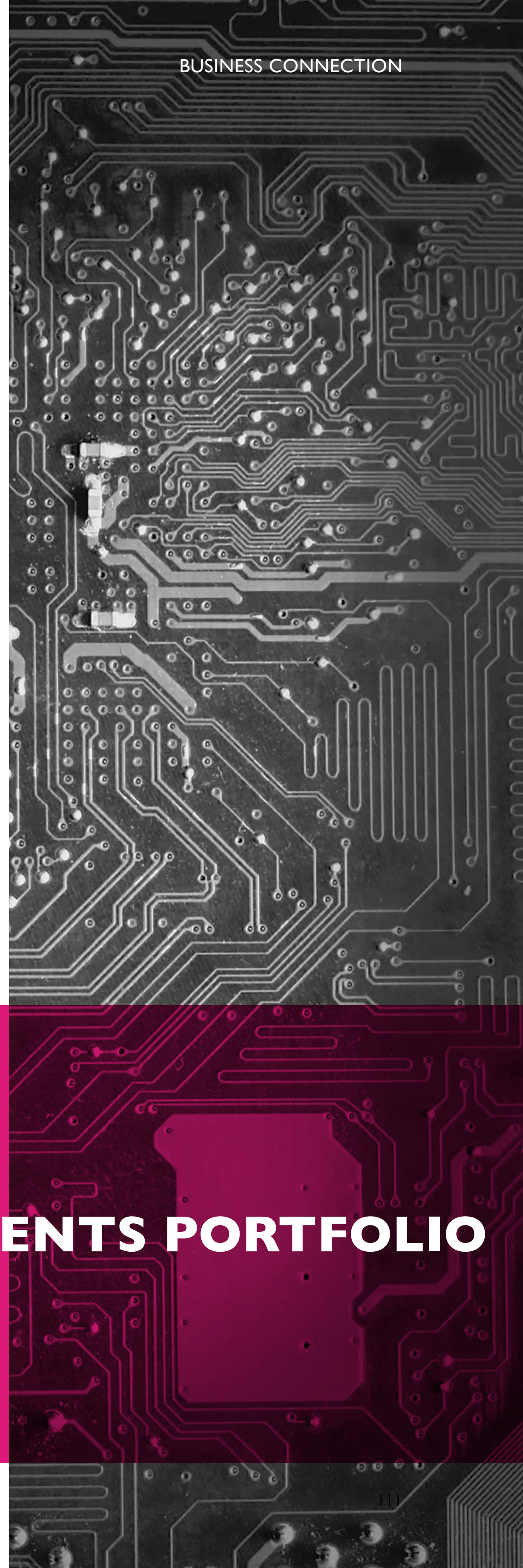
P. Vavassori, R. Bertacco, M. Cantoni, M. Donolato, M. Gobbi, S. Brivio, and D. Petti

Biosensor based on measurements of the clustering dynamics of magnetic particles

M. Donolato, P. Vavassori, and M. Fought-Hansen

Shared with the Danish Technical University (DTU)

Licensed to Blusense Diagnostics ApS



ELECTRONICS

Quality inspection of thin-film materials

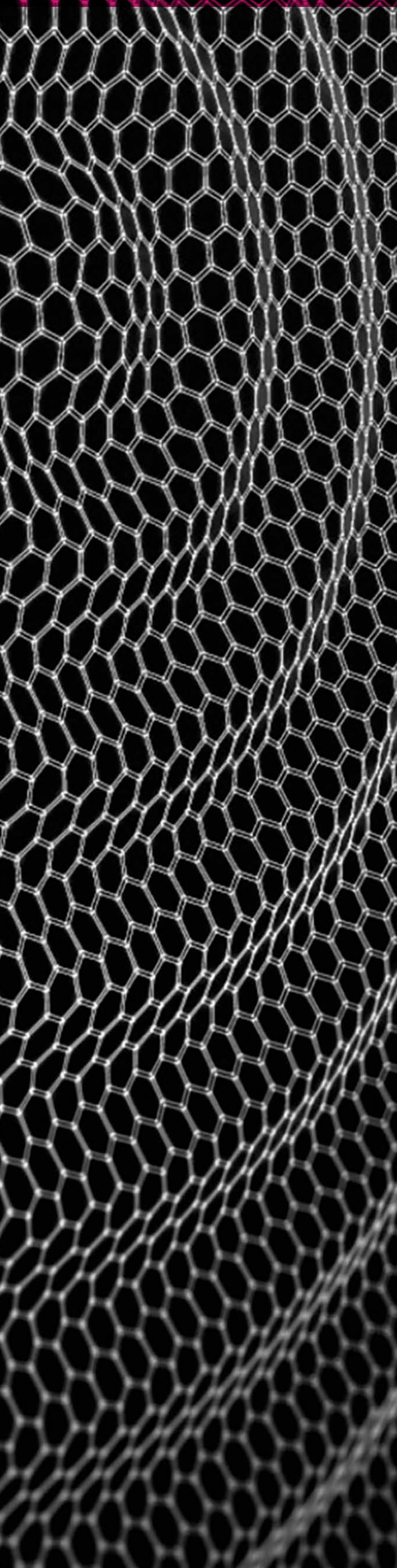
L. Hueso, E. Azanza, M. Chudzik, A. López, A. Zurutuza, and D. Etayo

Sharend with das-Nano

Licensed to das-Nano

PATENTS PORTFOLIO

PATENTS PORTFOLIO



MATERIALS SCIENCE

Endocellulases and uses thereof

R. Perez-Jimenez

Licensed to Evolgene S.L.

Atomic Layer Deposition Chamber

M. Knez, M. Beltran, D. Talavera, and M. Vila

Shared with Ctech-nano S.L.

Licensed to Ctech-nano S.L.

Ancestral cellulases and uses thereof

R. Pérez Jiménez, N. Barruetabeña, and M. A. Eceiza

Shared with the UPV/EHU

Licensed to Evolgene S.L.

Method for producing organic-inorganic hybrid materials

I. Azpitarte and M. Knez

A highly corrosion protective thin bi-layer stack for steel

C. Agustín, F. Brusciotti, M. Brizuela, M. Knez, and J. Willadean-Dumont

Shared with Tecnalia Research and Innovation

OPTICS

Synthetic optical holography

R. Hillenbrand, P. Scott-Carney, and M. Schnell
Shared with University of Illinois
Liscenced to Neaspec GmbH

Optical devices and authentication methods

M. Knez and E. Azanza
Shared with das-Nano
Liscenced to das-Nano

Method for producing a barrier layer and carrier body comprising such a barrier layer

K. Gregorczyk, M. Knez, F. Vollkommer, J. Bauer, and K. Dieter-Bauer
Shared with Osram
Liscenced to Osram

Near-field optical microscope for acquiring spectra

R. Hillenbrand, E. Yoxall, and M. Schnell
Licensed to Neaspec GmbH

A device for operating with THz and/or IR and/or MW radiation

R. Hillenbrand, M. Autore, K.-J. Tielrooij, and F. Koppens
Shared with ICFO

STARTUP COMPANIES

GRAPHENEA, A HIGH-QUALITY GRAPHENE PRODUCER

graphenea.com

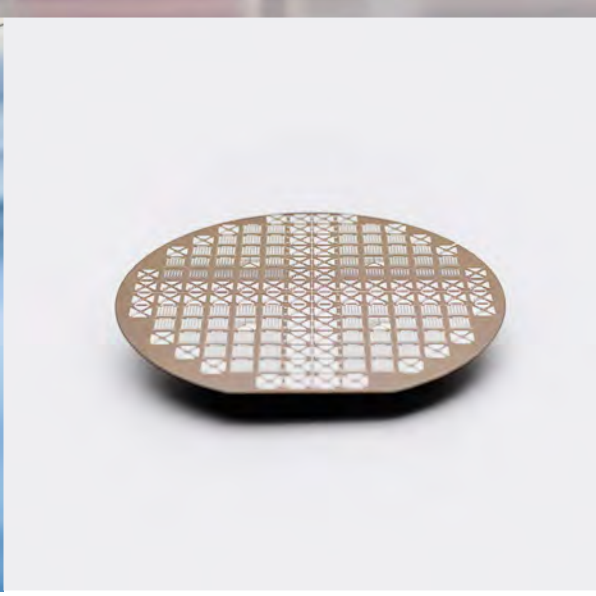
Graphenea, nanoGUNE's first startup company launched in April 2010 as a joint venture with private investors, has become a world leader in the production of high-quality graphene. In 2013, Repsol and the Spanish Center for Industrial Technology Development (CDTI) signed an agreement to invest one million euros in Graphenea. Following the foundational agreement of the company, in April 2015 Graphenea started to fly alone, and new laboratories were opened in September 2017 at the Science and Technological Park of Gipuzkoa. In 2018, Graphenea launched sales of Graphene Field-Effect Transistors (GFETs) aimed at lowering barriers for the adoption of graphene, especially the existing barriers in the market of sensors.

The company, which at the end of 2018 was employing more than 20 people and was exporting graphene to 54 countries, supplies its products to universities, research centers, and industries worldwide. It has more than 700 customers worldwide. Graphenea is also a partner of the European Graphene Flagship, which with a budget of one billion euros aims at taking graphene from the realm of academic laboratories into the European society in a period of ten years.

Graphene research represents a rapidly-growing strategic research field with a considerable economic potential. Graphenea aims at collaborating with the global scientific community, thus helping the graphene industry to move forward. Graphenea, committed to innovation, is constantly investing in the development of new products that would help its customers advance their work.

Graphenea's main industrial focus is the production of high-quality graphene films grown by chemical vapor deposition (CVD) and also the production of chemically exfoliated graphene oxide. On the one hand, Graphenea develops the potential of CVD graphene for electronic systems, optoelectronics and sensors, and, on the other hand, is operating an industrial pilot unit with the capacity to produce 1 ton per year of graphene oxide in dispersion and powder forms.


Graphenea



SIMUNE, ATOMISTIC SIMULATIONS

simuneatomistics.com

Simune was launched in January 2014 as a joint venture with a group of scientific experts. In July 2014, a group of private investors became shareholders of the company. Simune was selected in 2016 as a Techconnect Innovation Awardee, as one of the top early-stage innovators chosen worldwide through an industry-review process of the top 15% of technologies that are annually submitted to the Techconnect National Submission Summit. In 2017, Simune participated in various European projects and materialized agreements in Japan with JSOL Corp. (www.jsol.co.jp) in order to expand its client base. *"To date our client base continues to grow with some of the most prominent companies worldwide, such as DuPont, Panasonic, Toyota, Honda, Daihatsu, Sumitomo, and the renowned National Institute of Advanced Industrial Science and Technology (AIST) in Japan"*. In 2018, Simune has continued its expansion through agreements in India with DHIO engineering to serve both academic and industrial clients. Simune has received funds from the European Union in the framework of the SME program and will continue growing with an ambitious plan for 2019.

Simune offers atomic-scale simulations to academic and industrial customers in a variety of fields: semiconductors, energy storage, and others. Simulations are oriented to accelerate and optimize the design of new materials and processes, thus providing the best solution for the identification of each property. Simune also offers consultancy services, expert support, and training. Recently, Simune has produced a software suite called **ASAP** (Atomistic Simulation Advanced Platform) that is offering a number of scientific software tools for many applications in the academic and industrial segments.

Simune's main expertise is based on applications related to advanced materials with highly-technological needs. The company focuses on identifying the best solution to solve materials-related challenges. Starting from an industrial problem, Simune identifies a workflow for its solution by doing simulations and materials modeling and by offering cutting-edge scientific software tools and expertise to researchers and companies. Some of the advantages of simulations are: to save cost and time by identifying new materials for new products, to understand the results of experimental measurements, and to characterize materials properties.

CTECHnano, INNOVATION WITH ALD SOLUTIONS

ctechnano.com

CTECHnano was launched in July 2014 as a joint venture with two Basque companies (AVS and Cadinox). The company provides thin-film coating solutions with Atomic Layer Deposition (ALD). CTECHnano provides both R&D services and specific coating systems. The company collaborates with its customers in order to supply custom-made and innovative solutions.

Atomic Layer Deposition (ALD) is a technique that allows changing the properties of materials. A very thin layer only a few nanometers thick is deposited onto a given substrate covering its entire surface. With such a thin coating many properties of the original material are retained; but, at the same time, additional properties can be supplemented.

ALD provides a very controlled way to deposit thin films with an atomic-scale thickness control. The growth of multilayer structures composed of different materials is also straightforward. Due to the precision of the process and its reproducibility, ALD represents a well-establised processing technology in the field of modern micro and nanoelectronics. The temperature that is needed to run this technology is typically lower than the temperature that is needed to run other deposition processes such as chemical vapor deposition and thermal evaporation. The lower processing temperature allows to work with fragile substrates, such as biological or polymeric samples, and a diversity of substrate materials can be coated from flat two-dimensional (2D) to complex three-dimensional (3D) porous shapes and nanoparticles.

A wide variety of materials can be deposited with ALD: oxides, nitrides, carbides, metals, sulfides, fluorides, organics, etc. This small but important difference makes ALD the method of choice for many emerging applications, such as flexible electronics or composite materials design. ALD applications can be found in many different sectors: electronics, optoelectronics, optics, energy, biotechnology, metallurgy, decorative coatings, textile and packaging, and many others. The customers of CTECHnano are commonly oriented to innovation, looking for new product functionalities and/or trying to improve their existing processes and products.

CTECHnano offers versatile and high-quality ALD and Vapor-Phase-Infiltration systems with a portfolio of machines oriented to a variety of customers: from low-cost high-quality basic models for research and development activities to industrial machines to be implemented in production lines.

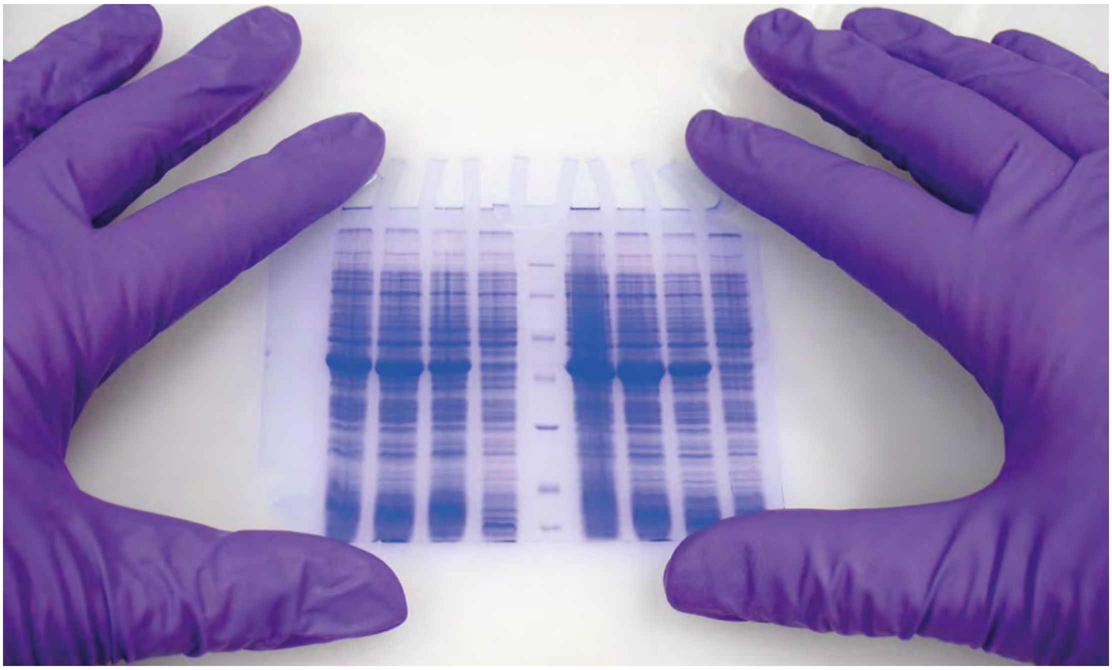
EVOLGENE GENOMICS, ENZYMES FROM THE PAST FOR THE FUTURE

evolgene.com

Evolgene Genomics, founded in February 2018, is the end product of a previous initiative launched in 2014 in the framework of and "Idea" that was supported by the Entrepreneurs Fund of the Spanish oil company Repsol, an initiative designed for entrepreneurs who have created or intend to create an energy-efficient company.

Evolgene is a pioneer company in using ancestral sequence reconstruction (ARS) to develop novel and outstanding enzymes. Using bioinformatic resources and genomic data, Evolgene designs and produces enzymes from billions of years back that can be used in a wide range of industrial applications including biomedical, pharmaceutical, and chemical applications. The company offers this ability as R&D services.

Furthermore, Evolgene is developing a novel, efficient, and environmentally friendly process to produce cellulose nanocrystals, a new biomaterial with extraordinary properties. Cellulose nanocrystals can be used in various applications, such as drug delivery, tissue engineering, biosensors, electronic devices, cosmetics, water treatment, and many others. The process is based on the use of ancestral enzymes, cellulases and xylanases, which are immobilized on carriers to yield highly efficient biocatalysts. The resulting biocatalysts are then used to hydrolyze different cellulose sources. Evolgene is currently working to optimize this process in the laboratory as a previous stage to scale it up in a pilot plant.



PROSPERO BIOSCIENCES, NEW APPLICATIONS WITHIN THE MASS-SPECTROMETRY INDUSTRY

prospero-biosciences.com

Prospero Biosciences, nanoGUNE's 5th spin-off company, was launched in October 2015 by a group of entrepreneurs that included Robert Blick (professor of Physics at the University of Hamburg), two nanoGUNE researchers, and Hasten Ventures, a company devoted to the acceleration and promotion of business ideas. Prospero seeks to take advantage of the potential of nanotechnology in order to develop and commercialize an innovative technology capable of opening up a new field of applications within the mass-spectrometry industry.

Prospero is in the process of developing and producing an innovative detector for mass spectrometry, which is based on the use of a nanomembrane enabling a tremendous improvement with respect to existing solutions. There is no technology in the market that can reliably identify high-mass molecules; and this is precisely what Prospero is offering. Prospero's technology is expected to open the door to a broad field of applications, such as research into biological markers, medical research and diagnosis, or the development of biosimilar drugs that require an accurate identification of high-mass molecules.

Prospero is developing various high-mass molecule detector prototypes, which are already being successfully tested by various end users in the health sector.

BUSINESS CULTURE IN THE TRAINING OF SCIENTISTS

In the framework of our 2015-2020 Strategic Plan, specific training activities have been programmed in order to strengthen the business culture of young researchers, thus making it easier for some of them to become part of the industrial world. A training program with three main courses for PhD students and post-doctoral researchers has been designed and implemented and special seminars have been given by experts with a scientific background that are currently working in industry.

Oral communication skills

This course, mainly oriented to first-year PhD students, has been offered in November 2017 and November 2018. In this training course the participants develop their skills in the preparation and delivery of top-quality presentations, as well as in communicating with different audiences.

A total of 18 researchers have participated in this course.

Entrepreneurship

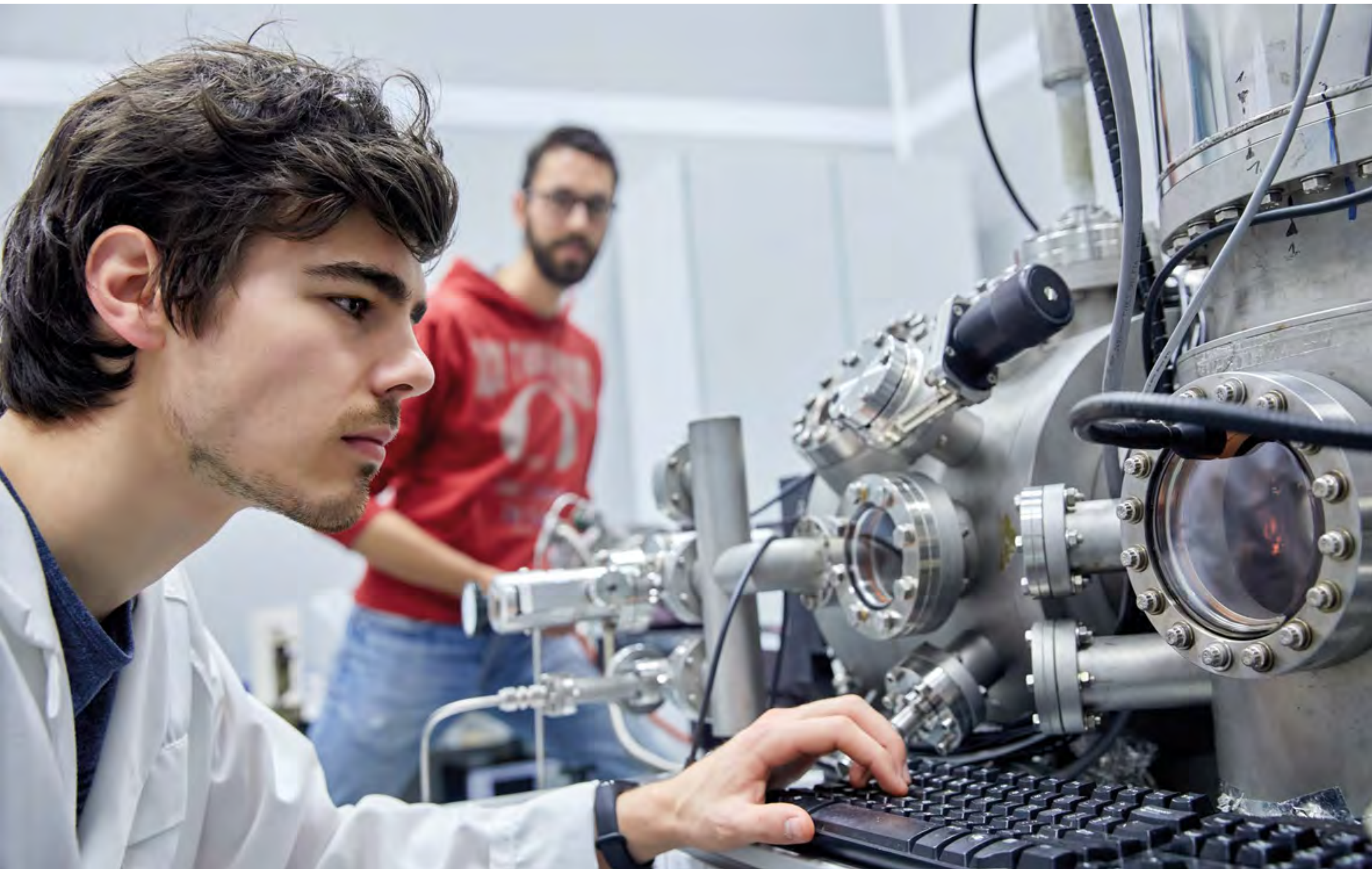
This course, mainly oriented to second-year PhD students, has been offered in October 2017 and November 2018. The goal of this course is to train researchers on how to transform an idea into an entrepreneurial project by giving them the basic knowledge about what an entrepreneur is, different business models, and how to write a business plan.

A total of 16 researchers have participated in this course.

Take the step. From academia to industry

This course, mainly oriented to third-year PhD students, has been offered in November 2017 and November 2018. The goal of this course is to train the researchers on how to show their skills and attitudes when looking for a job within an industrial environment, as well as to invite them to think over their near future and help them defining their goals and professional expectations.

A total of 20 researchers have participated in this course.



4

CONNECTING WITH SOCIETY

24 OPEN EVENTS
332 VISITORS FROM HIGH SCHOOL AND UNIVERSITIES
649 TIMES IN THE MEDIA

CONNECTING WITH SOCIETY

Advances in nanoscience and nanotechnology are nowadays at the heart of the technological development of our society. Using nanotechnology, materials can effectively be made stronger, lighter, more durable, more reactive, or better electrical conductors, among many other traits.

The words nanoscience and nanotechnology are often used these days, but many of us do not realize the amazing impact it has on our daily lives. Faster, smaller, and more powerful computers that consume far less energy, with longer-lasting batteries; faster, more functional, and more accurate medical diagnostic equipment, etc. These are just a few of the thousand ways that nanotechnology impacts society.

Nanotechnology is not the future. It is the present already. Nevertheless, a large majority of our society still does not really understand what it is. What is nano? At nanoGUNE, we are convinced that our role as a research center does not end at achieving great scientific and technological advancements. This is the reason why we are committed to spread truthful information in a responsible and understandable way throughout our communication channels. We are really thankful to all our outreach collaborators as well as to all the media for helping us to fulfill this objective.

Our responsibility for the development of a sustainable society goes beyond the generation of knowledge and technology

Watch video

Follow us on

OPEN EVENTS

Women in Science

In 2017, nanoGUNE joined the International Day of Women and Girls in Science (11 February) declared by the United Nations Assembly in order to achieve full and equal access to and participation in science for women and girls, and further achieve gender equality and the empowerment of women and girls. With this objective, nanoGUNE celebrated that day organizing a series of events which aimed to bring visibility to the work of women in nanoscience, to break with the archetypical masculine roles usually attributed to science and technology, and to encourage scientific career choices among girls and teenagers.

In 2018, three more research centers in San Sebastian (the Donostia International Physics Center, the Materials Physics Center, and CIC biomaGUNE) joined the initiative, making possible the design of a more diverse program that would reach a larger audience.

Zientzia Azoka

Since 2017 nanoGUNE collaborates with the Zientzia Azoka (Science Fair) organized by the Elhuyar Foundation. This initiative is a fair of research projects carried out by 12- to 18-years-old students, and it is also a long-term process, since students develop the project throughout the academic year.

Science Week

NanoGUNE, together with the Donostia International Physics Center (DIPC) and the Materials Physics Center (MPC), has been collaborating in the Science Week organized every November by the University of the Basque Country through a nanoscience and materials-science exhibition space.

Donostia Week INN

NanoGUNE participates in the Week of Innovation, Donostia week INN, organized by Fomento of San Sebastian. This event offers a complete program of activities around the innovation strategy that takes place in the city.

EDUCATION-DRIVEN ACTIVITIES

Undergraduates: summer internship and final project

In the period 2017-2018, 37 undergraduate students have joined nanoGUNE's summer-internship program and/or have done their final project under the supervision of our researchers.

Master

NanoGUNE collaborates with the Master in Nanoscience and the Master in New Materials of the University of the Basque Country (UPV/EHU), and gives master students the opportunity to join its research groups in order to do their master thesis under the supervision of one of our principal investigators.

PhD

PhD-thesis projects are offered to physics, chemistry, biology, engineering, and materials-science graduates. We closely collaborate, in particular, with the PhD program "Physics of Nanosctructures and Advanced Materials [PNAM]" offered by the University of the Basque Country. Currently we have 33 ongoing PhD theses at nanoGUNE and we are cosupervising the thesis of another 7 PhD students that are enrolled at other research centers and universities in the Basque Country.

Nanotechnology course for high-school teachers

NanoGUNE offers a nanotechnology introductory course to high-school science teachers in the framework of the "PrestGara" program launched by the Department of Education of the Basque Government.

Visits for educational centers

Following our open-doors policy, we run a program for high-school and university students to visit our facilities, thus offering them the opportunity to have a closer look at nanoscience research. More than 300 students have visited nanoGUNE during the 2017-2018 period.

NANOKOMIK, THE POWER OF NANOSCIENCE IN A COMIC

NanoGUNE and the Donostia International Physics Center (DIPC) have organized the second edition of nanoKOMIK, a project that brings together science and art in order to produce a nanofictional comic.

This project was launched in order to translate to the general public the potential of the advances that are taking place in the field of nanoscience and nanotechnology, and also to stimulate creativity among young people.

After the success reaped in 2016, the second edition of the nanoKOMIK challenge was launched at the beginning of 2017. This second edition involved more than 240 participants over 14 years of age who partook in a free creative process. In the framework of this challenge, participants brought their own comic superheroines and superheroes to life, endowing them with nanopowers thanks to the surprising properties that matter acquires at the nanoscale. A series of comic and science workshops were held at various schools in the Basque Country and also in Barcelona thanks to a collaboration with the University of Barcelona. Finally, 70 pieces of artistic work took part in the challenge in Basque, Spanish, and English.

Using the best ideas from the comics that had been submitted originally and in collaboration with the winners of the adult category, new comics began to take shape: World Domi(nano)tion, Mister Flames, and Among Plants. These stories feature (i) the adventures of an ingenious neuro-nanoscientist who grants the power of ubiquity to a corrupt politician, (ii) those of a lover of space travel that saves a mission about to explode, and (iii) those of a scientist immersed in the creation of a nanohybrid capable of reproducing the photosynthetic process of plants artificially, respectively.

The nanoKOMIK project was partially funded by the Spanish Foundation for Science and Technology (FECYT) of the Ministry of Science, Innovation, and Universities.

www.nanokomik.com

10ALAMENOS9

10ALaMenos9 is a festival organized by various Spanish institutions and research centers with the aim of bringing the world of nanoscience and nanotechnology to the society.

The10ALaMenos9 nanoscience and nanotechnology festival aims in a straightforward way to bring all sectors of the public closer to the nanoscale and its effects. In the various activities organized for this purpose (exhibition, workshops, and lectures), visitors delve into the nanoworld, i.e. the world of tiny things of the order of one billionth (10^{-9}, 10 to minus 9) of a meter, typically composed of a few atoms and/or molecules like, for example, the DNA.

A number of cities hosted this third edition of the festival in March and April 2018: Zaragoza, Madrid, Barcelona and Donostia - San Sebastian, thanks to the support of the FECYT.

In the Basque Country, the second edition of the festival took place in 2017 at the Okendo house of culture in the framework of a collaboration agreement between nanoGUNE and the Donostia-Kultura agency of the San Sebastian City Council.

In its third edition, the festival (including exhibitions, workshops, and lectures) took place in 2018 at the Laboratorium museum of Bergara in the framework of a collaboration agreement between nanoGUNE and Bergara's City Council.

5

ORGANIZATION AND FUNDING

97 GRANTS IN PLACE
26 EUROPEAN GRANTS
15 MARIE SKLODOWSKA-CURIE
1 ERC
2 GRAPHENE FLAGSHIP

ORGANIZATION AND FUNDING

NanoGUNE is a non-profit making Association promoted by the Basque Government in 2006 and officially inaugurated in 2009.

The Governing Board, currently composed by all partners, is the final responsible for the overall management of the center.

An International Advisory Committee, composed of internationally renowned researchers and professionals, advises on the orientation that should be given to the center.

Research activities at nanoGUNE are organized under an Innovation Management System, which was certified in 2017 according to the standard UNE 166002:2014. This standard aims to guide organizations in the development, implementation, and maintenance of a framework for systematic innovation management practices, integrating them within a R&D and innovation management system.

All our achievements would have not been possible without the support of the Basque Government and also the Basque Science Foundation (Ikerbasque) through its program to attract talented researchers from all over the world. This support, combined with our capacity to attract a considerably large amount of competitive funding from the Regional Government of Gipuzkoa, the Spanish Government, the European Commission, and private initiatives, has allowed us to achieve a good progress towards a balanced and sustainable funding structure.

Since the opening of nanoGUNE ten years ago, we have been able to place the Basque Country at the forefront of nanoscience research. From this position, the challenge for the coming years will be to increase the transfer of our knowledge and technology to our industrial environment, thus contributing to the competitiveness of the Basque economy and the well-being of our society.

	2017	2018
Personnel (on 31 December)	96	108
Full-Time Equivalent (FTE)	93	101
R&D exploitation income (in thousand EUR)	6 454	7 207
% of non-competitive public funding from the Basque Government	42	23
% of competitive public funding from the Regional Council of Gipuzkoa	2	2
% of competitive public funding from the Basque Government	22	35
% of competitive public funding from the Spanish Government	11	13
% of competitive public funding from the European Commission	16	17
% of private funding	7	10

GOVERNING BOARD

Chair
Donostia International Physics Center
Pedro Miguel Echenique

Vice-chair
Tecnalia Technology Corporation
Joseba Jaureguizar (until 05/03/2017)
Joseba Iñaki San Sebastián (from 06/03/2017)

Secretary - Treasurer
IK4 Research Alliance
Jose Miguel Erdozain

Board members

University of the Basque Country (UPV/EHU)
Fernando Plazaola (until 14/02/2017)
Arturo Muga (from 15/02/2017)

Regional Council of Gipuzkoa
Ainhoa Aizpuru

CAF
José Antonio Gortazar (until 05/03/2018)
Josu Imaz (from 06/03/2018)

IKOR
Jon Sierra

PETRONOR
Valentín Ruiz Santa Quiteria (until 09/07/2017)
Elias Unzueta (from 10/07/2017)

Guest members, on behalf of the Basque Government

Department of Economic Development and Infrastructure
Leire Bilbao (until 31/01/2017)
Iosu Madariaga (from 01/02/2017)

Department of Education
Adolfo Morais

10 years of nanoGUNE

"NanoGUNE has known how to become attractive enough for top-class people to choose us"

Pedro M. Etxenike
President

At nanoGUNE's opening, its director José María Pitarke stated the following: "We would like to find our place at the international level and to be internationally recognized for our contributions". What is the balance after ten years?

Remarkably positive. NanoGUNE is today on the world map of nanoscience and nanotechnology.

What is nanoGUNE's recipe for success?

An excellent team of researchers that have chosen our project, since nowadays talented researchers of any discipline can choose where to develop their career. NanoGUNE has known how to create the right conditions and how to become attractive enough for top-class people to choose us. The solid direction and leadership of the director José María Pitarke has been decisive. He has combined technical proficiency with human leadership, dedication, tenacity, and generosity, and he has known how to set up a team where mutual correlation comes together with collaboration. This together with the excellent performance of the technical team, administration, and services has been the guarantee of success. The beauty of a tree is to be found not in its branches but on its roots and trunk.

Do you believe that nanoGUNE bears a hallmark within the Basque network of science, technology, and innovation?

Absolutely. Right now, there is no other center in the Basque Country at the level of nanoGUNE in its fields of research. In addition to its scientific leadership, nanoGUNE has founded five startup companies and has been collaborating with a good number of companies locally and worldwide. NanoGUNE's clients are companies with an eye on the future as, for example, Intel and Thermo Fisher Scientific. At nanoGUNE, research is conducted at the cutting edge of knowledge. Success is guaranteed by the creative freedom of its researchers.

What objectives would you like nanoGUNE to reach over the next ten years?

First of all, I would like nanoGUNE to keep on the right track, because with its current size it would be difficult to increase the scientific excellence it has already achieved quantitatively and qualitatively. On the other hand, I would like to see how nanoGUNE contributes to build a competitive environment, since a competitive industry needs to live in an environment that is competitive. That environment should be able to help in the development of the industry of the future. And the objective to keep the scientific excellence —which is splendid— together with the mission to tackle technology-transfer activities contribute, no doubt, to the industrial development of the Basque Country.

What long-term future awaits nanoGUNE?

A tremendously brilliant future awaits nanoGUNE if it keeps on the right track, with exigency and at the same time enjoying a continuity in long-term policies. The future might be tough, but I am optimistic for the people and the long-term policies that we have. I believe in the austere optimism that has characterized nanoGUNE, where wastefulness is avoided and reality is not hidden behind the accumulation of appearances.

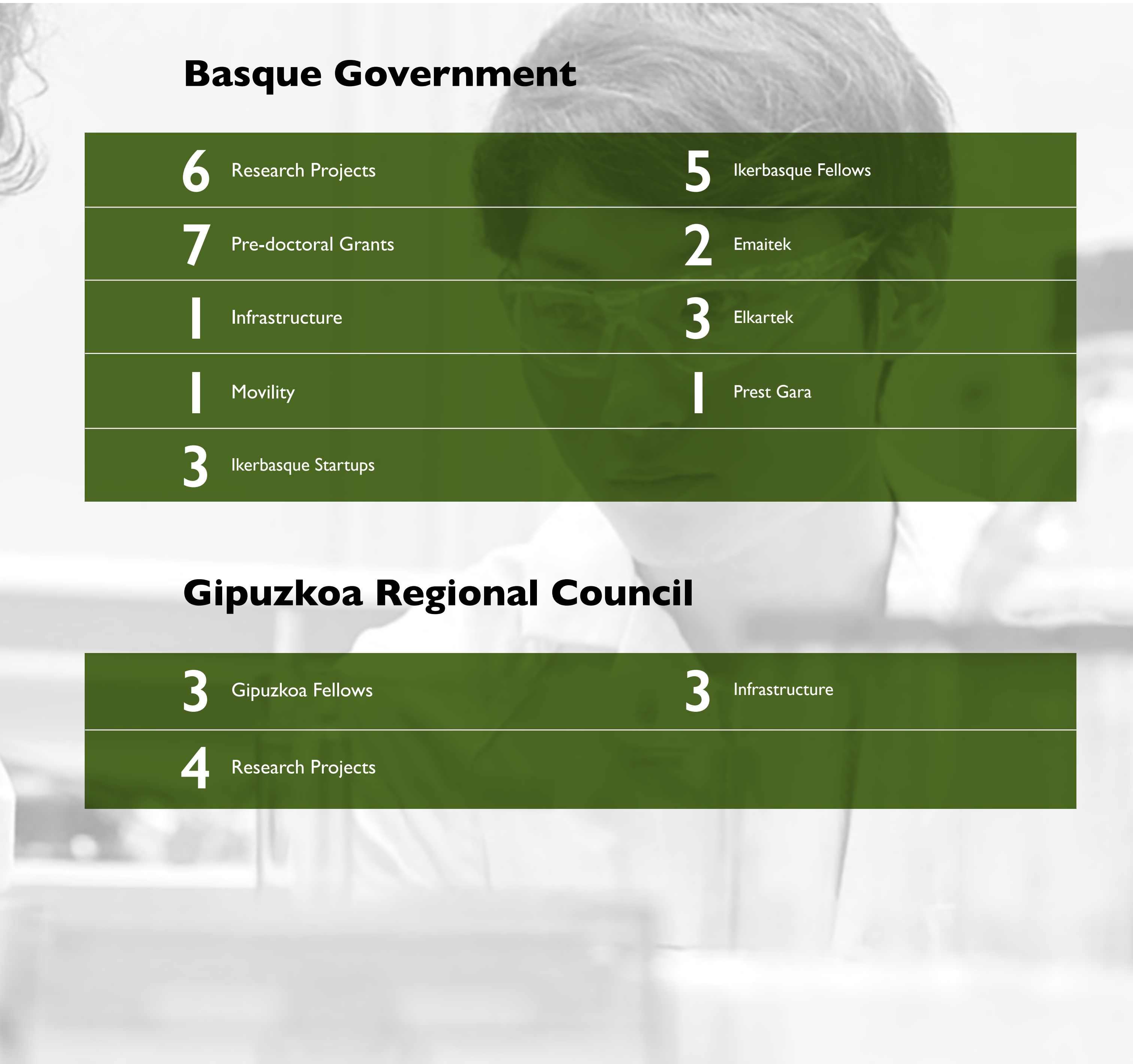
GRANTS IN PLACE 2017/2018

European Commission

15	Marie Sklodowska-Curie Actions (CIG, ITN, European and Global Fellowships)	3	H2020 Coordination and Suport Actions
2	Graphene Flagship	1	H2020 Research and Innovation Action
3	H2020 FET Open	1	M-ERA.NET
1	ERC		

Spanish Government

1	María de Maeztu	2	FECYT
13	Retos	1	Ramón y Cajal
1	Retos Collaboration	1	Juan de la Cierva Incorporation
1	Europa Excellence	10	FPI Pre-doctoral Grants
1	Explora	1	FPU Pre-doctoral Grant



Basque Government

6	Research Projects	5	Ikerbasque Fellows
7	Pre-doctoral Grants	2	Emaitek
1	Infrastructure	3	Elkartek
1	Movility	1	Prest Gara
3	Ikerbasque Startups		

Gipuzkoa Regional Council

3	Gipuzkoa Fellows	3	Infrastructure
4	Research Projects		

INTERNATIONAL ADVISORY COMITTEE

The International Advisory Committee gives advice on the orientation that should be given to the center

Prof. Sir John Pendry (Chair), Imperial College, London (UK)

Prof. Anne Dell, Imperial College, London (UK)

Prof. Marileen Dogterom, Delft University of Technology, Delft (The Netherlands)

Prof. Jean Marie Lehn (Chemistry Nobel Laureate, 1987), Strasbourg University, Strasbourg (France)

Dr. José Maiz, Intel Fellow, Oregon (USA)

Prof. Emilio Mendez, Brookhaven National Laboratory, New York (USA)

Prof. Sir John Pethica, CRANN, Dublin (Ireland), and University of Oxford (UK)

FUNDING INSTITUTIONS

EUROPEAN UNION
European Regional Development Fund

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GOBIERNO VASCO

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

ikerbasque
Basque Foundation for Science

Gipuzkoako Foru Aldundia

DISTINCTION

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