2011 - 2012
Activity Report

CIC nanoGUNE
nanoscience cooperative research center

2011-2012
Activity Report

CIC nanoGUNE
nanoscience cooperative research center

Message from the Director

Advances in nanoscience and nanotechnology are nowadays at the heart of the technological development of our society. Our current ability to observe and control matter at the atomic and molecular scale (the nanoscale) will allow, in the next few decades, the design of new objects and the development of more efficient and less expensive manufacturing processes in a great variety of industry sectors.

At CIC nanoGUNE Consolider, it is our mission to carry out world-class nanoscience research, thus contributing to the creation of the necessary conditions for the Basque Country (and the humanity, in general) to benefit from a wide range of nanotechnologies: confronting new scientific challenges through cooperation with other research and technological agents in the Basque Country and worldwide, building bridges that fill the gap between basic science and technology, as well as promoting high-level training and outreach activities.

In the launching period 2007-2010, we were successful in putting together a state-of-the-art infrastructure and

Jose M. Pitarke
Director

Donostia – San Sebastian, December 2012

five research groups that have been making outstanding contributions in various fields of nanoscience and nanotechnology, and we also succeded in launching our first start-up company, Graphenea, with the mission of producing and commercializing graphene (a nanomaterial consisting of one single layer of carbon atoms) and developing graphene-based technologies.

During the last two years, we have opened three new research groups, all led by scientists of international recognition, thereby bringing our activity to a cruising speed and placing the Basque Country at the forefront of nanoscience research. So far, we have opened new areas of strategic research in the fields of nanomagnetism, nanooptics, self-assembly, nanodevices, electron microscopy, theory, nanomaterials, and nanoimaging, with a team of more than 70 researchers, including graduate students, post-docs, technicians, and visitors, all coming from 21 different countries worldwide.

The bases have also been set for the creation of an effective framework of cooperation among existing research and technological agents in the Basque Country, several technology-transfer activities have been initiated within our industrial environment, and we are now in the process of launching new spin-off companies.

A world-class research team, state-of-the-art facilities, close collaboration with other research laboratories and with industry, and a commitment to our society define our way of understanding scientific research. In this exciting journey, we have benefited from the generous support of a good number of individuals and public institutions, especially the Basque Government, our International Advisory Committee, and all outstanding researchers and employees who have believed in our project and have contributed so much to it.

Being a small center in a small country, we will keep competing and collaborating with many other research laboratories around the world, with the expectation that we will always find the niche for us to offer something different. This is the big challenge of the small.

"We are now approaching a cruising speed"

The Very Best of nanoGUNE

86
ISI publications

1 359
citations

7.1
average impact factor

8
research groups

73
researchers

65
invited talks

42
guest researchers

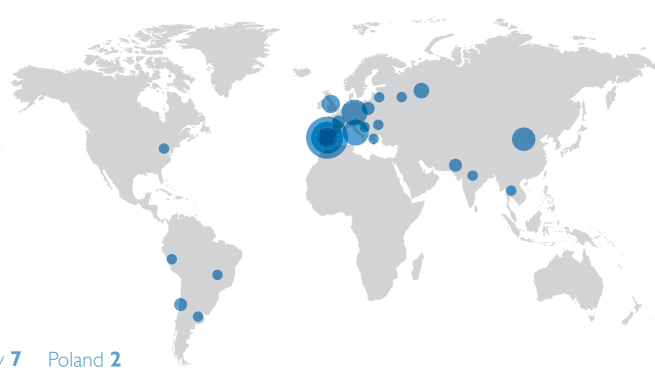
70
seminars

9
conferences and workshops organized

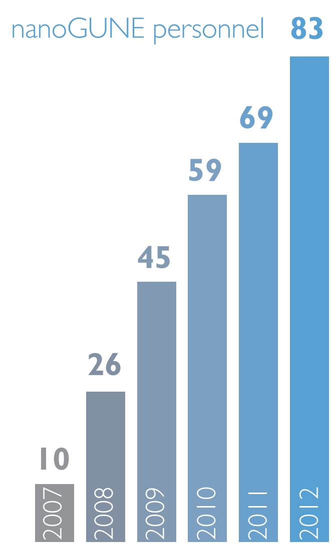
Researchers from

21

countries:



Argentina **1**
Belarus **1**
Brazil **1**
Chile **2**
China **6**
Croatia **1**
France **2**
Germany **7**
Greece **1**
India **1**
Italy **7**
Latvia **1**
Pakistan **1**
Peru **1**
Poland **2**
Romania **1**
Russia **3**
Spain **28**
Thailand **1**
USA **1**
UK **4**



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

35
cooperation agreements in place

1
new patent

2
PhD theses accomplished

24
PhD theses ongoing

350
visitors from high-schools and universities

200
times in the media

2
new spin-off projects

5
contracts with companies

26
grants awarded

10 Senior Scientists

17 Post-docs

24 Pre-docs

3 Master students

8 Guest Researchers

11 Technicians

10 Management & Services

nanoGUNE personnel on 31 December 2012

Researchers in Action

8 Research Groups

73 Researchers

- Nanomagnetism
- Nanooptics
- Self-Assembly
- Nanoimaging
- Nanodevices
- Nanomaterials
- Theory
- Electron Microscopy

Nanomagnetism

“Nanomagnetism at a glance”

In the Nanomagnetism Group, we devise novel materials and nanostructures to achieve control over their magnetic properties at the nanoscale and we develop processes to fabricate them. In addition, we design, build, and utilize advanced magnetic characterization techniques for studying such systems with a particular strong emphasis on magneto-optical techniques. In parallel, we develop theoretical and computational models for achieving a quantitative nanoscale understanding of magnetic materials and nanostructures.

Our group has been consolidated over the last two years, and, as a result, several relevant scientific achievements have been accomplished. For instance, we have been able to achieve precise tuning of key properties controlling the magnetic-field response of nanostructured materials such as the exchange-bias effect and magnetic anisotropy. These are vital properties; future progress in the field of magnetism and its technological applications will be reliant on their precise control. The materials we make are of relevance for the electronics industry, especially for the magnetic storage industry, and our characterization methodologies can be scaled up for large-scale, precise industrial materials metrology.

Our research has also achieved relevance for the biomedical industry. We have designed magnetic structures, with which we demonstrated that it is possible to remotely manipulate magnetic nanoparticles, carrying molecules or living cells in liquid biocompatible environments. Moreover, we have recently managed to transfer these lab-type magnetic structures into microfluidic channels defined on a chip for applications in biotechnology, nanochemistry, and nanomedicine. One outcome of this work is a collaborative project with Hospital Donostia, the University of the Basque Country, and Regennia (Basque Country, Spain) for the purpose of utilizing this approach in regenerative medical treatments.

Apart from the above-mentioned collaborations, we work together with FEI and numerous universities worldwide, such as the universities of Hamburg (Germany), Nancy (France), California San Diego (USA), Federico Santa María (Chile), Milano (Italy), Singapore, and Daejeon (Korea).

Andreas Berger
Research Director
and Group Leader

Paolo Vavassori
Ikerbasque Research Professor
and Group Coleader

Nanomagnetism

Andreas Berger
Research Director and Group Leader

PhD in Physics in 1993, RWTH Aachen University (Germany)

Paolo Vavassori
Ikerbasque Research Professor and Group Coleader

PhD in Physics in 1994, Politecnico di Milano (Italy)

Post-doctoral researchers

Marco Donolato, Bioftalmik Fellow (until 31/10/12)
Juan González, nanoGUNE Fellow
Ondrej Hovorka, Marie Curie (until 31/03/11)
Anandakumar Sarella, nanoGUNE Fellow
Anna Suszka, nanoGUNE Fellow

Pre-doctoral researchers

Jon Ander Arregi, FPI Fellow, *Study of ultrafast magnetization dynamics in thin-films and nanostructures for technical applications*
Lorenzo Fallarino, nanoGUNE Fellow, *Fabrication and magnetic characterization of Co-based magnetic alloy films, multilayers, and nanostructures*
Olatz Idigoras, PFPI fellow, *Magnetization reversal in magnetic films, multilayers, and nanostructures*
Nicolo Maccaferri, nanoGUNE Fellow, *Magneto-optical activity in spatially confined geometries*
José María Porro, PFPI Fellow, *Fast magnetization dynamics near magnetic ordering temperatures*

Master Students

Eric Beitia, UPV/EHU (until 30/09/12)
Andrea La Porta, University of Ferrara (until 13/06/11)
Tindara Verduci, University of Ferrara (until 13/06/11)

Undergraduate Students

Irati Alonso, UPV/EHU (until 12/08/11)
Eneko Bergaretxe, UPV/EHU (until 12/08/11)
Ane Etxebarria, UPV/EHU (until 31/08/12)
Usue Palomares, UPV/EHU (until 31/08/12)

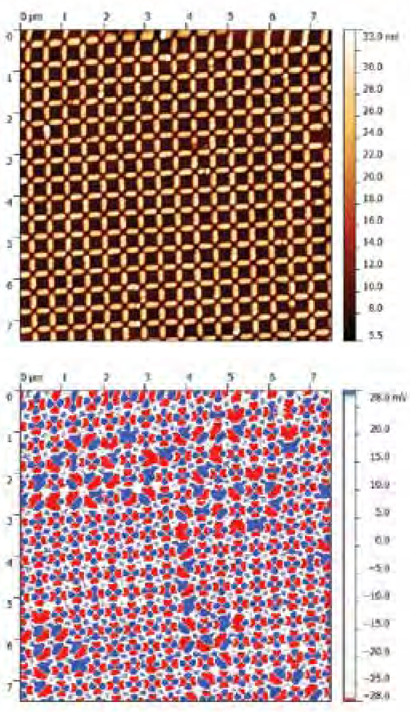
Technician

Cesar Rufo
Marie Fertin

Guest Researchers*

Claudio Gonzalez, UTFSM-Chile pre-doc (until 13/12/12)
Maxim Ilin, UPV/EHU post-doc (until 30/06/11)
Veli Mikko Kataja, Aalto University pre-doc (until 30/04/12)
Hans-Peter Oepen, Ikerbasque Visiting Professor (until 30/09/11)
Fabio Saccone, UBA-CONICET Professor (until 01/07/11)
Andrea Torti, University of Milano pre-doc (until 31/12/12)
Patricia Wolny, Bioftalmik Fellow (until 31/05/12)

* One-month stay minimum



Interacting nanomagnets in a so-called square artificial spin-ice configuration: topography & magnetic images

Nanooptics

> “We have visualized graphene plasmons”

Since 2008, we have been following three main lines of research. First, we develop new optical-microscopy techniques for mapping and identifying materials on the nanometer scale. Then, we apply the microscope to study semiconductor nanowires used in solar-cell applications and biological objects. We also apply the microscope to characterize antennas for light. These antennas are based on metal nanostructures and graphene, and are fabricated at nanoGUNE, among others.

From a scientific point of view, our group has reached a great number of relevant achievements in the past two years. We have developed nano-FTIR, an infrared spectroscopy technique that improves the spatial resolution of conventional FTIR by a factor of 100 to 1 000. We have also demonstrated that infrared light can be guided by nanoscale metal nanowires in a similar fashion as radio waves are transported by metallic cables. One final success to underline is that we have visualized graphene plasmons for the first time.

All our research has not been done alone. Among other collaborations, we have been working with the Nanodevices group, which fabricates metal nanostructures, and with the Electron-Microscopy team, which makes advanced focused-ion-beam (FIB) nanostructures for us. With them, we also developed an infrared-electron-correlation microscopy technique. We also work very closely with the ICFO in Barcelona, IQFR-CSIC in Madrid, CENS and Neaspec in Munich, and with CFM, DIPC, IK4-Cidetec and Graphenea in San Sebastian.

Rainer Hillenbrand
Ikerbasque Research Professor
and Group Leader

Nanooptics

Rainer Hillenbrand
Ikerbasque Research Professor and Group Leader

PhD in Physics in 2001, Technical University of Munich (Germany)

Post-doctoral researchers

Pablo Alonso, FP7
Jianing Chen, FP7
Alexander Govyadinov, ERC
Dimitry Melnikau, nanoGUNE Fellow
Martin Schnell, ERC

Pre-doctoral researchers

Iban Amenabar, nanoGUNE Fellow, *Infrared near-field imaging and near-field spectroscopy of biological nanostructures*
Florian Huth, ERC, *nano-FTIR - Broadband infrared near-field spectroscopy*
Roman Krutohvostovs, nanoGUNE Fellow, *Characterization and application of infrared resonant scanning probe tips in near-field microscopy*
Simon Poly, nanoGUNE Fellow, *Molecular toxicity of nanomaterials*
Paulo Sarriugarte, PFPI Fellow, *Development of novel infrared near-field probes based on antenna and waveguide structures*
Johannes Stiegler, nanoGUNE Fellow, *Nanoscale-resolved free-carrier mapping in nanostructures by infrared near-field microscopy*

Master students

Stefan Mastel, Heidelberg University

Undergraduate Students

Xabier Marcano, UPV/EHU (until 31/08/11)

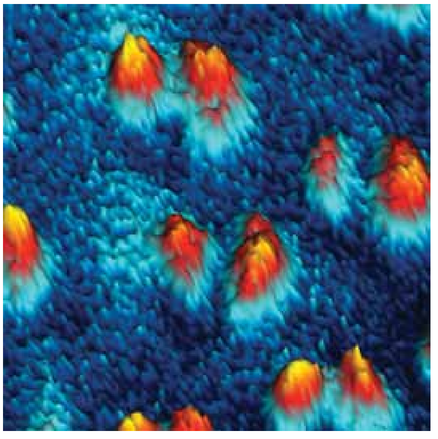
Technician

Carlos Crespo

Guest Researchers*

Pablo Albella, CSIC post-doc (until 31/12/12)
Paul Scott Carney, ERC Visiting Professor (until 15/08/12)
Francisco José García-Vidal, DIPC Visiting Professor (until 11/08/12)
Alexey Kuzmenko, DIPC Fellow (until 15/02/12)
Ulrich Männl, Cape-Town pre-doc (until 16/03/12)

* One-month stay minimum



Near-field amplitude image of dipolar plasmon modes in nickel nanodisks

Self-Assembly

> "We persuade proteins to form fibers and tubes"

Considering self-assembly, we often find that nature's structures and methods are not merely inspirations, but actually provide tools for experiments. We currently work with very small fibers and tubes built from proteins, and we try to understand how such one-dimensional nanostructures assemble. We also produce inorganic materials (oxides, metals) on the fibers and in the tubes. Some of them can be shaped on the "molecular scale", e.g. below 5 nm, such that their physical properties are far from the bulk material.

We have expanded our research to liquids, the most important one being, of course, water. The first question here is how and where a liquid contacts a fiber, or flows into a tube. We made an important move forward from simply using liquids as solvents (chemistry) to asking how they interact with nanofibers and nanotubes (physics). Our long-term objective is handling extremely small amounts of liquids, e.g. using our tubes as nanoscale pipettes. As always, we find that our experimental skills from biochemistry, chemistry, and physics automatically merge at the nanoscale; we do not even have to invoke the buzzword "transdisciplinarity".

Our research has links to applications in medicine: Cells sometimes need to grow outside the body before being implanted, and for this they require an especial environment. We are currently finding out how well various cell types grow on our protein fibers, in collaboration with Inbiomed in San Sebastian. As for our nanotubular systems, we found that they can store and release platinum-based anticancer drugs surprisingly well. We hope to lay the foundation for slow, highly localized drug delivery.

The Self-Assembly group works closely with the Electron-Microscopy team, and more recently our fibers have turned out to be a very useful playground for the Nanooptics group.

Alexander M. Bittner
Ikerbasque Research Professor
and Group Leader

Self-Assembly

Alexander M. Bittner
Ikerbasque Research Professor and Group Leader

PhD in Chemistry in 1996, Free University of Berlin (Germany)

Post-doctoral researchers

José María Alonso, nanoGUNE Fellow (until 30/09/12)
Marcin Gorzny, nanoGUNE Fellow
Amaia Rebollo, nanoGUNE Fellow

Pre-doctoral researchers

Thales De Oliveira, nanoGUNE Fellow, *Nanoscale organic lateral spin valves*
Abid Ali Khan, FP7, *Tobacco mosaic virus (TMV) as a nanoscaffold for inorganic assemblies* (awarded on 23/10/12)
Wiwat Nuansing, nanoGUNE Fellow, *Electrospinning of biomolecules*

Master students

Usue Zubia, UPV/EHU (until 27/07/12)

Undergraduate students

Amaia Benitez, University of Navarre (until 09/08/12)
Manuel García, University of Valladolid (until 31/08/11)
Iñaki Munarriz, University of Navarre (until 31/07/12)

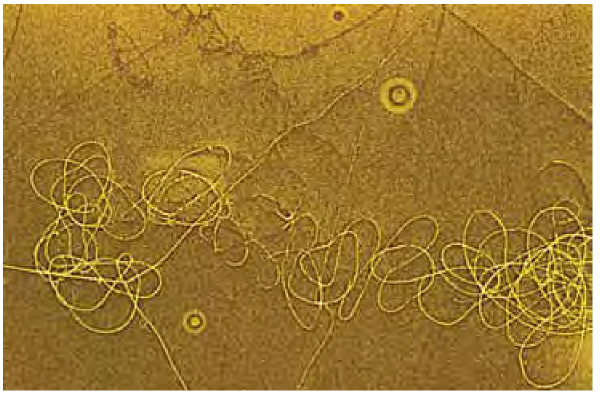
Technician

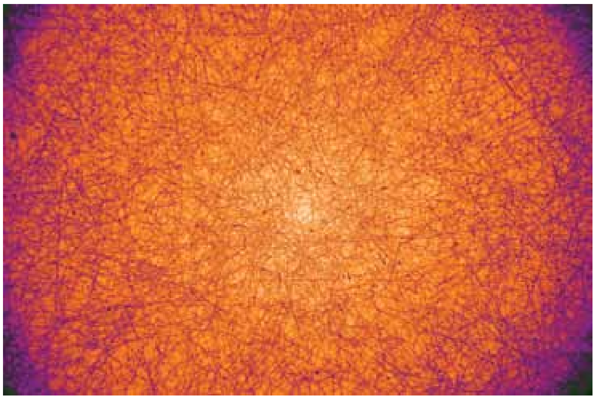
Monika Goikoetxea, Innpacto Fellow

Guest researchers*

Sven Degenhard, Stuttgart pre-doc (until 31/12/11)
Daniela Frauchiger, Basel pre-doc (until 12/08/11)
Pablo Rodal, pre-doc (until 31/12/11)
Mario Ruben, nanoGUNE Visiting Professor (until 30/09/12)
Charlotte Stenner, Hamburg pre-doc (until 31/03/11)

* One-month stay minimum





Electrospun fibers of pure albumin

Nanodevices

> “Our research has potential applications in multiple industry fields”

Our research group studies how electrons behave within a wide range of materials whose dimensions have been greatly reduced down to the nanometer scale. This is a very common problem in the transistors used by the electronics industry, but it is also transferable to other gadgets, such as electronic memory, light-emitting, or photovoltaic devices.

In order to do so, we can produce these devices using different nanofabrication tools, or we can make use of naturally small entities, such as molecules. Regarding the first option, our group has made an important effort achieving an expertise in electron-beam lithography and other techniques, and we are now able to reach down to 10 nm. In reference to the second option, we are interested in how to connect electrically such small objects and to understand how electrons propagate in assemblies of different molecules.

We are working to develop three main lines of research with possible applications in multiple industry fields. Nanofabrication aims at producing nanometric structures with very diverse methods. Although we are mostly focused on electronic and photonic structures, our expertise proves to be useful whenever we need to massively reduce the dimensions of a device.

If in standard electronics the electron charge is used to transmit information, spintronics (our second line of research) is based on the use of the electron spin, a purely quantum mechanical entity, with the same purpose. It is, in fact, the underlying principle of read-heads in magnetic hard disks. We are currently studying different strategies for exploring how spintronics could become a niche field in the future of electronics, merging spin transport in metals with interfacial spin studies using diverse molecules.

Finally, we are also interested in electronic memory. In spite of the current success of flash-memory devices, the industry is actively looking for possible future replacements of this technology. That is why we are investigating resistive memory in oxides, a popular topic in the electronic industry. We are interested in understanding the basic processes behind such effect, but also trying to replicate complex neuronal progresses, such as learning and forgetting information, in a solid-state device.

Luis E. Hueso
Ikerbasque Research Professor and Group Leader

Fèlix Casanova
Ikerbasque Research Professor

Nanodevices

Luis E. Hueso
Ikerbasque Research Professor and Group Leader

PhD in Physics in 2002, University of Santiago de Compostela (Spain)

Fèlix Casanova
Ikerbasque Research Professor

PhD in Physics in 2003, University of Barcelona (Spain)

Post-doctoral researchers
Amilcar Bedoya, FP7
David Ciudad, Marie Curie
Federico Golmar, nanoGUNE Fellow (until 30/11/12)
Xiangnan Sun, ERC
Mariana Ungureanu, Juan de la Cierva

Pre-doctoral researchers
Libe Arzubiaga, PFPI Fellow, *Electronic transport in molecular nanocontacts*
Marco Gobbi, nanoGUNE Fellow, *Organic spin tunnel devices*
Miren Isasa, PFPI Fellow, *Generation and detection of pure spin currents in metallic nanostructures*
Emmanouil Masourakis, FP7 Fellow, *Electronic transport in single molecular devices*
Luca Pietrobon, FP7 Fellow, *Spintronics on graphene*
Oihana Txoperena, FP7 Fellow, *Evaluation of spin transport properties using Hanle effect and application to amorphous carbon*
Estitxu Villamor, PFPI Fellow, *Spin injection, manipulation, and detection using lateral spin valves*
Raul Zazpe, nanoGUNE Fellow, *Resistive switching in oxides*

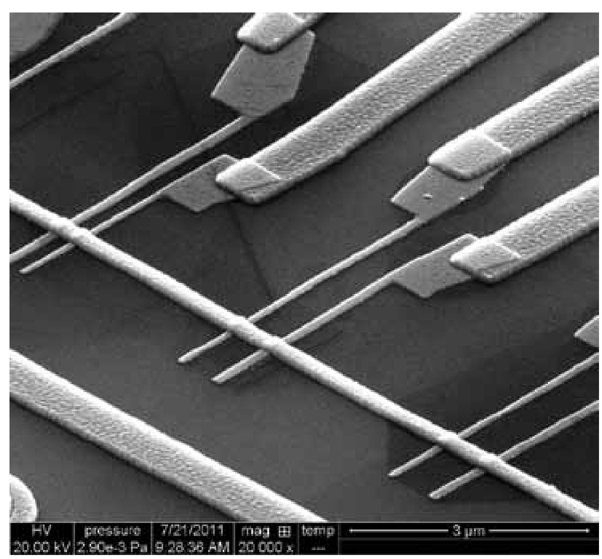
Master students
Federico Marchesin, University of Ferrara (until 31/05/11)

Undergraduate students
Alexander Arias, University of Navarre (until 31/08/12)
Laura García, UPV/EHU (until 31/08/11)

Technician
Roger Llopis

Guest researchers*
Mirko Cinchetti, Kaiserslautern Visiting Fellow (until 11/10/12)
Pablo Stoliar, UNSAM-Argentina Visiting Fellow (until 25/11/11)

* One-month stay minimum



Lateral spin valve, a nanodevice fabricated to study the spintronic properties of several materials

Electron Microscopy

"We provide world-level support to nanoGUNE and the whole Basque scientific community"

The Electron-Microscopy Laboratory is a general-use facility. We provide a world-level microscopy and focused-ion-beam (FIB) nanofabrication support to nanoGUNE's research groups, as well as to the whole Basque scientific community.

Throughout the last two years, we have been able to settle a very complex and dedicated facility, to make it fully operational and then further develop it. We have acquired a high level of expertise in the FIB-based fabrication of nanostructures. In fact, we are well recognized experts in the focused-electron-beam induced deposition (FEBID) of cobalt-based magnetic nanostructures. This has been a research carried out in cooperation with nanoGUNE's Nanomagnetism and Nanodevices groups.

A second field of expertise is FIB fabrication of plasmonic structures. Here we work together with the Nanooptics group at nanoGUNE, the CEMES in Toulouse (France), and Tekniker in the Basque Country.

Currently, we are working with the University of the Basque Country (UPV/EHU), CIC bioGUNE, CIC biomaGUNE, Tekniker, Tecnalia, and Hospital Universitario Donostia. The facility, along with our knowledge, should also be useful for industry. As a result, we might be able to develop extensive industry contacts in the future.

Andrey Chuvilin
Ikerbasque Research Professor

Electron Microscopy

Andrey Chuvilin
Ikerbasque Research Professor

PhD in Physics and Mathematics in 1998, Siberian Branch of the Russian Academy of Sciences, Novosibirsk (Russia)

Post-doctoral researcher

Elizaveta Nikulina, FEI Fellow

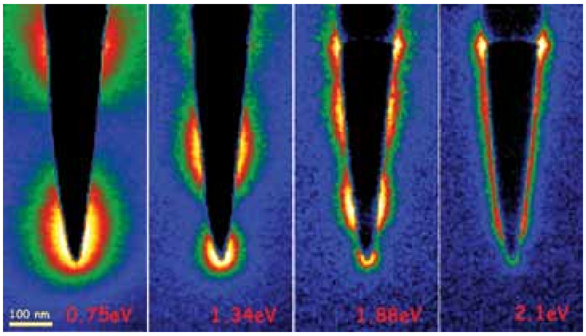
Technician

Christopher Tollan

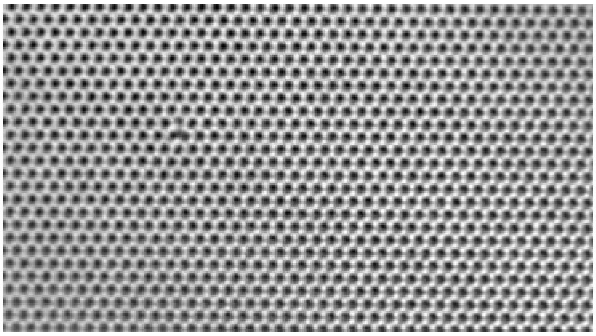
Guest researchers*

Victor Koroteev, Novosibirsk Visiting Fellow (until 15/12/12)

* One-month stay minimum



Energy filtered images of a gold rod plasmonic nanoantenna



A graphene monolayer with the absence of a one single atom

Theory

> "We create a kind of virtual reality where we can see atoms moving"

We use computers to simulate matter (solids, liquids, living matter, nanoobjects) at the atomic scale. Knowing the fundamental laws of quantum physics and introducing quite sophisticated theoretical and computational techniques, we can "see" how electrons, atoms, molecules, or nuclei interact and move in matter, giving us insights into why matter behaves as it does. Our methodology also allows us to predict how a new material, substance, or nanoobject would behave before we fabricate it. It is a kind of virtual reality at the very small scale in space and time in which we can see atoms moving.

We work both in the development of simulation techniques and in their application to different problems. A valuable achievement has been the introduction of our simulation techniques to attack problems related to radiation damage of materials, of importance in many situations and contexts, from the nuclear industry to the treatment of cancer. Our first studies have been relatively technical, but their importance is that they are pioneering the subfield of simulations in such important contexts.

Many industries are interested in understanding the behavior of matter at the nanoscale, along with its prediction, on computers. Pharmaceutical companies are extremely interested in knowing certain specific properties of possible new molecules they consider promising candidates for new drugs: their healing potency, solubility, and so on. They seem to be very interested in knowing as much as possible "before" synthesizing or creating the new molecule in the lab, which can be a long and expensive process. Simulations do routinely help in this context. There are many similar examples in micro or nanoelectronics or in energy research (materials for storing hydrogen, new light batteries, etc.), and many other contexts.

Emilio Artacho
Ikerbasque Research Professor
and Group Leader

Emilio Artacho
Ikerbasque Research Professor and Group Leader

PhD in Physics in 1990, Autonomous University of Madrid (Spain)
Comes from the University of Cambridge (UK)
Joining date: 1 October 2011

Post-doctoral researcher

Fabiano Corsetti, nanoGUNE Fellow

Pre-doctoral researchers

Rafi Ullah, nanoGUNE Fellow, *Non-adiabatic processes in the radiation damage of materials from first principles*
Jon Zubeltzu, nanoGUNE Fellow, *Theoretical simulation of nanoconfined water from first principles*

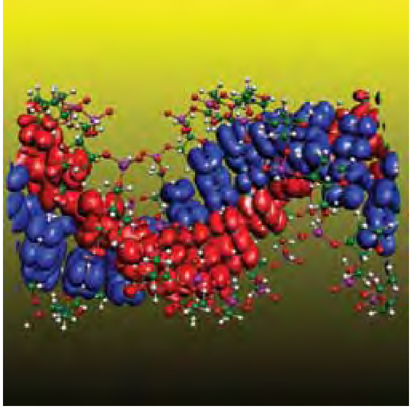
Undergraduate students

Beñat Mencia, UPV/EHU (until 31/08/12)

Guest researchers*

Nicholas Bristowe, Cambridge pre-doc (until 30/09/12)
Michele Pisarra, Calabria pre-doc (until 30/09/12)
Oliver Strickson, Cambridge pre-doc
Ahsan Zeb, Cambridge pre-doc

* One-month stay minimum



Electrons in DNA: Simulation of dry DNA in its A helical form

new group

Nanomaterials

> “We create new functional nanoscale materials”

Functional materials are the most important building blocks for the development of new technologies or the improvement of existing ones. Compared to macroscopic materials, nanomaterials often exhibit improved functionality in various aspects or even introduce entirely new functions.

We are dedicated to the development of functional nanoscale materials as thin films, nanoparticles, nanotubes, or nanowires. Our main objective is to improve the potential applications of these materials in catalysis, optics, sensing, energy storage, and production or even nanomedicine. A modern and very promising approach towards novel materials is the combination of inorganics and (bio-)organics. Ideally, such compositions shall benefit from the physical or (bio-)chemical properties of both material components at the same time. Such composite or hybrid materials are one major focus of research in our group. First results in our initial year have shown approaches towards catalytic hybrid nanomaterials.

Given the great demand for new material compositions and structures, our research is highly compatible with current industrial needs in many sectors. Furthermore, we are willing to work with the nearby industry, be it regional, national, or international, in order to exploit the technological opportunities our research field offers.

We are also tightening internal and external collaborations that include companies, such as OSRAM (Germany) and Eight19 (UK) in the framework of an FP7 project, and Torresol Energy (Spain) in the framework of the Basque Government's Gaitek program, but also research institutions involving the Max-Planck Institute of Colloids (Germany), diverse Fraunhofer Institutes (Germany), EMPA (Switzerland), the Coal Research Institute of the Chinese Academy of Sciences (China), and many more.

Mato Knez
Ikerbasque Research Professor
and Group Leader

Nanomaterials

Mato Knez
Ikerbasque Research Professor and Group Leader

PhD in Physical Chemistry in 2003, Max Planck Institute of Solid State Research, Stuttgart (Germany)
Comes from the Max Planck Institute of Microstructure Physics, Halle (Germany)
Joining date: 1 January 2012

Post-doctoral researcher

Lianbing Zhang, nanoGUNE Fellow

Pre-doctoral researchers

Mabel Andrea Moreno, nanoGUNE Fellow, *Hybrid materials with potential application in nanodevices by means of atomic layer deposition (ALD)*
Fan Yang, nanoGUNE Fellow, *Functionalization of materials through coating and infiltration by atomic layer deposition (ALD)*

Master Students

Unai Carmona, UPV/EHU
Ivan Espinosa, UPV/EHU (until 31/07/12)
Peng Yang, Max-Planck Halle (until 31/08/12)

Technicians

Mikel Beltrán
Le Li, FP7

* One-month stay minimum

Gold nanoparticle chains in a helical dielectric shell

new group

Nanoimaging

> “We study and manipulate molecules one at a time”

Our group was launched in September 2012. Since then, we have worked intensively in building and equipping our three laboratories. The laboratories are now at the most advanced level of performance, what will allow us to implement highly sensitive measurements of surfaces using scanning tunneling microscopy and spectroscopy.

Our research investigates how the laws of quantum physics govern the behavior of individual atoms and molecules on a surface. We study chemistry, magnetism, electronics, and optics at the level of one molecule at a time, and learn how to artificially manipulate them. The research is at a very fundamental level. Its goal is to reveal the basic properties of the building blocks of matter, because only in this way can we aim at building materials with tailored functionalities.

Highlights of our research are the resolution of magnetic information of an atom inside a molecule by using superconducting electrodes, as well as the measurement of the temperature of an individual molecule by detecting the light emitted during electron tunneling through it.

José Ignacio Pascual
Ikerbasque Research Professor
and Group Leader

Nanoimaging

José Ignacio Pascual
Ikerbasque Research Professor and Group Leader

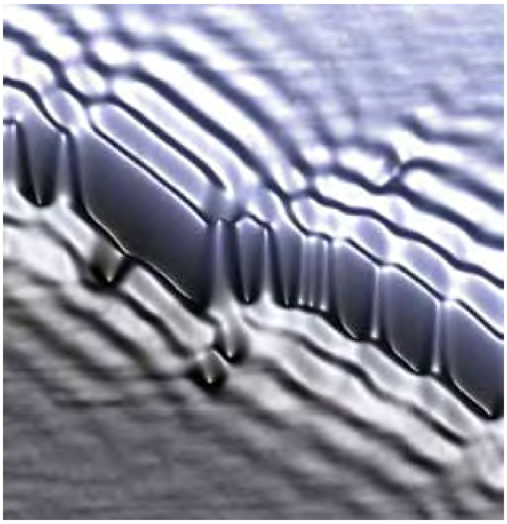
PhD in Physics in 1998, Autonomous University of Madrid (Spain)
Comes from the Free University of Berlin (Germany)
Joining date: 1 September 2012

Post-doctoral researcher
Jingcheng Li, DFG Fellow

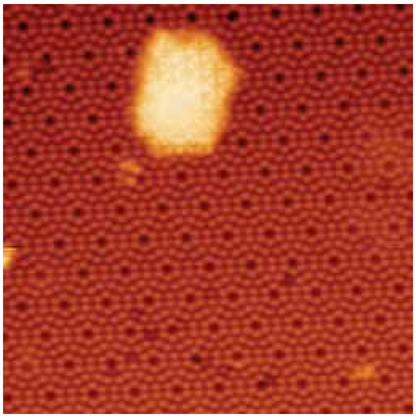
Technician
David Arias

Guest Researchers*
Martina Corso, CFM Ikerbasque Research Fellow

* One-month stay minimum



Electron standing waves at a silver monoatomic step



Silicon (111) 7x7 and Silicon Carbide

new group

2 State-of-the-art Infrastructure

4 new laboratories

2 new ultra-high-vacuum low-temperature scanning tunneling microscopes

State-of-the-art Infrastructure

> “We provide access to external users to our state-of-the-art facilities and cutting-edge equipment staffed by our expert scientists and technicians”

Ralph Gay
Cleanroom Manager

Carlos Garbayo
Maintenance Technician

Gorka Pazos
Equipment Engineer

Gorka Arregui
Facilities Manager

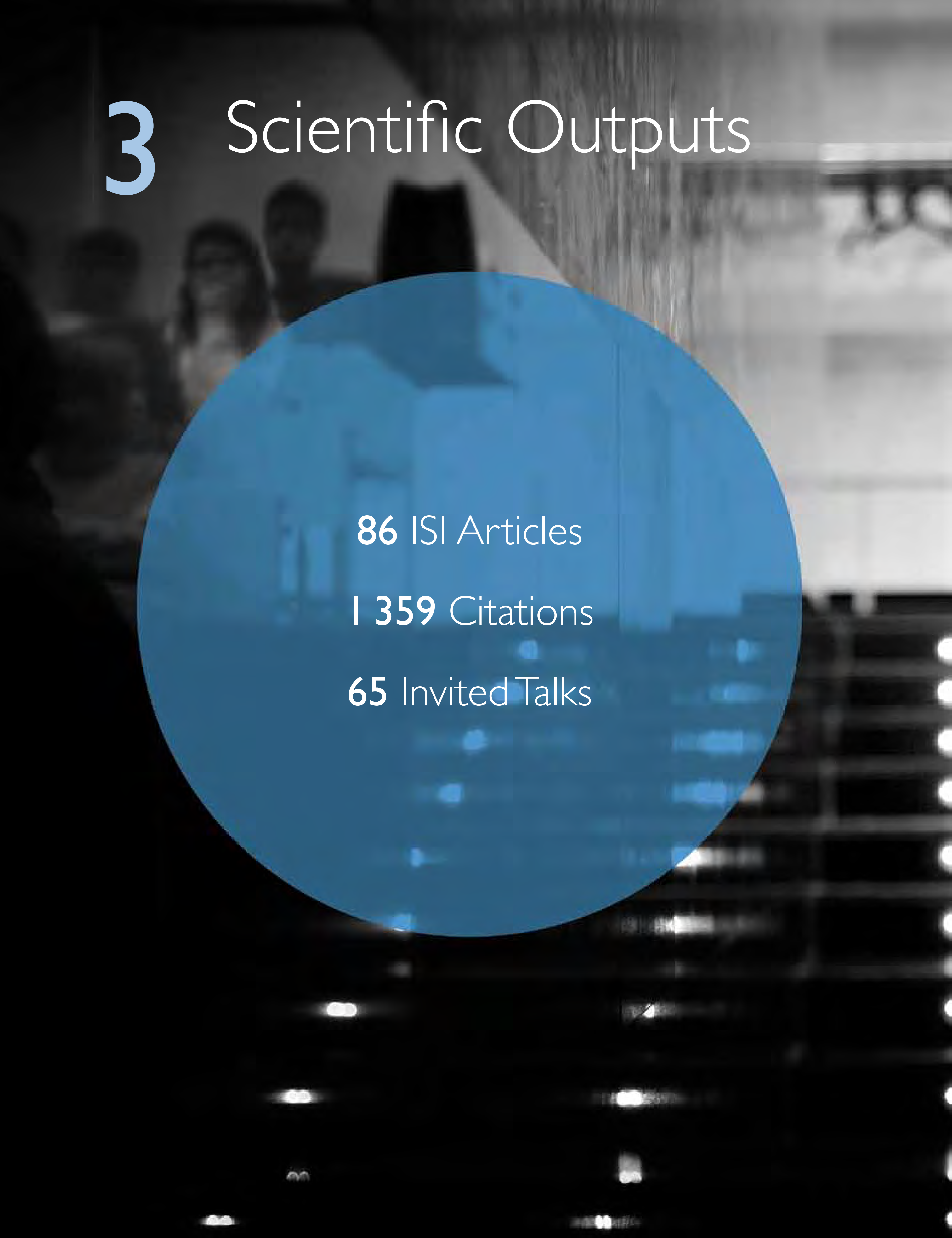
State-of-the-art Infrastructure

The nanoGUNE infrastructure, located at the Ibaeta Campus of the University of the Basque Country, is unique. It was built on the basis of sophisticated architectural and engineering solutions that followed the specific requirements of the research tools to be installed. This is a building of 6 200 m^2, housing 15 ultrasensitive laboratories in the basement and a cleanroom of about 300 m^2 where the air purity is under strict supervision. The whole infrastructure was envisioned with a long-term perspective to fabricate nanoscale materials and characterize their properties on the nanometer scale and with sufficiently high sensitivity.

Over the last two years, four new laboratories have been fitted out and equipped to a high technological standard: a nanomaterials laboratory of 68 m^2 in the ground floor, and three laboratories of about 35 m^2 in the basement with nanoimaging capabilities. Two of these nanoimaging laboratories were designed for ultra-high-vacuum low-temperature scanning tunneling microscopes to be sitting on a 100-ton concrete foundation that floats on air dampers and is therefore decoupled from the sorrounding building.

Leading manufacturers of tools that are critical to exploring the frontiers of nanoscience and nanotechnology are aware that their prestige depends, in some extent, on the performance that skilled researchers are capable of providing from their tools. This is reflected at nanoGUNE by the fact that world-leading companies like FEI (world leader in the production and distribution of electron microscopes) collaborate with us in a cooperative framework for the benefit of both parties.

In 2011, a high-performance computing cluster was purchased and hosted at the computing laboratory of the University of the Basque Country, which has a long-term experience on the management of this kind of equipment, thereby establishing synergies with other computing infrastructures and research groups at the University. In 2012, the nanomaterials laboratory was equipped with two cutting-edge pieces of equipment to develop the Atomic Layer Deposition (ALD) technique; and, after carefully fitting out three nanoimaging laboratories, we have been installing three key pieces of scientific equipment: a low-temperature probe microscope (LT-PM) and two ultra-high-vacuum (UHV) low-temperature scanning tunneling microscopes (LT-STMs).



3 Scientific Outputs

86 ISI Articles

1 359 Citations

65 Invited Talks

Highlighted publications

1. *Nanofocusing of mid-infrared energy with tapered transmission lines*

   Nature Photonics **5**, 283-287 (2011)

2. *Infrared-spectroscopic nanoimaging with a thermal source*

   Nature Materials **10**, 352-356 (2011)

3. *Inducible site-selective bottom-up assembly of virus-derived nanotube arrays on RNA-equipped wafers*

   ACS Nano **5**, 4512-4520 (2011)

4. *Self-assembly of a sulphur-terminated graphene nanoribbon within a single-walled carbon nanotube*

   Nature Materials **10**, 687-692 (2011)

5. *Designer magnetoplasmonics with nickel nanoferromagnets*

   Nano Letters **11**, 5333-5338 (2011)

Highlighted publications

6 *Proposal of a one-dimensional electron gas in the steps at the $LaAlO_3$-$SrTiO_3$*

Physical Review Letters **108,** 166802 (2012)

7 *Magneto-optical magnetometry of individual 30 nm cobalt nanowires grown by electron-beam induced deposition*

Applied Physics Letters **100**, 142401-142404 (2012). Selected for the Virtual Journal of Nanoscale Science & Technology.

8 *A light-controlled resistive switching memory*

Advanced Materials **24**, 2496-2500 (2012)

9 *Optical nano-imaging of gate-tunable graphene plasmons*

Nature **487**, 77-81 (2012)

10 *Driving a macroscopic oscillator with the stochastic motion of a hydrogen molecule*

Science **338**, 779-782 (2012)

1

Nanofocusing of mid-infrared energy with tapered transmission lines

Nature Photonics **5**, 283-287 (2011)
M. Schnell, **P. Alonso-González**, **F. Casanova**, **L. Arzubiaga**, **L. E. Hueso**, **A. Chuvilin**, and **R. Hillenbrand**

This paper shows an innovative method that uses tapered transmission lines to focus infrared light to nanometer-size dimensions. This device could trigger the development of novel chemical and biological sensing tools, including ultra-small infrared spectrometers and lab-on-a-chip integrated biosensors.

In conventional optical instruments, light cannot be focused to spot sizes smaller than half the wavelength because of diffraction effects. An important approach to beat this diffraction limit is based on optical antennas. They have the ability to focus light to tiny spots of nanometer-scale dimensions, which are orders of magnitude smaller than what conventional lenses can achieve. Tiny objects such as molecules or semiconductor nanoparticles that are placed into these so-called "hot spots" of the antenna can efficiently interact with light. Thus, optical antennas boost single-molecule spectroscopy or the sensitivity of optical detectors. However, the hot spot is bound to the antenna structure, which limits the flexibility in designing nanooptical circuits.

The experiments now show that infrared light can be transported and nanofocused with miniature transmission lines, consisting of two closely spaced metal nanowires. While lenses and mirrors manipulate light in the form of a free-space propagating wave, transmission lines guide the infrared light in the form of a tightly bound surface wave.

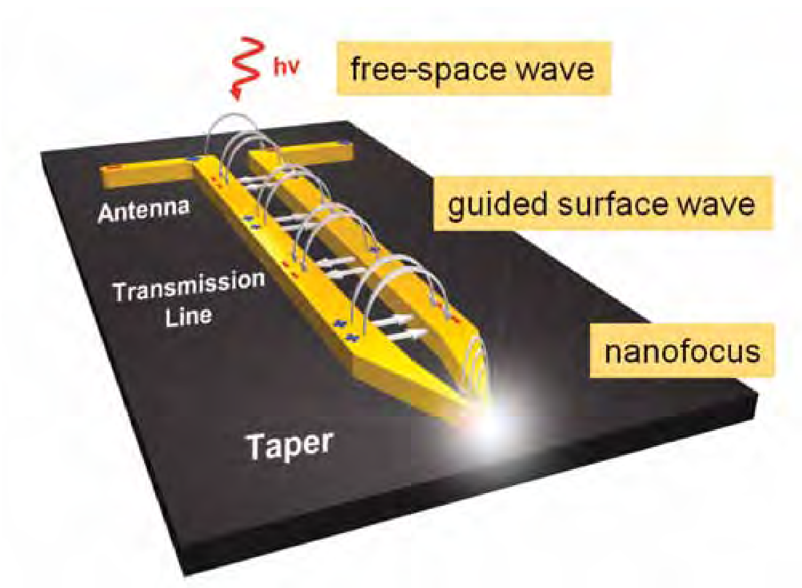


Figure 1
Concept and design of the device

> Tapered transmission lines can be used to focus infrared light to nanometer spot sizes

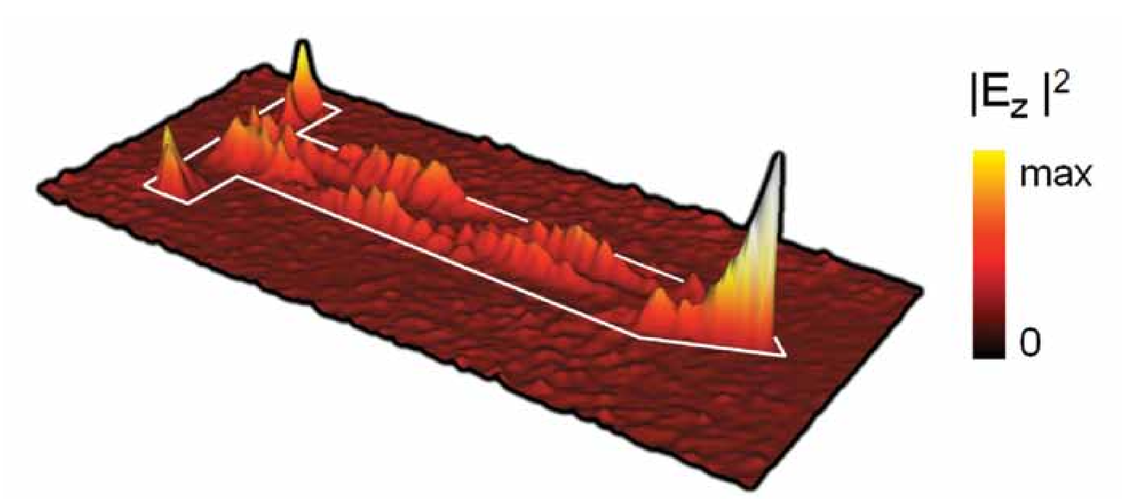
The concept of classical transmission lines has been adapted to the infrared frequency range. Transmission lines are specialized cables for carrying, for example, radio-frequency signals. A simple form consists of two metal wires running closely in parallel, also called ladder line. This structure was widely used in former times for connecting the radio receiver or television set to the rooftop antenna. Applied at MHz frequencies, where typical wavelengths are in the range of centimeters to several meters, it is a prime example for transport of energy in waveguides of strongly subwavelength-scale diameter.

As shown in Figure l, this study demonstrated that infrared light can be transported in the same way, by scaling down the size of the transmission lines to below 1 μm. Two metal nanowires connected to an infrared antenna were fabricated. The antenna captures infrared light and converts it into a propagating surface wave traveling along the transmission line. By gradually reducing the width of the transmission line ("tapering"), it is demonstrated that the infrared surface wave is compressed to a tiny spot at the taper apex with a diameter of only 60 μm (see Figure 2). This tiny spot is 150 times smaller than the free-space wavelength, emphasizing the extreme subwavelength-scale focus achieved in the experiments. The near-field microscopy technique is applied to map the different electric-field components of the infrared focus with nanoscale resolution.

Nanofocusing of infrared light with transmission lines has important implications in spectroscopy and sensing applications. Connecting a transmission line to the antenna, the infrared light captured by the nanoantenna can be transported over significant distances and nanofocused in a remote place.

Figure 2

Near-field microscopy image of the tapered transmission line structure, taken at a 9.3 μm wavelength (30 THz). This image shows the infrared field intensity along the transmission line, revealing a tiny infrared hot spot at the taper apex.



2 *Infrared-spectroscopic nanoimaging with a thermal source*

Nature Materials **10**, 352-356 (2011)
F. Huth, **M. Schnell**, J. Wittborn, N. Ocelic, and **R. Hillenbrand**

This article presents the development of nano-FTIR, an instrument that allows the recording of infrared spectra with a thermal source at a resolution that is 100 times better than in conventional infrared spectroscopy. Nano-FTIR has an interesting application potential in widely different sciences and technologies, ranging from semiconductor industry to nanogeochemistry and astrophysics. In future, the technique could be applied to the analysis of the local chemical composition and structure of nanoscale materials in polymer composites, semiconductor devices, minerals, or biological tissue.

The absorption of infrared radiation is characteristic for the chemical composition and structure of materials. For this reason, an infrared spectrum can be considered as a material's "fingerprint". Infrared spectroscopy has thus become an important tool for characterizing and identifying materials and is widely applied in different sciences and technologies, including materials science and biomedical diagnostics. However, with conventional optical instruments, such as Fourier-transform (FTIR) infrared spectrometers, the light cannot be focused to spot sizes below several micrometers. This fundamental limitation prevents infrared-spectroscopic mapping of single nanoparticles, molecules, or modern semiconductor devices.

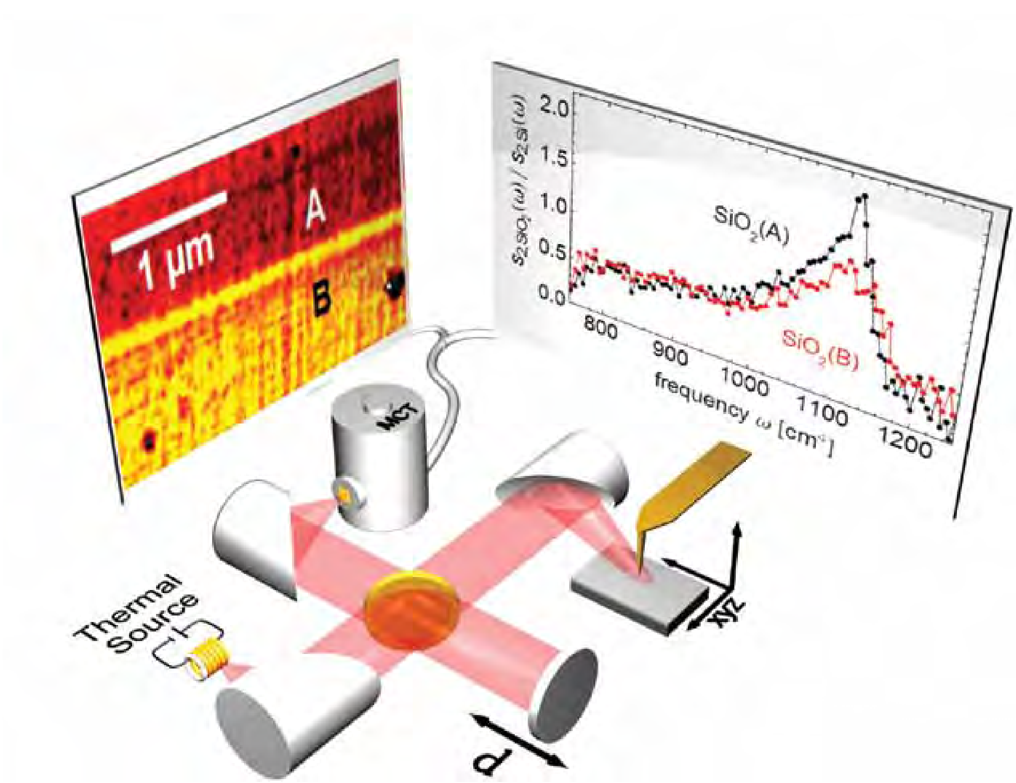
The new infrared spectrometer allows for nanoscale imaging with thermal radiation. The setup – in short nano-FTIR (see Figure) – is based on a scattering-type scanning near-field microscope (NeaSNOM) that uses a sharp metallic tip to scan the topography of a sample surface. While scanning the surface, the tip is illuminated with the infrared light from a thermal source. Acting like an antenna, the tip converts the incident light into a nanoscale infrared spot (nanofocus) at the tip apex. By analyzing the scattered infrared light with a especially designed FTIR spectrometer, infrared spectra was recorded from ultra-small sample volumes.

Our experiments recorded infrared images of a semiconductor device from Infineon Technologies AG (Munich) with a spatial resolution better than 100 nm. The study demonstrated that nano-FTIR can be applied for the recognition of differently processed silicon oxides or to measure the local electron density within complex industrial electronic devices. The technique allows the recording of spectra in the near- to far-infrared spectral range. This is an essential feature for the analysis of the chemical composition of unknown nanomaterials.

Figure

Infrared nanospectroscopy with a thermal source. The sketch shows an atomic-force-microscope tip probing a sample. The tip is illuminated with broadband infrared radiation from a thermal source; the backscattered light is analyzed with a Fourier-transform spectrometer, yielding local infrared spectra with a spatial resolution better than 100 nm. The displayed graph shows local infrared spectra of differently processed oxides in an industrial semiconductor device.

> “nano-FTIR allows the recording of infrared spectra with a thermal source at a resolution that is 100 times better than in conventional infrared spectroscopy”



3 *Inducible site-selective bottom-up assembly of virus-derived nanotube arrays on RNA-equipped wafers*

ACS Nano **5**, 4512-4520 (2011)
A. Mueller, F. J. Eber, C. Azucena, A. Petershans, **A. M. Bittner**, H. Gliemann, H. Jeske, and C. Wege.

The assembly of the *Tobacco mosaic virus* from RNA and proteins is the textbook example for self-assembly, *in vivo* (tobacco plants) or *in vitro* (test tube). A biotechnologically engineered RNA was chemically anchored to micropatterned silicon/polymer, and allowed RNA/protein assembly to virus-like particles on a technically relevant surface.

The *Tobacco mosaic virus* (TMV) is a tube-shaped, exceptionally stable plant virus. Besides being the first virus that was discovered, isolated, and characterized in detail, TMV is among the biomolecule complexes offering most promising perspectives for nanotechnology applications. The TMV structure is one of the simplest virus architectures: Each viral nanotube self-assembles from a single RNA strand and numerous identical coat protein (CP) subunits. Depending on pH, the CPs can exist as a mixture of monomers and oligomers; they attach to the RNA strand such that they build up a highly defined CP helix. In this way also the RNA is wound up helically, buried inside the CP helix.

The details of the assembly are more complex: A especial base sequence, the so-called origin of assembly, acts as nucleation center for the first CPs. From this point, the helix grows in two directions, but at two speeds, since only one direction allows for the attachment of preformed CP oligomers (specifically the 34mer). These processes can be advantageously employed also for artificial RNA.

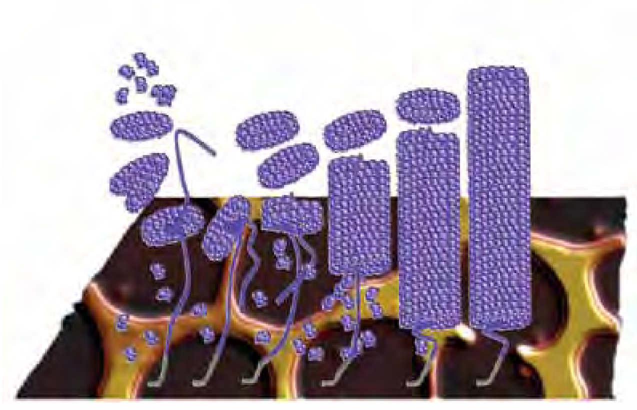


Figure 1
Schematics of viral coat proteins assembling on RNA, selectively attached to a chemically patterned surface

Biotechnologically engineered RNA species were designed to contain the origin of assembly. At the same time, one RNA end was chemically modified to allow to be attached to solid surfaces. Hence, CPs attached to this immobilized RNA, and assembled to surface-linked TMV-like nanotubes.

This classical TMV self-assembly process was achieved on silicon wafers that were patterned by polymer blend lithography. For this, a polymer mixture was spin-coated on the wafer, and the solvent was evaporated. The ensuing demixing produced patches on the 100 to 500 nm scale. After dissolution of one of the polymers, bare patches of the wafer were functionalized with single-stranded DNA linkers, while the polymer patches remained unreactive. The RNA was thus selectively bound to the wafer surface, and only there the assembly to virus-like particles was achieved.

This novel approach may promote technically applicable production routes toward a controlled integration of multivalent biotemplates into miniaturized devices to functionalize poorly accessible components prior to use. Furthermore, the results mark a milestone in the experimental verification of viral self-assembly mechanisms.

> “The textbook example of self-assembly, proteins and nucleic acid forming a virus particle, works not only in solution, but also when the nucleic acid is immobilized on a chemically patterned wafer”

Figure 2

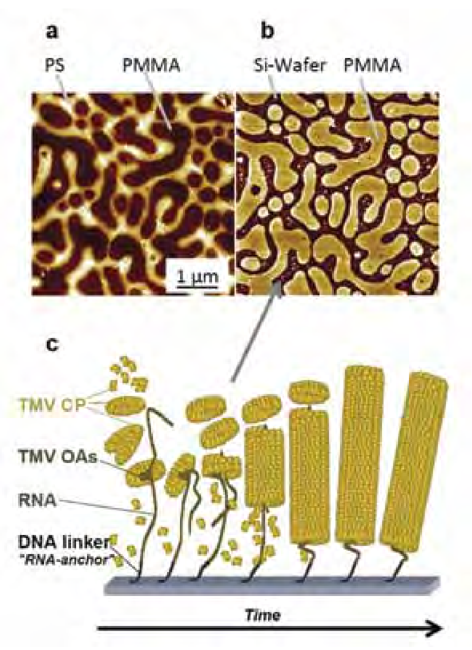


Figure 3

Figure 2
Experimental principles of inducible, RNA-guided bottom-up assembly on surface patches. Polymer blend lithography, based on (a) a pattern of the two immiscible polymers polystyrene (PS) and polymethyl-methacrylate (PMMA), and on (b) selective removal of PS (AFM images). c) Silicon wafer patches functionalized with DNA linkers. Ligation of RNA, including the origin of assembly (OAs), and assembly of TMV coat proteins (CPs) and CP multimers on the RNA.

Figure 3
Chemically patterned silicon wafer after assembly of TMV-derived tubes (white). Selective growth of tubes on the silicon wafer areas (dark) equipped with RNA-DNA anchors. Uncoated areas: Nonfunctionalized PMMA patches. AFM image size: 5 µm.

4 *Self-assembly of a sulphur-terminated graphene nanoribbon within a single-walled carbon nanotube*

Nature Materials **10**, 687-692 (2011)
A. Chuvilin, E. Bichoutskaia, M. C. Gimenez-Lopez, T. W. Chamberlain, G. A. Rance, N. Kuganathan, J. Biskupek, U. Kaiser, and A. N. Khlobystov

In this work, it has been demonstrated that carbon nanotubes can be used as nanoscale chemical reactors not only providing the volume for interaction between atoms, but also templating the shape of the resulting molecules. We show that chemical reactions involving carbon and sulphur atoms held within a nanotube lead to the formation of long atomically thin strips of carbon, known as graphene nanoribbons (GNR), decorated with sulphur atoms around the edge. Unique electrical and mechanical properties of GNRs inside nanotubes open the prospective for their application as nanoswitches, nanoactuators, and nanotransistors integrated in computers or data storage devices.

Carbon nanotubes are remarkable nanostructures with a typical diameter of 1-2 nanometers, an atomically thin wall, and electronic properties defined by a chiral angle of the wall structure. The inner volume of the tubes is considered to be chemically inert and thus they represent a class of chemical test tubes with a capacity of a few molecules across. This made carbon nanotubes, especially single wall nanotubes (SWNT), almost unique chemical containers to investigate the interaction of individual molecules and atoms. Over the past decade, a great effort has been made to introduce different molecular species inside SWNTs and to study their interaction by means of aberration-corrected high-resolution transmission electron microscopy (AC-HRTEM).

As part of this effort, it was suggested to use fullerene molecules as a tractor to trail desired organic ligands into the nanotube. AC-HRTEM studies have confirmed

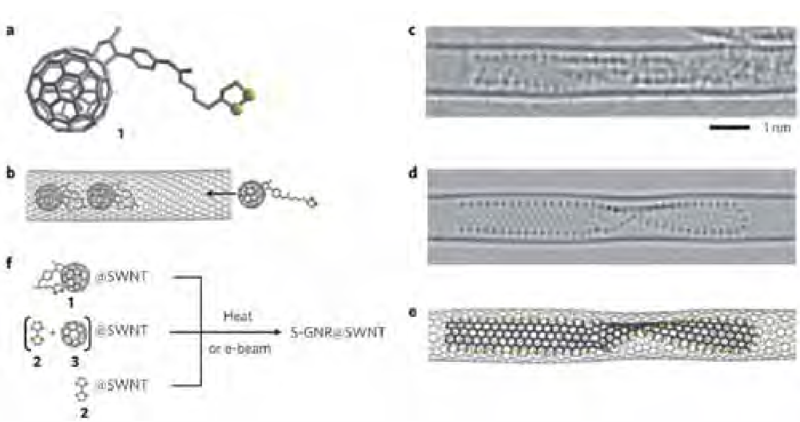


Figure 1
Carbon nanotubes serve as containers for chemical reactions.
(a, b) Usage of fullerene as a tractor to trail the sulfur-containing ligand into the nanotube.
(c, d, e) Experimental and simulated images and a model of sulfur-terminated graphene nanoribbon.
(f) Other precursors found to form graphene nanoribbons upon irradiation by e-beam or annealing at 1000 °C

the success of this idea [Chem. Commun. **47**, 2116 (2011)] and as a by-product have revealed a simple yet so far unrecognized fact, that introduction of heteroatoms (for example sulfur) along with carbon in the inner volume of the tube inhibits the formation of closed structures typically observed under these conditions. The usual end product for any carbon precursor heated or beam treated in the inner volume of SWNT is a second tube confined within the inner volume. The new role of the heteroatoms in this process is to saturate the dangling bonds, which makes closed structures energetically unfavorable. As a result, a flat graphene flake confined by the walls is formed inside the tube (see Figure 1) and continues to grow along the tube axis only limited by the supply of carbon and heteroatoms.

> Graphene nanoribbons inside nanotubes have unique electrical and mechanical properties that open the prospective for their application as nanoswitches, nanoactuators, and nanotransistors

Besides the very peculiar templated growth process, the as grown GNRs exhibit very interesting mechanical behavior. Due to the heating caused by the electron beam, GNRs continuously change their conformation and twist, and locally deform the confining nanotube. As far as the electronic properties of GNRs were shown to depend on its curling, the utilization of the ability of GNRs to twist inside SWNTs may potentially lead to a new class of mechano-electrical nanodevices.

Theory has unambiguously shown (see Figure 2) that, provided the dangling bonds are terminated by heteroatoms, GNRs are the most thermodynamically stable structures inside a SWNT, which immediately opens the route for bulk synthesis of this material by annealing of nanotubes impregnated with a sulfur-containing organic precursor. This theoretical prediction has been successfully confirmed in subsequent experimental work [ACS Nano **6**, 3943 (2012)]. The ribbons can potentially be made as long as the host CNT up to lengths of 1mm, which will provide a real opportunity of integrating GNR@SWNT complexes into electronic devices.

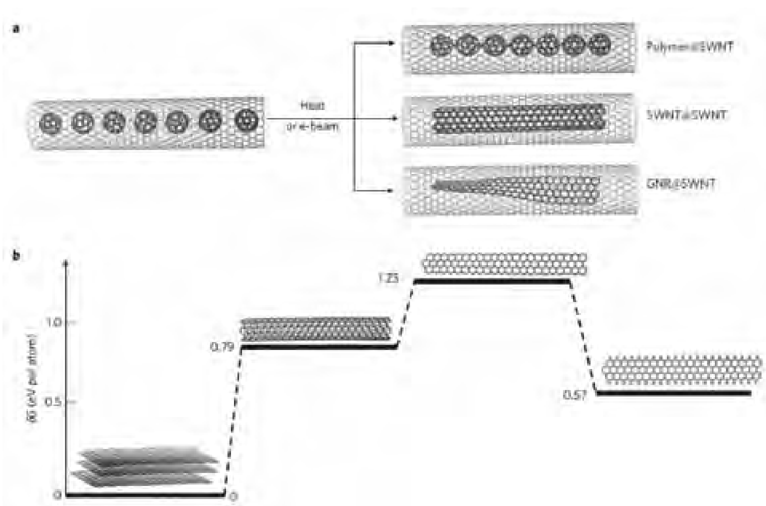


Figure 2
Guest molecules encapsulated within a carbon nanotube can be transformed into a 1D structure under the influence of heat or an electron beam. Density-Functional calculations show that graphene nanoribbons are the most energetically favorable structures in the presence of heteroatoms.

5 Designer magnetoplasmonics with nickel nanoferromagnets

Nano Letters **11**, 5333-5338 (2011)
V. Bonanni, S.Bonetti, T. Pakizeh, Z. Pirzadeh, **J. Chen**, **P .Vavassori**, **R. Hillenbrand**, J. Nogues, J. Åkerman, and A. Dmitriev

This article shows the discovery of a fundamentally new property in nanoscale ferromagnetic nanoantennas – their ability to control the sign of rotation of polarized scattered light. This "Kerr rotation reversal" effect, which arises from the interplay between magneto-optical (MO) and nanoplasmonic properties of such nanoantennas, could be exploited to make novel bio-chemical sensors and in a variety of nanophotonics applications.

Nanoplasmonics –the physics of nanoconfined collective oscillations of charge carriers (localized surface plasmons, LSPs) induced by incoming electromagnetic (EM) radiation– is a burgeoning research field. The strong localization and the sensitivity toward the surrounding medium allow a multitude of potential applications from nanophotonics to optical bio-chemical sensing. Virtually any nearly-free-electron metal would support such resonances in the optical region of the EM spectrum, and it is thus not surprising that concepts from nanoplasmonics increasingly spill over to research in nanomagnetism, leading to a range of intriguing effects.

Large magnetic-field-dependent modulation of particle transparency has been observed in Co/Au core/shell microparticles due to spin-dependent interface effects. An anomalous magneto-optic Kerr effect (MOKE) due to the resonant excitation of localized and/or propagating plasmonic modes has been reported in various systems: Au/Co/Au nanosandwiches, bilayer systems of perforated Au and uniform bismuth iron garnet films, gold-coated magnetic nanoparticles,

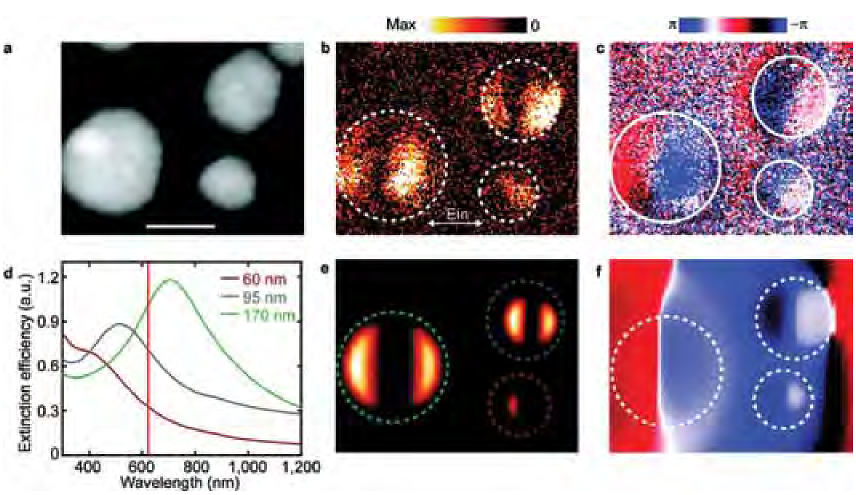


Figure 1
(a) Topography image of nickel nanodisks with diameters of 60, 95, and 170 nm, combined on the same glass substrate. Scale bar, 100 nm. (b, c) s-SNOM-near-field amplitude and phase images, recorded simultaneously with topography. (d) Far-field extinction efficiencies of three separate systems of Ni nanodisks of sizes 60 (brown), 95 (gray), and 170 nm (green). The vertical red line marks excitation at 633 nm. Finite-difference time-domain (FDTD) calculated near-field amplitude (e) and near-field phase (f) at 633 nm. The white or correspondingly colored (60 nm, brown; 95 nm, gray; 170 nm, green) circles in (b), (c), (e), and (f) outline the nickel nanodisk dimensions.

Ni nanowires, Co or Au/iron garnet films perforated with holes, ferrimagnetic garnet films incorporating Au particles, Co/Ag core-shell nanoparticles, or Co/Pt multilayers deposited on arrays of polystyrene spheres.

Notably, so far, the use of LSPs in pure ferromagnets has been hampered by the notion of high Ohmic losses in these materials, which partially suppress the excitation of LSPs. In the present work, we introduce a new perspective on magnetoplasmonics in nanoferromagnets by exploiting the phase tunability of the optical polarizability due to LSPs and simultaneous magneto-optical activity. We show how LSPs in pure ferromagnetic nanostructures, despite the high Ohmic losses, can be exploited to achieve a controlled manipulation of the MO response of Ni nanostructures. The ferromagnetic nature of the material allows the investigation of MO phenomena, whereas the plasmonic nature allows exploring intrinsic features of the polarizability and its strong dependence on the external dielectric medium, to control a plasmon-modified MO response. We demonstrate how the concerted action of nanoplasmonics and magnetization can manipulate the sign of rotation of the reflected light's polarization (i.e., to produce Kerr rotation reversal) in ferromagnetic nanomaterials and, further, how this effect can be dynamically controlled and employed to devise conceptually new schemes for biochemosensing.

“Ferromagnetic nanoantennas for the control of scattered-light polarization”

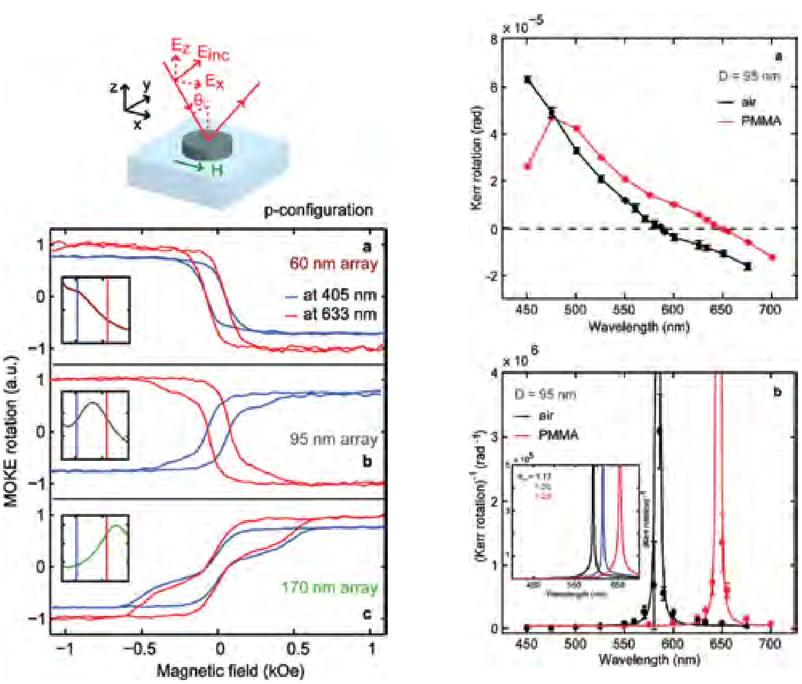


Figure 2

Left panel: Normalized *p*-polarization magneto-optic Kerr (MOKE) rotation hysteresis loops on nickel nanodisks of 60 (a), 95 (b), and 170 nm (c), using two different excitation wavelengths [405 nm (blue) and 633 nm (red)]. The sketch on top is schematic of the MOKE configuration used. The insets schematically show far-field extinction spectra for the corresponding nanodisk types in relation to the two excitation wavelengths of MOKE experiments. Right panel: (a) Experimental wavelength dependence of the MOKE rotation on 95 nm nickel disks in air (black symbols) and in PMMA (red symbols). (b) Corresponding experimental inverse Kerr rotation for 95 nm nanodisks in air (black symbols) and in PMMA (red symbols). The lines are to guide the eye. The inset shows the calculated inverse Kerr rotation in media with three different surrounding refractive indices [nm = 1.17 (black), 1.20 (blue), 1.23 (red)] for nickel nanodisks with diameter 100 nm and thickness 30 nm.

6 *Proposal of a one-dimensional electron gas in the steps at the $LaAlO_3$-$SrTiO_3$*

Physical Review Letters **108**, 166802 (2012)
N. C. Bristowe, T. Fix, M. G. Blamire, P. B. Littlewood, and **E. Artacho**

The recent discovery of a two-dimensional electron gas (a metallic sheet of nanometric width) at the interface between two insulating oxides opened up enormous new possibilities for new electronic devices. The recent understanding of its origin has led us to the proposal of equally thin conducting wires (one-dimensional electron gas) along the step edges of the same interfaces when grown on substrates with stepped surfaces. These electron nanowires embedded in oxide structures could be coupled to many kinds of materials with very different properties, from multiferroic to superconducting, thereby allowing switching on and off the wire with different possible external control signals, possibly allowing for smaller, cheaper, more energy efficient, and/or faster electronics.

Perovskite oxides offer an enormous plethora of materials with different useful and controllable properties, including ferroelectric, ferromagnetic, ferroelastic, multiferroic (coupling any of the previous), high-temperature superconducting, and magnetoresistive, to name a few. Nanometer-scale artificial structures, such as thin films or superlattices allow cross coupling of many of these properties. It is thus not surprising that when in 2004 a two-dimensional electron gas was found at the interfaces between two insulating materials within this class, it was received with enormous interest. It has given rise to vast numbers of publications related to the characterization, origin, and possible extensions of the systems observed.

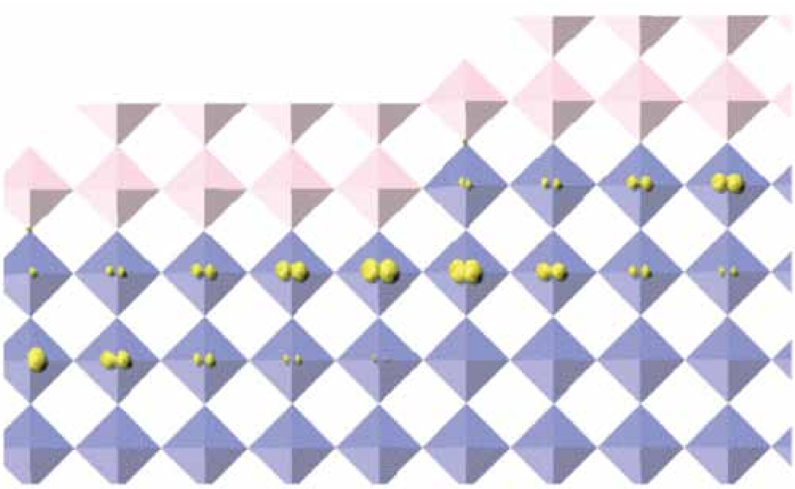


Figure 1
On a cross section of the interface, the two different materials being depicted with different colour octahedra, an isosurface for the density of the electron carriers is depicted. It goes infinitely in the direction perpendicular to the plot. It can be seen how the carriers concentrate close to the step edges.

From a purely scientific point of view, the appearance of a sheet of mobile electrons at the interface of such insulating materials is at first quite odd. The interface is quite ideally ordered and the atoms of the two materials match quite perfectly, so that one would expect the system to remain insulating. The fundamental reason behind the observations, however, comes from basic electrostatics - Gauss's law. The two oxides have different bulk polarization, which generates a huge electric field across the film attracting mobile electrons to the interface, wherever they may come from.

Having understood that, one can take a further step and note that the step edges in a stepped interface generate a polar discontinuity as well. Indeed, the same arguments explaining the above predict the attraction of electronic carriers (electrons or holes) to step edges at the interface. We confirmed the prediction using first-principles calculations on a system with two identical interfaces. The flat interfaces displayed the same density of carriers, but when stepped, carriers from around the step edges of one interface moved across to the step edges of the other. It then just takes some further analysis to realize for what conditions (character of the interfaces, character of the steps, thickness of the layer, and separation between steps) one can get a one-dimensional electron gas. The science behind it is quite fundamental and the arguments quite robust. It is a matter of being able to control experimentally the quality of the structure needed. Interestingly, though, it is a result for pristine systems, unlike other kinds of electron-gas realizations that critically depend on the presence of impurity atoms in the underlying material.

“One can produce nanowires for electron conduction embedded within materials that display a huge variety of interesting properties”

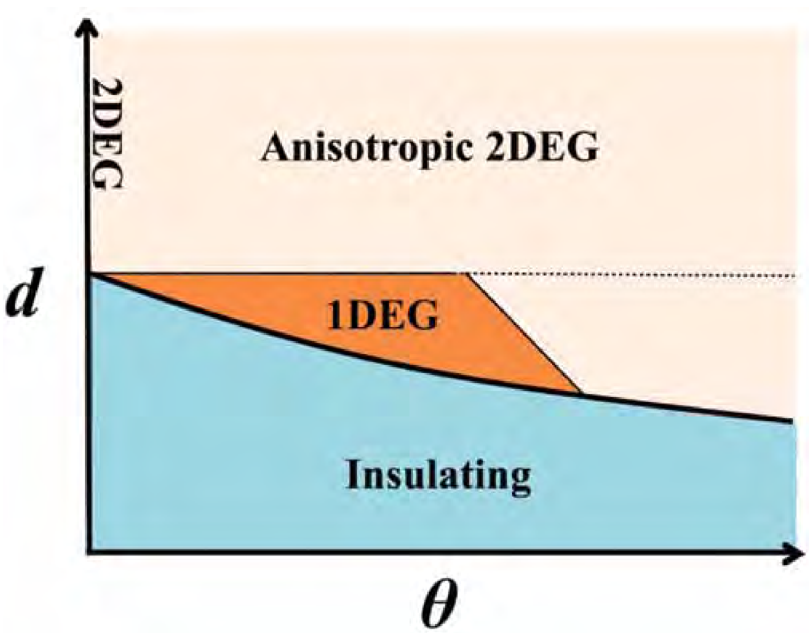


Figure 2

Expected phase diagram for the different conduction behaviours, as a function of film thickness, *d*, and angle of deviation from the flat interface, θ (the distance between steps diverges for θ tending to zero). On the vertical axis, for θ = 0, we have the known behaviour for flat interfaces: a two-dimensional electron gas beyond a minimum critical thicknesses, and an insulating interface for thinner films. For very separated steps and thicknesses close to critical, electron carriers are expected to appear close to steps only, therefore giving a one-dimensional electron gas. For higher thickness and/or lower distance among the steps, the electrons will span the interfacial plane, giving two-dimensional conduction, although the conduction along the two directions in the plane will be different (anisotropic two dimensional electron gas).

7 Magneto-optical magnetometry of individual 30 nm cobalt nanowires grown by electron-beam induced deposition

Applied Physics Letters **100**, 142401-142404 (2012). Selected for the Virtual Journal of Nanoscale Science & Technology.
E. Nikulina, **O. Idigoras**, **P. Vavassori**, **A. Chuvilin**, and **A. Berger**

It is demonstrated that magnetometry measurements based upon the magneto-optical Kerr effect and high-resolution optical microscopy can be used as a noninvasive probe of magnetization reversal for individual nanostructures. Our measurements demonstrate single-pass hysteresis loop measurements for sample sizes down to 30 nm width. A quantitative signal-to-noise ratio evaluation shows that the nanoGUNE approach achieves an at least 3-fold improvement in sensitivity if compared to focused laser based nanomagnetometry. An analysis of the physical limits of the here presented detection scheme allows an estimation that measurements for structures with single-digit nm widths and magnetic moments of only 10^{-16} Am^2 are feasible by far-field optical measurements.

Miniaturization of ferromagnetic elements is a key thrust area in the field of magnetism and relevant for a wide range of applications, such as magnetic devices for high-density storage, magnetic-field sensors, biosensors, and logic elements. Continuous advances in nanofabrication technology are therefore pushing the dimensions of ferromagnetic structures into the realm of the extreme nanoscale regime. In this paper, we report on the fabrication of high-purity ultrasmall Co nanostructures with lateral dimensions down to 30 nm and high-sensitivity measurements of their magnetic properties by means of Magneto-Optic Kerr-Effect (MOKE) magnetometry. All magnetic structures have been fabricated via focused-electron-beam induced deposition (FEBID). FEBID resembles "drawing" by means of an electron beam on a substrate in presence of gas precursor molecules. It is a one-step technique providing high deposition resolution (possibly to the 1 nm size scale) as well as the possibility of engineering 3-dimensional nanostructures.

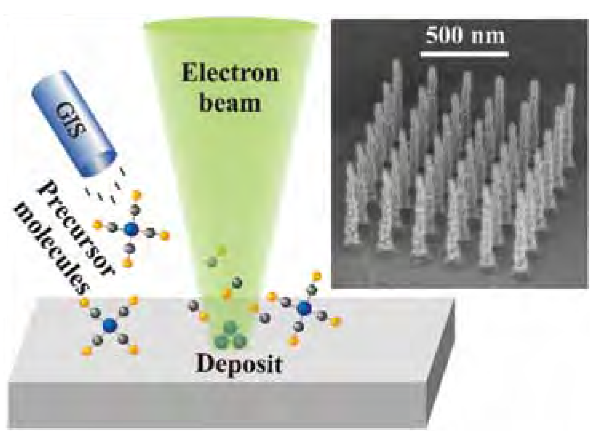


Figure 1
Schematics of the FEBID process; the inset shows a scanning-electron-microscopy image of a cobalt pillar array fabricated by FEBID.

> This approach achieves an at least 3-fold improvement in sensitivity

The magnetic analysis of the test structures was carried out with an optical wide-field polarization microscope optimized for MOKE microscopy. The key feature of our approach is that we can measure the field-dependent local magnetization, i.e., local hysteresis loops, by selecting an arbitrary region of interest (ROI) on the CCD camera pixel array, and use this array selection as a conventional light intensity detector. In this way, the magneto-optical difference signal $\Delta I/I_0$ is optimized and a very substantial improvement of the signal-to-noise (S/N) ratio is achieved, so much so that nanostructures far smaller than the optical diffraction limit can be characterized.

Applying this approach, we were able to record single-shot hysteresis loops with an individual data point S/N of 4.1 for a 20 nm high and 30 nm wide Co nanowire. By comparing our experimental results to other magnetometry techniques, it is clear that our MOKE-microscopy based magnetometry allows magnetic characterizations with sensitivities that are 2-3 orders of magnitude better than the latest-generation commercial SQUID instruments, for instance. Hereby, it is worth to note that in this study we have not reached the fundamental limit of our experimental approach. An analysis of the physical limits of our detection scheme enables us to estimate that measurements for structures with a single-digit nm width and magnetic moments in the range of 10^{-16} Am^2 will be feasible.

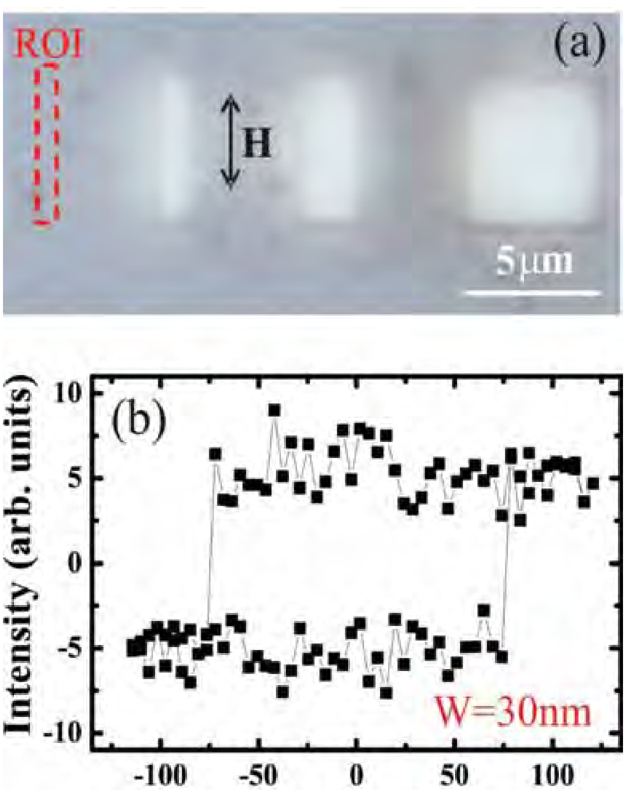


Figure 2

Optical-microscope image of a set of cobalt FEBID structures, as acquired by the MOKE enabled microscope; the red dashed frame shows schematically the ROI selected to enclose the thinnest cobalt line, which is only 30 nm wide and barely visible here. (b) Single-shot MOKE hysteresis loop signal using a ROI as indicated in panel (a) for the 30 nm wide wire.

8 *A light-controlled resistive switching memory*

Advanced Materials **24**, 2496-2500 (2012)
M. Ungureanu, **R. Zazpe**, **F. Golmar**, **P. Stoliar**, **R. Llopis**, **F. Casanova**, and **L. E. Hueso**

Resistive switching memory devices are systems in which the electrical resistance of a material can be modulated between two non-volatile states by applying voltage pulses. These devices are some of the most promising candidates for the next generation of non-volatile computer memories, although they are also being investigated for other advanced applications such as bioinspired neuromorphic systems. Within our study, we demonstrate a metal-insulator-semiconductor resistive switching memory in which the resistance of the insulator can be controlled both by voltage-pulses and by light. Our devices (Figure 1) stem from the traditional voltage-pulses manipulated resistive memories, adding the light as an extra control parameter. This new design allows data encoding by using a certain light irradiance during the writing process and can be involved in the storage and transport of secured information.

The measured saturation current scales with the irradiance values of the light reaching the device surface (Figure 2). Thus we can also deduce the light-irradiance values by measuring the current at an appropriate applied voltage. This is equivalent to detecting in our system an extra capability of light sensor, offering an additional functionality to our memory devices.

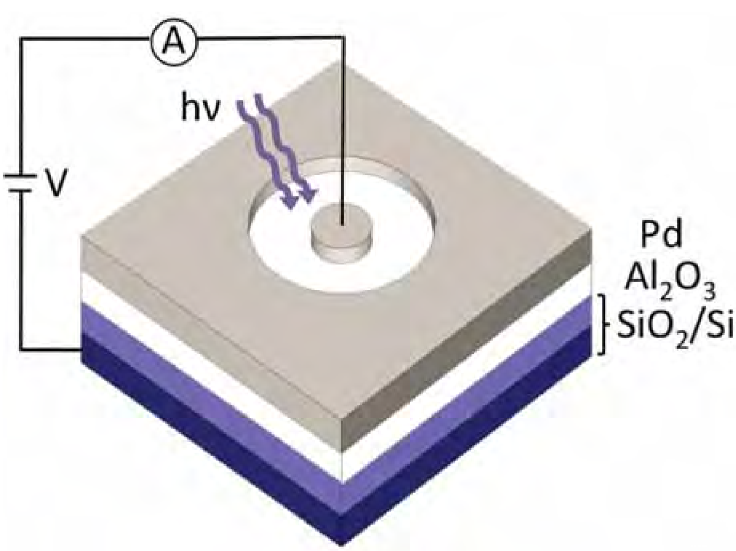


Figure 1
Schematic representation of our light-controlled resistive switching memory devices. An Al_2O_3 film is deposited on the SiO_2/Si substrate, followed by the fabrication of circular Pd top contacts. Around the top contacts, $Al_2O_3/SiO_2/Si$ rings, through which light is transmitted, are kept. The remaining surface is covered with Pd to block the light from reaching the optically active Si. The bottom electrical contact is on the *p*-doped Si substrate.

“These devices stem from the traditional resistive memories, adding the light as an extra control parameter”

The behavior of our light-controlled memory devices is based on the photogeneration of charge carriers in silicon under illumination. With suitable applied voltage pulses, the photogenerated electrons from the Si substrate are injected into the Al_2O_3 layer. A fraction of these electrons is then trapped in the Al_2O_3 layer, changing quasi-permanently its resistance state. When the device is measured in dark conditions, the current is strongly suppressed since photogeneration of charge carriers does not take place. Moreover, our devices work with low currents, below the μA. This low-current operation is beneficial for memory devices, meaning fast data processing and reduced heat dissipation. The results of our investigations offer the possibility for extra degrees of freedom to be exploited in prospective complex memory architectures.

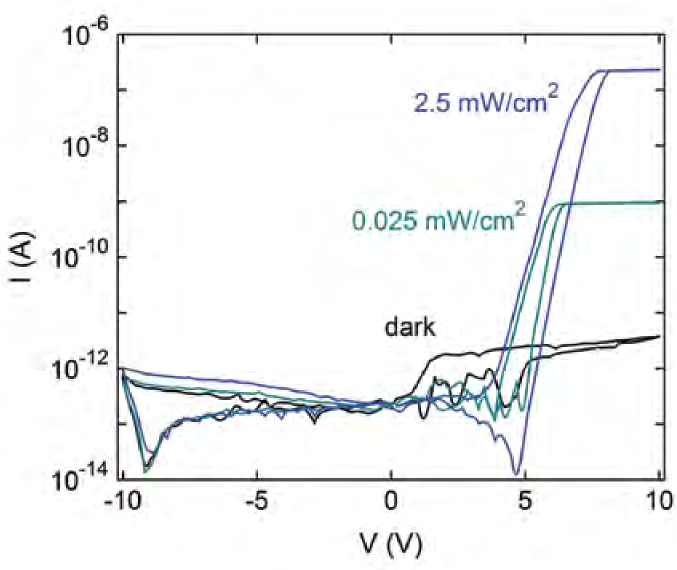


Figure 2

Current (I) - Voltage (V) curves for an $Al_2O_3/SiO_2/Si$ device on which light of different irradiances is shined. The saturation current, measured at 10 V, scales with the light irradiance reaching its surface.

9 *Optical nano-imaging of gate-tunable graphene plasmons*

Nature **487**, 77-81 (2012)
J. Chen, M. Badioli, **P. Alonso-González**, S. Thongrattanasiri, **F. Huth**, J. Osmond, M. Spasenovic, A. Centeno, A. Pesquera, P. Godignon, A. Zurutuza-Elorza, N. Camara, F. Javier Garcia de Abajo, **R. Hillenbrand**, and F. H. L. Koppens

The launch and detection of propagating optical plasmons in tapered graphene nanostructures using near-field scattering microscopy with infrared excitation light is reported. While optical graphene plasmon resonances had recently been investigated spectroscopically, no experiments so far had directly resolved propagating plasmons in real space. These results pave the way towards graphene-based optical transistors and a plethora of novel nanooptoelectronic devices and functionalities.

The article reports first ever visualizations of light guided with nanometric precision on graphene (a one-atom-thick sheet of carbon atoms). This visualization proves what theoretical physicists had long predicted; that it is possible to trap and manipulate light in a highly efficient way, using graphene as a novel platform for optical information processing and sensing. Synergies between theoretical proposals, specializations in graphene nanophotonics and nanooptoelectronics, and the experimental expertise in optical nanoimaging give rise to these noteworthy results.

Graphene is a material that, among many other fascinating properties, has an extraordinary optical behavior. Particularly interesting optical properties had been predicted for the case that light couples to so-called plasmons, wave-like excitations that were predicted to exist in the "sea" of free carriers of graphene. However, no direct experimental evidence of plasmons in graphene had been shown before. This is largely due to the dispersion mismatch between photons and graphene plasmons.

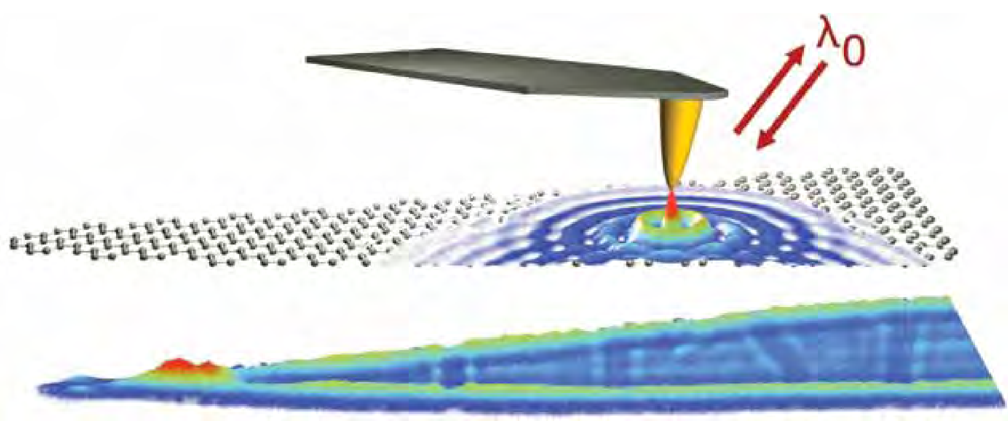
Here, the first experimental images of graphene plasmons are shown. A near-field optical microscope is used, with a sharp tip to convert the illumination light into a nanoscale light spot that provides the extra push needed for the plasmons to be created. At the same time, the tip probes the presence of plasmons (see Figure). As demonstrated here, graphene plasmons can be used to electrically control light in a similar fashion as is traditionally achieved with electrons in a transistor. These capabilities, which until now were impossible with other existing plasmonic materials, enable new highly efficient nanoscale optical switches that can perform calculations using light instead of electricity.

Near-field microscopy provides the first real-space images of propagating and localized plasmos in graphene

This work shows that graphene is an excellent choice for solving the long-standing and technologically important problem of modulating light at the speed of today's microchips. In addition, the capability of trapping light in very small volumes could give rise to a new generation of nanosensors with applications in diverse areas such as medicine and biodetection, solar cells and light detectors, as well as quantum information processing. This result literally opens a new field of research and provides a first viable path towards the ultrafast tuning of light, which was not possible before.

Figure

Optical nanoimaging of graphene plasmons. Upper panel: Sketch of the imaging method. A laser-illuminated scanning tip launches plasmons on graphene. The detection is achieved by recording the light backscattered from the tip. Lower panel: Optical image of graphene, where the fringes visualize the interference of graphene plasmons.



10 *Driving a macroscopic oscillator with the stochastic motion of a hydrogen molecule*

Science **338**, 779-782 (2012)
C. Lotze, **M. Corso**, K. J. Franke, F. von Oppen, and **J. I. Pascual**

In nature, processes like the motion of fluids, the intensity of electromagnetic signals, and the chemical composition are subject to random fluctuations that we normally call 'noise'. Noise is an energy source driving many phenomena in continuous evolution like, for example, earth climate, or the evolution of biological systems. Harvesting energy from noise is a paradigm that nature has shown to be possible.

Here it is demonstrated the possibility to use the energy of a moving hydrogen molecule to power up a "mechanical machine". It is found experimentally that the random motion of an individual hydrogen molecule can cause the motion of a macroscopic mechanical oscillator.

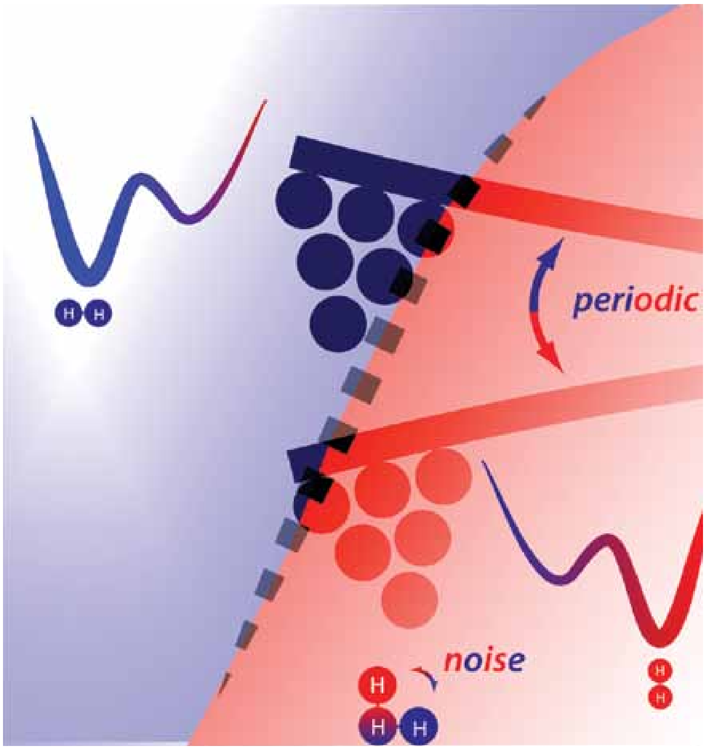
The underlying principle behind, known as stochastic resonance, uses the concerted motion of random hydrogen fluctuations and the periodic motion of a mechanical oscillator to amplify the energy transfer from the molecule to the oscillator. To couple their motion, the molecule was enclosed in the small gap between a flat surface and the sharp tip of an atomic-force microscope. The random motion of the molecule exerted forces against the tip, making it to oscillate. The oscillation of the tip, in turn, modulated the random motion of the hydrogen molecule and, hence, of the forces acting on itself. This resulted in a concerted "dance" of the tip with the noisy molecule. In this way, the tip oscillates distances larger than the size of the molecule using the energy extracted from the noise.

In the experiment, realized using an ultra-sensitive atomic-force microscope, the motion of the hydrogen molecule is induced by externally passing electrical currents through it, not by temperature, but nothing speaks against this effect occurring for molecular fluctuations induced by other sources of energy like, for example, light. The stochastic-resonance mechanism has been proposed to be behind biomolecular engines powering up the cellular activity. A promising aspect of this result is that it could be considered in the design of artificial molecular motors. In this way, energy from noisy environments could be extracted to drive the functional activity of a molecular motor like, for example, its unidirectional rotation.

> The 'noise' of a hydrogen molecule is transformed into mechanical energy

Figure

Representation of the concerted motion of an oscillating tip (the periodically moving system) and a H-H molecule switching between two positions (the noisy fluctuations). When the tip approaches closer to the molecule (indicated as red in the figure), the randomly moving molecule tends to spend more time in a configuration that pushes the tip upwards. For higher tip positions, the noisy molecule changes to a form (blue) with less effect on the tip. The periodically changing forces on the tip feed its motion.



NFO 12 conference

Conferences, workshops, and schools

Imaginenano
(11-14/04/2011)

- The largest European event on nanoscience and nanotechnology
- Organizers: Phantoms Foundation, DIPC, UPV/EHU, BEC, and nanoGUNE.
- More than 1 500 participants

Nanobiomedicine Seminar
(15/04/2011)

- Exploring the application of nanotechnology in neurodegenerative diseases
- Organizers: Inbiomed and nanoGUNE
- 60 participants

Spin challenges
(15/04/2011)

- Discussion forum about future trends in the fields of nanomagnetism and spintronics
- 45 participants

PCAM Summer School 2011
(4-7/07/2011)

- Electronic and Optical Properties of Nanoscale Materials
- Organizers: UPV/EHU, CFM, DIPC, and nanoGUNE
- 100 participants

EM Opening Workshop
(16-17/06/2011)

- On the latest developments in the field of electron microscopy
- Organizers: FEI and nanoGUNE
- 70 participants

Train2 Sudoe Workshop on Nanomagnetism & Spintronics
(22-24/02/2012)

- Organizer: nanoGUNE
- 82 participants

nanoIKER Workshop
(12/03/2012)

- Strategic nanoscience research in the Basque Country
- Organizer: nanoGUNE
- 60 participants

NFO12
(3-7/09/2012)

- One of the most important international conferences addressing optics at the nanometer scale
- Organizers: DIPC and nanoGUNE
- 424 participants in the conference and 115 participants in the school (held at nanoGUNE)

5th Nanolito Workshop
(13-15/11/2012)

- Strengthening research in nanolithography
- Organizer: nanoGUNE
- 75 participants

Invited Talks

2011

Nanofluidics in viral tubes
02/03/2011, **Alexander Bittner**
Schloss Ringberg Conference Abt. Dietrich, Tegernsee (Germany)

Virus/metal (oxide) hybrids
17/03/2011, **Alexander Bittner**
Ednano8 Conference, Milan (Italy)

IR and THz near-field nanoscopy
21/03/2011, **Rainer Hillenbrand**
APS March Meeting 2011, Dallas (USA)

Magnetic information in the light diffracted by arrays of nanometer-scale magnets
11/04/2011, **Paolo Vavassori**
Imaginenano 2011, Bilbao (Spain)

Technology of hard disk drives
11/04/2011, **Andreas Berger**
Imaginenano 2011, Bilbao (Spain)

Hysteresis loop based characterization of nanoscale granular magnetic materials
09/05/2011, **Andreas Berger**
8th International Symposium on Hysteresis and Micromagnetics Modeling, Levico (Italy)

Vector near-field nanoscopy of mid-infrared antennas
15/05/2011, **Rainer Hillenbrand**
5th International Conference on Surface Plasmon Photonics (SPP5 2011), Busan (Korea)

Mid-infrared nanophotonics based on antennas and transmission lines
17/06/2011, **Rainer Hillenbrand**
CLEO/Europe-EQEC, Munich (Germany)

Mid-infrared nanophotonics based on antennas and transmission lines
26/06/2011, **Rainer Hillenbrand**
International Conference on Materials for Advanced Technologies (ICMAT 2011), Singapore

Spin injection and diffusion in metallic lateral spin valves
03/07/2011, **Felix Casanova**
7th International Workshop on Magnetism and Superconductivity at the Nanoscale, Coma-Ruga (Spain)

IR and THz near-field nanoscopy
04/07/2011, **Rainer Hillenbrand**
PCAM Summer School 2011: Electronic and Optical Properties of Nanoscale Materials, San Sebastian (Spain)

Tuning of magnetization reversal in nanosized magnets
12/09/2011, **Paolo Vavassori**
2011 International Conference on Electromagnetics in Advanced Applications (ICEAA2011), Turin (Italy)

Squeezing magnetic vortices in nanostructures
19/09/2011, **Paolo Vavassori**
Nanoscience & Nanotechnology 2011, Rome (Italy)

Magneto-optical materials characterization
24/10/2011, **Andreas Berger**
3rd Chilean School on Magnetism, Viña del Mar (Chile)

Magnetization reversal in nanoscale granular materials
25/10/2011, **Andreas Berger**
3rd Chilean School on Magnetism, Viña del Mar (Chile)

Biological nanoobjects in artificial nanostructures
14/11/2011, **Alexander Bittner**
Nano SWEC Bio-Inspired Nanotechnologies, Bordeaux (France)

Invited Talks

Thin-film fabrication and nanoscale processing for magnetic, spintronic, and plasmonic research and applications
17/11/2011, **Andreas Berger**
5th International Conference on Innovations in Thin-Films Processing and Characterization, Nancy (France)

Nanoscale fabrication for magnetic, spintronic, and plasmonic research and applications
21/11/2011, **Andreas Berger**
Trends in Nanotechnology (TNT2011), Tenerife (Spain)

2012

Nanofocusing of mid-infrared light
25/01/2012, **Rainer Hillenbrand**
SPIE Photonics West: The Conference and Marketplace for the Photonics, Biophotonics, and Laser Industry, San Francisco (USA)

Generation and manipulation of pure spin currents
25/01/2012, **Felix Casanova**
VII Reunión Grupo Especializado de Física del Estado Sólido, Sevilla (Spain)

Electron-beam-induced deposition of cobalt nanostructures
07/02/2012, **Andreas Berger**
Magnetic Single Nano-Object Workshop & School, Nancy (France)

Origin of 2DEG at oxide interfaces, relation with topology and redox defects, and possible 1DEG
20/02/2012, **Emilio Artacho**
Towards Reality in Nanoscale Materials V, Levi (Finland)

Peptide fibers: Electrospinning from solutions, molecular vibrational analysis
27/02/2012, **Alexander Bittner**
Nanospain 2012, Santander (Spain)

Magneto-optical measurement techniques for magnetic materials metrology
08/03/2012, **Andreas Berger**
8th International Conference on Industrial Dimensional Metrology, Bilbao (Spain)

Challenges and progress in the atomistic simulation of liquid water and wet interfaces
13/03/2012, **Emilio Artacho**
1st Baskrete Workshop – Industry Open Days, San Sebastian (Spain)

Materials design by atomic layer deposition
27/03/2012, **Mato Knez**
DPG Spring Meeting (Geade-prize lecture), Berlin (Germany)

Biomedical applications of magnetic nanoparticles and nanostructures
29/03/2012, **Paolo Vavassori**
9th International Life-science Meeting, Krems (Austria)

Real-space mapping of infrared plasmons on antennas, transmission lines, and graphene
10/04/2012, **Rainer Hillenbrand**
2nd International Conference on Frontiers of Plasmonics, Sichuan (China)

Constrained domain walls in magnetic nanostructures for the manipulation and detection of individual nanoparticles in biocompatible environments
10/04/2012, **Paolo Vavassori**
MRS Spring Meeting & Exhibit, San Francisco (USA)

Graphenic insulators: Topological considerations and the implications
25/04/2012, **Emilio Artacho**
Chemical and Topological Functionalization of Graphitic Surfaces: Open Challenges for Computational Modeling, Lausanne (Switzerland)

Invited Talks

Controlled displacement of constrained domain walls in magnetic nanostructures for the manipulation of individual nanoscale particles in biocompatible environments
29/04/2012, **Paolo Vavassori**
International Conference on Superconductivity and Magnetism, Kumburgaz-Istanbul (Turkey)

Magneto-optical measurement techniques for magnetic materials metrology
03/05/2012, **Andreas Berger**
SUDOE Nanometrology Workshop, Bellaterra (Spain)

Hot-electron spin transport in C_{60} fullerene
07/05/2012, **Luis Hueso**
IEEE International Magnetics Conference, Vancouver (Canada)

Nano and near-field spectroscopy
11/05/2012, **Rainer Hillenbrand**
CLEO 2012: Laser Science to Photonic Applications, San José (USA)

Peptide fibers: Electrospinning and nanoscale wetting of peptide and protein fibers
13/05/2012, **Alexander Bittner**
E-MRS Spring Meeting 2012, Strasbourg (France)

Perspectives of thin-film processing in materials research
16/05/2012, **Mato Knez**
Journées Scientifiques des C'Nano PACA, Île de Porquerolles (France)

Bumpy road towards superconducting electronics - Superconductivity in the presence of a magnetic field
04/06/2012, **Anna Suszka**
Greater Poland Regional Nanotechnology Forum, Pomerania (Poland)

Plant viruses - Future of nanotechnology?
04/06/2012, **Marcin Gorzny**
Greater Poland Regional Nanotechnology Forum, Pomerania (Poland)

Towards a first-principles simulation of electron heating in radiation damage; between liquids and plasmas
22/06/2012, **Emilio Artacho**
MATGEN-IV School on Frontiers of Computational Materials Science, Santa Fe (USA)

Electronic stopping power from first principles
24/06/2012, **Emilio Artacho**
Computer Simulations of Radiation Effects in Solids, Santa Fe (USA)

Magneto-optic properties of nanostructures
04/07/2012, **Paolo Vavassori**
nanoSELECT Annual Meeting: Advanced Materials and Nanotechnologies for Innovative Electrical, Electronic, and Magnetoelectronic Devices, Sant Feliu de Guíxols (Spain)

Biological uptake pathway for cellular delivery of nanomaterials
05/07/2012, **Lianbing Zhang**
31st IUBS General Assembly and Conference on Biological Sciences and Bioindustry, Sozhou (China)

Infrared near-field spectroscopy: From nanoscale chemical identification of polymers to real-space imaging of graphene plasmons
09/07/2012, **Rainer Hillenbrand**
Seeing at the Nanoscale, Bristol (UK)

The interaction of a biological tube with particles and with liquids
08/07/2012, **Alexander Bittner**
Ordered and Non-Ordered Superstructures of Nanosized Objects: Preparation, Properties, Applications, and Modeling, Dresden (Germany)

Invited Talks

Infrared nanospectroscopy and nanophotonics based on antennas and transmission lines
23/07/2012, **Rainer Hillenbrand**
International Conference on Nanoscience and Technology, Paris (France)

Infrared nanospectroscopy of plasmons in semiconductors, metal nanoantennas, and graphene
27/07/2012, **Rainer Hillenbrand**
Low-Energy Electrodynamics in Solids, Napa (USA)

Construction and architecture of virus-inorganic nanostructures
19/08/2012, **Alexander Bittner**
63rd Annual Meeting of the International Society of Electrochemistry: Electrochemistry for Advanced Materials, Technologies, and Instrumentation, Prague (Czech Republic)

Real-space mapping of infrared plasmons on antennas, transmission lines, and graphene
30/08/2012, **Rainer Hillenbrand**
17th International Workshop on Microchip Plasmonics, Erlangen (Germany)

Molecular electronics
03/09/2012, **Luis Hueso**
European School on Nanoscience and Nanotechnology, Grenoble (France)

Experimental verification of the shift between near-field and far-field peak intensities in plasmonic nanoantennas
03/09/2012, **Pablo Alonso-González**
12th International Conference on Near-Field Optics, Nanophotonics, and Related Techniques, San Sebastian (Spain)

Complex response of superconductivity to inhomogeneous magnetization states in epitaxial Nb/DyFe$_2$/YFe$_2$]23 multilayer
03/09/2012, **Anna Suszka**
Superconducting Nanohybrids Workshop, San Sebastian (Spain)

Probing magnetization reversal at the nanoscale
09/09/2012, **Paolo Vavassori**
Joint European Magnetic Symposia, Parma (Italy)

C_{60} spintronic devices
11/09/2012, **Luis Hueso**
4th International Meeting on Spins in Organic Semiconductors, London (UK)

Sensing elementary processes in molecular junctions through force and light spectroscopy
12/09/2012, **José Ignacio Pascual**
Workshop at Prof. Rieder Dept., Free University of Berlin (Germany)

Infrared near-field spectroscopy - From nanoscale chemical identification of polymers to real-space imaging of graphene plasmons
14/09/2012, **Rainer Hillenbrand**
Congreso Fuerzas y Túnel 2012, San Lorenzo de El Escorial (Spain)

TDDFT and its application to energy deposition of slow projectiles in metals and insulators
16/09/2012, **Emilio Artacho**
19th International Workshop on Inelastic Ion-Surface Collisions, Frauenchiemsee (Germany)

Bioinorganic nanoparticles as catalysts and trojan horses
01/10/2012, **Mato Knez**
Ringberg symposium, Tegernsee (Germany)

Infrared nanospectroscopy - From nanoscale chemical identification of polymers to real-space imaging of graphene plasmons
03/10/2012, **Rainer Hillenbrand**
Spanish Conference on Nanophotonics, Carmona (Spain)

Nanoscience and Nanotechnology
06/10/2012, **Jose M. Pitarke**
Iran Nano Forum 2012, Tehran (Iran)

Invited Talks

The interaction of liquids with virus tubes and with protein fibers
07/10/2012, **Alexander Bittner**
ECI Fibrous Protein Nanocomposites, Crete (Greece)

Functional nanoparticle assemblies by atomic layer deposition
10/10/2012, **Mato Knez**
International Conference on ALD Applications, Shanghai (China)

Fabrication of individual nanomagnets and nanomagnet arrays by electron-beam-induced deposition and focused-ion-beam modification
25/10/2012, **Andreas Berger**
Workshop on Surface/Interface Effects in Nanomagnets, Porto (Portugal)

Molecular spintronics
31/10/2012, **Luis Hueso**
5th European School on Molecular Nanoscience, Cuenca (Spain)

Probing molecular excitations with tunneling electrons
08/11/2012, **José Ignacio Pascual**
1st Workshop on Fabrication and Properties of Nanostructures, Alicante (Spain)

Nanoscale magnetism research at nanoGUNE
20/11/2012, **Andreas Berger**
nanoGUNE/Tecnion/BNC-B Symposium, Barcelona (Spain)

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 and are announced at **www.nanogune.eu/seminars**

2011

PhD at the University of the Basque Country
24/01/2011, **Enrique Zarate**
nanoGUNE

Supramolecular spintronic devices
27/01/2011, **Mario Ruben**
Karlsruher Institut für Technologie (Germany)

Electronic and spin reconstruction at complex oxide interfaces
31/01/2011, **Jacobo Santamaría**
Complutense University of Madrid (Spain)

Influence of the crystallographic order onto magnetization reversal in granular uniaxial Co films
07/03/2011, **Olatz Idigoras**
nanoGUNE

Nanofocusing of infrared light with antennas and transmission lines
14/03/2011, **Martin Schnell**
nanoGUNE

Microliter-electrospinning of biomolecules
21/03/2011, **Wiwat Nuasing**
nanoGUNE

Electron-beam induced cobalt deposition
04/04/2011, **Elizaveta Nikulina**
nanoGUNE

Spintronics
08/04/2011, **Samuel Bader**
Argonne National Laboratory (USA)

Current-induced magnetization dynamics
02/05/2011, **Mathias Kläui**
Laboratory of Nanomagnetism and Spin Dynamics, EPFL (Switzerland)

Resistive switching in HfO_2 thin films
16/05/2011, **Raul Zazpe**
nanoGUNE

Breakdown of the Ising-like behavior in elliptical nanomagnets induced by dipolar interactions
23/05/2011, **José María Porro**
nanoGUNE

Nanoscale free-carrier profiling of individual semiconductor nanowires by infrared near-field spectroscopy
30/05/2011, **Johannes Stiegler**
nanoGUNE

Pure spin currents: Discharging spintronics
02/06/2011, **Axel Hoffmann**
Argonne National Laboratory (USA)

Opening the black box of Physical Review Letters
06/06/2011, **Daniel Ucko**
Physical Review Letters (USA)

How physics and modern computers have revolutionized imaging
28/07/2011, **Paul-Scott Carney**
University of Illinois (USA)

New challenges and opportunities in nanoplasmonics: From transformation-optics cavity design to applications in biosensing and solar light harvesting
01/08/2011, **Stefan Maier**
Imperial College, London (UK)

Light-dependent resistive switching in metal/Al_2O_3/SiO_2/Si devices: Memory and sensor applications.
12/09/2011, **Mariana Ungureanu**
nanoGUNE.

Nanomagnetism in the air "Hamburg-Donostia: back and forth"
19/09/2011, **Hans-Peter Oepen**
University of Hamburg (Germany)

Assembly of nanoscale building blocks to control the collective magnetic behavior through specific interfaces
26/09/2011, **Veronica Salgueiriño**
University of Vigo (Spain)

Whispering gallery-mode resonators with J-aggregates
03/10/2011, **Dmitry Melnikau**
nanoGUNE

Genetic and chemical modifications of Tobacco mosaic virus derivatives for nanotechnology and materials sciences
10/10/2011, **Sabine Eiben**
University of Stuttgart (Germany)

Viral cages for drug delivery
24/10/2011, **Marcin Gorzny**
nanoGUNE

Seminars

Resistive-switching-based non-volatile multilevel memory cells
31/10/2011, **Pablo Stoliar**
CONICET (Argentina)

Electron Microscopy lab - A guided tour
08/11/2011, **Andrey Chuvilin**
nanoGUNE

Towards the near-field tomography
21/11/2011, **Alexander Govyadinov**
nanoGUNE

Magnetic nanostructures; confinement, proximity, and induced phenomena
29/11/2011, **Ivan Schuller**
University of California San Diego (USA)

Exchange bias revisited
12/12/2011, **Anna Suszka**
nanoGUNE

Electric-field control of magnetic-domain wall motion and local magnetization dynamics in multiferroic heterostructures
13/12/2011, **Sebastiaan van Dijken**
Aalto University (Finland)

2012

How to glue negatively charged particles to a negatively charged rod
16/01/2012, **Abid A. Khan**
nanoGUNE

Chirality switching and ultra-fast vortex domain wall motion in magnetic nanotubes
23/01/2012, **Pedro Landeros**
Technical University Federico Santa María (Chile)

Is gold in silicon a negative-U center?
30/01/2012, **Fabiano Corsetti**
nanoGUNE

High throughput statistical approaches in label-free biosensing
3/02/2012, **Filippo Bosco**
Technical University (Denmark)

Magneto-plasmonics of graphene
13/02/2012, **Alexey Kuzmenko**
University of Geneva (Switzerland)

A C_{60}-based hot-electron magnetic tunnel transistor
20/02/2012, **Amilcar Bedoya**
nanoGUNE

Generalized magneto-optical ellipsometry for systems with optical anisotropy
27/02/2012, **Juan González-Díaz**
nanoGUNE

Synthesis and evaluation of the application potential of ferritin-encapsulated metal nanoparticles
05/03/2012, **Lianbing Zhang**
nanoGUNE

Electronic reconstructions in hybrid C/BN heterostructures
29/03/2012, **Miguel Pruneda**
Catalan Institute of Nanotechnology (CIN2), Barcelona (Spain)

Combined theoretical-experimental studies of defect-interface interactions in oxides
02/04/2012, **Blas Uberuaga**
Los Alamos National Laboratory (USA)

Femtosecond magnetism
16/04/2012, **Mirko Cinchetti**
Technical University Kaiserslautern (Germany)

Magnetism in oxide nanoparticles
24/04/2012, **Miguel A. García-Tuñón**
Institute of Ceramics and Glass (CSIC), Madrid (Spain)

Experimental search for spin-polarized transport in intrinsically conductive organic semiconductors
30/04/2012, **Thales de Oliveira**
nanoGUNE

Interface engineering for morphology controlling in organic thin-film transistors
07/05/2012, **Xiangnan Sun**
nanoGUNE

Polymer embedded magnetic micro and nanostructures
14/05/2012, **Marco Donolato**
nanoGUNE

Determination of the coalescence temperature of latexes by environmental scanning electron microscopy
21/05/2012, **Edurne González**
Polymat UPV/EHU, San Sebastian (Spain)

Tutorial on Van der Waals forces and colloidal interactions
23/05/2012, **Adrian Parsegian**
University of Massachusetts Amherst (USA)

High-speed high-resolution atomic-force microscopy
24/05/2012, **Stephen Minne**
Vecco - Bruker, Santa Barbara (USA)

Hybrid metal-carbon nanostructures
28/05/2012, **Maria del Carmen Giménez-López**
University of Nottingham (UK)

Seminars

Nanotechnology, ethics, and policy
28/05/2012, **Carl Mitcham**
University of Colorado (USA)

Optical nano-imaging of gate-tuneable graphene plasmons
04/06/2012, **Jianing Chen**
nanoGUNE

Ultra-doping germanium with atomic precision: nanowires, 2DEGs, and possibly 3D epitaxial circuits
12/06/2012, **Giordano Scappucci**
University of New South Wales (Australia)

Cooperative rearranging regions in water at biological and inorganic interfaces
14/06/2012, **Giancarlo Franzese**
University of Barcelona (Spain)

Application of nanotechnology in plant sciences: Efficient introduction of nanoparticles to plant cells
02/07/2012, **Susana Martin-Ortigosa**
Iowa State University (USA)

Integration of Tobacco mosaic virus in electron-beam-lithography nanostructures
16/07/2012, **José María Alonso**
nanoGUNE

Characterization of $PbTiO_3/SrTiO_3$ superlattices by means of first-principles simulations
23/07/2012, **Pablo Aguado**
University of Cantabria (Spain)

Nanoplasmonics: Quantum and non-local effects, nanoantennas for active plasmonics, and new applications
03/08/2012, **Stefan Maier**
Imperial College, London (UK)

The structure of liquid water
03/09/2012, **Emilio Artacho**
nanoGUNE

Germanium thin layer splitting and transfer using the smart-cut method
10/09/2012, **Fan Yang**
nanoGUNE

Spin accumulation and spin diffusion in aluminum using Hanle measurements
17/09/2012, **Oihana Txoperena**
nanoGUNE

Accessing the ground state in artificial spin-ice systems
01/10/2012, **José María Porro**
nanoGUNE

Fabrication of heterostructured nanoelectrodes through atomic layer deposition for next generation energy storage devices
22/10/2012, **Keith Gregorczyk**
University of Maryland (USA)

Biomolecules detection using a simple magneto-optical method
29/10/2012, **Marco Donolato**
nanoGUNE

Molecular Spintronics
30/10/2012, **Mario Rubén**
Karlsruher Institut für Technologie (Germany)

Stability and kinetics of divacancy defects in bilayer graphene from first principles
05/11/2012, **Jon Zubeltzu**
nanoGUNE

Infrared spectroscopic near-field microscopy of nanoparticles and semiconductor nanowires
12/11/2012, **Johannes Stiegler**
nanoGUNE

Interaction and analysis of nucleic acids with lipids
19/11/2012, **Felix Olasagasti**
Department of Biochemistry and Molecular Biology, UPV/EHU

Nanofluidics: From fundamentals to applications
26/11/2012, **Jan Eijkel**
University of Twente (The Netherlands)

Novel rare-earth quinolines on metallic surfaces: Interfacial effects and potential for organic spintronics
3/12/2012, **Amilcar Bedoya-Pinto**
nanoGUNE

Bose condensation of polaritons
10/12/2012, **Peter Littlewood**
Argonne National Laboratory (USA)

Quantum transport in disordered graphene: Scaling properties, magnetism, and spin relaxation mechanism
17/12/2012, **Stephan Roche**
Catalan Institute of Nanotechnology (CIN2), Barcelona (Spain)

What we have learned and what we still learn in soft matter electronic transport
18/12/2012, **Frank Ortman**
Catalan Institute of Nanotechnology (CIN2), Barcelona (Spain)

ISI Publications

	ISI Publications	Average Impact Factor	Citations
2011	28	9.3	510
2012	58	6.0	849

2011

M. Donolato, A. Torti, N. Kostesha, M. Deryabina, E. Sogne, P. Vavassori, M. F. Hansen, and R. Bertacco
Lab On a Chip **11**, 2976 (2011)
Magnetic domain wall conduits for single cell applications

M. C. Gimenez-Lopez, A. Chuvilin, U. Kaiser, and A. N. Khlobystov
Chemical Communications **47**, 2116 (2011)
Functionalized endohedral fullerenes in single-walled carbon nanotubes

L. A. Constantin and J. M. Pitarke
Physical Review B **83**, 075116 (2011)
Adiabatic-connection-fluctuation-dissipation approach to long-range behavior of exchange-correlation energy at metal surfaces: A numerical study for jellium slabs

J. C. Meyer, S. Kurasch, H. Jin Park, V. Skakalova, D. Kuenzel, A. Gross, A. Chuvilin, G. Algara-Siller, S. Roth, T. Iwasaki, U. Starke, J. H. Smet, and U. Kaiser
Nature Materials **10**, 209 (2011)
Experimental analysis of charge redistribution due to chemical bonding by high-resolution transmission electron microscopy

M. Navarro-Cia, M. Beruete, I. Campillo, and M. Sorolla
Physical Review B **83**, 115112 (2011)
Enhanced lens by ε and μ near-zero metamaterial boosted by extraordinary optical transmission

A. Rakovich, A. Sukhanova, E. Lukashev, V. Zagidullin, V. Pachenko, A. B. Rubin, Y. P. Rakovich, A. O. Govorov, I. Nabiev, and J. F. Donegan
Abstracts of Papers of the American Chemical Society **241** (2011)
Semiconductor quantum dots as light-harvesting antennae for artificial photosynthesis applications

D. Tripathy, P. Vavassori, and A. O. Adeyeye
Journal of Applied Physics **109**, 07B902 (2011)
Tailoring the magnetization reversal in antidot nanostructures using lithographically engineered inhomogeneities

M. Gobbi, F. Golmar, R. Llopis, F. Casanova, and L. E. Hueso
Advanced Materials **23**, 1609 (2011)
Room-temperature spin transport in C_{60}-based spin valves

M. Schnell, P. Alonso-Gonzalez, L. Arzubiaga, F. Casanova, L. E. Hueso, A. Chuvilin, and R. Hillenbrand
Nature Photonics **5**, 283 (2011)
Nanofocusing of mid-infrared energy with tapered transmission lines

F. Huth, M. Schnell, J. Wittborn, N. Ocelic, and R. Hillenbrand
Nature Materials **10**, 352 (2011)
Infrared-spectroscopic nanoimaging with a thermal source

N. Perez, F. Casanova, F. Bartolome, L. M. Garcia, A. Labarta, and X. Batlle
Physical Review B **83**, 184411 (2011)
Griffiths-like phase and magnetic correlations at high fields in Gd_5Ge_4

M. Navarro-Cia, M. Beruete, I. Campillo, and M. Sorolla
IEEE Transactions on Antennas and Propagation **59**, 2141 (2011)
Beamforming by left-handed extraordinary transmission metamaterial bi- and plano-concave lens at millimeter-waves

ISI Publications

A. Mueller, F. J. Eber, C. Azucena, A. Petershans, A. M. Bittner, H. Gliemann, H. Jeske, and C. Wege
ACS Nano **5**, 4512 (2011)
Inducible site-selective bottom-up assembly of virus-derived nanotube arrays on RNA-equipped wafers

A. Zabaleta, I. Gonzalez, J. I. Eguiazabal, and J. Nazabal
Polymer Engineering and Science **51**, 1428 (2011)
Structure, thermal stability, and mechanical properties of nanocomposites based on an amorphous polyamide

M. Navarro-Cia, M. Beruete, F. Falcone, J. M. Illescas, I. Campillo, and M. Sorolla
IEEE Transactions on Antennas and Propagation **59**, 2980 (2011)
Mastering the propagation through stacked perforated plates: Subwavelength holes vs. propagating holes

J. M. Stiegler, Y. Abate, A. Cvitkovic, Y. E. Romanyuk, A. J. Huber, S. R. Leone, and R. Hillenbrand
ACS Nano **5**, 6494 (2011)
Nanoscale infrared absorption spectroscopy of individual nanoparticles enabled by scattering-type near-field microscopy

D. Weber, P. Albella, P. Alonso-Gonzalez, F. Neubrech, H. Gui, T. Nagao, R. Hillenbrand, J. Aizpurua, and A. Pucci
Optics Express **19**, 15047 (2011)
Longitudinal and transverse coupling in infrared gold nanoantenna arrays: Long range versus short range interaction regimes

C. E. Rodriguez-Torres, F. Golmar, M. Ziese, P. Esquinazi, and S. P. Heluani
Physical Review B **84**, 064401 (2011)
Evidence of defect-induced ferromagnetism in $ZnFe_2O_4$ thin films

J. Chen, P. Albella, Z. Pirzadeh, P. Alonso-Gonzalez, F. Huth, S. Bonetti, V. Bonanni, J. Akerman, J. Nogues, P. Vavassori, A. Dmitriev, J. Aizpurua, and R. Hillenbrand
Small **7**, 2341 (2011)
Plasmonic nickel nanoantennas

T. Verduci, C. Rufo, A. Berger, V. Metlushko, B. Ilic, and P. Vavassori
Applied Physics Letters **99**, 09250 (2011)
Fourier magnetic imaging

P. Alonso-Gonzalez, M. Schnell, P. Sarriugarte, H. Sobhani, C. Wu, N. Arju, A. Khanikaev, F. Golmar, P. Albella, L. Arzubiaga, F. Casanova, L. E. Hueso, P. Nordlander, G. Shvets, and R. Hillenbrand
Nano Letters **11**, 3922 (2011)
Real-space mapping of Fano interference in plasmonic metamolecules

A. Chuvilin, E. Bichoutskaia, M. C. Gimenez-Lopez, T. W. Chamberlain, G. A. Rance, N. Kuganathan, J. Biskupek, U. Kaiser, and A. N. Khlobystov
Nature Materials **10**, 687 (2011)
Self-assembly of a sulphur-terminated graphene nanoribbon within a single-walled carbon nanotube

A. Bedoya-Pinto, C. Zube, J. Malindretos, A. Urban, and A. Rizzi
Physical Review B **84**, 104424 (2011)
Epitaxial delta-Mn(x)Ga(1-x) layers on GaN(0001): Structural, magnetic, and electrical transport properties

O. Idigoras, A. K. Suszka, P. Vavassori, P. Landeros, J. M. Porro, and A. Berger
Physical Review B **84**, 132403 (2011)
Collapse of hard-axis behavior in uniaxial Co films

D. Melnikau, D. Savateeva, A. Chuvilin, R. Hillenbrand, and Y. P. Rakovich
Optics Express **19**, 22280 (2011)
Whispering gallery mode resonators with J-aggregates

L. Giovannini, F. Montoncello, F. Nizzoli, P. Vavassori, and M. Grimsditch
Applied Physics Letters **97**, 152502 (2011)
Comment on "Mapping of localized spin-wave excitations by near-field Brillouin light scattering"

A. A. Govyadinov, G. Y. Panasyuk, J. C. Schotland, and V. A. Markel
Physical Review B **84**, 155461 (2011)
Theoretical and numerical investigation of the size-dependent optical effects in metal nanoparticles

V. Bonanni, S. Bonetti, T. Pakizeh, Z. Pirzadeh, J. Chen, J. Nogues, P. Vavassori, R. Hillenbrand, J. Akerman, and A. Dmitriev
Nano Letters **11**, 5333 (2011)
Designer magnetoplasmonics with nickel nanoferromagnets

ISI Publications

2012

P. Carney, B. Deutsch,
A. A. Govyadinov, and R. Hillenbrand
ACS Nano **6**, 8 (2012)
Phase in Nanooptics

R. Krutokhvostov, A. A. Govyadinov,
J. M. Stiegler, F. Huth, A. Chuvilin,
P. Carney, and R. Hillenbrand
Optics Express **20,** 593 (2012)
Enhanced resolution in subsurface near-field optical microscopy

A. K. Suszka, F. S. Bergeret, and
A. Berger
Physical Review B **85**, 024529 (2012)
Domain-wall-induced magnetoresistance in pseudo-spin-valve/superconductor hybrid structures

P. Alonso-Gonzalez, P. Albella,
M. Schnell, J. Chen, F. Huth, A. Garcia-Etxarri, F. Casanova, F. Golmar,
L. Arzubiaga, L. E. Hueso, J. Aizpurua,
and R. Hillenbrand
Nature Communications **3**, 684 (2012)
Resolving the electromagnetic mechanism of surface-enhanced light scattering at single hot spots

M. Gottwald, M. Hehn, D. Lacour,
T. Hauet, F. Montaigne, S. Mangin,
P. Fischer, M. -Y. Im, and A. Berger
Physical Review B **85**, 064403 (2012)
Asymmetric magnetization reversal in dipolarly coupled spin valve structures with perpendicular magnetic anisotropy

R. Alcaraz, J. M. Saiz, F. Moreno,
P. Vavassori, and A. Berger
Physical Review B **85**, 064414 (2012)
Transverse magneto-optical effects in nanoscale disks

M. Gobbi, A. Pascual, F. Golmar,
R. Llopis, P. Vavassori, F. Casanova, and
L. E. Hueso
Organic Electronics **13**, 366 (2012)
C_{60}/NiFe combination as a promising platform for molecular spintronics

D. Savateeva, D. Melnikau, V. Lesnyak,
N. Gaponik, and Y. P. Rakovich
Journal of Materials Chemistry **22**,
10816 (2012)
Hybrid organic/inorganic semiconductor nanostructures with highly efficient energy transfer

R. Gaudoin, I. G. Gurtubay, and
J. M. Pitarke
Physical Review B **85,** 125125 (2012)
Momentum-space finite-size corrections for quantum Monte Carlo calculations

A. M. Bittner, M. Zhu, Y. Yang,
H. F. Waibel, M. Konuma, U. Starke, and
C. J. Weber
Journal of Power Sources **203**, 262
(2012)
Ageing of electrochemical double layer capacitors

M. Donolato, F. Lofink, S. Hankemeier,
J. M. Porro, H. P. Oepen, and
P. Vavassori
Journal of Applied Physics **111**, 07B336
(2012)
Characterization of domain wall-based traps for magnetic beads separation

J. M. Porro, A. Berger, M. Grimsditch,
V. Metlushko, B. Ilic, and P. Vavassori
Journal of Applied Physics **111,** 07B913
(2012)
Effect of spatially asymmetric dipolar interactions in the magnetization reversal of closely spaced ferromagnetic nanoisland arrays

E. Nikulina, O. Idigoras, P. Vavassori,
A. Chuvilin, and A. Berger
Applied Physics Letters **100**, 142401
(2012)
Magneto-optical magnetometry of individual 30 nm cobalt nanowires grown by electron-beam-induced deposition

N. C. Bristowe, T. Fix, M. G. Blamire,
P. B. Littlewood, and E. Artacho
Physical Review Letters **108**, 166802
(2012)
Proposal of a one-dimensional electron gas in the steps at the $LaAlO_3$-$SrTiO_3$ interface

O. Idigoras, P. Vavassori, and A. Berger
Physica B-Condensed Matter **407**, 1377
(2012)
Mean field theory of dynamic phase transitions in ferromagnets

ISI Publications

A. Berger
Physica B-Condensed Matter **407,** 1322 (2012)
Magnetization reversal in granular thin films

F. Casanova, C. E. Chiang, A. M. Ruminski, M. J. Sailor, and I. K. Schuller
Langmuir **28**, 6832 (2012)
Controlling the role of nanopore morphology in capillary condensation

T. W. Chamberlain, J. Biskupek, G. A. Rance, A. Chuvilin, T. J. Alexander, E. Bichoutskaia, U. Kaiser, and A. N. Khlobystov
ACS Nano **6**, 3943 (2012)
Size, structure, and helical twist of graphene nanoribbons controlled by confinement in carbon nanotubes

A. Kumar, T. M. Arruda, Y. Kim, I. N. Ivanov, S. Jesse, C. W. Bark, N. C. Bristowe, E. Artacho, P. B. Littlewood, C. Eom, and S. V. Kalinin
ACS Nano **6**, 3841 (2012)
Probing surface and bulk electrochemical processes on the $LaAlO_3$-$SrTiO_3$ interface

I. Crassee, M. Orlita, M. Potemski, A. L. Walter, M. Ostler, Th. Seyller, I. Gaponenko, J. Chen, and A. B. Kuzmenko
Nano Letters **12**, 2470 (2012)
Intrinsic terahertz plasmons and magnetoplasmons in large-scale monolayer graphene

J. C. Meyer, F. Eder, S. Kurasch, V. Skakalova, J. Kotakoski, H. Jin Park, S. Roth, A. Chuvilin, S. Eyhusen, G. Benner, A. V. Krasheninnikov, and U. Kaiser
Physical Review Letters **108**, 196102 (2012)
Accurate measurement of electron-beam-induced displacement cross sections for single-layer graphene

M. Ungureanu, R. Zazpe, F. Golmar, P. Stoliar, R. Llopis, F. Casanova, and L. E. Hueso
Advanced Materials **24**, 2496 (2012)
A light-controlled resistive switching memory

J. A. Arregi, J. B. Gonzalez-Diaz, E. Bergaretxe, O. Idigoras, T. Unsal, and A. Berger
Journal of Applied Physics **111**, 103912 (2012)
Study of generalized magneto-optical ellipsometry measurement reliability

M. Erekhinsky, F. Casanova, I. K. Schuller, and A. Sharoni
Applied Physics Letters **100**, 212401 (2012)
Spin-dependent Seebeck effect in non-local spin valve devices

A. A. Correa, J. Kohanoff, E. Artacho, D. Sanchez-Portal, and A. Caro
Physical Review Letters **108**, 213201 (2012)
Nonadiabatic forces in ion-solid interactions: The initial stages of radiation damage

M. Ahsan Zeb, J. Kohanoff, D. Sanchez-Portal, A. Arnau, J. I. Juaristi, and E. Artacho
Physical Review Letters **108**, 225504 (2012)
Electronic stopping power in gold: The role of d electrons and the H/He anomaly

R. Hillenbrand
CLEO, Conference on lasers and Electro-Optics (2012)
Infrared nanophotonics

M. Donolato, B. T. Dalslet, and M. F. Hansen
Biomicrofluidics **6**, 024110 (2012)
Microstripes for transport and separation of magnetic particles

D. Savateeva, D. Melnikau, and Y. P. Rakovich
Journal of Nanoelectronics and Optoelectronics **7**, 297 (2012)
Energy transfer in hybrid organic/inorganic semiconductor nanostructures

H. Santos, A. Ayuela, L. Chico, and E. Artacho
Physical Review B **85**, 245430 (2012)
Van der Waals interaction in magnetic bilayer graphene nanoribbons

J. A. Arregi, O. Idigoras, P. Vavassori, and A. Berger
Applied Physics Letters **100**, 262403 (2012)
Field-orientation dependent decorrelation of magnetization reversal in uniaxial Co-films

ISI Publications

M. Knez
Semiconductor Science and Technology **27**, 074001 (2012)
Diffusion phenomena in atomic layer deposition

J. Chen, M. Badioli, P. Alonso-Gonzalez, S. Thongrattanasiri, F. Huth, J. Osmond, M. Spasenovic, A. Centeno, A. Pesquera, P. Godignon, A. Zurutuza-Elorza, N. Camara, F. Javier Garcia de Abajo, R. Hillenbrand, and F. H. L. Koppens
Nature **487**, 77 (2012)
Optical nano-imaging of gate-tunable graphene plasmons

P. Sarriugarte, M. Schnell, P. Alonso-Gonzalez, L. Arzubiaga, F. Golmar, F. Casanova, L. E. Hueso, and R. Hillenbrand
Optics Communications **285**, 3378 (2012)
Propagation and nanofocusing of infrared surface plasmons on tapered transmission lines: Influence of the substrate

A. Sukhanova, S. Poly, A. Shemetov, I. Bronstein, and I. Nabiev
Biopolymers **97**, 577 (2012)
Implications of protein structure instability: From physiological to pathological secondary structure

E. Gonzalez, C. Tollan, A. Chuvilin, M. J. Barandiaran, and M. Paulis
ACS Applied Materials & Interfaces **4**, 4276 (2012)
Determination of the coalescence temperature of latexes by environmental scanning electron microscopy

F. Huth, A. Govyadinov, S. Amarie, W. Nuansing, F. Keilmann, and R. Hillenbrand
Nano Letters **12**, 3973 (2012)
Nano-FTIR absorption spectroscopy of molecular fingerprints at 20 nm spatial resolution

A. Rosales-Rivera, N. A. Salazar, O. Hovorka, O. Idigoras, and A. Berger
Physica B-Condensed Matter **407**, 3141 (2012)
Determination of critical exponents of inhomogeneous Gd films

C. Castan-Guerrero, J. Sese, J. Bartolome, F. Bartolome, J. Herrero-Albillos, F. Kronast, P. Strichovanec, K. J. Merazzo, M. Vazquez, P. Vavassori, and L. M. Garcia
Journal of Nanoscience and Nanotechnology **12**, 7437 (2012)
Fabrication and magnetic characterization of cobalt antidot arrays: Effect of the surrounding continuous film

I. Garcia, J. Echeberria, G. N. Kakazei, V. O. Golub, O. Y. Saliuk, M. Ilyn, K. Y. Guslienko, and J. M. Gonzalez
Journal of Nanoscience and Nanotechnology **12**, 7529 (2012)
Evolution of the magnetic properties of $Co_{10}Cu_{90}$ nanoparticles prepared by wet chemistry with thermal annealing

M. Gobbi, A. Bedoya-Pinto, F. Golmar, R. Llopis, F. Casanova, and L. E. Hueso
Applied Physics Letters **101**, 102404 (2012)
C_{60}-based hot-electron magnetic tunnel transistor

X. Ao, X. Tong, D. Sik Kim, L. Zhang, M. Knez, F. Mueller, S. He, and V. Schmidt
Applied Physics Letters **101**, 111901 (2012)
Black silicon with controllable macropore array for enhanced photoelectrochemical performance

A. Torti, V. Mondiali, A. Cattoni, M. Donolato, E. Albisetti, A. M. Haghiri-Gosnet, P. Vavassori, and R. Bertacco
Applied Physics Letters **101**, 142405 (2012)
Single-particle demultiplexer based on domain wall conduits

A. S. Kumskov, V. G. Zhigalina, A. Chuvilin, N. I. Verbitskiy, A. G. Ryabenko, D. D. Zaytsev, A. A. Eliseev, and N. A. Kiselev
Carbon **50**, 4696 (2012)
The structure of 1D and 3D CuI nanocrystals grown within 1.5-2.5 nm single-wall carbon nanotubes obtained by catalyzed chemical vapor deposition

ISI Publications

W. Nuansing, A. Rebollo, J. M. Mercero, J. Zuniga, and A. M. Bittner
Journal of Raman Spectroscopy **43**, 1397 (2012)
Vibrational spectroscopy of self-assembling aromatic peptide derivates

J. M. Stiegler, R. Tena-Zaera, O. Idigoras, A. Chuvilin, and R. Hillenbrand
Nature Communications **3**, 1131 (2012)
Correlative infrared-electron nanoscopy reveals the local structure-conductivity relationship in zinc oxide nanowires

A. Strozecka, A. Eiguren, M. Bianchi, D. Guan, C. H. Voetmann, S. Bao, P. Hofmann, and J. I. Pascual
New Journal of Physics **14**, 103026 (2012)
Unconventional spin texture of a topologically nontrivial semimetal Sb(110)

A. K. Suszka, O. Idigoras, E. Nikulina, A. Chuvilin, and A. Berger
Physical Review Letters **109,** 177205 (2012)
Crystallography-driven positive exchange bias in Co/CoO bilayers

J. P. Perdew, J. Tao, P. Hao, A. Ruzsinszky, G. I. Csonka, and J. M. Pitarke
Journal of Physics-Condensed Matter **24**, 424207 (2012)
Spherical-shell model for the Van der Waals coefficients between fullerenes and/or nearly spherical nanoclusters

O. Hovorka, J. Pressesky, G. Ju, A. Berger, and R.W. Chantrell
Applied Physics Letters **101**, 182405 (2012)
Distribution of switching fields in magnetic granular materials

F. Golmar, M. Gobbi, R. Llopis, P. Stoliar, F. Casanova, and L. E. Hueso
Organic Electronics **13**, 2301 (2012)
Non-conventional metallic electrodes for organic field-effect transistors

R. A. Gallardo, O. Idigoras, P. Landeros, and A. Berger
Physical Review E **86**, 51101 (2012)
Analytical derivation of critical exponents of the dynamic phase transition in the mean-field approximation

C. Lotze, M. Corso, K. J. Franke, F. von Oppen, and J. I. Pascual
Science **338**, 779 (2012)
Driving a macroscopic oscillator with the stochastic motion of a hydrogen molecule

X. Tong, Y. Qin, X. Guo, O. Moutanabbir, X. Ao, E. Pippel, L. Zhang, and M. Knez
Small **8**, 3390 (2012)
Enhanced catalytic activity for methanol electro-oxidation of uniformly dispersed nickel oxide nanoparticles - carbon nanotube hybrid materials

A. Ruzsinszky, J. P. Perdew, J. Tao, G. I. Csonka, and J. M. Pitarke
Physical Review Letters **109**, 233203 (2012)
Van der Waals coefficients for nanostructures: Fullerenes defy conventional wisdom

M. Ungureanu, P. Stoliar, R. Llopis, F. Casanova, and L. E. Hueso
Plos One **7**, 1 (2012)
Non-hebbian learning implementation in light-controlled resistive memory devices

Y. Qin, R. Vogelgesang, M. Esslinger, W. Sigle, P. van Aken, O. Moutanabbir, and M. Knez
Advanced Functional Materials **22**, 5157 (2012)
Bottom-up tailoring of plasmonic nanopeapods making use of the periodical topography of carbon nanocoil templates

T. R. Umbach, M. Bernien, C. F. Hermanns, A. Krüger, V. Sessi, I. Fernandez-Torrente, P. Stoll, J. I. Pascual, K. J. Franke, and W. Kuch
Physical Review Letters **109**, 267207 (2012)
Ferromagnetic coupling of mononuclear Fe centers in a self-assembled metal-organic network on Au(111)

Cooperation agreements

University of the Basque Country (UPV/EHU)
08/02/2007 – 50 years
Land transfer for the nanoGUNE building
17/10/2008 - Unlimited
Cooperation and development of lecturers, researchers, and students
01/09/2011 – 4 years
Commodatum contract for the use of computing nodes and data storage
24/03/2011 – Unlimited
Collaboration agreement for the supervision of master and PhD students

Ikerbasque
10/01/2008 – Unlimited
Collaboration framework agreement

University of California San Diego
01/02/2008 – 5 years
Memorandum of Understanding

SPRI-nanoBasque
01/07/2008 – 5 years
Development of nanotechnology-based projects

Max Planck Institute for Solid State Research
10/10/2008 - Unlimited
Equipment non-permanent loan

Iñaki Goenaga Foundation
14/10/2008 - Unlimited
Participation in calls for training and specialization

Max Planck Institute for Biochemistry
01/12/2008 - Unlimited
Equipment non-permanent loan

PoliMilano
31/03/2009 – 5 years
Agreement for the exploitation of a joint-patent
12/02/2010 – 5 years
Agreement for the exploitation of a joint-patent led

ETP nanomedicine
17/06/2009 – 3 years
Services of the secretariat of the ETP nanomedicine

Plataforma Española de Nanomedicina – Unidad de Innovación Internacional (NanoMed UII)
30/11/2009 - Unlimited
Development of proposals for collaborative projects in the 7th Framework Program in the area of nanotechnology applied to life science

Biodonostia Research Institute
10/12/2009 - Unlimited
Collaboration in research projects

Biolan Microbiosensores
01/02/2010 - Unlimited
Foster collaboration, exchange, and integration

Euskampus
28/04/2010 - Unlimited
Development of a Campus of International Excellence UPV/EHU-TECNALIA-DIPC

FEI
01/05/2010 – 31/03/2015
Development of the Electron-Microscopy Laboratory and related research projects

Cooperation agreements

Main Nano
19/05/2010 – 4 years
Development of tools and instruments of collaborative and joint work between excellent institutions in the area of nanoscience, nanotechnology, financial institutions, and industry

University of Ferrara
20/07/2010 – 31/10/2011
Agreement for the training and guidance of master students
02/08/2011 – Unlimited
Agreement for cultural, educational, and scientific cooperation

Bioftalmik
01/10/10 - 01/04/12
Research project

Bic Gipuzkoa Berrilan
21/10/2010 – Unlimited
Development of an incubator for nanotechnology-based new companies

Universidad de Valladolid
04/05/2011 – Unlimited
Framework collaboration agreement for internship opportunities

University of Illinois
05/07/2011 – Unlimited
Collaborative research agreement

Massachusetts Institute of Technology (MIT)
01/08/2011 – 2 years
Partnership agreement

Brookhaven Science Associates
12/09/2011 – Unlimited
Non-Proprietary user agreement

Inbiomed
02/11/2011 – Unlimited
Framework collaboration agreement
15/02/2012 – 2 years
Development of a research project to grow neurons *in vitro* from stem cells

MagForce Nanotechnologies
01/08/11 - 31/07/12
Material transfer agreement

Fundación Empresa Universidad de Navarra
30/05/2012 – 1 year
Collaboration agreement for internship opportunities

Telstar Technologies
09/09/2012 – 1 year
Collaboration agreement related to Atomic Layer Deposition

Torresol Energy Investments
19/11/12 - 28/02/14
Research project

Mondragón Componentes
01/12/2012 – 1 year
Collaborative project to design and develop an innovative energy storage device

Mi.To. Technology
01/12/12 - 31/07/13
Technology transfer agreement

4 Industry Overview

Our first start-up company, Graphenea, is a leading producer of monolayer graphene films

Industry Overview

In a framework in which the Basque Country keeps promoting and diversifying its industrial fabric, nanotechnology has revealed itself to represent a key ingredient that should be able to provide the development of more efficient and less expensive industrial manufacturing processes in multiple sectors. With this objective in mind, we have been pursuing a relationship model with industry based on our commitment to listen, discuss, and brainstorm together on specific problems, bridging the gap between industry and science, and integrating innovative solutions.

During the last two years, we have made considerable progress in the opening of new venues for the creation of knowledge through the support and participation of industry, academic intervention in the solution of industry problems, the utilization by industry of our state-of-the-art equipment, and, last but not least, moving skilled researchers into close interaction with various companies and institutions.

Miryam Asunción
Techtransfer Manager

Industry Overview

"Optical Nanoholography", new patent application

nanoBusiness

With the aim of bridging the gap between basic science and technology, the nanoBusiness initiative has been launched on the basis of two programs. The IDEAS program consists in bringing experts from companies to work temporarily at nanoGUNE, so they can benefit from our research capabilities and we can learn about their ideas and needs. The TALENT program consists in sending our PhD students to work also temporarily at companies, so they can get first-hand information about the reality of the industrial world and the companies can benefit from their talent and research experience.

Encounters with companies

A number of encounters and workshops have been organized at nanoGUNE with the Gipuzkoa Association of Employers (ADEGI), in order to introduce nanoscience and nanotechnology to the employers of small and medium-sized companies and to open a framework of discussion for the development of links between nanoscience and industry and for the identification of niches of collaboration.

Start-ups and spin-offs

During the last two years, nanoGUNE has been playing a key role in the development of our first start-up company Graphenea. Graphenea, which is located at the nanoGUNE headquarters, was founded in April 2010 as a joint venture of private investors and nanoGUNE with the mission of commercializing good-quality graphene wafers and developing graphene-based technologies. Since the launching of the company, it has benefited immensely from our scientific advice, through collaboration with nanoGUNE researchers, and from the infrastructure that is available at nanoGUNE.

Recently, we have initiated the launching of two new spin-off companies: one is led by our Theory Group Leader Emilio Artacho (together with researchers from the Autonomous University of Madrid, the Spanish Research Council, and the Catalan Institute of Nanotechnology) on atomic-scale simulations; the other is led by our Nanomaterials Group Leader Mato Knez on coatings by atomic-layered deposition.

5 Connecting with society

350 visitors from high-schools and universities

200 times in the media


nano

Connecting with Society

The importance of science and technology in today's society has been increasing everyday; nevertheless, several organizations and studies point out that society knows less and less about these two subjects. Science and technology are directly related to social and economic development, so it is important for us to highlight the idea that all individuals should understand and value the key role that scientific development plays in our society.

Our objective is to promote a scientific culture that should inspire a critical society, capable of building a future in a sustainable and intelligent manner. Integrate science as part of our culture, breaking down existing barriers, has been and will continue to be our goal in this field.

With this objective in mind, we have organized a good number of initiatives, all centered around the propelling of scientific careers and the spreading of our science, from the most general to the most specific. We are convinced that proactive and open communication represents the best way to pursue our objectives.

The extremely successful turn out reflected in our activities shows that our society does not have the willingness to remain on the sidelines. We will continue contributing in this manner.

Enrique Zarate
Outreach Manager (until 31/08/2012)

Itziar Otegui
Outreach Manager (from 01/09/2012)

Connecting with Society

Fostering research careers

- ***Master in nanoscience***
  Participation in the organization and involvement in the lectures of the Master in Nanoscience, in collaboration with the University of the Basque Country.

- ***Course on nanotechnology for high-school teachers***
  Organization of the course "Nanotechnology: The big challenge of the small" in the framework of the Garatu program launched by the Department of Education, Universities, and Research of the Basque Government.

- ***Visits from educational centers***
  During the last two years, 350 high-school and university students have been visiting nanoGUNE, with the aim of having them exposed to the world of nanoscience and nanotechnology.

- ***Open doors***
  Giving undergraduate students the chance to get to know the center and speak to our researchers.

- ***Summer internships***
  Allowing undergraduate students to spend up to two months working at nanoGUNE in the framework of specific research projects.

nanoGUNE in the media

Cooperation with the media is fundamental to reduce the existing gap between science and the general public. Thanks to this cooperation, nanoGUNE's activity has been able to reach our society appearing more than 200 times in the media. In particular, we are actively involved (together with the other CIC's) in the preparation of the CIC Network magazine, and we participate regularly in the science dissemination programme Teknopolis that is regularly released on the Basque television.

Playnano event (22/11/2012)

The event (organized in collaboration with the Donostia International Physics Center, Euskampus, and the nanoBasque Agency) consisted of a participating game based on a European-Union initiative to learn and debate about the challenges that nanotechnology is facing. 50 individuals participated in this event.

6 Organization and Funding

26 grants awarded

2 Starting Grants

6 Cooperation & Capacities projects

5 Marie Curie actions

Organization and Funding

NanoGUNE was established as a non-profit making Association in February 2006, promoted by the Basque Government. A Governing Board, currently composed by all partners, is the final responsible for the overall management of the center. We also have an International Advisory Committee, composed of internationally renowned researchers and professionals, which advises on the orientation that should be given to the center.

The strategic support of public institutions to boost the development of nanoscience and nanotechnology in the Basque Country has been decisive in the start-up and development of our center's activity. In particular, the funding received from the Basque administration and the Spanish Ministry of Science and Innovation (especially through the Consolider-Ingenio 2010 Program) has been fundamental. In addition to this, since the very beginning of our activity we have aimed at increasing our ability to receive external funding through the participation in European programs and private initiatives; this has contributed to establishing ourselves as an internationally recognized center in the fundamental and technological development of nanoscience and nanotechnology. We have also benefited immensely from the Basque Science Foundation (Ikerbasque) through their program to atract talented researchers from all over the world.

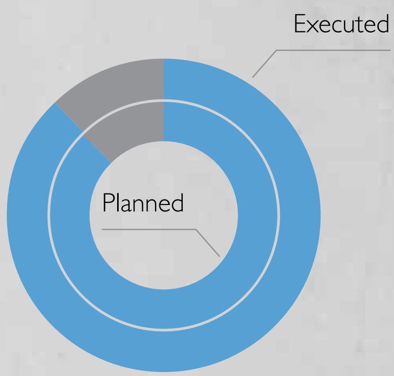
It is our commitment to take advantadge of the very strong support that we have received by the administration, in order to place the Basque Country at the forefront of nanoscience research and to contribute to the competitiveness of our industrial environment and the welfare of our entire society.

Yurdana Castelruiz
Projects Manager

Miguel Odriozola
Finance Director

Organization and Funding

Personnel on 31 December 2012	Planned	Executed
Research (including technicians and guests)	71	73
Management & Services	10	10
TOTAL	**81**	**83**



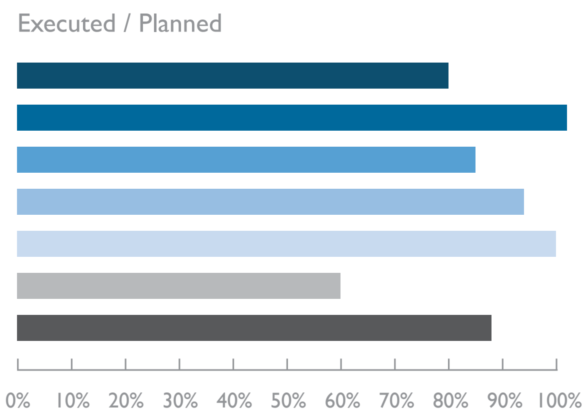
Julene Lure
Secretary

Eider García
Secretary

María Rezola
Director's Assistant

Origin

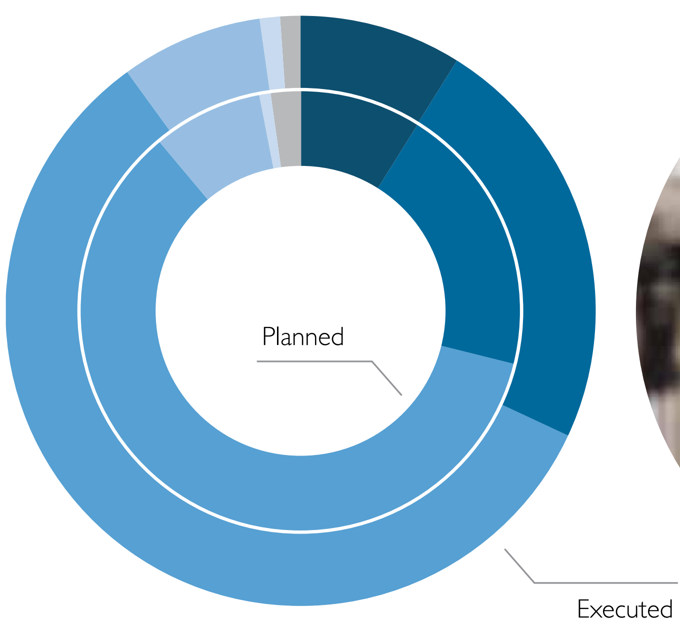
	2011-2012 (M€) Planned	Executed
Europe	2.0	1.6
Spanish Government	4.3	4.4
Basque Government - DIICT	13.1	11.1
Basque Government - DEUI *	1.6	1.5
Regional Council of Gipuzkoa	0.2	0.2
Industry & Others	0.5	0.3
TOTAL	**21.7**	**19.1**



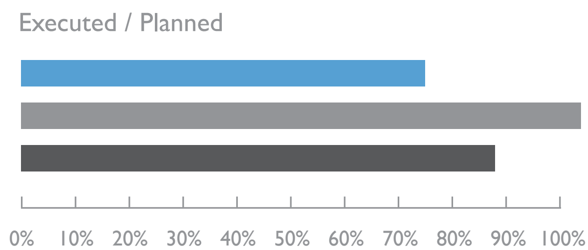
* Includes the cost of the assignment by the Basque Science Foundation of 9 Ikerbasque Research Professors and 1 Ikerbasque visiting Professor

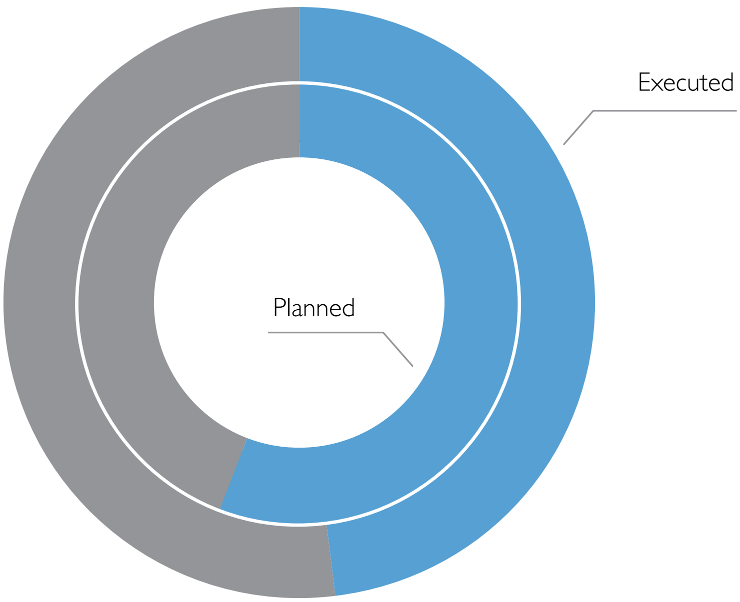
DIICT: Department of Industry, Innovation, Trade, and Tourism

DEUI: Department of Education, Universities, and Research



Destination	2011-2012 (M€)	
	Planned	Executed
Infrastructure	12.2	9.2
Operational costs	9.5	9.9
TOTAL	21.7	19.1





Funding Institutions

Governing Board

"The bases have been set for nanoGUNE to evolve into an internationally recognized center of excellence, advancing the frontiers of knowledge and using ideas to create wealth and social development"

Chairman

Donostia International Physics Center
Pedro Miguel Echenique

Vice-chairman

Tecnalia Technology Corporation
Joseba Jaureguizar

Secretary - Treasurer

IK4 Research Alliance
Javier Rodríguez (until 25/01/2011)
Jose Miguel Erdozain (from 26/01/2011)

Board members

University of the Basque Country (UPV/EHU)
Iñaki Goirizelaia

Regional Council of Gipuzkoa
Joseba Iñaki Ibarra (until 11/10/2011)
Oscar Usetxi (from 12/10/2011)

Guest members, on behalf of the Basque Government

Department of Industry, Innovation, Trade, and Tourism
Edorta Larrauri

Department of Education, Universities, and Research
Pedro Luis Arias

International Advisory Committee

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

Prof. Sir John B. Pendry (Chairman), *Imperial College, London (UK)*

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

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

Prof. Emilio Mendez, *Center for Functional Nanomaterials, Brookhaven Nat. Lab., NY (USA)*

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

Prof. Jean Marie Lehn (Chemistry Nobel Laureate, 1987), *Universite Louis Pasteur, Strasbourg (France)*

Prof. Heinrich Rohrer (Physics Nobel Laureate, 1986), *Switzerland* (until 22/10/2011)

nanoPeople

www.nanogune.eu

www.nanogune.eu

Tolosa Hiribidea, 76
E-20018 Donostia - San Sebastian
+ 34 943 574 000

CIC nanoGUNE
nanoscience cooperative research center